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Sanitary and Phytosanitary Standards as Bridge to Cross

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ABSTRACT

This research assesses the effects of sanitary and phytosanitary (SPS) standards in international trade by introducing a new concept, *bridge to cross* (BTC), with product standards. The BTC in this paper is the regulatory gap between the exporting and importing countries with regard to any particular SPS measure. Assuming that each country's standard is binding in its own domestic markets, the standard of the importing country emerges as an effective trade barrier only when it exceeds the standard in the domestic market of the exporting country. Given the need to account for unobserved heterogeneity (multilateral resistance) in empirical trade models, if SPS regulations do not vary significantly over time, the effect of the regulation cannot be identified. However, the effect of BTC can still be identified because it varies by the pair of countries involved in the trade. As an application we apply the method to an SPS regulation relating to aflatoxin contamination in maize. In our empirical analysis we find that the effect of BTC varies by the size of the exporter and that the effect is stronger for poorer countries.

Keywords: sanitary and phytosanitary standards, gravity model, multilateral resistance, bridge to cross

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1. INTRODUCTION

This paper assesses the effects of nontariff barriers on trade, in particular the sanitary and phytosanitary (SPS) measures. According to the World Trade Organization (WTO) rules, countries can choose their own SPS standards to protect human, animal, and plant health—along with other objectives such as protection of environment—as long as they are nondiscriminatory and can be justified by science. The near-perfect sovereignty in choosing SPS measures has meant that several disputes under the SPS and Technical Barriers to Trade (TBT) agreements have occurred. Yet, a scant literature exists on the assessment of the effects of standards on trade, owing to various reasons that have been cited in Clougherty and Grajek (2008).

Several difficulties arise in assessing the impact of standards on trade, the most important being measurability, especially in a form that captures the intensity of product standards. Deardorff and Stern (1998) list standards as the most difficult nontariff barriers to quantify. The Deardorff and Stern (1998) argument has been seconded by several other studies (for example, Laird and Yeats 1990; Maskus, Wilson, and Otsuki 2001; Blind 2004; Shepherd 2007). In the absence of a quantifiable measure to capture the SPS regulation, most studies use an inventory approach, that is, one that counts the number of standards, the number of documents, or the number of import refusals while accessing the export markets (Clougherty and Grajek 2008; Baylis, Nogueira, and Pace 2010). This approach is obviously inadequate to capture the intensity of product standards across markets.

An additional data-driven constraint that applies to SPS measures follows from the sluggishness in the standards that, once set, tend to change very infrequently. The implication of this is that generally there is very little variation over time in the standards to capture their effect on trade. In the reduced-form empirical trade models, the now-well-established need to account for unobserved multilateral resistance terms requires inclusion of exporter and importer fixed effects. With the inclusion of these fixed effects, the effect of any covariate that does not vary either by trading pairs or over time cannot be identified. Product standards for a large number of cases tend to fall in this category. National treatment rule under the WTO mandates that each importing country apply the same standards to all exporters. This implies that importing country regulation, if it does not vary over time, will be subsumed in importer fixed effects.

A handful of papers that have looked at the effects of SPS measures have focused only on importing country regulations and used various proxies of SPS measures. Baylis, Nogueira, and Pace (2010), for example, show that a greater number of import refusals at the European ports has a negative effect on trade flows. While they account for the multilateral resistance in their gravity specification (as import refusals vary over time), the nature of their data does not allow accounting for zero trade (import refusals can occur only when trade happens), which makes their results susceptible to selection bias. Additionally, the number of import refusals is an imperfect measure of the intensity of SPS measures because they are driven by several other factors including reputation of the exporter.

This paper proposes an alternative method for assessing the impacts of product standards by introducing a trading-pair-varying measure of product standards in the form of a regulatory gap. The basic principle behind this measure of SPS regulation is that the gap between the importing country standards and the domestic standards is what determines the burden on the exporters. Since the BTC varies by the trading pair, it is amenable to identification in empirical models that include exporter and importer fixed effects. Apart from this technical rationale, we argue below that a BTC measure in regulation has an intuitive appeal.

Another empirical challenge in the literature on standards and trade relates to the issue of reverse causality (Casella 1996; Blind 2002). The BTC measure as defined is less likely to be subject to such concerns. For the bilateral BTC measure to be endogenous, it must be true that changes in pair-specific trade flows have an effect on the standard chosen by the exporter, by the importer, or by both and, in turn, on BTC. However, such induced change in regulation in one county would affect its BTC with all its trading pairs. The fact that standards, even if chosen in response to increases or decreases in trade flows, would apply to all countries implies that such induced variation in BTC is not likely to be systematic. Thus, suppose any country j (exporting or importing country) does change its SPS regulation in response to its trade with country i. This change will affect its BTC not only with country i but also with all other countries k that country j trades with. Thus, a systematic causality in the direction from trade flow to BTC could be unlikely.

Our variable of interest in the analysis is thus modified to be the BTC term as distinct from the importing country regulation per se. The regulatory gap in effect is what needs to be bridged to get market access. Assuming that stricter standards are achieved with higher costs, the costs because of BTC in accessing markets will vary positively with the size of the bridge. Moreover, meeting standards often imposes both fixed as well as variable costs. Thus, we hypothesize that the effect of a BTC would differ by the size of the producers that could be contextually defined.

This paper is closest to Moenius (2004, 2006), which assess the effect of bilaterally shared and country-specific standards. Moenius (2004) focuses on industrial products in 12 countries during the period 1980–1995, while in Moenius (2006) the focus is on SPS measures in agricultural trade during the same time period.

The specification in both Moenius papers (2004, 2006) measures harmonized versus country-specific standards in terms of an indicator variable. Thus, there is no role of exporting country standards when the standard is import-country specific (and not harmonized with the exporter). This is in sharp contrast to formalization in this paper, where BTC figures in all cases, regardless of whether the standards are harmonized. Comparing with the characterization in Moenius (2004, 2006), harmonized standards translate to eliminating the regulatory gap, that is, drawing the BTC measure to zero while country-specific standards could imply either a nonzero BTC for exporting country or a BTC that equals zero (when the importing country standard is weaker). Further, as a measure of regulatory barrier, the indicator variable for harmonization in these papers cannot capture the intensity when country-specific standards exist, but the BTC measure captures the intensity of standardization in all cases.

