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Keith E. Maskus a, Tsunehiro Otsuki b & John S. Wilson c

a Department of Economics, University of Colorado, Boulder, CO, USA
b Osaka School of International Public Policy, Toyonaka, Japan
c Development Economics Research Group, The World Bank, Washington, DC, USA


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Do foreign product standards matter? Impacts on costs for developing country exporters

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*Department of Economics, University of Colorado, Boulder, CO, USA; bOsaka School of International Public Policy, Toyonaka, Japan; cDevelopment Economics Research Group, The World Bank, Washington, DC, USA

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We estimate the impact on production costs of firms in developing countries from conforming to regulations imposed by major importing countries, using firm-level data from 16 developing countries. The findings indicate that standards increase variable production costs by requiring additional labor and capital. A 1% increase in initial investment to meet foreign compliance costs raises variable costs by between 0.06 and 0.13%. Fixed costs of compliance are non-trivial, averaging about 4.7% of annual variable costs. The cost impacts might be an important determinant of export success for firms in developing countries. The results may provide one indication of the potential barriers to trade facilitation that technical regulations can pose.

Keywords: standards; regulations; compliance; translog costs

JEL Codes: F1, L15

1. Introduction

Technical regulations, such as product certification requirements, performance mandates, testing procedures, and labeling standards, exist to ensure consumer safety, network reliability, and other goals. They can also act to facilitate trade when such regulations are promulgated in an open and transparent manner. However, such regulations and mandatory standards can also significantly raise startup and production costs. As a consequence, they may act as impediments to competition by blocking firm entry and expansion within a country or, as is frequently alleged by exporting firms, as barriers to trade. Indeed, evidence suggests that there has been increased 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 are of particular concern to firms in developing countries. Such countries may bear relatively larger costs in meeting their requirements than their counterparts in developed nations.

The costs associated with meeting foreign standards and technical regulations may be borne both publicly and privately. The least developed countries, however, typically have neither the public resources required to establish and maintain 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 is often borne
directly by individual firms, such as those in Africa (Wilson and Abiola 2003). Despite the evident importance of this question, to date the impacts of foreign technical standards 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 would inform current theoretical debates. There are 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, evidence could inform domestic policy on technical standards. By illustrating the potential cost of compliance with standards, the harmonization of domestic with international standards may be judged as preferable by governments of exporting countries seeking to expand trade opportunities for domestic firms.

Third, in principle such analysis could play a role in informing World Trade Organization (WTO) dispute settlement cases. A finding that costs are raised in meeting product standards could indicate that technical regulations may be used to limit market access. In cases where the importing country’s regulations may not conform to WTO obligations, empirical data and analysis can help assess damages to the exporting country’s trade. Thus, information on the cost impact of non-harmonized standards can facilitate the resolution of trade disputes (Maskus and Wilson 2001).

Finally, evidence could help design effective policies to offset cost disadvantages incurred due to product standards. By disaggregating the impact of foreign technical standards on fixed-cost and variable-cost components for firms, a more efficient policy solution to offsetting these disadvantages might be designed by governments.

In this paper, we develop an econometric model to estimate the incremental production costs of firms in developing countries associated with achieving conformity to standards imposed by major importing countries. We use firm-level data generated through the World Bank Technical Barriers to Trade (TBT) 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. We find that complying with foreign technical standards raises a firm’s variable cost. Specifically, the elasticity of (variable) production costs with respect to standards and technical regulations is estimated to range between 0.06 and 0.13. In absolute cost terms, this translates into a rise in variable costs that is at least as large as the rise in the initial compliance costs due to more stringent standards.

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

Theoretically, product standards may either facilitate or impede international trade. Therefore, we summarize the positive and negative impact of product standards and review the relevant empirical literature below.
There are a number of different ways in which the positive effects of standards may manifest themselves. 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. Efficient and non-discriminatory standards allow consumers to compare products on a common basis in terms of regulatory characteristics, enhancing competition. For firms, production of goods adhering to recognized international standards increases output as producers are able to supply larger markets, giving rise to economies of scale. Furthermore, since standards themselves embody information about technical knowledge, conformity to efficient standards encourages firms to improve the quality and reliability of their products.

Through increased transparency of product information and compatibility across product components, technical standards may reduce business transaction costs (David and Greenstein 1990). Consumers also benefit as technical regulations could increase the flow of information between producers and consumers regarding the inherent characteristics and quality of products, thereby reducing consumer uncertainty (Jones and Hudson 1996).

International standards, in the absence of multilateral consensus on the appropriate level or setup of norms, also provide common reference points for countries to follow, so that transaction costs can be reduced. For example, in 1961, the Codex Alimentarius was developed as an international benchmark for food safety and quality. Similarly, standards developed by the International Standards Organization (ISO) and International Electrotechnical Commission (IEC), among others, provide one 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 and facilitate global trade.

Despite the potential benefits of standards, they can also restrict competition by raising compliance costs. This is particularly the case where domestic firms may be favored over foreign importers by the standard-setting countries, thereby restricting trade (Fischer and Serra 2000). Small exporting firms in developing countries are also more likely to be disproportionately affected by being required to comply with multiple international regulations without benefiting from economies of scale.

Like economic theory, empirical evidence is mixed on these issues. Some studies support the claim of an efficiency-increasing effect. Swann, Temple, and Shurmer (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 (2003) found that standards shared by two countries had a positive and significant effect on trade volumes in a gravity model. An and Maskus (2009) discovered evidence that where developing countries negotiated mutual recognition agreements with developed nations, the exports of their manufacturing firms were significantly enhanced. However, where their exporters were required to comply with international norms there was no significant impact on trade.

