Implications of the Sanitary and Phytosanitary (SPS) regulations on the EU – U.S. Corn Trade Sector and the Case of the 'Agenda 2000' Reforms

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Abstract

Corn trade between the European Union (EU) and the United States has undergone substantial changes over the past decade. EU Reforms of the Common Agricultural Policy (CAP), beginning with the Mac Sharry Reforms of 1992 and continuing with the Agenda 2000 Reforms, were directed at bringing EU agricultural policy into compliance with World Trade Organization (WTO) provisions. These reforms have brought about considerable changes in the market structure in corn trade. However, while trade has been facilitated by decoupling payments and removing levies and tariffs on imported corn, EU's Sanitary and Phytosanitary (SPS) measures have negated some of the progress in trade between EU countries and the United States. Technical Barriers to Trade (TBT), in the form of SPS measures, have progressively replaced traditional tariff and non-tariff trade barriers while allowing the EU to remain in compliance with WTO regulations. The absence of recognizing equivalency in production procedures has created a further decline in corn trade accounting for over $300 million loss annually to U.S. corn exports since 1997 (Weyerbrock and Xia 2000). Using data obtained from the USDA and EUROSTAT, we develop a three stage simultaneous equation model to estimate the economic impact of TBTs on EU-U.S. bilateral corn trade for specific EU countries. Further, welfare effects for producers and consumers in EU countries are also estimated.

Key Words: Sanitary and Phytosanitary measures, Technical Barriers to Trade, Common Agricultural Policy, Agenda 2000 Reforms, Genetically Modified corn, welfare effects

Introduction

Trade in corn between the European Union (EU) and the United States (U.S.) has substantially decreased over the last twenty years. U.S. share of corn exports to the EU, which was 44% in 1980, declined to slightly less than 21% by 2003 (Anderson and Jackson 2003). EU-U.S. bilateral cereal trade in general and corn trade, in particular, is largely governed by domestic and agricultural trade policies. Trade negotiations under the General Agreement on Tariff and Trade (GATT), specifically the Agreement on Agriculture (AoA), and later under the Doha Round of the World Trade Organization (WTO) have bought about considerable changes in the market structure in corn trade. Additionally, bilateral trade has been affected by the expiration in 2004 of concession treaties like the Blair House Accord (WTO).

Technical Barriers to Trade (TBT), which are WTO-compliant, have progressively replaced traditional tariff and non-tariff trade barriers. On the one hand, trade between the EU and United States has been facilitated by decoupling payments and removing import restrictions like levies and high tariffs on corn (as a result of the Mac Sharry Reforms of 1992 and the Agenda 2000 Reforms of the Common Agricultural Policy). On the other hand, Sanitary and Phytosanitary measures (SPS), that are conspicuous TBT, have set back some of the gains realized from trade reform between these trade partners. By not recognizing equivalency in production procedures, the United States has lost $300 million annually since 1997 in lower corn exports to the EU (Weyerbrock and Xia 2000). While the Uruguay round initiated a substantial cut in the corn export subsidies and granted more market access to the EU (Kennedy, Koo and Marchant 1999), policy differences in these countries toward Genetically Modified (GM) corn created a new TBT. New technologies and products led to regulatory changes that created trade frictions between trade partners. Labeling directives and low tolerance for the unintentional presence of GM materials for approved grain products have negatively impacted EU consumer preferences for U.S. products (Redick and Adrian 2005).

Internal changes for both of these major players in world agricultural trade, coupled with transformed bilateral trade relations under the auspices of the WTO, have affected bilateral transactions and global markets. These reforms have impacted both EU and U.S. consumption and production, trade and world prices, and could subsequently provoke trade liberalization and new policy initiatives in other sectors. This paper investigates the effects of CAP reforms and SPS regulations on corn imported from the U.S. on EU production and consumption. Additionally we estimate welfare effects of SPS regulations on EU countries.