Another difference yet is in the identification strategy in this paper, where the variation that is being exploited is across trading pairs for the same product. The effects in Moenius (2004, 2006) are also identified using pairwise variation, that is, whether the importing and exporting country standards are shared or not, but the variation that it used for identification is across different products.

We apply the method of BTC to the case of regulations related to aflatoxin (a type of mycotoxin) contamination in maize to illustrate its applicability.[1] There are several reasons for this choice. Summary evidence exists on the market losses following greater stringency of mycotoxin regulations. Thailand, for example, was at one time among the world's leading corn exporters, regularly ranking among the top five exporters during the 1970s and 1980s. But partly due to aflatoxin problems, Thai corn regularly sold at a discount on international markets, costing Thailand about $50 million per year in lost export value (Tangthirasunan 1998). According to the Food and Agriculture Organization of the United Nations (FAO), the direct costs of mycotoxin contamination of corn and peanuts in Southeast Asia (Thailand, Indonesia, and the Philippines) amounted to several hundred million dollars annually (Bhat and Vasanthi 1999). Total peanut meal imports by the European Union (EU) member countries fell from more than one million tons in the mid-1970s to just 200,000–400,000 tons annually after 1982, when the mycotoxin regulations were tightened in the EU.

Standards related to aflatoxin contamination are specified in parts per billion and hence represent one of the few situations where intensity of the standards is directly measured. Secondly, in the literature as well as in policy discourses, the potential of these standards to limit trade is widely discussed (Otsuki, Wilson, and Sewadeh 2001a, 2001b). In 2001, then Secretary General of the United Nations Kofi Anan had the following remark on European harmonization of aflatoxin standards, the ex-ante effect of which

[1] Aflatoxins are highly toxic metabolites produced by the soilborne fungi Aspergillus flavus that, when in the food supply, contribute to developmental delays, morbidity, and mortality in humans and domestic animals. The Food and Agriculture Organization of the United Nations (FAO) estimates that 25 percent of the world food exports are affected by mycotoxins each year (Scholthof 2004).

was assessed in Otsuki, Wilson, and Sewadeh (2001a, 2001b): "A World Bank study has calculated that the European Union regulation on aflatoxins costs Africa $750 million each year in exports of cereals, dried fruit and nuts. And what does it achieve? It may possibly save the life of one citizen of the European Union every two years … Surely a more reasonable balance can be found."[2]

Otsuki, Wilson, and Sewadeh (2001a) explored the trade effect of the European Commission (EC) proposal to harmonize aflatoxin standards, announced in 1998, that would tighten the average level of aflatoxin standards in the EU. It was later implemented in 2002. The paper predicted the trade effect of setting aflatoxin standards under three regulatory scenarios: standards set at pre-EU harmonized levels (status quo), the harmonized EU standard adopted across Europe, and a standard set by the Codex.[3] Their findings suggested that the trade of nine African countries would potentially decline by $400 million under the proposed stringent new EU standards, whereas this trade would have increased by $670 million had the EU based its new harmonized standards on Codex guidelines that were less stringent. A second study, focusing only on edible groundnut exports from Africa by the same authors, estimated that the new EU standard for aflatoxin would result in an 11 percent decline in EU imports from Africa and a trade flow some 63 percent lower than it would have been had the Codex standards been adopted (Otsuki, Wilson, and Sewadeh 2001b).

Since the publication of these papers, two main developments have occurred in the evolution of the gravity model of trade. The first development relates to the analysis in Anderson and van Wincoop (2003), who showed that trade costs had to be measured as a "multilateral resistance" term as opposed to a bilateral cost. This term was reflected in exporter and importer price indexes (in fact an ideal price index of composite goods).

The second major development was regarding the issue of zero trade in empirical analysis. Note that both at the product level and at the aggregate level some countries do not trade with each other on a sustained basis. Following Melitz (2003) and Helpman, Melitz, and Rubinstein (2008), gravity models of international trade have been derived that can accommodate the presence of zero trade flows between countries.

We believe such a framework that incorporates zero trade is a clear improvement in empirical analysis of trade flows. Hence, the empirical model that we use for estimation is based on Melitz (2003); Helpman, Melitz, and Rubinstein (2008); and Djankov, Freund, and Pham (2010), all of which consider the fixed costs of exporting. In our case we assume that the level of these costs of exporting vis-à-vis aflatoxin regulations is a function of the level of the regulation.

We find that the effects that are obtained in log linear ordinary least squares specifications as in Otsuki, Wilson, and Sewadeh (2001a, 2001b) mostly disappear when accounting for multilateral resistance (exporter and importer hetereogeneity), sample selection, and zero trade. We also find that accounting for zero trade is important and that significant selection bias can occur if zero trade is not accounted for. We think of BTC to be more detrimental for the smaller producers because it directly affects the bilateral fixed costs of exporting.

Our BTC measure, particularly its interaction with a measure of producer size, shows that regulatory gap is an important factor in explaining the effect of SPS measure on trade flows for smaller producers. We explore the effect of our BTC measure that varies by the size of the producers in three subsamples: global sample, poor country sample, and a sample of African countries. Compared with the global sample, the effects of the BTC variable are greater in the poor and African countries.

The paper is organized as follows. The next section outlines the methodology for estimating the effect of SPS measures as a bridge to cross. Section 3 presents details on data and descriptive statistics related to these data. Section 4 presents the results of regression analysis, and Section 5 concludes and provides the possible policy implications.

[2] Kofi Anan (2001) – UN conference on Least Developed Economies, 2001.

[3] In addition, the authors examined the trade-off between human health and trade flows for each of these three regulatory scenarios based on risk assessment studies.