In contrast, the fact that regulations can act as barriers to trade is evident in several 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 9 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 Organization Economic
Cooperation and Development (OECD) importing countries and trade data from 19
exporting countries. The results indicated that a 10% increase in regulatory stringency –
tighter restrictions on the pesticide chlorpyrifos – would lead to a decrease in banana
imports of 14.8%. In another paper Wilson, Otsuki, and Majumdar (2003) addressed
the question of whether cross-country standards for maximum tetracycline (a widely
used antibiotic) affected beef trade. They examined the effects of the tetracycline stan-
dard on beef trade between 6 importing and 16 exporting countries. The results
suggested that a 10% more stringent regulation on tetracycline use would cause a
decrease in beef imports by 6.2%.

Focusing on regional standards, Chen and Mattoo (2008) found that harmonization
of technical regulations within the EU significantly expanded intra-EU trade and also
raised imports from industrialized non-member nations. However, there was a “trade
diversion effect”, in that exports to the EU from developing countries were significantly
reduced. Finally, using a bilateral gravity model, Cougherty and Grajek (2011) found
that richer OECD countries benefited from higher exports as they adopted relatively
more ISO-9000 standards. However, poorer countries with lower adoption rates found
their trade diminished, which they interpreted as the result of the costs of complying
with global norms.

Survey evidence also points to the cost-raising characteristics of technical regula-
tions. For example, a survey by the OECD (2000) of 55 firms in three sectors in the
USA, Japan and the UK, found that the additional costs of complying with foreign stan-
dards can be as high as 10%. The United States International Trade Commission (1998)
informally interviewed representatives of the US information technology industry and
revealed that standards-related costs are considered the most significant trade barrier in
that sector.

Empirical studies, undertaken to date, adopt indirect approaches to understanding
the cost impact of mandatory product standards. Econometric investigations estimate
reduced-form or gravity models of bilateral trade in which standards are entered as a
determinant of trade flows. Such studies, however, do not address the firm-level impact
of foreign standards. Survey evidence can be informative; however, previous studies
have not incorporated firm responses directly into a well-specified cost function. There-
fore, in our analysis, we undertake a systematic and parametric analysis of the actual
cost impact of complying with international standards on individual firms.

3. Modeling the cost effects of standards

Our focus here is strictly on the supply side and we leave aside the demand for stan-
dards 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 in the short run, presently leaving aside the rich variety of long-
term considerations.

3.1. Cost function

Consider a firm exporting a product to a foreign market that mandates conformity with
a standard $s$. The standard may theoretically affect both fixed and variable firm costs.
Fixed costs are incurred through the initial compliance efforts such as a one-off product redesign or purchase of capital equipment. Among the direct impacts of standards on variable costs are the costs associated with meeting processing and packaging requirements, multiple conformity assessment marks required in importing countries, and laboratory accreditation fees for product certification. However, there would also be indirect effects if labor and capital usages are altered to meet recurrent costs.

To capture the above effects, we model initial investment in compliance with the standard as a quasi-fixed factor and estimate a short-run variable cost function. The model, therefore, does not consider the full adjustment of costs in the long run.

The general cost function for the firm is specified as

\[ C = C(w, y; s, z) \]  

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: nondecreasing 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

Before specifying the precise model, we discuss three central assumptions that are required in any estimation of firm-level parametric cost functions. Theoretical considerations and our survey evidence require that we either augment these assumptions or make explicit provisions in our formal framework to accommodate them. These assumptions, with shorthand labels in parentheses, are as follows. First, firms across all industries and countries share an identical production structure (same technology). Second, the cost function is weakly separable from the aggregator for raw materials and intermediate inputs (separability).

Application of the transcendental logarithmic (translog) function to industry-level production data across OECD countries shows that the same-technology assumption is unlikely to hold (Harrigan 1997). Instead, we make the less stringent assumption that firms within an industry within each country share the same cost functions and that efficiency differences by industry and country are Hicks-neutral. This assumption is implemented by including industry and country fixed effects in vector \( z \) of the above cost function in every specification to control for differences in technology relative to the benchmark function.

The separability assumption is necessitated by the fact that to incorporate intermediate inputs into the cost function would require firm-level data on prices of materials and intermediates. Our survey data do not provide these. Accordingly, we specify Equation (1) as the cost of producing net output, or value added, introducing only labor and capital as variable inputs – the meaning of weak separability in this instance. This implies
that the choice of relative labor and capital inputs is independent of material and intermediate input prices. As a result, the cost function that reflects this technology is rewritten as

\[ C(w, y; s, z) = (C^1(y, w^1; s, z), C^2(y, w^2; s, z)), \]

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 are taken to be homogeneous of degree one in \( w^1 \) and \( w^2 \), respectively, in order to be consistent with the linear homogeneity of \( C \) in \( w \). Separating the cost function enables us to focus on the variable costs associated with labor and capital. In turn, this permits us to estimate the elasticity of value-added cost (which corresponds to \( C^1 \)) with respect to standards. This elasticity may be written as

\[ \sigma_s = \frac{\partial C^1}{\partial s} \frac{s}{C^1} = \frac{\partial \ln C^1}{\partial \ln s} \]

The exogeneity assumption is rejected by a cursory inspection of our survey data. 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. Put differently, firms select input levels and our measures of both costs and factor prices are at least partially determined by those choices. In turn, rather than being exogenously taken from factor markets, our measured factor prices are jointly determined with production costs. Moreover, within each country there is considerable variability across firms and industries in measured wages and capital prices, suggesting that we face measurement error from unobserved strategies or simply reporting problems.