Related Literature

Understanding the complex economics of these relatively recent regulatory barriers is vital for future trade liberalization. Ambiguity still exists in defining these SPS regulations. Roberts, Joslings and Orden (1999) proposed a comprehensive definition for these TBTs and present an analytical framework for evaluating them that summarizes most of what the various authors have adopted. They distinguish three economic effects: (1) the “regulatory protection” effect, which reflects rents to the domestic sector from trade-restrictive regulations; (2) the “supply shift” effect, which focuses on the effects of imports on the domestic supply and compliance costs; and (3) the “demand shift” effect, which accounts for the fact that a regulation may increase information about a product and increase consumer demand for that product. Using comparative statics in a partial equilibrium framework, the authors illustrate the different effects of these three components of TBTs, including welfare effects.

Calvin and Krissoff (1998) estimated the tariff rate equivalent of technical regulations for the apple market using the price wedge method. The study compared the CIF price of US apples in a foreign country to the wholesale price and assumed that this gap consisted of the tariff and the technical barrier tariff rate. The method incorporates quality adjustments to make products homogenous. This method measures the gap of a country's tariff equivalent and also adjusts for quality differences. The major limitation of this method is that though it can quantify the effect of a set of NTB's (Non Tariff trade barriers) it cannot identify each NTB that could affect the price of foreign good. Also a major assumption is that imported goods are perfect substitutes to domestically produced goods which may not be the case in a large amount of agricultural products. Finally, for large scale studies available, the data is too aggregated to provide for quality differentiation for imported goods.

Swann Temple and Shurmer (1996) defined a measure called the import coverage ratio constructed as the value of imports of each commodity subject to an NTB, as a percentage of imports in the corresponding product category. The authors regressed British net exports, exports, and imports over a period of 1985 to 1991 on variables including frequency indicators of NTB's. Wilson and Sewadeh (2000) employed a direct measure of severity of food safety standards expressed in minimum allowable contamination. A major limitation of these two studies was that they showed very little correlation between the number of measures and the effect on trade.

More recent studies show that risk-assessment based Cost-Benefit measures provide more insight on the impact of NTB's on bilateral trade. Bigsby and Whyte (2000) and James and Anderson (1998)

To gauge the welfare effects and implications to various players in bilateral trade, micro-econometric studies that rely on partial equilibrium models have been used by various authors. Marett Bureau and Gozhan (2000) show how regulations could change the costs of signaling quality of products. This gives rise to network externalities and economies of scale where the major contribution of this study was that they could assess not only the impact of regulations on trade flows but also quantify attendant welfare effects.

To account for the welfare effects of a standard in the presence of negative externalities, Maskus, Wilson and Otsuki (2001) and Fisher and Serra (2000) characterize a standard as non-protectionist if it is used by all domestic firms . Peterson et al., (1988), suggested that sanitary regulations could be artificial barriers to trade. However, they pointed out the difficulty in distinguishing between legitimate barriers to protect consumer health as opposed to non-legitimate methods, designed rather for the purpose of protecting domestic producers from cheaper imports. In their analysis, they indicated that an EU ban on hormones in livestock production would significantly decrease the world price of edible offal, while domestic price could increase by 35% - 45%. U.S. livestock sales to the EU were estimated to have decreased by 32% since 1986 due to these specific EU directives.

Weyerbrock and Xia (2000) identified 57 TBTs that the EU has put into place since 1997. Of these, the major economic impacts have been on cereals and animal products which accounted for over one-third of the United States' total trade loss. In a recent study on the structure of Non-tariff Trade Barriers (NTB's), Disdier, Fontagne and Mimouni (2008) analyzed the coverage ratio (affected imports to total imports) and found that it was quite high for extra-EU trade. Their results suggested that EU's SPS regulations formed a significant barrier to trade.

Because SPS regulations appear to be used as a TBT by the EU to protect domestic farmers, there is interest in determining how significant an effect this has had on U.S. corn exports. Jayasinghe, Beglin, and Moschini (2008) investigated the determinants of world demand for U.S. corn and the cost associated with the introduction of SPS regulations. They concluded that tariffs by foreign countries, including the EU (a major importer), form the major impediment to U.S. corn exports. However, they also indicated that SPS regulations are fast replacing these tariffs as trade barriers.

