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A review of empirical studies of the trade and economic effects of food-safety regulations

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Introduction

This paper is a synthesis of the empirical work analyzing the trade (e.g. trade volume) and economic (e.g. welfare) effects of food-safety regulations. Several papers provide a descriptive discussion of the general issues of food-safety and international trade (e.g. Henson et al. (Henson et al. 2000), Hooker and Caswell (Hooker and Caswell 1999), IATRC (*Agriculture in the WTO: the role of product attributes in the agricultural negotiations* 2001), OECD (*Food safety and quality issues: trade considerations* 1999), Roberts, Josling and Orden (Roberts, Josling and Orden 1999), Thilmany and Barrett (Thilmany and Barrett 1997)). While these studies provide interesting frameworks and conceptualizations of the trade and economic effects of food-safety regulations, the papers fail to provide quantitative evidence of the effects of regulations.

This paper is a review of the few empirical papers on the food-safety regulations. The emphasis of the empirical literature is to begin toestablish a benchmark of the effects of the food-safety regulations. This literature review provides the results of analyses of a limited group of food-safety regulations.

The regulations restricting trade to maintain food safety, in addition to regulations affecting the trade of products that may carry pests or disease that harm plant or animal life and health (and loosely, the environment), fall under the rubric of the Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) of the World Trade Organization (WTO). In the broadest sense, food-safety regulations affecting international trade are non-tariff barriers (NTB). OECD (*Measurement of sanitary, phytosanitary and technical barriers to trade* 2001) drew attention to NTB and suggested four reasons for empirical research on NTB:

- Domestic regulations may constitute major trade impediments and their use is proliferating. However, these NTBs may simply become more visible because of international scrutiny or more trade-restrictive because of the decrease in tariffs.
- Quantification of the economic effects of SPS and technical regulations is an important step in the regulatory reform process (Regulatory reform in the agri-food sector 1997). Quantitative analyses help inform governments as to the cost of their SPS policies and provide the elements for defining more efficient regulations (Antle 1995).
- More satisfactory techniques for estimating the damage caused to a country by foreign regulations may help to solve disputes and may serve as a basis for calculating compensation claims.

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– Sectoral studies suggest that technical regulations in developed countries constitute a considerable obstacle to agricultural food and feed exports of developing countries (Cato and Lima dos Santos 1998; Otsuki, Wilson and Sewadeh 2001a).

Despite the relevance of understanding the trade and economic effects, the literature on the trade and economic effects of SPS regulations, particularly food-safety regulations, is small. Thilmany and Barrett (Thilmany and Barrett 1997) stated, "Currently, little is understood about how regulatory barriers affect trade and investment volumes, nor how they affect the economic welfare of various global consumer populations." Since the mid-1990s, researchers have generated additional studies of the trade and economic effects of regulations of the SPS Agreement. At most this literature just begins to establish a benchmark of the effects.

Study 1

Otsuki, T. J, S. Wilson, and M. Sewadeh (Otsuki, Wilson and Sewadeh 2001b). "What Price Precaution? European Harmonisation of Aflatoxin Regulations and African Groundnut Exports"

What was the question?

The authors questioned the trade effects on nine African countries (Chad, Egypt, The Gambia, Mali, Nigeria, Sudan, Senegal, South Africa, and Zimbabwe) of a proposed, more stringent food-safety regulation in the EU (14 EU Member States except Greece). The proposed regulations would harmonize all Member States of the EU to a regulation of 2 ppb for aflatoxin B1, a carcinogen found in groundnuts. The proposed change in regulation would have been more stringent for all but four of the Member States.

What was the method employed?

The authors used the gravity model to estimate bilateral trade flows and the effect of regulations on these flows. The model "specifies that a flow from origin [*j*] to destination [*i*] can be explained by economic forces at the flow's origin, economic forces at the flow's destination, and economic forces either aiding or resisting the flow's movement from origin to destination" (Bergstrand 1985). A simplified specification of the model as presented in Otsuki, Wilson and Sewadeh (Otsuki, Wilson and Sewadeh 2001b) is[i]:

$$\ln(M_{ijkt}) = b_{ok} + b_{1k}\ln(GNPPC_{it}) + b_{2k}\ln(GNPPC_{jt}) + b_{3k}\ln(DIST_{ij}) + b_{4k}\ln(ST_{ikt}) + b_{5k}\ln(RAIN_{jt}) + b_{6k}COL_{ij} + b_{7k}YEAR + \varepsilon_{ijkt}.$$