To illustrate further, we obtain the average salary per firm by dividing the total payroll figure by firm employment. Table 1, summarizing the input data, clearly demonstrates that salaries vary across firms within each country. It is unreasonable to assume, as a result, that all firms face a common wage set in a competitive labor market. Similarly, we calculate the average price of capital per firm as operating surplus (value added less payroll), divided by the value of fixed assets. Table 1 again illustrates that this input price varies across firms as well.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total variable costs (value added) (US$1000)</td>
<td>9087</td>
<td>22,744</td>
<td>13</td>
<td>189,463</td>
</tr>
<tr>
<td>Sales (US$1000)</td>
<td>21,382</td>
<td>49,297</td>
<td>48</td>
<td>336,216</td>
</tr>
<tr>
<td>Wage rate (US$1000)</td>
<td>3.14</td>
<td>3.14</td>
<td>0.11</td>
<td>15.38</td>
</tr>
<tr>
<td>Wage rate instrumented (US$1000)</td>
<td>2.47</td>
<td>1.78</td>
<td>0.34</td>
<td>8.15</td>
</tr>
<tr>
<td>Unit price of capital (US$1000)</td>
<td>1.92</td>
<td>4.10</td>
<td>0.00</td>
<td>29.91</td>
</tr>
<tr>
<td>Unit price of capital instrumented (US$1000)</td>
<td>0.82</td>
<td>0.63</td>
<td>0.06</td>
<td>4.01</td>
</tr>
<tr>
<td>Per capita GDP (US$1000)</td>
<td>2.22</td>
<td>1.89</td>
<td>0.26</td>
<td>7.47</td>
</tr>
<tr>
<td>Real interest rate (lending) (%)</td>
<td>9.00</td>
<td>4.78</td>
<td>1.68</td>
<td>29.09</td>
</tr>
<tr>
<td>Number of years since foundation</td>
<td>27.58</td>
<td>23.71</td>
<td>2</td>
<td>142</td>
</tr>
<tr>
<td>Standards (compliance costs of previous year) (US$1000)</td>
<td>425</td>
<td>1441</td>
<td>0.357</td>
<td>12,310</td>
</tr>
</tbody>
</table>

*Please see Section 5 for the instruments used for the wage rate and the unit price of capital.
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 may 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. Instead, 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. The model is specified as follows:

\[
\begin{align*}
    w_{iL}^{jk} &= a_0 + a_1 w_{iL}^{k} + a_2 w_{iK}^{k} + \sum a_3 D^j + \sum a_{4k} D^k + a_5 AGE_{iL}^{jk} + \sum a_{6m} D^m \\
    w_{iK}^{jk} &= b_0 + b_1 w_{iL}^{k} + b_2 w_{iK}^{k} + \sum b_3 D^j + \sum b_{4k} D^k + b_5 AGE_{iK}^{jk} + \sum b_{6m} D^m
\end{align*}
\]

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.

Having examined and augmented the three central assumptions of a parametric cost function, we move to specifying a short-run variable cost translog function. Our function treats the standard with which a firm must comply as a quasi-fixed factor. 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. The proposed translog function permits a flexible second-order approximation to a cost structure depending on output, input prices, and standards. Thus, the central specification of costs for firm \( i \) is as follows:

\[
\ln \tilde{C}_i = \beta_0 + \beta_y \ln y_i + \beta_L \ln w_{Li} + \beta_K \ln w_{Ki} + \frac{1}{2} \beta_{LL} (\ln w_{Li})^2 + \frac{1}{2} \beta_{KK} (\ln w_{Ki})^2 \\
+ \frac{1}{2} \beta_{yy} (\ln y_i)^2 + \beta_{LK} \ln w_{Li} \ln w_{Ki} + \beta_{Ly} \ln w_{Li} \ln y_i + \beta_{Ky} \ln w_{Ki} \ln y_i + \beta_s \ln s_i \\
+ \beta_{Ls} \ln w_{Li} \ln s_i + \beta_{Ks} \ln w_{Ki} \ln s_i + \beta_{ys} \ln y_i \ln s_i + \frac{1}{2} \beta_{ss} (\ln s_i)^2 + \sum_{n=1}^{N} \beta_{zn} z_n \\
+ \sum_{c=1}^{C} \beta_{zc} z_c + \beta_{D} D_{dom} + \epsilon_i
\]

where \( \tilde{C} \) denotes value-added (cost of labor and capital, referred to as production cost hereafter), \( w_{Li} \) denotes the instrumented wage rate, \( w_{Ki} \) denotes the instrumented unit price of capital, \( y \) denotes sales as a measure of output, and \( s \) denotes the firm-specific measure of standards. Table 1 summarizes the variables in the estimation sample. The variables \( z_n \) and \( z_c \) denote industry-specific and country-specific factors, respectively,
Table 2. Industries in the sample.

<table>
<thead>
<tr>
<th>Aggregate industry</th>
<th>Sub-industry</th>
<th>Number of firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw food</td>
<td>Raw agricultural and meat products</td>
<td>18</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td><strong>18</strong></td>
</tr>
<tr>
<td>Processed food, tobacco, drug and liquor</td>
<td>Processed food, tobacco, drug and liquor</td>
<td>24</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td><strong>24</strong></td>
</tr>
<tr>
<td>Equipment</td>
<td>Electronics</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Industrial equipment</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Transportation equipment and auto parts</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Other equipment</td>
<td>6</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td><strong>31</strong></td>
</tr>
<tr>
<td>Textiles and materials</td>
<td>Metal and mineral</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Chemical</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Leather</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Plastics material</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Textiles and apparel</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>Wood product</td>
<td>2</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td></td>
<td><strong>86</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>159</strong></td>
</tr>
</tbody>
</table>

Table 3. Number of surveys used for the analysis by country.