2. METHODOLOGY FOR ESTIMATING EFFECTS

The basic specification in this paper for assessing the effects of sanitary and phytosanitary (SPS) standards on trade is presented as a two-stage Heckman estimation process as given in equations (1) and (2),

$$T_{ij} = \gamma_1 + \pi_i + \tau_j + \mathbf{Z}_{ij}\boldsymbol{\theta} + \rho H_{ij} + \varphi BTC_{ij} + \varepsilon_{ij}, \quad (1)$$

$$X_{ij} = \gamma_2 + \pi_i + \tau_j + \alpha BTC_{ij} + \beta\{(producer\, size) * BTC_{ij}\} + \mathbf{Z}_{ij}\boldsymbol{\theta} + \vartheta \mu_{ij} + \varepsilon_{ij}, \quad (2)$$

where T_{it} is a binary variable that equals 1 if the maize exports from country j to country i is nonzero and equals 0 otherwise, and X_{ij} is the value of export from country j to country i. The intercepts are γ_1 and γ_2; the importer and exporter fixed effects are π_i and τ_j, respectively; $\mathbf{Z}_{ij}$ is a vector of pair-varying controls such as bilateral distance and other measures of trade costs (for example, common border, common language, whether or not the trading partners belong to the World Trade Organization, whether or not the two countries belong to the same legal origin, and partnerships in a preferential trading arrangement); H_{ij} is the exclusion variable that does not enter the second-stage regression (more on this later in the paper); and μ_{ij} is the inverse Mills ratio from the first stage. Note that the importer and exporter fixed effects control for multilateral resistance and are likely determinants of both propensity to export as well as the actual value of realized exports. Furthermore, the selection equation also includes the pair-varying bridge to cross (BTC) variable.

The first stage of the regression models whether or not countries trade with each other is specified as a probit regression. The second stage models the value of trade flows, taking into account the selection into trading captured in the first stage (by adding the inverse Mills ratio as one of the regressors in the second stage).

We test two versions of the second-stage regression of nonzero trade: one with the BTC variable and the other that includes an interaction between BTC and the size of the producer. As a measure of size we use a binary variable that indicates whether the cultivated maize area as a proportion of a country's agrarian population is less than that of the global median of the same variable. In other words, the variable indicates if the exporter is a small producer. If fixed costs are to be incurred that are monotonic with the size of BTC, the marginal effect of BTC can be hypothesized to be greater for the smaller producers. A negative and significant sign on the coefficient β would imply that a given BTC is more detrimental to the smaller producers and exporters.[4]

As for the excluded variable, it is challenging to find variables that are highly correlated with a country's propensity to export and not significantly correlated with the actual levels of exports.[5] Our exclusion variable is the historical frequency of nonzero trade (H_{ij}), that is, a proportion of years in a moving window that the two countries traded with each other. Thus, for 1995, the historical frequency of positive trade for any trading pairs will be given by the proportion of years in the five-year window

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[4] Note that the size variable does not appear in the regressions other than in the interaction because it is subsumed in the exporter fixed effect due to lack of variation over time.

[5] Finding an exclusion variable in the context of trade flows is extremely difficult. Most variables that affect whether or not two countries trade are also likely to affect the amount of trade between them. It can be argued that some of the exclusion variables that have been used in the literature suffer from this problem. Helpman, Melitz, and Rubinstein (2008), in their pioneering work on deriving the empirical specifications of the gravity model from theory, use common religion as an exclusion variable. But common religion, like common language, can reduce trade costs and hence affect both the outcomes—that is, whether a pair of countries trade or not—and the value of trade that is realized.

beginning 1988 that nonzero trade occurred. Subsequently, for 1996, the window would start in 1989. The premise is that the higher the frequency of positive trade in the past, the greater the likelihood of two countries having a nonzero trade flow in the current period. This fraction of positive trade in the past moreover can be argued to affect the likelihood of trade but not necessarily the current level of trade flows.

Equations (1) and (2) are thus a standard gravity model, at the product or sector level. Estimation of trade flows with a gravity model is usually subject to two kinds of biases (Helpman, Melitz, and Rubinstein 2008). The first is the standard sample selection problem in a regression such as in equation (2), where the sample of nonzero exports is nonrandom. The Heckman correction through the inclusion of the inverse Mills ratio as a regressor in the second stage has been employed for addressing this bias in the coefficients in the second stage.

Another bias that relates to the extensive margins in trade, where not accounting for the number of firms exporting within an industry, results in omitted variable bias (Helpman, Melitz, and Rubinstein 2008). The number of firms exporting is jointly determined by the bilateral fixed costs of exporting and the productivity distribution of firms. Owing to the fixed costs, only firms with a level of productivity beyond a threshold end up exporting. In our setting, SPS standard and by extension the BTC would directly result in introducing fixed costs in exporting and thereby affect the extensive margin of trade. In models like Krugman-Dixit-Stiglitz, with fixed costs of exporting, the size of the extensive margin of trade, however, is a direct function of the elasticity of substitution across varieties in a sector that tends to be high in agriculture.

Belenkiy (2009) decomposes the biases in gravity models in the manufacturing, mining, and agriculture industries and shows that the extensive margin correction bias in standard gravity models does not hold uniformly across all industries. In agriculture, characterized by high elasticity of substitution between the exported varieties, the extensive margin correction is not a significant determinant of trade flows. At the same time, Belenkiy (2009) finds that the nonrandom selection (Heckman) correction is significant in agricultural exports. The estimation strategy in equations (1) and (2) is in line with these findings.

Finally, note that the identification strategy for the effects on trade is based on exploiting cross-sectional trading pairwise variation. Recall that standards tend to be sluggish over time. For this reason our BTC measure also has low intertemporal variation (though possibly more than country-specific standards per se), but there is significant variation in BTC across trading pairs. By treating each observation for a trading pair at different points in time as a unique entry, only bilateral variables such as distance or BTC can be identified. All other variables that are exporter- or importer-specific (gross domestic product, for example) get subsumed in the fixed effects even if they vary over time. This identification strategy is identical to Helpman, Melitz and Rubeinstein(2008) and Manova (2006), where the effect of distance is to be identified.

3. DATA AND DESCRIPTIVE STATISTICS

As discussed above, we chose to study aflatoxin regulation because of its uniqueness as a continuous measure of sanitary and phytosanitary (SPS) standards. Maize trade is chosen because it is one of the most highly traded staples in the world, both as food as well as feed. Maize is moreover highly prone to mycotoxin (including aflatoxin) contamination, and regulations apply to both food and feed trade. Wu (2008) points out that the issue of mycotoxins has been historically observed for a long time but the real recognition came from the 1960 discovery of aflatoxins in the United Kingdom that resulted in the deaths of 100,000 turkeys. Wu (2008) further points out that now several dozen mycotoxins have been identified. This paper focuses only on aflatoxins, which has drawn the maximum attention with regard to food safety. The SPS regulations related to food and feed in aflatoxin contamination, however, are different among countries, and in some cases quite significantly. In the analysis in this paper we do account for this distinction.