M_{ijkt} was the trade flow in the amount of product k to EU Member State i from African country j in year t[ii]. The products were edible groundnuts, oil, and oilseed. The b parameters were the coefficients to be estimated, while the error term ε_{ijkt} was assumed to have a zero mean and to be normally and independently distributed. $GNPPC_{it}$ and $GNPPC_{jt}$ were the real per capita gross national products (GNP) in EU Member Country i and African country j in year t adjusted to the 1995 US dollar. $DIST$ was the geographical distance between countries i and j. ST_{ikt} was the maximum aflatoxin (Aflatoxin B1) level imposed on groundnut products by country i for product k for year t (since data were only available for 1995, the authors used that

level for all years, assuming no change in maximum levels). $RAIN_{jt}$ was the average rainfall in African country *j*. The authors included the average rainfall because moisture levels positively influence aflatoxin levels during storage. COL_{ij} was a dummy variable for a colonial tie between countries *i* and *j*. *YEAR* was a linear time trend (with 1989=1 to 1998=10) to account for technological change.

The regression was a pooled regression with dummy variables for oilseeds and oil interacted with the coefficients of per capita GNP, rainfall, regulations and the intercept. The model also had a fixed effects structure where the groups were defined by the exporting country.

What were the results and implications?

The results showed that the per capita GNP of the EU countries had a positive and significant effect on exports for all products. The variable representing colonial ties was significant and positive. The variable representing the regulation was significant and positive for edible groundnuts and oil. The authors also estimated the model as unpooled five-year, rolling-average blocks, which generated elasticities of increasing value, suggesting that the regulation became more substantial over time. Using the estimated elasticities (covering the entire period) of the regulations and the trade volume and prices of 1998, the authors showed that making the regulation more stringent at 1 ppb, the estimated loss of value for African exports would be 482,400 US$ or 72 percent of the 1998 value. If the EU countries adjusted their regulations to the proposed EU regulation of 2 ppb, then the loss to African exports would be 238,900 US$ or 36 percent of the 1998 value. If all of the Member States of the EU adjusted their regulations to 9 ppb, the international standard that Codex Alimentarius[iii] suggested, the increase in trade value would be 480,600 US$ or 72 percent of the 1998 value.

Study 2

Otsuki, T., J. S. Wilson, and M. Sewadeh (Otsuki, Wilson and Sewadeh 2001a), "Saving Two in a Billion: Quantifying the Trade Effect of European Food Safety Standards on African Exports."

What was the question?

Otuski, Wilson, and Sewadeh investigated the effect on the value of trade flows of a proposed, harmonized regulation on maximum allowable aflatoxin levels for two food product groups: i) cereals and cereal preparations and ii) dried fruits, nuts, and vegetables. Specifically the authors made comparisons among the status-quo regulation; the proposed EU regulation, which would harmonize the Member States and was more stringent than the status quo for most Member States; and the suggested Codex regulation, which was less stringent for most Member States. The results of the changes in the regulation were linked to the differences of estimated health outcomes in terms of number of liver cancer deaths resulting from the different maximum aflatoxin levels. The countries included in the model were 15 European countries (Norway and the Member States of the EU except Greece) and nine African countries (Chad, Egypt, the Gambia, Mali, Nigeria, Senegal, South Africa, Sudan, and Zimbabwe).

What was the method employed?

The authors used a similar gravity model as presented in paper 1 to look at the effect of aflatoxin regulations on the value of trade flows for two food product groups.

$$\ln(V_{ijkt}) = b_{ok} + b_{1k}\ln(GNPPC_{it}) + b_{2k}\ln(GNPPC_{jt}) + b_{3k}\ln(DIST_{ij}) + b_{4k}(COL_{ij}) + b_{5k}YEAR + b_{6k}\ln(ST_{ikt}) + \varepsilon_{ijkt}.$$

The variables in this model were described in the methods section of paper 1, except for the dependent variable. The dependent variable V_{ijkt} was the value, not the volume, of trade of product *k* imported by country *i* and exported country *j* in year *t*.

The authors stated "Dummy variables for exporting countries are included in the model in order to control unobserved factors such as environment and product quantity, which may vary across these countries" (p. 505). Therefore, additional dummy variables were included in the model. The specification for the gravity model also included a fixed-effect specification for the importing countries.

What were the results and implications?