<table>
<thead>
<tr>
<th>Region</th>
<th>Country</th>
<th>Number of firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>East Europe</td>
<td>Bulgaria</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Czech Republic</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Poland</td>
<td>9</td>
</tr>
<tr>
<td><strong>East Europe total</strong></td>
<td></td>
<td><strong>38</strong></td>
</tr>
<tr>
<td>Latin America and Caribbean</td>
<td>Argentina</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Chile</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Honduras</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Panama</td>
<td>6</td>
</tr>
<tr>
<td><strong>Latin America and Caribbean Total</strong></td>
<td></td>
<td><strong>21</strong></td>
</tr>
<tr>
<td>Middle East</td>
<td>Iran</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Jordan</td>
<td>6</td>
</tr>
<tr>
<td><strong>Middle East total</strong></td>
<td></td>
<td><strong>20</strong></td>
</tr>
<tr>
<td>South Asia</td>
<td>India</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>Pakistan</td>
<td>30</td>
</tr>
<tr>
<td><strong>South Asia total</strong></td>
<td></td>
<td><strong>41</strong></td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>Kenya</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Nigeria</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Senegal</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>South Africa</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Uganda</td>
<td>5</td>
</tr>
<tr>
<td><strong>Sub-Saharan Africa total</strong></td>
<td></td>
<td><strong>39</strong></td>
</tr>
<tr>
<td><strong>16 country total</strong></td>
<td></td>
<td><strong>159</strong></td>
</tr>
</tbody>
</table>
affecting firm costs. As discussed in the previous section, 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 survey was designed specifically to measure cost associated with foreign technical regulations and standards. In addition, however, 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. Finally, the variable \( e_i \) 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:

\[
S_{Li} = \beta_L + \beta_{LL} \ln w_{Li} + \beta_{LK} \ln w_{Ki} + \beta_{Ly} \ln y_i + \beta_{Ls} \ln s_i + \mu_i
\]  

(7)

The error term is also assumed to be 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:

\[
\begin{align*}
\beta_L + \beta_K &= 1 \\
\beta_{KK} + \beta_{LK} &= 0 \\
\beta_{LL} + \beta_{LK} &= 0 \\
\beta_{Ly} + \beta_{Ky} &= 0 \\
\beta_{Ls} + \beta_{Ks} &= 0
\end{align*}
\]  

(8)

Equations (6) and (7) are estimated jointly in an iterative three-stage least squares procedure (I3SLS), subject to the constraints in Equation (8). When one of the share equations is dropped, the I3SLS procedure 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 Equation (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 \( \beta_{Ls} \) in the share Equation (7) measures the bias in labor use (impact on labor share) from an increase in the foreign standard \( \left( \frac{\partial S_L}{\partial \ln s} = \beta_{Ls} \right) \), and likewise for the bias in capital use, \( \left( \frac{\partial S_K}{\partial \ln s} = \beta_{Ks} \right) \). 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

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

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

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

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

\[
\sigma_{ii} = \frac{\beta_{ii} + S_{ii}^2 - S_i}{S_i}, \quad i = L \text{ or } K
\]

\[
\sigma_{ij} = \frac{\beta_{ij} + S_{ij}^2}{S_{ij}}, \quad i = L, \ j = K.
\] (11)

4. Data and variable construction

The data used for cost estimation are taken from a novel 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 TBT Survey data

The World Bank TBT 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. The survey was administered in 2002 to 689 firms in 17 developing countries. The objective of the survey is to obtain information on the relevant standards, government regulations, and TBT confronting exporters from developing countries seeking to enter major developed-country markets.

The countries cover a range of economic development and export experience and also 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 is listed in Table 3.

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: “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, and form of ownership, employment, payroll and 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 survey selection procedure 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 exported in 2002 is 646 or 93.6% of the total. The number of firms that clearly did not export is 43 or 6.4% of the total. Seventy percent of the firms in the total sample faced the need to comply with technical regulations (as defined in the survey) in their export markets.

Across all five regions, 55% of the firms may be categorized as the headquarters location of a privately held, non-listed company. About 20% are the headquarters location of a publicly traded or listed company and 18% are subsidiaries or joint ventures of a domestic enterprise. About 6.5% 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. Measuring the stringency of standards

We use the increase in previous year’s reported investment cost for compliance as our measure of the short-run fixed cost of standards and technical regulations. A direct measure of the stringency of these standards confronting a variety of industries and importing partner countries is difficult to define, quantify or aggregate across firms. However, the relative increase in setup costs incurred in complying with these standards is a good proxy for their stringency. In addition, this proxy is expressed in dollar terms and is therefore comparable across industries and countries. Finally, 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 4. 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?” Three categories were listed, and respondents indicated their dollar costs within the percentage ranges. To focus on incremental investment as a measure of quasi-fixed costs, we construct a standards-cost aggregate. Weighted-average setup costs with regard to each category were computed

<table>
<thead>
<tr>
<th>Share of investment costs</th>
<th>1–10%</th>
<th>11–25%</th>
<th>26–50%</th>
<th>51–75%</th>
<th>76–100%</th>
<th>&gt;100%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Additional plant or equipment</td>
<td>62</td>
<td>32</td>
<td>14</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>120</td>
</tr>
<tr>
<td>One-time product redesign</td>
<td>70</td>
<td>17</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>96</td>
</tr>
<tr>
<td>Product redesign for each market</td>
<td>57</td>
<td>15</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>80</td>
</tr>
</tbody>
</table>
by multiplying the midpoint percentage within each range by reported investment cost of each firm, yielding a dollar figure per category per firm. The overall measure per firm is simply the sum of 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 setup costs arising from additional plant and equipment and product redesigns (in total and for multiple markets). As shown in Table 1, the total standard cost varies from a minimum of $357 to a maximum of $12.3 million, with a mean of $425,000. Reported set-up costs for compliance obviously are greater for larger firms.