According to Dohlman (2003), food contaminated with mycotoxins, and particularly with aflatoxins, can cause acute illness that is sometimes fatal and are associated with increased cancer risk. Dohlman (2003) further states that diverging perceptions of tolerable health risks—associated largely with a nation's level of economic development and susceptibility of crops to contamination—have led to widely varying standards among different national or multilateral agencies. Considering a set of 48 countries with established limits for total aflatoxins in food, Dohlman (2003) states that standards varied widely, ranging from 0 to 50 parts per billion.

This paper uses secondary data from several sources. Data on maize trade flows is obtained from United Nations Comtrade database. Agricultural trade is often subject to seasonal fluctuations. We therefore average the data over eight years to control for the possibility of abnormal trade flows.

The level of mycotoxin regulations is obtained from two publications from the Food and Agriculture Organization of the United Nations (FAO) titled *Worldwide Regulations for Mycotoxins in Food and Feed*—one in 1995 (FAO 1997) and the other in 2003 (FAO 2004). The data on the regulations were from the responses to queries that were sent to different governments. Note that some countries in the dataset at some points followed the Codex standard.[6] For those countries, the Codex standard relevant for that period was assigned to the countries. Also, a good number of low-income countries do not have any official mycotoxin regulations. Another set of countries includes those that did not respond to the query sent by FAO/WHO (World Health Organization). The regulation data are missing for these countries and hence we do not include them in our sample.

As discussed above, even though the aflatoxin regulations constitute a continuous measure of regulation (as opposed to count measures in inventory approaches), the construction of the SPS measure as a trade barrier needs some explanation. The aflatoxin regulations are specified as permissible limits in terms of parts per billion or micrograms per kilogram. Suppose the permissible limit in country i is μ_i. We define the regulation in country i to equal $(1/\mu_i)$; that is, the smaller the permissible limit of contamination, the tighter the standard. We then assign a value equal to 0 for countries that have reported to the FAO/WHO inquiry stating that they do not have any restriction on the permissible limits. Defined in this way, our regulation variable takes a value between 0 and 1 (with 1 being the lowest permissible limit in parts per billion in the data and the most stringent regulation, and 0 depicting the weakest regulation). There is significant variation in the data on regulation; see the example of a few countries in Table 3.1.

[6] The Codex standard is specified only for the aggregate level of mycotoxins and not specifically aflatoxins. Assuming a 60 percent share of aflatoxins in total mycotoxins, the level employed is $6 \mu g/kg$.

Table 3.1—Aflatoxin standards in select countries, 2003

Country/Region	Aflatoxins limit in human food (parts per billion)	Standard regulation defined in the paper
Australia	5	0.2
China	20	0.05
European Union	4*	0.25
Guatemala	20	0.05
India	30	0.03
United States	20	0.05

Source: Wu and Bryden (2009).
Notes: * applies to cereals and cereal products, nuts not subject to further processing and dried fruit.

Moreover, the stringency of regulations in different countries has changed over time. The European Union (EU) harmonized their regulation in 2002. After that, as new members joined the EU, they were required to apply the regulation that existed per the harmonized regulations. Table 3.2 shows when the new members joined the EU, which has a bearing on the regulations that would be applied. In our five-year slabs, this factor is particularly important for countries joining the EU in 2004. In the Czech Republic, for example, the permissible limits on aflatoxins went down to 2, from 5 when it was not a member of the EU. Hence, both the harmonization of standards in 2002 as well as entry of new members into the EU implies that globally the average level of regulation related to aflatoxins increased. Since our data on trade flows is until 2008, we do not make adjustments for Bulgaria and Romania in the dataset.

Table 3.2—Changing composition of the block with the toughest aflatoxins regulation

Original EU members	Members joining	
	May 1, 2004	January 1, 2007
Austria	Czech Republic	Bulgaria
Belgium	Cyprus	Romania
Denmark	Estonia	
Finland	Hungary	
France	Latvia	
Germany	Lithuania	
Greece	Malta	
Ireland	Poland	
Italy	Slovakia	
Luxembourg	Slovenia	
The Netherlands		
Portugal		
Spain		
United Kingdom		

Source: European Commission.

Apart from the regulation in the importing country, our modified SPS measure captures a bridge to cross (BTC) in terms of the regulatory gap. The regulatory gap is the difference in the aflatoxins standard between the importing country and the exporting country. The rationale for BTC is that costs have to be incurred to meet the domestic standards, and therefore the extra costs in exports is taken to be a function of the gap that needs to be bridged to meet the cutoff. In construction of the *BTC* variable we follow the scheme as given in Table 3.3, which lists the combination of possible scenarios regarding the regulatory situation in the exporting and importing countries and the corresponding BTC that it leads to.

Table 3.3—Scheme for construction of bridge to cross (BTC) based on regulatory gap

Regulation in		Bridge to cross
exporting country	importing country	
√	×	= 0
×	√	= import country standard
√	√	= (importer standard – exporter standard) if difference > 0 = 0, if difference ≤0
×	×	= 0

Source: Author's creation.
Note: (×) denotes no regulation, (√) denotes presence of regulation.

The bridge as defined in Table 3.3 has the following features. It equals zero if the exporting and importing countries have the same standard, including no regulation. In situations where the importing country has a regulation but the exporting country has no regulation, we define the importing country standard as the bridge. Finally, in other cases it is the difference between the importing and exporting country standards with the provision that the bridge is zero if the importing country has a laxer standard than the exporter. The BTC measure constructed like this increases with the stringency of the standard in the importing country relative to the exporting country and is bound between 0 and 1.