The models were estimated for i) cereals and cereal preparations, and ii) dried fruits, nuts, and vegetables, separately. For the cereal and cereal-preparation model, the per capita GNP of European countries, the regulation and the colonial-tie dummy variables were positive and significant at the five-percent level. The distance variable was negative and significant at the five-percent level. For the dried fruits, nuts and vegetable model, per capita GNP for European countries, the aflatoxin regulation, and the colonial tie were all positive and significant at the five-percent level. The per capita GNP for the African countries variable was also positive but significant at the ten-percent level. For the dried fruits, nuts and vegetable model, the distance variable was negative and significant at the five-percent level.

These coefficients showed that an increase in the per capita GNP would increase the import of the products. The positive sign on the regulation suggested that increased stringency of the regulation, that is lowering the maximum allowable level of aflatoxin B1, would lower the trade of the products. The colonial tie had a positive effect on the trade of goods between countries. The negative sign on the distance suggested that countries that were more distant trading partners traded less than trading partners closer together.

The authors separated the data into three groups: i) coconuts, Brazil and cashew nuts; ii) groundnuts and other edible nuts; and iii) dried and preserved fruit. Two of the estimated elasticities for the regulation (because of the double-log specification, the elasticity is the estimated coefficient from the regulation variable) were positive and statistically significant at five-percent significance level - (groundnuts and other edible nuts; and dried and preserved fruit) and at the ten-percent level (coconuts, Brazil and cashew nuts). The elasticity of the regulation for dried and preserved fruit was not significant. The elasticity of the regulation on the trade of groundnuts and other edible nuts was larger than the elasticity for Brazil and cashew nuts. Given that most of the concern for aflatoxins has to do with groundnuts, the result was not surprising.

Given the estimated elasticities the authors calculated the impact of harmonizing the various EU regulations to the proposed, more stringent policy or to the less stringent Codex standard. In 1998 the value of cereal and cereal-product exports from Africa to Europe was 298 million US$. A move to the more stringent proposed EU

regulation would generate a loss of 177 million US$ or 59 percent of the 1998 value. A move to the less stringent Codex standard would generate a gain in trade value of 202 million US$ or 68 percent of the 1998 value. The reduction in value of using the proposed EU harmonized regulation rather than the Codex standard would be 76 percent of the 1998 value.

The results were similar for the value of edible nuts. In 1998 the value of edible nuts from Africa to Europe was 472 million US$. A move to the more stringent, proposed EU regulation would generate a loss of 220 million US$ or 47 percent of the 1998 value. A move to the less stringent Codex standard would generate a gain in trade value of 66 million US$ or 14 percent of the 1998 value. The reduction in value when using the EU harmonized regulation rather than the Codex standard would be 53 percent of the 1998 value.

According to the estimated results and estimates from the Food and Agriculture Organisation (FAO), the number of lives saved from liver cancer from the more stringent aflatoxin regulations would be 0.9 lives saved per one billion persons. The loss in value of African food exports to the EU of moving to the more stringent, proposed EU aflatoxin regulation would be 340 million US$. Comparing the EU regulation with the Codex standard, the loss in value of African food exports would be 670 million US$ and the gain would be 2.3 lives saved per one billion persons.

Study 3

Wilson, J. S. and T. Otsuki (Wilson and Otsuki 2001), "Global Trade and Food Safety: Winners and Losers in a Fragmented System."

What was the question?

The question that Wilson and Otsuki attempted to answer was: what would be the effect of harmonizing of aflatoxin regulations on trade for cereal, edible nuts, and dried fruit on trade of these products? The authors also investigated the effects on the different importers and exporters.

What was the method employed?

The authors used a modification of the gravity model as given in papers 1 and 2 to look at the trade between 15 importing (4 developing) countries and 31 exporting (21 developing) countries.

$$\begin{aligned}\ln(V_{ijt}) = {} & b_o + b_1 \ln(GNPPC_{it}) + b_2 \ln(GNPPC_{jt}) + b_3 \ln(DIST_{ij}) + b_4 (ST_{it}) \\ & + b_5 (COL_{ij}) + b_6 EU_{ij} + b_7 ASEAN_{ij} + b_8 NAFTA_{ij} + b_9 MERCOSUR_{ij} \\ & + b_{10} YEAR96 + b_{11} YEAR97 + b_{12} YEAR98 + \varepsilon_{ijt}.\end{aligned}$$

The descriptions of most terms in the model are given in the methods section of paper 1. EU_{ij}, $ASEAN_{ij}$ (Association of South East Asian Nations), $NAFTA_{ij}$ (North American Free Trade Agreement), and $MERCOSUR_{ij}$ (Southern Common Market) were dummy variables, which are equal to one if the exporting and importing countries were members of the trade union and equal to zero otherwise. The variables *YEAR96*, *YEAR97*, and *YEAR98* were dummy variables representing the different years in the study. The authors limited the data set to the years 1995 to 1998, which was a shorter timeframe relative to the timeframe of the other two papers.