Not all firms responded to all three categories. One reason is that firms may have invested in some forms of compliance needs in a period before the year prior to the survey. However, to include only those cases with responses in all of these categories would greatly 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 missing fixed costs and should result in conservative cost estimates.\(^{11}\)

5. Estimation results

The first-stage regressions to instrument labor and capital prices were run based on Equations (4) and (5). The instruments used include per capita gross domestic product (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, adjusting it for inflation as measured by the GDP deflator. These two equations were estimated jointly using seemingly unrelated regression (SUR).

In the second stage, the cost function was run jointly with the labor share equation under alternative specifications.\(^ {12}\) The parameter estimates with respect to translog models are presented in Table 5. Standard errors are reported in parentheses. In Model I, we test only for direct impact of standards on variable costs, without secondary effects through scale and variable inputs. Therefore, we exclude the quadratic term on standards and the cross-terms on standards, input prices, and output. Model II contains the full translog specification and is consistent with theory. Both of these regressions employ the instrumented factor prices from the first stage. Model III also follows the full specification but uses the raw (uninstrumented) wage rates and unit prices of capital. Model IV is estimated as the full translog function with instrumented wages and capital prices but limiting the “standards” variable to one-time product redesign costs only (excluding plant and equipment investment).\(^ {13}\) We are particularly interested here in examining if the redesign costs alone have different impacts on costs.

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

The results of the translog model estimation indicate that the signs for the coefficients for the linear and quadratic terms of the wage rate and capital price are all
Table 5. Variable cost function estimation (including industry and country effects).

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
<th>Model IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta_0$</td>
<td>-0.810</td>
<td>-1.585**</td>
<td>0.031</td>
<td>-1.751</td>
</tr>
<tr>
<td></td>
<td>(0.660)</td>
<td>(0.804)</td>
<td>(0.977)</td>
<td>(1.146)</td>
</tr>
<tr>
<td>$\beta_s$</td>
<td>0.761***</td>
<td>1.068***</td>
<td>1.153***</td>
<td>1.181***</td>
</tr>
<tr>
<td></td>
<td>(0.145)</td>
<td>(0.219)</td>
<td>(0.309)</td>
<td>(0.296)</td>
</tr>
<tr>
<td>$\beta_{sy}$</td>
<td>0.019</td>
<td>-0.040</td>
<td>-0.116**</td>
<td>-0.067</td>
</tr>
<tr>
<td></td>
<td>(0.018)</td>
<td>(0.034)</td>
<td>(0.016)</td>
<td>(0.041)</td>
</tr>
<tr>
<td>$\beta_L$</td>
<td>0.351***</td>
<td>0.376***</td>
<td>0.286***</td>
<td>0.416***</td>
</tr>
<tr>
<td></td>
<td>(0.083)</td>
<td>(0.087)</td>
<td>(0.067)</td>
<td>(0.104)</td>
</tr>
<tr>
<td>$\beta_K$</td>
<td>0.649***</td>
<td>0.624***</td>
<td>0.714***</td>
<td>0.584***</td>
</tr>
<tr>
<td></td>
<td>(0.083)</td>
<td>(0.087)</td>
<td>(0.067)</td>
<td>(0.104)</td>
</tr>
<tr>
<td>$\beta_{LL}$</td>
<td>0.013</td>
<td>0.113</td>
<td>0.005</td>
<td>(0.012)</td>
</tr>
<tr>
<td>$\beta_{KK}$</td>
<td>0.079***</td>
<td>0.077***</td>
<td>0.078***</td>
<td>0.065***</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.005)</td>
<td>(0.012)</td>
</tr>
<tr>
<td>$\beta_{LK}$</td>
<td>-0.079***</td>
<td>-0.077***</td>
<td>-0.078***</td>
<td>-0.065***</td>
</tr>
<tr>
<td></td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.005)</td>
<td>(0.012)</td>
</tr>
<tr>
<td>$\beta_{LY}$</td>
<td>-0.011</td>
<td>-0.016</td>
<td>0.006</td>
<td>-0.016</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.012)</td>
<td>(0.510)</td>
<td>(0.014)</td>
</tr>
<tr>
<td>$\beta_{KY}$</td>
<td>0.011</td>
<td>0.016</td>
<td>-0.006</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>(0.011)</td>
<td>(0.012)</td>
<td>(0.510)</td>
<td>(0.014)</td>
</tr>
<tr>
<td>$\beta_s$</td>
<td>0.055*</td>
<td>-0.254*</td>
<td>-0.528**</td>
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</tr>
<tr>
<td></td>
<td>(0.031)</td>
<td>(0.153)</td>
<td>(0.015)</td>
<td>(0.257)</td>
</tr>
<tr>
<td>$\beta_{ss}$</td>
<td>-0.050**</td>
<td>-0.084**</td>
<td>-0.079**</td>
<td>-0.079**</td>
</tr>
<tr>
<td></td>
<td>(0.025)</td>
<td>(0.018)</td>
<td>(0.037)</td>
<td>(0.037)</td>
</tr>
<tr>
<td>$\beta_{LS}$</td>
<td>-0.002</td>
<td>-0.024***</td>
<td>-0.016</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.004)</td>
<td>(0.014)</td>
<td></td>
</tr>
<tr>
<td>$\beta_{KS}$</td>
<td>0.002</td>
<td>0.024***</td>
<td>0.016</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.010)</td>
<td>(0.004)</td>
<td>(0.014)</td>
<td></td>
</tr>
<tr>
<td>$\beta_{ys}$</td>
<td>0.058**</td>
<td>0.133***</td>
<td>0.090**</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.026)</td>
<td>(0.037)</td>
<td>(0.036)</td>
<td>(0.036)</td>
</tr>
<tr>
<td>$\beta_{DOM}$</td>
<td>0.008</td>
<td>0.013</td>
<td>-0.355***</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>(0.113)</td>
<td>(0.111)</td>
<td>(0.025)</td>
<td>(0.172)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Standards</th>
<th>Redesign and equipment</th>
<th>Redesign and equipment</th>
<th>Redesign and equipment</th>
<th>One-time redesign only</th>
</tr>
</thead>
<tbody>
<tr>
<td>$w_L$ and $w_K$ instrumented</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Statistics