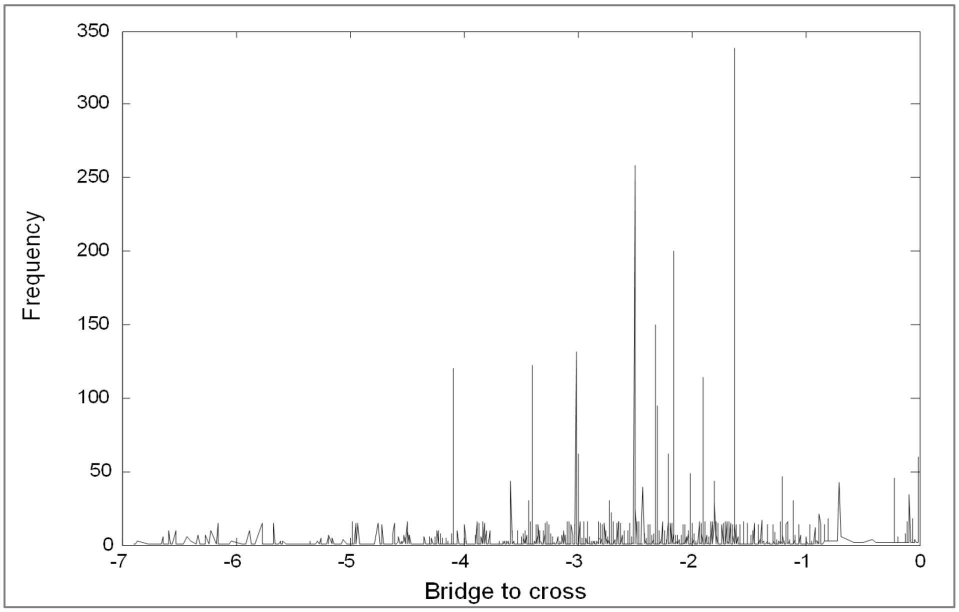
The BTC variable as constructed has the feature of capturing the benefits of the harmonization of standards between the exporting and importing countries as in Moenius (2004) and other papers. At the same time, the BTC variable mitigates the problem in harmonization measures where an even lower standard in the importing country would imply a barrier as long as it is more stringent than the one in the exporting country. While this characterization of the Technical Barriers to Trade (TBTs) agreement could be plausible in some cases (mainly where standards impose horizontal differentiation, that is, not high or low standards but different standards; for example, left-side drive versus right-side drive vehicles), it is certainly not suitable in most SPS measures. In SPS measures, the more stringent the regulation, the higher the cost of compliance and consequently the greater the trade barrier in effect. In this situation, we would argue that BTC is the logical measure for capturing the effect of SPS regulations on trade.

An important point to note particularly in maize trade is the distinction between food and feed maize. A large portion of global trade in maize is in fact as feed. The regulations between maize as food and as feed are different in all countries that report permissible limits. In the feed category, regulations vary as well. For example, feed for very young animals are often subject to a tighter regulation than feed for matured animals. We choose the weakest regulation among feed for the importing country where available.

The Comtrade data do not make a distinction between the two types of maize. Since the maize trade flow data are aggregated between food and feed, it is difficult to say what the relevant regulation is for recorded trade. In the absence of such a distinction in the trade flows data, we draw from FAOSTAT, the FAO agricultural and food database, which gives the share of maize production for food and for feed in most countries. We have no way of dividing the trade into food and feed components and to subject them to different standards; therefore, we create a new regulation variable by taking a weighted average of regulation for food and for feed, where the weight is the food-to-feed ratio in the country.

Figure 3.1 shows the distribution of the ln(BTC) variable for countries where the variable takes a nonzero value. Since $\mathrm{BTC} \in (0,1]$, ln(BTC) plotted in Figure 3.1 takes on negative values. The frequency of country pairs is high with bigger regulatory gaps, which comes from a large set of countries with notifications of no regulation.

Figure 3.1—Distribution of ln (BTC)



Source: Based on mycotoxins regulation data.

In our empirical analysis we are interested in effects across three samples, namely, global, low-income exporters, and African countries. Note that given the two-stage specification, the sample in the second-stage regression is much smaller because it includes only nonzero exports. Table 3.4 presents the summary statistics from the data. A large number of bilateral pairs do not involve trade in maize. Globally, 24 percent of trading pairs have maize trade, but only 18 percent and 14 percent in the case of poor countries and African exporters, respectively.

Table 3.1—Summary statistics for maize sample

	Full sample (N=17,038)		**Nonzero trade (N=4055)**	
All countries	Mean	Standard deviation	Mean	Standard deviation
Proportion of sample with nonzero trade	0.238	0.426	1.000	0.000
Bilateral maize trade (in 1,000 US deflated dollars)	1,191.988	25,712.250	5,008.408	52,528.540
Historical frequency of nonzero maize trade	1.296	3.146	5.129	4.625
Regulation index of importing countries	0.126	0.140	0.135	0.120
Regulation index of exporting countries	0.134	0.165	0.140	0.151
Pairwise bridge to cross (BTC)	–4.817	2.364	–4.973	2.290
Agricultural area	38,625.230	90,985.400	76,446.630	132,727.700
Agricultural population	21,989.010	104,285.900	45,580.140	165,245.200
	Full sample (N=10,681)		**Nonzero trade (N=1,965)**	
Low income (poor) exporters	Mean	Standard deviation	Mean	Standard deviation
Proportion of sample with nonzero trade	0.184	0.387	1.000	0.000
Bilateral maize trade (in 1,000 US deflated dollars)	468.399	7,011.131	2,546.043	16,186.780
Historical frequency of nonzero maize trade	0.822	2.444	4.243	4.197
Regulation index of importing countries[a]	0.115	0.153	0.118	0.135
Regulation index of exporting countries	0.134	0.165	0.139	0.150
Pairwise bridge to cross (BTC)[b]	–4.607	2.389	–4.656	2.348
Agricultural area	38,277.520	82,482.410	88,586.640	135,096.400
Agricultural population	34,459.460	130,118.900	92,223.560	228,335.700

Table 3.4—Continued

African exports	Full sample (N=3,210)		Nonzero trade (N=447)	
	Mean	Standard deviation	Mean	Standard deviation
Proportion of sample with nonzero trade	0.139	0.346	1.000	0.000
Bilateral maize trade (in 1,000 U.S. deflated dollars)	128.435	2,355.873	922.317	6,260.972
Historical frequency of nonzero maize trade	0.518	1.813	3.416	3.638
Regulation index of importing countries	0.103	0.107	0.122	0.081
Regulation index of exporting countries	0.134	0.165	0.129	0.110
Pairwise bridge to cross (BTC)	–4.595	2.410	–4.944	2.346
Agricultural area	26,306.530	26,063.830	42,521.290	38,521.190
Agricultural population	13,460.540	10,550.660	13,975.880	9,060.063

Source: Author's estimation.