While earlier studies have tried to isolate the effects of TBT regulations on multilateral trade or have focused on the welfare impacts, little has been done to understand the disaggregated affect of these TBTs on the two main trading blocks in the corn trade sector. In this study we analyze policy changes in the EU Common Agricultural Policy (CAP) and their effects on the corn trade with the U.S. This study contributes to the literature by estimating empirically whether changes in the corn policies of the EU (including the SPS regulations and CAP reforms) have had a significant impact on the trade between the U.S. and member nations of the EU. We incorporate the effects of interest group diversity in the two trading entities, the effects of trade frictions caused by the five year moratorium on GM grown corn in the U.S. (that accounts for the complex TBT and SPS regulations on GM grown corn and could have significant effects on U.S. trade position), the EU Traceability and Labeling (Commission Regulation 1829/2003, 2003 O.J. (L 268)) directive, and finally major CAP reforms aimed at decoupled payments and trade liberalization between the EU and U.S. Finally, we estimate welfare effects on producers and consumers of EU member nations.

Theoretical Model

We develop a theoretical model based on the Fischer and Serra (2000) trade model for implications of standards on trade. The basic premise in the introduction of standards (SPS regulations) is to increase quality both in the exporting and in the importing country. This, though, has a negative externality of increased production cost and indirect effect of protecting domestic farmers in the importing country. Considering that goods are homogenous in both trading blocks, which is true in the case of corn, but dissimilar standards between the two trading partners could potentially create trade barriers. Under a minimum standard τ, the EU tries to maximize exports which solves for

(A) $$\max_{q_h} \prod (q_d, q_e, \tau) = p(q_d + q_e)q_d - c(\tau)q_d$$

Where π is domestic profits, q_d is the quantity of home production demand in domestic markets, q_e is the quantity of imports demanded by domestic consumers, and p is the domestic inverse demand function. When there are no minimum standards, τ will equal 0 and the constant term c(τ) will fall out of the equation.

The minimum standard requirement will increase U.S. production cost and decrease profits. U.S. production will choose to produce under two standards – one for home and the other for exports or produce under the higher standard set by EU. Thus, the United States will maximize its profits by solving for either producing under one standard in which case it solves for

(B) $$\max \prod_1^{*}(\tau) = \max_{(q_e, q^*)} \{p(q_d + q_e)q^* - c(\tau)(q_e - q^*)\}$$

or use two standards and incur a fixed cost *F*, where it solves for

(C) $$\max \prod_2^{*}(\tau) = \max_{(q_e, q^*)} \{p(q_d + q_e)q^* - c(\tau)q_e - c(0)q^* - F\}$$

When $\pi_1 > \pi_2$, the U.S. will then start producing under the new standard set by EU regulations.

Finally, the welfare loss due to this standard in the EU can be calculated as the sum of consumer surplus and negative externality due to standards minus the sum of cost of domestic production and the cost of imports. Formally

(D) $$W(\tau) = \int_0^q p(s)ds + L(q_d, \tau) - [c(\tau)q_d + p(q)q_e]$$

Where $L(q_d, \tau)$, is the loss associated with the standard and is less than zero.

Economic Model

Numerous studies have analyzed the effect of SPS regulations; employing diverse empirical estimation techniques. For example, Deardoff and Stern (1998) and Laird and Yeats (1990) used the price wedge method to estimate a tariff equivalent to these TBTs. Though this method measures trade impacts, it can be used in the initial stages of partial and general equilibrium models that focus on the welfare effects of the TBTs (Beglin and Bureau 2001).

The inventory-based approach has become more prominent with two studies that related trade flows to measures of a country's stock of standards. Swann, Temple, and Shurmer (1996) used counts of voluntary national and international standards recognized by the United Kingdom and Germany. In that study, British net exports, exports, and imports over the period from 1985 to1991 were analyzed with frequency indicators of standards. In that study, and one by Moenius (1999), the authors used counts of binding standards in a given industry as a measure of stringency of standards. Otsuki, Wilson, and Sewadeh (2000) extended that approach by developing a direct measure of the severity of food safety standards as a function of the maximum allowable contamination.