What were the results and implications?

The model was used for i) cereals, ii) edible nuts, and iii) dried and preserved fruit, separately. For the cereals model, the coefficients of per capita GNP of the importer, the regulation, the dummy variables for colonial ties, EU membership, and MERCOSUR membership were positive and significant at the one-percent significance level. The coefficient of the per capita GNP of the exporting country was also positive but significant at the five-percent level. The coefficients of the distance variable and the dummy variable for membership in NAFTA were negative and significant at the one-percent level.

For the edible nuts model, the coefficients of the variables per capita GNP for importing nations, the regulation, and the dummy variables for colonial ties and EU membership were all positive and significant at the one-percent level. The coefficient of the distance variable was negative and significant at the one-percent level.

For the dried and preserved fruits model, the coefficients of per capita GNP of the importer and exporter, the dummy variables for colonial ties, EU membership, and MERCOSUR membership were positive and significant at the one-percent level. The coefficient for the dummy variable of membership in ASEAN and NAFTA were positive and significant at the five- and ten-percent levels, respectively. The coefficients of the distance variable and the time dummy for 1998 were negative and significant at the one- and ten-percent levels, respectively. However, the coefficient for the regulation was not statistically significant; thus, further analysis of the variable was omitted.

The authors provided scenarios in which they compared different settings of the aflatoxin regulation. Under the base scenario all importers had different aflatoxin regulations. Of the 15 importers only four had a regulation that was less stringent than the Codex standard. Of the six EU Member States, only two had regulations, which were more restrictive than the proposed EU regulation. The different cases were 1) all nations move to the proposed, more stringent EU regulation, 2) only the EU nations move to the proposed EU regulation, and 3) all nations move to the Codex standard. The authors found that if all importing nations would adopt the Codex standard the trade of cereal and nuts would increase by 6.1 billion US$ or 51 percent compared to the 1998 level. The result was 7.1 billion US$ (65 percent) more than the value in the case where only the Member States of the EU adopt the proposed EU standard. In the case where all importing countries adopted the proposed EU regulation, the trade under the Codex standard would be 12.2 billion US$ (or 67 percent) more than the 1998 level.

Study 4

Overton, B. J. Begin, and W. Foster (Overton, Beghin and Foster 1995). "Phytosanitary Regulation and Agricultural Flows: Tobacco Inputs and Cigarettes Outputs"

What was the question?

Overton, Begin and Foster stated that at the time of publishing this paper, Germany, Italy, and Spain restricted the level of maleic hydrazide to 80 ppm in domestic and imported cigarettes[iv]. Maleic hydrazide is a growth inhibitor used in the production of tobacco. However, the regulation restricted the presence of the chemical in the final product, not on unprocessed tobacco. Because different levels of the market are affected by the regulation, the authors investigated the trade and economic

effects of the maximum residue levels on the input and output levels. In particular, the authors simulated the effects of making more stringent EU regulation on tobacco-growing and tobacco-manufacturing industries on production costs, factor demands, and trade flows.

What was the method employed?

The authors used a partial equilibrium model to simulate the effect of a 10-percent reduction in the maximum residue level of maleic hydrazide in cigarettes. The model had supply and demand equations for US and EU cigarettes, assuming a constant elasticity of substitution for inputs and constant returns to scale. The model had derived demand equations for tobacco (from both the US, which contained the residue, and the EU, which did not have the residue) and other inputs. The authors made the level of the residue endogenous, which had to remain below the exogenous regulated level. The level of the residue was a function of the amount of US tobacco used and the quota lease rate US producers received, which was endogenous and a function of the US price and marginal cost.

What were the results and implications?

The authors estimated the impact of a 10-percent reduction in the maximum residue level under two scenarios:

- The US government maintained the pre-policy price of US tobacco by lowering the tobacco quota, which would cause the US marginal cost to increase, and
- the US tobacco price was allowed to fall by holding the amount of quota constant.