Notes: (a) The regulation indexes are calculated as weighted average of regulation for food and feed, where the weight is the proportion of food to feed production ratio. Also, these indices have the range 0.001 to 1. (b) The BTC variable is in log. The range of this variable is –6.908 to –0.001.

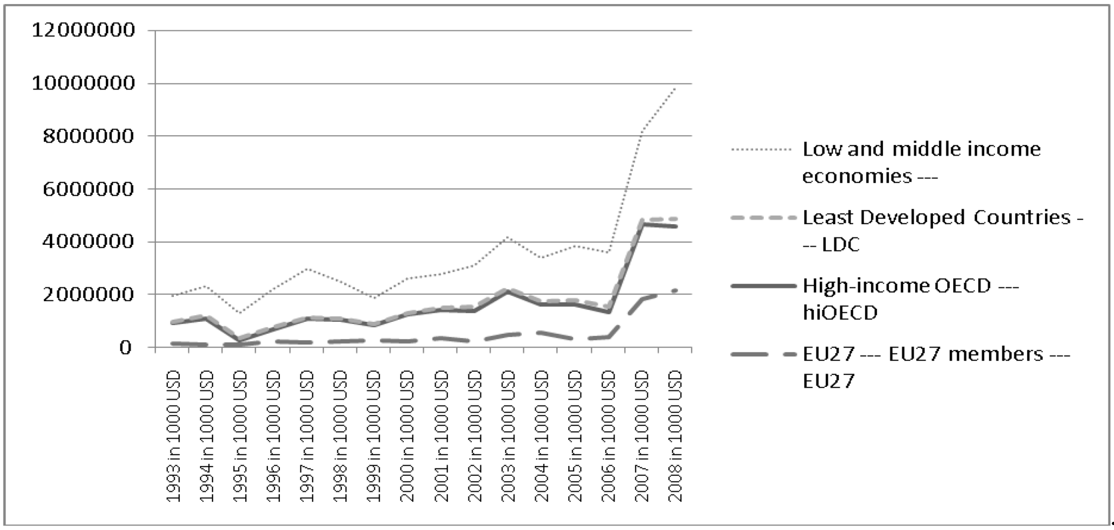
According to FAO (2006), the structure of the world maize market can be characterized as one with a high level of concentration in terms of exports but very low concentration on the import side. The main reason for this is that few countries usually have a significant maize surplus for exports, while many rely on international markets to meet their needs mostly for domestic animal feeding purposes by importing maize, a primary feed ingredient (FAO 2006). The United States is the world's largest maize exporter and accounts for roughly 60 percent of the global share (in 2006), down from more than 70 percent a decade ago, followed by Argentina and China. Brazil, the Republic of South Africa, and Ukraine are among a few other countries that often have surplus for exports.

On the side of nontariff measures, regulatory gap (BTC) is our main variable of interest. The regulation regarding permissible limits is on average weakest in Africa, followed by other poor countries relative to the world as a whole. On a worldwide basis, at least 99 countries had mycotoxin regulations for food, feed, or both in 2003—an increase of approximately 30 percent compared with 1995. In fact, in 2003 , all countries with mycotoxin regulations have regulatory limits at least for Aflatoxin B1 or the sum of Aflatoxins B1, B2, G1, and G2 (other mycotoxins) in food, feed, or both .

The number of countries regulating mycotoxins has significantly increased over the years. Only 15 African countries have any regulation. Thus, in terms of the BTC, to meet the regulation of the trading partner, poor countries in general and particularly in Africa have longer bridges to cross vis-à-vis the rest of the world. Note that African countries have on average nearly equal bridges to cross as other poor country exporters (Table 3.4).

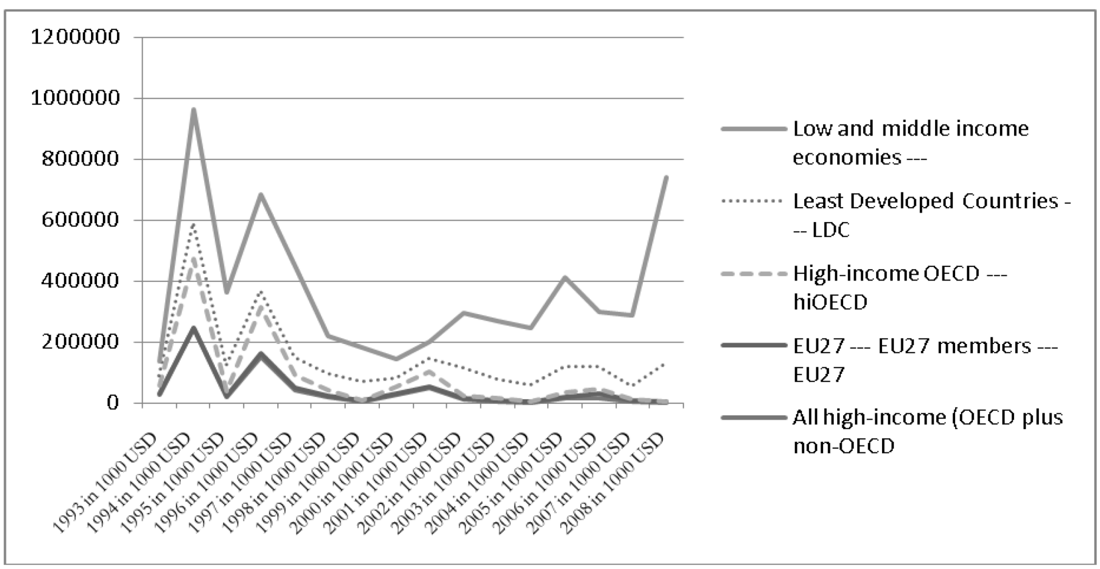
Figures 3.2 and 3.3 present the exports of maize from low- and middle-income countries and from Sub-Saharan Africa. For brevity, the figures for least-developed countries are not presented here; but the pattern is that the relatively well-off nations export to both poor and rich countries, while the poorer countries are confined mostly to exporting to low- and middle-income economies. Thus, on the intensive margin, the poor exporters have a small BTC, but taking into account the lost trade, the effect of BTC could be higher for poorer countries.