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$N$</td>
<td>159</td>
<td>159</td>
<td>159</td>
<td>96</td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.923</td>
<td>0.923</td>
<td>0.873</td>
<td>0.924</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-95.435</td>
<td>-92.754</td>
<td>-108.765</td>
<td>-47.915</td>
</tr>
</tbody>
</table>

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. 13SLS estimation technique was used. Figures in parentheses are standard errors and coefficients are significantly different from zero as indicated by *** (1%), ** (5%) and * (10%).

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 $\beta_s$ is positive, suggesting that costs rise in parallel with the severity of foreign standards. However, in the general models II, III, and
both the linear and quadratic coefficients on standards are negative, suggesting that
the direct effect of standards is negative or cost saving.

Coefficients $\beta_S$ and $\beta_{SS}$ measure only the direct impacts and fail to account for the
effects 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(a). We evaluate this elasticity at the mean and first and third quartiles of
standards, sales, and input prices. We find that the total elasticity of variable costs with
respect to variations in the stringency of foreign standards is between 0.055 and 0.325,
depending on the estimation approach and sample quartile. This signifies that a 1% increase in initial compliance costs leads to a rise in variable costs, in the short-run, of
between 0.06 and 0.33%. 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. The result suggests
a quantitatively large impact of foreign standards stringency on variable input costs in
exporting firms. The source of this increase is made clear by Table 7, which contains
labor and capital elasticities with respect to standard severity. Elasticity estimates for
Model III indicate that a 1% rise in foreign standards would induce a 0.3% increase in
labor and a 0.24% increase in capital employment. 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.

However, these estimates in Model III fail to account for the endogeneity between
the jointly determined production costs and factor prices in our firm-level data. The
instrumental variables approach in Models II and IV should offer more reliable esti-
mates. 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(a) 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 sug-
gests that increases in foreign standards compliance costs modestly affect variable cost.

It is not surprising that the elasticity estimates are smaller using instrumented factor
prices (Models I, II and IV) than in the case with raw data (Model III). Looking again
at Table 3, it shows that the cross-coefficients between the standards measure and both
input prices and unit costs are higher in magnitude and more significant in Model III
than in the other cases. This outcome likely reflects the joint determination of firm-level
unit costs and factor prices discussed earlier in addition to any systematic reporting
errors in the standards measures. In the likely situation that higher reported costs are
associated with both higher measured factor prices and standards charges, the (uninstru-
mented) regression coefficients and resulting factor elasticities would be overestimated.

<table>
<thead>
<tr>
<th></th>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
<th>Model IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>25th percentile</td>
<td>na</td>
<td>0.055</td>
<td>0.207***</td>
<td>0.142*</td>
</tr>
<tr>
<td></td>
<td>(1.473)</td>
<td>(4.32)</td>
<td>(1.894)</td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.055*</td>
<td>0.058*</td>
<td>0.270***</td>
<td>0.132***</td>
</tr>
<tr>
<td></td>
<td>(1.760)</td>
<td>(1.765)</td>
<td>(6.188)</td>
<td>(2.619)</td>
</tr>
<tr>
<td>75th percentile</td>
<td>na</td>
<td>0.056</td>
<td>0.325***</td>
<td>0.146***</td>
</tr>
<tr>
<td></td>
<td>(1.436)</td>
<td>(6.177)</td>
<td>(2.882)</td>
<td></td>
</tr>
</tbody>
</table>
Next, it is interesting that the estimated total cost elasticity is considerably higher in Model IV, which incorporates only the product-redesign costs as a fixed factor (compare Model IV and Model II in Table 6(a)). 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, they tentatively suggest that the need to meet foreign requirements on product characteristics matters rather more for sustaining export positions than additional capital investment. As may be seen in Table 7, the need for redesign implies induced increases in demand for labor and capital of 0.12–0.15%.

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 8, at the sample mean a 1% increase in compliance costs amounts to $4250 for the larger sample (recall from Table 1 that the average reported compliance costs were $425,000) and $1620 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 $5270 in Model II and $12,904 in Model IV. Thus, at the most conservative of estimates, the implied expansion of variable costs is as large as the rise in the initial compliance costs. The final line of Table 8 illustrates that the overall rise in costs, including both compliance expenditures and variable charges, is at least 0.1% of overall value-added costs.