Under the first scenario, the authors showed that the demand for US cigarettes would fall by 0.085 percent while the demand for EU cigarettes would increase by 0.02 percent. Because of the constant returns to scale assumption, US tobacco-leaf exports increased compared to the EU. This result was because of the increase in EU cigarette production, which mitigated the overall loss of US tobacco (leaf and cigarettes) to the EU of 1.6 percent. US production would decline by 7.1 percent, and non-US tobacco production increased by 12.9 percent. The lower production of US tobacco would lead to a lower residue level of 2.8 percent.

In the second scenario, the quota remained fixed after the 10-percent reduction of the maximum residue level. The demand for US cigarettes would fall by 0.013 percent under the new price of US tobacco leaf. The price of US tobacco leaf would fall by 0.26 percent; thus, the EU and rest of the world demand for US tobacco leaf would increase by 0.86 and 0.47 percent. Despite the increase in the demand for US tobacco leaf, total exports of tobacco exports (leaf and in cigarettes) would decline by 1.51 percent. The increase in US tobacco leaf in EU cigarettes was the result of a substitution away from EU tobacco, a reduction of EU tobacco by 0.059 percent[v]. The residue level does not fall. This result showed that EU tobacco producers would be hurt, if only slightly, by the more stringent, maximum residue policy.

Assessment

The trio of gravity model papers provided some evidence that a food-safety regulation may have an impact on international trade. The results collectively provide evidence that a less stringent regulation may increase trade flows and consequently increase the income of foreign producers. The latter point is particularly important for developing countries. The effect of a more stringent regulation in some countries may

reduce trade. However, the importance of that loss is unclear because of the mitigating effects of trade diversion. That is, while the trade to some countries is limited by a more stringent regulation, an importer with a less stringent regulation may purchase the diverted good. The diverted good may receive a lower price, but the trade is not lost necessarily as the gravity models predicted.

In general, the gravity model is not linked to the supply and demand of the product under study. The changes along or movements of the supply and/or demand curves to generate the changes in value (or volume) of trade that occur are not clear. Therefore, the welfare effects of the change in regulations are not known. The authors stated that they could not estimate the welfare effects of the different regulations with the gravity model. Nevertheless, estimating the welfare effects of changing regulations is important for understanding the differential effects of the regulations on different economic actors. Therefore, more work investigating the welfare effects of regulations is an important study area.

The four papers here and most of the other literature of NTB began with the hypothesis that the SPS regulations restrict trade. Overton, Beghin, and Foster (Overton, Beghin and Foster 1995) showed the surprising result that domestic producers might even be hurt by the regulation. Yet, the literature failed to explore the possibility that these regulations might improve trade. The trade-enhancing features of these regulations occur when measures reflect a movement toward greater harmonization or improved transparency. Disentangling the trade-enhancing effects of food-safety regulations, and more generally SPS regulations, from other factors that may enhance trade is difficult. Therefore, a useful area of research would be to look at whether harmonization and transparency can actually improve trade and welfare.

Another consideration for future research is an expansion of the geographic reach of the research. Studies that look at the effects of regulations from Northern countries on Southern countries would be beneficial. As seen in the SPS Committee, more and more regulations are being developed in Southern countries that are having an effect on other Southern countries.

Conclusion

Only a limited amount of research on the trade and economic effects of food-safety regulations exists. Further work needs to be done in this area. However, further research is hampered by the limited ability to generalize the various types of regulations. Another difficulty with research in this area is how to incorporate information from risk assessments into economic models appropriately. Such efforts require collaboration of food-safety scientists, regulators, and economists. This work will be beneficial in helping policymakers to develop food-safety policies that provide a nationally acceptable level of food safety with the least trade distorting policies.

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[i] All of the model specifications presented in this paper are presented as they were presented in the original papers with only minor adjustments for clarity.

[ii] The natural log was taken for all variables, as indicated by the function ln(*) except for the dummy variables.

[iii] Codex, along with the International Office of Epizootics (OIE) and the International Plant Protection Convention (IPPC), provides standards, which are not legally binding as compared to regulations.

[iv] While a study of maximum residue levels in cigarettes does not qualify as a food-safety concern as interpreted from the SPS Agreement, the issue is closely related to food-safety concerns.

[v] Note the residue levels of EU-produced cigarettes were sufficiently below the maximum that an increase in US tobacco would not put EU cigarettes in danger of surpassing the maximum residue level.