Figure 3.2—Maize exports of low- and middle-income economies (exports in thousand US dollars, y axis)



Source: UN Comtrade data.

Figure 3.3—Maize exports of Sub-Saharan African countries (exports in thousand US dollars, y axis)



Source: UN Comtrade data.

In addition to the variables related to the maize sector, several trade and other economic variables were used in the analysis. Several of those variables were obtained from the *World Development Indicators* publication of the World Bank. The distance between the trading partners and whether or not countries share a common border have also been obtained from the CEPII dataset. Similar pairwise variables include shared ethnicity; colonial link or heritage; whether the pair contains both landlocked countries, both coastal countries, both with the same legal origin, and both in a currency union; and, finally, whether the countries are involved in a conflict with each other at a particular time. The tariff data for maize in different countries are obtained from UNCTAD's TRAINS database.

4. RESULTS

Linear Effects of Bridge to Cross by Size

It is important to start the analysis with a naïve empirical model of trade, building upon which we can show the importance of the modifications that we bring to the analysis. There is an additional reason for bringing forth the discussion of a naïve gravity model of trade to assess the effects of sanitary and phytosanitary (SPS) regulations. The Otsuki, Wilson, and Sewadeh (2001a) paper on trade-inhibiting effects of SPS regulations that received a lot of attention in the press (see the discussion above), and subsequently also in the literature (with more than 40 citations), was based on the naïve empirical model of trade. For the sake of completeness, we replicate the specification in Otsuki et al. (2001a) to highlight the possibilities of under- or overestimating the effects of SPS regulations. Note that in this paper as well as in several others, the variable of interest is importing country regulation per se. Table 4.1 shows the results of the regressions with the importing country regulation as the control variable, once without accounting for multilateral resistance and zero trade flows and then again accounting for these factors. Accounting for sample selection makes a significant difference to the estimated effect of importing country regulation on trade. All these factors motivate our selection of BTC as the variable of interest in a framework that accounts for multilateral resistance, sample selection, and firm heterogeneity.

Table 4.1—Coefficient of importer regulation in gravity equation estimations

	Wilson–Otsuki (2001a) specification	Two-stage with a selection in the first stage (2)	(3)
Global sample	0.00447	–0.00438	0.0560
	(0.0369)	(0.0322)	(0.108)
Poor country exporters	0.0617	–0.0361	0.233
	(0.0513)	(0.0461)	(0.173)
African country exporters	0.0689	–0.0414	0.473
	(0.0858)	(0.0790)	(0.350)
Importer fixed effect	no	no	yes
Exporter fixed effect	no	no	yes
Other controls and constant	Colonial ties, bilateral distance, GDP exporter, GDP importer, time dummies	Pair varying control variables , GDP of exporter, GDP importer, time dummies	Pair varying control variables, time dummies

Source: Author's estimation.

Notes: (a) Pair-varying control variables include all the pair-varying variables listed in this table. (b) Gross domestic product (GDP) exporter, GDP importer, time dummies. (c) The coefficient is that of log of importer regulation. (d) Terms in parentheses denote standard errors.

The results from the two-step Heckman estimation of equations (1) and (2) for the global sample are presented in Table 4.2. Our variable of interest is the interaction between the size measure and bilateral bridge to cross (BTC). A negative and significant coefficient on this variable means that BTC has an effect on trade flows that varies by the size of the exporters.

Table 4.2—Global sample regression results

	Selection	Second stage with BTC	Second stage with interaction
Bridge-to-cross (BTC)	0.00696	0.00803	
	(0.0143)	(0.0316)	
Interaction (Size xBTC)			–0.0796*
			(0.0426)
Share common border (yes=1, no=0)	0.476***	1.321***	1.340***
	(0.164)	(0.189)	(0.188)
Trading pair ethnic–language commonality	0.254***	0.337**	0.337**
	(0.0640)	(0.147)	(0.148)
Trading pair has colonial ties	0.255*	–0.128	–0.113
	(0.151)	(0.249)	(0.247)
Both countries are landlocked	–5.916***	3.199	2.811
	(0.390)	(2.464)	(2.701)
Both countries have coasts	5.874***	–2.220	–1.822
	(0.347)	(2.447)	(2.686)
Same legal structure	0.150***	0.210**	0.215**
	(0.0441)	(0.100)	(0.101)
Trading pair belong to a currency union	–0.289	1.883***	1.870***
	(0.241)	(0.318)	(0.316)
Trading pair has a history of conflict	0.294	–0.176	–0.202
	(0.298)	(0.383)	(0.378)
Trading pair in GATT/WTO	0.139	1.428***	1.404***
	(0.141)	(0.346)	(0.351)
log (bilateral distance)	–0.559***	–1.269***	–1.252***
	(0.0319)	(0.0792)	(0.0796)
Historical frequency of trade	0.626***		
	(0.0176)		
IMR		–1.536***	–1.536***
		(0.0995)	(0.103)
Time-cluster fixed effect	yes	yes	yes
Exporter fixed effect	yes	yes	yes
Importer fixed effect	yes	yes	yes
N	17,038	17,038	4,055
R-square	.	0.745	0.745
MSE	.	2.565	2.564

Source: Author's estimations.
Note: Each regression includes a constant. GATT-General Agreement on Tariffs and Trade. IMR- Inverse Mills Ratio, MSE=Root Mean Square Error,

Table 4.3 shows the results of regressions for various subsamples. The exclusion of the United States in the global sample and of South Africa in a sample of African countries is important because both of these countries have a highly disproportionate share of exports in the respective samples. Results show that the effect of the BTC measure interacted with size is larger for poor countries, as expected. In fact, the effect is the highest for Africa (in a sample that excludes South Africa). Note that the framework takes into account zero trade; hence, even if Africa does not have significant maize trade with countries that have stringent regulation, the effect of the BTC variable in restraining market entry is accounted for.