Fontagné, von Kirchbach, and Mimouni (2001) used a more sophisticated indicator for assessing the impact of environmental regulations and their potential use as a trade barrier. Combining inventory-based approach with a gravity model, Disdier, Fontagne and Mimouni (2008), focused on 700 products and regional trading blocks to provide evidence that SPS and TBT regulations significantly effect trade flows. While these studies can direct attention to the frequency of occurrence and the trade or production coverage of various types of NTBs, inventory-based methods do not quantify the effects of regulations on trade per se.

Moenius (1999) attempted to measure directly the trade impact of TBTs using gravity-based analysis of bilateral trade volumes. Due to data limitations, he analyzed the trade impacts of standards (voluntary norms) rather than on regulations. Panel data that Moenius used included 471 industries in 12 western European nations and ranged in time from 1980 to 1995. He found that a shared standard has a large trade promoting effect between the nations sharing the standard. By correcting for autocorrelation and testing for causality, Moenius was able to estimate the impact of a one-percent increase in the number of bilaterally shared standards on bilateral trade volume.

Partial equilibrium models are used to assess the effects of policy on equilibrium prices, quantity, and welfare. Orden and Romano (1996) used explicit specification of supply and demand functions within such a model to estimate the costs and benefits of a ban on avocados. Calvin and Krissoff (1998) also combined the price wedge method with a simple partial equilibrium framework (using only estimated supply and demand elasticities) to analyze Japanese imports of U.S. apples. Paarlberg and Lee (1998) included a risk-based approach to a partial equilibrium framework in studying U.S. restrictions of beef imports from countries that may have foot-and-mouth disease (FMD).

Quantification of the trade and welfare effects of SPS and TBT regulations is possible when using a partial equilibrium approach to understand country-wise effects and to estimate the welfare of various interest groups vis-à-vis producers and consumers in each of the trading countries. We employ this partial equilibrium approach to develop our model and incorporate simultaneity in our model.

To understand the effects of policy re-instrumentation, including the SPS regulations in member countries of the EU, and the trade effects between each of these countries with the U.S.

we developed a static, partial equilibrium, simultaneous equation model which solves for the demand side equations and the supply side equations simultaneously. The model incorporates the interdependence of both the supply and demand side equations. An iterative, linear, three stage least square (3SLS) system is developed. Two dummy variables are introduced in the system that account for the two major policy changes in the CAP of the EU. SPS regulations were introduced as a dummy from 1998 to 2005 to capture any significant impacts of these regulations on prices and quantity of corn imported by each of the EU countries.

Demand side equations are disaggregated into four equations – inventory demand, domestic demand, export demand and import demand, while the supply side is a single equation. Table 1 contains descriptions of each variable defined in the equations below.

Demand Side System

The demand side system includes four equations which can help us understand the specific effects of policy changes in the EU.

Inventory Demand

In equation (1), inventory demand is expressed as the demand for opening stocks ($opstk$) and is a function of domestic price ($dmpr$) and the ratio of apparent production (*prod*) and apparent consumption (*conp*), defined over commodity *i*, country *j*, year *t*, and *e* serving as a random disturbance term.

$$(1)\quad \ln opstk_{ijt} = \alpha_{ijt} + \beta_1 \ln dmpr_{ijt} + \beta_2 \left[\left(\ln prod_{ijt} + \ln prod_{ij(t-1)} + \ln impq_{ijt} \right) \Big/ \ln conp_{ijt} \right] + e$$