At first blush this impact seems relatively small in economic terms, but two important factors should be kept in mind. First, some changes in foreign regulations might require an investment by exporting firms of far larger than 1% of existing standards costs. Second, our estimates capture only changes in variable costs. To the extent that international standards require a large fixed-cost component, which would be similar

| Table 6(b). Elasticity of variable costs with respect to scale. |
|------------------|------------------|------------------|------------------|------------------|
|                  | Model I          | Model II         | Model III        | Model IV         |
| 25 percentile    | 0.893***         | 0.998***         | 0.851***         | 0.876***         |
|                  | (21.031)         | (12.927)         | (7.785)          | (13.705)         |
| Mean             | 0.914***         | 1.112***         | 1.068***         | 1.086***         |
|                  | (23.734)         | (11.217)         | (7.404)          | (17.460)         |
| 75 percentile    | 0.939***         | 1.242***         | 1.296***         | 1.255***         |

Table 6(c). Substitution elasticities.

<table>
<thead>
<tr>
<th></th>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
<th>Model IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allen elasticity of substitution between $L$ and $K$ ($\sigma_{KL}$)</td>
<td>0.639</td>
<td>0.636</td>
<td>0.627</td>
<td>0.694</td>
</tr>
<tr>
<td>Own elasticity of $L$ ($\sigma_{LL}$)</td>
<td>-1.456</td>
<td>-1.450</td>
<td>-1.404</td>
<td>-1.600</td>
</tr>
<tr>
<td>Own elasticity of $K$ ($\sigma_{KK}$)</td>
<td>-0.280</td>
<td>-0.279</td>
<td>-0.280</td>
<td>-0.301</td>
</tr>
</tbody>
</table>

Note: Tables 6(a) and 6(b) – figures in parentheses are asymptotic $t$-values. */**/*** signify 10/5/1% significance levels.
across firms, the relative cost effect would be economically significant for smaller enterprises. Referring again to the data summary in Table 1, the smallest firms have value added of around $13,000. If the fixed-cost impact were of the same magnitude of the variable-cost impact identified here, the change could be prohibitive.

Estimates of the scale elasticity (Equation (10)) are presented in Table 6(b). This parameter measures the percentage change in variable cost with respect to a 1% 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 its estimate 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 the $j$th industry. Equations (6) and (7) may be rewritten as:

\[
\ln \tilde{C}_i = \beta_0 + \beta_L \ln y_i + \beta_L \ln w_{Li} + \beta_K \ln w_{Ki} + \frac{1}{2} \beta_{LL} (\ln w_{Li})^2 + \frac{1}{2} \beta_{KK} (\ln w_{Ki})^2 \\
+ \frac{1}{2} \beta_{yy} (\ln y_i)^2 + \frac{1}{2} \beta_{LK} \ln w_{Li} \ln w_{Ki} + \frac{1}{2} \beta_{Ly} \ln w_{Li} \ln y_i + \frac{1}{2} \beta_{Ks} D_j \ln w_{Ki} \ln y_i \\
+ \sum_j \beta_s D_j \ln s_i^j + \sum_j \beta_{lsD} D_j \ln w_{Li} \ln s_i^j + \sum_j \beta_{ksD} D_j \ln w_{Ki} \ln s_i^j \\
+ \sum_j \beta_{lsD} \ln y_i \ln s_i^j + \frac{1}{2} \sum_j \beta_{lsD} (\ln s_i^j)^2 + \sum_{c=1}^{N} \beta_{z_c} z_c + \beta_{D_d} D_{dom} + \epsilon_i
\]

(12)

\[
S_{Li} = \beta_L + \beta_{LL} \ln w_{Li} + \beta_{LK} \ln w_{Ki} + \beta_{Ly} \ln y_i + \sum_j \beta_{lsD} D_j \ln s_i + \mu_i
\]

(13)

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

\[
\beta_{lsD} + \beta_{ksD} = 0 \quad \text{where } j = 1, \ldots, J
\]

(14)

This revision of the equations and a constraint permits us to compute elasticities for four aggregated industries: textiles and materials, equipment, raw food, and processed food. The $j$th industry’s total elasticity of variable cost with respect to standards is:
The results for each model are presented in Table 9. There appear to be no significant impacts on variable costs in processed foods, 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 materials (Model IV). It must be acknowledged that interpreting these cross-industry results is difficult. Taken on face, they suggest that increases in quasi-fixed standards costs affect efficiency in equipment and textiles and materials relatively more than in processed foods and related industries. Recall, however, that the survey question referred to one-time investment costs in compliance a year prior to the survey. Thus, it is possible that firms in the processed foods and related sectors were more likely to have met such investment costs in earlier years.

As noted above, Table 7 displays the elasticities of labor and capital demand with respect to standards. These are defined as

\[
\sigma_s = \beta_s + \beta_s \ln s + \beta_{ls} \ln w_{Li} + \beta_{ks} \ln w_{Ki} + \beta_{ys} \ln y_i
\]

(15)

The results for each model are presented in Table 9. There appear to be no significant impacts on variable costs in processed foods, 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 materials (Model IV). It must be acknowledged that interpreting these cross-industry results is difficult. Taken on face, they suggest that increases in quasi-fixed standards costs affect efficiency in equipment and textiles and materials relatively more than in processed foods and related industries. Recall, however, that the survey question referred to one-time investment costs in compliance a year prior to the survey. Thus, it is possible that firms in the processed foods and related sectors were more likely to have met such investment costs in earlier years.