Table 4.3—Regressions on subsamples

	Global sample without United States		Poor countries		African countries		Africa without South Africa	
	2nd stage with BTC	2nd stage with interaction	2nd stage with BTC	2nd stage with interaction	2nd stage with BTC	2nd stage with interaction	2nd stage with BTC	2nd stage with interaction
Bridge-to-cross (BTC)	–0.00152 (0.0326)		0.0339 (0.0499)		–0.0742 (0.102)		–0.0953 (0.110)	
Interaction (Size*BTC)		–0.0805* (0.0433)		–0.119** (0.0552)		–0.156 (0.107)		–0.220** (0.108)
Pair-varying variables	yes	yes	yes	yes	yes	yes	yes	yes
IMR	–1.569*** (0.102)	–1.568*** (0.105)	–1.766*** (0.149)	–1.766*** (0.157)	–1.324*** (0.327)	–1.312*** (0.375)	–1.293*** (0.322)	–1.290*** (0.378)
Time-cluster fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Exporter fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
Importer fixed effect	yes	yes	yes	yes	yes	yes	yes	yes
N	16,850	3,873	10,681	1,965	3,210	447	3,022	318
R-square	0.713	0.714	0.699	0.700	0.695	0.697	0.689	0.694
MSE	2.592	2.590	2.770	2.767	2.672	2.665	2.402	2.383

Source: Author's estimation.

Notes: Each regression has a selection equation that has not been reported and is available upon request, each regression includes a constant and the pair-varying variables are the same as listed in Table 4.2.

In terms of the quantitative effects, a 1 percent increase in the BTC variable for the exporting country with below-median-size producers in the relevant sample decreases trade by 0.08, 0.12, and 0.22 percent in the global (with or without the United States), poor country, and African exporter (without South Africa) samples, respectively. Just to put these figures into perspective, for small producers, the effect of the bilateral measure of BTC in the global sample is about 6 percent of the effect of distance (7 percent without the United States) while it is 10 percent and 17 percent in poor countries and African countries (without South Africa), respectively.

Allowing for Nonlinear Effects of Size and BTC Interaction

In the specification above, where the BTC variable interacted with a size measure is postulated to have an effect on trade flows, the nature of the effect is modeled as linear. Thus, a very high BTC and a very low BTC are treated in a symmetric fashion in terms of their effects on trade flows. In reality it is possible that the effects are more pronounced for cases of high rather than low BTC, particularly in a framework where the option of not trading exists. Thus, for a very high BTC, exporters might not find it worthwhile to trade any amount. In general, the effects of BTC on trade could vary nonlinearly even along the intensive margin.

We thus break the BTC variable into two categories: (1) above the 50th percentile of BTC and (2) below the 50th percentile of BTC. We then introduce two interactions in the first- and second-stage regressions. In the first case, the interaction of the size measure is with below 50th percentile of BTC, while in the second case it is with above 50th percentile of BTC. A priori we expect the size of the effect to be larger for high-BTC cases. Again, for brevity we present only the coefficients of interaction terms in the second stage in Table 4.4. The results in Table 4.4 confirm that this is the case for the global sample with and without the United States, for the samples of poor countries, and for the sample of African exporters without South Africa.

Table 4.4—Regressions with nonlinear effects of BTC

	Global sample	Global sample without United States	Poor countries	African countries	Africa without South Africa
Size*(low BTC)	–0.0944**	–0.0984**	–0.141**	–0.184	–0.259**
	(0.0449)	(0.0456)	(0.0576)	(0.116)	(0.116)
Size*(high BTC)	–0.168*	–0.188**	–0.255**	–0.294	–0.411*
	(0.0946)	(0.0958)	(0.116)	(0.250)	(0.239)
Pair varying variables	yes	yes	yes	yes	yes
IMR	yes	yes	yes	yes	yes
Time-cluster fixed effect	yes	yes	yes	yes	yes
Exporter fixed effect	yes	yes	yes	yes	yes
Importer fixed effect	yes	yes	yes	yes	yes
N	4,055	3,873	1,965	447	318
R-square	0.745	0.714	0.700	0.697	0.695
MSE	2.564	2.590	2.766	2.668	2.384

Source: Author's estimation.

Notes: (a) Each regression has a selection equation that has not been reported and is available upon request. (b) Each regression includes a constant. (c) The pair-varying variables are the same as listed in Table 4.2.

5. CONCLUSIONS AND POLICY IMPLICATIONS

In this paper we introduced the concept of a *bridge to cross* (BTC) for estimating the effects of sanitary and phytosanitary (SPS) regulations measures. Our gravity model specification accommodates the requirements demanded by the recent developments in the literature to overcome biased estimates. We apply the proposed method to aflatoxin regulations to illustrate an application.

With the proper specification of the gravity model and improved data, we find evidence that the BTC measure interacted with the size of the producer does have a significant effect on trade flows. We further find that the effects not only vary by the size of the producers but are also larger in poorer countries and particularly in Sub-Saharan Africa.

We would like to argue that although importing country regulation can be a rigid policy measure for the exporting country, the regulatory gap could be an actionable variable for the exporting country. This is so because an effective regulatory gap contains the domestic standard as well. In many countries, mainly developing countries, the two diverge; and consequently the burden of the regulatory gap is enhanced. In many poor countries de facto standards could be much less stringent in practice and BTC could in effect be higher.

Our idea of BTC thus has somewhat different policy implications than studies that focus on importing country regulation, the effects of which we have argued in general are difficult to identify. Even though importing country standards may not be altered, altering the size of the bridge by varying the regulation in domestic markets of exporting countries could bring in benefits. Improving domestic standards (in line with the health and other benefits) could thus be one prescription for countries to reduce the effective barrier from SPS measures.

We have proposed the idea in terms of the regulatory gap with regard to contaminants or pollutants. In these cases, a modified BTC as a gap between contamination and regulation could also be considered. The benefits could be clear in terms of reduced contamination—many countries, given their contamination levels, have a very long bridge to cross, implying that those exporters do not find it worthwhile to incur the costs of crossing the bridge and then exporting. To the extent that contaminations in an exporting country are a function of the prevailing standards, the BTC as a regulatory gap would overlap with the BTC in terms of the regulation–contamination gap.

With fixed costs and product standards as trade barriers (modeled here as a bridge to cross), there are implications for the true costs of protection along the lines of Roemer (1994). Standards invoke bridges to cross because costs need to be incurred to scale the regulatory gaps. In a world that loves variety, varieties operating near the margin would be thrown off the market as BTC becomes prohibitive. The welfare loss could thus be augmented through loss in the number of available varieties. The varieties that will drop off are likely to be from smaller producers. Hence, only if standards bring in strong gains could the welfare loss from binding BTC (through reduced varieties) outweigh the benefits.

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