Domestic Demand

The demand for a commodity in a specific country is the domestic demand function. An inverse demand function is used to estimate the effect on domestic prices of other independent variables. Inverse demand functions have been widely used in farm commodity market analysis (see Wescott and Hull 1985, Salathe, Price and Gadson 1982, Subotnik and Houck 1979, Meilke and Young 1972, Cromarty 1959). The importance of a normalized simultaneous system of equation needs a causative specification for each variable including the price. This justifies the use of an inverse demand function because it otherwise would give erroneous results if none of the equations normalized on price. The domestic price (*dmpr*) is a function of domestic consumption (*conp*), opening stocks (*opstk*), income as measured by the Gross Domestic Product (*gdp*) and two dummy variables (*mref, aref*) for the two major CAP reforms as indicated in equation (2).

$$(2)\quad \ln dmpr_{ijt} = \alpha + \beta_1 \ln conp_{ijt} + \beta_2 \ln opstk_{ijt} + \beta_3 \ln gdp_{ijt} + \beta_4 mref_{ijt} + \beta_5 aref_{ijt} + e$$

Export Demand

The export demand equation relates the effect of policy changes on demand of exports for commodities of a specific country. Policy effects causing changes in trade yield insights about the impact on trade and world prices. Equation (3) models the demand for EU exports (*expq*) as a function of the two CAP reform measures (*mref, aref*), export refunds (*expr*), domestic price (*dmpr*), world price (*worldp*) and exchange rates (*exrt*). Since SPS regulations are hypothesized to affect exports, we include a dummy (*sps*) to capture any significant impact of this policy change on domestic exports.

$$(3)\quad \ln \exp q = \alpha + \beta_1 \ln dmpr + \beta_2 \ln worldp + \beta_3 \exp r + \beta_4 \ln exrt + \beta_5 mref \\ + \beta_6 aref + \beta_7 sps + e$$

Import Demand

Import demand is modeled in the system of equations to understand the effect on corn imports brought about by EU policy changes. We include a ratio of quantities imported from the U.S. to total EU imports of corn as a measure of significance. Significance of this ratio suggests that policy changes in the EU have affected the demand of corn imports from the U.S. Equation

(4) relates the log of the import quantities as a function of domestic price (*dmpr*), exchange rate (*exrt*), world price (*worldp*), import levies (*impl*) and the ratio of imports from the U.S. to total EU imports.

$$(4)\quad \ln impq = \alpha + \beta_1 \ln dmpr + \beta_2 \ln worldp + \beta_3 impl + \beta_4 \ln exrt + \beta_5 mref + \beta_6 aref + \beta_7 (impqu / impq) + \beta_8 sps + e$$

Supply Equation

The supply equation relates total domestic supply of commodities or production (*prod*) as a function of domestic price (*dmpr*), total imports, production refunds (*prodr*), the two policy changes in the CAP (*mref* and *aref*) and GDP (*gdp*) in equation (5).

$$(5)\quad \ln prod_{ijt} = \alpha + \beta_1 \ln dmpr_{ijt} + \beta_2 \ln prodr_{ijt} + \beta_3 \ln gdp_{ijt} + \beta_4 mref_{ijt} + \beta_5 aref_{ijt} + e$$

Data and Methods

The basic data for corn for the fifteen EU countries (EU-15) analyzed, included annual production, consumption and crop yield information collected from the 'AGRIS' Database of EUROSTAT. External trade data between EU nations and the United States (annual exports and imports) were collected from the 'COMEXT' database ('Internal and External Trade of the European Union'). Demographic information on population, Gross Domestic Product (GDP) and Nominal Exchange Rates were collected from the International Financial Statistics database published by the International Monetary Foundation (IMF).

Domestic price information for the EU-15 was obtained from the office of the Director General (DG) of Agriculture for the EU. Price support data for corn were based on *The Common Organization of the Market in Cereals* (Council Regulation (EEC) No. 2727/75) and *Particular and Special Intervention Measures for Cereals* (Council Regulation (EEC) No. 1146/76). Prior to 1995, three prices were defined by the European Commission – Target Price, Threshold Price and Intervention Price. Price supports, including import levies, export refunds and production refunds, were derived from these three reference prices. Legislation from 1994 repealed such derived price measurements and replaced it with direct aid payments under each category (Council Regulation (EEC) No. 1866/94).