As noted above, Table 7 displays the elasticities of labor and capital demand with respect to standards. These are defined as

\[
\sigma_{ls} \equiv \partial \ln L / \partial \ln s = \partial \ln C / \partial \ln s - \partial \ln S_l / \partial \ln s
\]

\[
\sigma_{ks} \equiv \partial \ln K / \partial \ln s = \partial \ln C / \partial \ln s - \partial \ln S_k / \partial \ln s
\]

(16)

Table 9. Elasticity of variable cost with respect to standards by industry.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Model I</th>
<th>Model II</th>
<th>Model III</th>
<th>Model IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery and equipment</td>
<td>0.114** (2.000)</td>
<td>0.322*** (3.862)</td>
<td>0.475*** (3.888)</td>
<td>0.225 (1.409)</td>
</tr>
<tr>
<td>Processed food, tobacco, drug, and liquor</td>
<td>-0.004 (-0.060)</td>
<td>-0.053 (-0.633)</td>
<td>0.077 (0.667)</td>
<td>-0.026 (-0.148)</td>
</tr>
<tr>
<td>Raw food</td>
<td>0.018 (0.310)</td>
<td>0.079 (1.175)</td>
<td>0.419*** (4.795)</td>
<td>0.190 (1.177)</td>
</tr>
<tr>
<td>Textiles and materials</td>
<td>0.058* (1.740)</td>
<td>0.033 (0.866)</td>
<td>0.236*** (4.738)</td>
<td>0.124** (2.214)</td>
</tr>
</tbody>
</table>

Note: Figures in parenthesis are asymptotic t-values. **/*/*/* signify 10/5/1% significance level.
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 \( \sigma_{Ls} = 0.060 \) and \( \sigma_{Ks} = 0.056 \). 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, helping to explain the higher variable cost elasticity with respect to standards.

Allen partial elasticities of substitution in Table 6(c) indicate a moderate substitutability between labor and capital (\( \sigma_{KL} \)) 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. Conclusion

This paper estimates the impact of short-run costs of compliance with standards and technical regulations required by importing countries. It uses firm-level data on TBT for 16 developing countries based on the World Bank TBT Survey Database. Our 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% higher when the initial setup cost for compliance with foreign standards is increased by 1%. In this case, 0.060% additional labor and 0.056% additional capital are employed. In absolute terms, as indicated in Table 8, the rise in variable costs associated with foreign standard stringency is at least as great as the initial increase in the cost of compliance. This may be up to six times larger, depending on the estimation technique used. Furthermore, when we focus on product redesign costs only, we find the impacts on variable costs to be considerably higher, at 0.13–0.14%, with correspondingly higher effects on variable factors.

There are additional perspectives to illuminate these results. Consider the findings of the earlier-mentioned OECD study, which estimated that additional costs of compliance with foreign standards were as high as 10% of total investment. In our sample of developing countries, if such costs were as high as 10% of investment expenditures, the impact on variable costs suggested by our estimates would be as high as 1.3% or more.

There are two important caveats to our analysis, which likely lead to our estimates being at the lower end of actual elasticities. The first is that we focus only on labor and capital costs. It is possible that compliance with foreign standards gives rise to other types of input costs. Changes to manufacturing plants and new product modifications, for example, require additional raw material, energy and intermediate inputs. As a result, an estimate of variable cost elasticity with respect to standards that incorporates intermediate inputs may be significantly higher.

The second caveat is that we estimate only a short-run variable cost function. This is important to underline the lower-bound nature of our estimates. For instance, our observations only span one year of investment data and do not provide precise insight into how the impact of more stringent standard extends over later investment decisions.

With these caveats in mind, our analysis demonstrates the possible supply response in developing-country firms 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 the light of the impacts on production expenditures, particularly when considering the parity...
between the initial compliance cost increases and the concomitant rises in variable costs.

The results may be interpreted as an indication of the extent to which mandatory standards – when such standards differ substantially from international norms – may 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 continued research into estimating the cost of compliance with mandatory standards, for example in cases where the importing country’s standards do not conform to principles in the WTO TBT Agreement. For example, the TBT Agreement encourages the use of international standards, the harmonization of national standards to international ones, and seeks to promote transparency in technical regulations. In cases where countries have been found to violate these obligations, estimates of the differential cost of compliance with standards could be used to inform dispute settlement talks. Resolution of disputes could be informed with these estimates and by identifying the extent to which subsidies or public support programs are needed to offset the cost disadvantage that stems from discriminatory standards. Furthermore, identifying cost disadvantages for firms in meeting standards associated either with initial setup or variable production costs could help inform policy disputes over standards. The existence of both setup and variable costs in meeting discriminatory standards, for example, could imply that settlement of disputes should include funding to upgrade infrastructure and employee training programs to overcome cost disadvantages.

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Notes

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 practical cases “standards” cover mandatory technical requirements.
3. See the discussion in Maskus, Wilson, and Otsuki (2001).
4. Our data are insufficient for analyzing demand for compliance. Such an analysis would require data on unit prices of products that comply with standards and those that do not in each export market. These data are not currently available.
5. 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.
6. 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.
7. Ideally we would want to 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. This is not feasible given the degrees of freedom available.
8. In our particular case, the separability condition is written as

\[ \frac{\partial}{\partial w_i} \left( \frac{\partial C(w,y,z)}{\partial w_i} \right) = 0, \quad j \neq L, K, \]

or

\[ \frac{\partial}{\partial w_i} \left( \frac{\partial C(w,y,z)}{\partial w_k} \right) = 0, \quad j \neq L, K. \]

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

11. 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.

12. The maximum number of observations included in these regressions was 159. This loss in observations is largely due to the low response to the questions regarding compliance with the foreign standards and technical regulations.

13. In this case, the sample size falls to 96.

References