Because trade data were unavailable for Finland and Sweden for the entire time series analyzed, they were excluded from our analysis. However, it may be reasonable to assume that these countries would follow the general trend in trade along with the rest of the EU nations analyzed.

Calculating the Import Levies

Data for import levies were collected from the Official Journal of the European Union maintained by the EURO-LEX (European Legislation). Import levies (*IL*), as defined by the European Commission (EC), consisted of a fixed component (calculated as the difference between Threshold Price (*ThP*) and World Price (*WP*)) and a variable component (Z) (defined as a factor of the fixed component and revised bi-monthly). Thus, annual import levies were the sum of the difference of Threshold Price and World Price and the average of the monthly weighted import levy (*K*), based on the ratio of the import quantity in that month to total imports in that year, as described in equation (6).

$$
(6)\qquad \left.\begin{aligned}
&IL_{ij} = \left(ThP_{ij} - WP_{ij}\right) + \overline{Z}_{ij} \\
&K_\alpha = \left[\frac{ILQ_\alpha}{\sum_{\alpha=1}^{12} K_\alpha / 12} \times il_\alpha \right] \text{ where } (\alpha = 1 \text{ - } 12) \\
&\overline{Z} = \left(\sum_{\alpha=1}^{12} K_\alpha \Big/ 12 \right)
\end{aligned}\right\} \text{ Import Levy for commodity } i \text{ in year } j
$$

World Price as calculated in equation (7) is an average of the weighted export price, based on the quantity of the commodity exported by that country relative to the total exports for that commodity in a specific year. The prices of major exporting countries that constituted 80 percent of total world market exports defined the world price.

$$
(7) \quad \left.\begin{aligned}
& WP_{ij} = \overline{G_{ij}} \big/ N \;\; \text{(where } N = \text{number of exporting countries)} \\
& \overline{G}_{ij} = \left[\frac{ExQ_{lij}}{\sum_{k=1}^{n} ExQ_{kij}} \times P_{lij} \right] \text{(where } l \in k\text{)}
\end{aligned}\right\} \text{where } k \text{ is exporting countries}
$$

Calculating the Export Refunds

Export refunds (ER) were calculated in equation (8) as the difference between the intervention price (IP) and the world price (WP) (Regulation (EEC) No 2746/75).

$$
(8) \quad ER_{ij} = \left(IP_{ij} - WP_{ij} \right)
$$

Calculating Production Refunds

Production refunds (PR) for corn were calculated for each marketing year and were available from the 'EUROLEX' database. These were calibrated to total domestic production for each of the fifteen European countries. While the EC reviewed the amount of production refund, it also enacted legislations governing the calculation of production refunds (Council regulation (EEC) No: 1863/88). In estimating production refunds for years in which data were not available, we used equation (9).

$$
(9) \quad PR_{ij} = K - IP_{ij}
$$

The Mac Sharry reforms (Council regulation (EEC) No: 1766/92) introduced co-responsibility levies and voluntary set-asides. These instruments, aimed at making producers more responsive to markets, were included as a part of production refunds, as seen in equation (10).

(10) $PR_{ij} = K - \left[SP_{ij} - CRL_{ij} \right]$

Conversion Factor and Exchange Rates

To incorporate the effects of the Monetary Compensatory Amount (MCA) system that was utilized until 1992, we used the Agri-Monetary System conversion rate (Swinbank 1988). MCAs were collected from the Economic Accounts for Agriculture (EAA) and the Handbook for EU price statistics. After 1992, conversion factors for U.S. dollars were based on nominal exchange rates given by the (IMF).

Apparent Production and Consumption

Production (*prod*) for each of the country was derived in equation (11) as a function of area under a specific crop (*area*) and yield per hectare (*yield*).

(11) $PROD_{ijk} = YIELD_{ijk} \times AREA_{ijk}$

In equation (12), consumption (*conp*) for each country is a function of domestic production (*dmpr*), imports (*impq*), opening stocks (*opstk*) and total exports (*expq*).

(12) $CONP_{ijk} = \left(DPROD + IMPQ + OPSTK \right)_{ijk} - EXPQ_{ijk}$

Results and Discussions

The simultaneous system of equations helps us to understand the cross correlation effects of the independent variables across different equations. The parameter estimates give us elasticities for independent variables because of the double log model estimated. Elasticity results for the independent variables in the system are found in table 3. We tested for normality for the entire time series data using the Shapiro-Wilk method and rejected the null hypothesis that the distribution of the residuals was not normal. Heteroscedasticity for the residuals was assessed using the Breusch-Pagan test and White's test. The null hypothesis, that the error variance of the independent variables was not constant, was rejected in the case where the *p*-

value was greater than 0.05 for a 95 percent confidence interval. Finally, we tested for co-linearity in the independent variables using the Durbin Watson test. No correlation between the independent variables for each of the countries was found.

The system of equations was evaluated using four criteria: the magnitude of the coefficient (suggesting how elastic or inelastic it is relative to the dependent variable), the sign of the coefficient (is dependent variable positively related to the independent variable), the statistical significance of the coefficient at the 90 percent significance level, the goodness of fit for each of the equations in the system. In Table 2 we present the effect of the policy re-instrumentations in the member countries of the EU for corn. In each row, the table presents the parameter name, the number of counties for which that specific independent variable was significant (90%-level), and the expected sign for that variable. For example in the first row, domestic price (*a2*) was significant in eight countries had a negative relationship with inventory demand.

Inventory Demand

Inventory demand, which relates opening stocks, domestic price and the ratio of apparent production to apparent consumption of corn, had the expected results as to significance. An increase in domestic prices, influenced by the increased quantity demanded, decreases opening stocks. This relation holds true in the EU, with the exception of the Netherlands, demonstrating that domestic prices are related to the opening stocks. Eight (France, Austria, Belgium, Germany, Ireland, Italy, the UK and Greece) of the twelve EU countries analyzed showed this significant, negative relationship (Table 2 and Table 3).

With the exception of the Netherlands, the magnitude of the parameters suggests that the relationship between the apparent production-apparent consumption ratio to opening stocks is highly elastic. An increase in the ratio would increase the opening stocks. This relationship holds for all the twelve EU countries in our analysis. Empirical findings suggest this relationship is significant for most EU countries included: France, Austria, Belgium, Germany, Denmark, Ireland, Italy, Spain, the UK and Greece.

Domestic Demand

The domestic demand equation was modeled as a price dependent equation with the domestic price being a function of consumption, opening stocks, country GDP (proxy for expendable income of the population), and dummy variables for each policy change to the CAP. Empirical results showed that consumption decreased as domestic prices increased and thus were inversely related as economic theory suggests. However, this relationship was only significant in three countries: Austria, Denmark and Portugal.

An increased quantity of opening stocks should decrease the domestic prices since the supply of the commodity increases. This negative relationship was observed empirically in ten of the twelve EU countries, with seven being significant: France, Austria, Belgium, Germany, Denmark, Greece and Portugal. Elasticity estimates indicate that the relationship is highly elastic for Portugal, Denmark, Germany and Ireland while it is inelastic for the rest of the EU nations (Table 2 and Table 4).

GDP was positively related to domestic prices; suggesting that as expendable income increases the demand for goods increases and prices, hence, tend to increase. This conforms to economic theory which suggests that increased income has a positive effect on prices. Eight of the EU countries show a significant and negative relationship: France, Austria, Belgium, Germany, Denmark, the Netherlands, the UK and Portugal.

The dummy variables for the two policy reforms show that they had a significant, negative impact on domestic price. All EU countries showed that the relation was significant for both policy reforms (Mac Sharry and Agenda 2000).

Export Demand

Estimated parameters for export demand displayed signs consistent with economic expectations, and were significant, for the most part. The quantity exported depends on domestic price, world price, export refund, exchange rates and dummy variables for each of the two reforms of the CAP modeled. As hypothesized, exports also were affected by the SPS regulations.

Economic theory suggests that an increase in domestic price should decrease quantity exported as domestic markets become more attractive for the sale of the commodities. Our empirical findings confirmed this for all EU countries with Austria, Italy, the Netherlands and Greece showing a significant, elastic relationship. On the other hand, an increase in world price should increase quantity exported. All EU countries in our analysis demonstrated this relationship with France, Austria, Italy, The Netherlands and Spain being statistically significant at the 90 percent level and elastic.

In theory, export refunds tend to increase the amount of quantity exported and our results for all EU countries demonstrated this positive relationship for corn (Table 2 and Table 5), with France, Austria, Germany, Ireland, The Netherlands, Greece and Portugal being statistically significant. France, Germany, and the Netherlands had highly elastic responses to these export refunds for corn.

An increase in the exchange rate of an exporting country tends to increase the amount of exports to other countries. Our findings demonstrate that this relationship held for all EU nations with eight countries being statically significant. France, Germany, Denmark, Ireland, Italy, The Netherlands, the UK and Greece showed an elastic response in corn exports to changes in the exchange rates.

The policy re-instrumentation of the CAP showed mixed effects on the quantity exported with Denmark and Ireland increasing exports as a result of implementing Mac Sharry Reforms, though these were not significant statistically. On the other hand, our findings indicate that Germany, the UK and Greece significantly decreased exports as a result of the Mac Sharry Reforms. The Agenda 2000 Reforms of the CAP had a positive and statistically significant impact on exports of corn from France and Ireland. The rest of the EU countries had negative coefficients in our model estimation from the Agenda 2000 reforms, suggesting that exports of corn to other countries declined considerably.

In all but two EU countries, SPS regulations decreased the amount of exports from the EU. This is evidence that domestic consumption of EU products tended to increase with SPS policy initiatives. The dummy variable for SPS regulations was statistically significant in one-half of EU countries, including all the major corn producing countries: Germany, France and the UK.

Import Demand

Quantity of corn imported depends on the domestic prices of corn, the world prices, the exchange rate, applied import levies (a combination of fixed and variable levies), expendable income of the population (GDP), and the policy dummies to capture changes in the amount of imports resulting from that policy. Statistically significant relations were observed for most of the variables in the model (Table 2 and Table 6).

Theory suggests that an increase in domestic price should attract more imports and this is the relationship found empirically for all EU countries. For Austria, France, Germany, Denmark, Ireland, Italy, The relationship between imports and domestic prices for the Netherlands, the UK and Portugal was statically significant and elastic. On the other hand, an increase in world price should decrease the amount of imports since imports would become relatively costly. This relationship was found for all EU countries in our analysis, though only the UK had a statistical significant parameter estimate. The fact that world price was insignificant for most countries could be due to domestic markets being insulated from the world market via an extensive system of price regimes controlled by CAP policies. Figure 1 illustrates this finding where domestic prices in the UK were kept relatively higher than the world price while imports were kept low through the presence of import levies and the internal exchange rate system. This was true for all EU countries, though the magnitude of the difference between the domestic and world prices differed.

As the exchange rate increases, the amount of imports should decrease since commodities become relatively costly. This economic relationship held true for all EU nations in our analysis with France, Germany, The Netherlands, Spain, the UK and Portugal having statistically significant yet relatively inelastic relationships between import quantity and exchange rates.

As with increases in exchange rates, import levies also act to deter imports from other countries and hence an increase in the import levies decreased the quantity of corn imported to the EU. All EU nations, save for Italy and Ireland, demonstrated this negative relationship. France, Belgium, the Netherlands and Greece showed a statistically significant negative relationship between import levies and the quantity of imported corn.

An increase in the spending power of the population would effectively enable them to demand more imported goods. Findings from our analysis corroborate this for the demand of corn imported by EU nations. This relationship was statistically significant in France, Germany, Denmark, Ireland, Spain, Greece and Portugal. The magnitude of the coefficients suggests that except for Spain, Greece and Portugal the relation is inelastic.

Changes in the CAP had mixed impacts on the imports of corn in the EU nations. Implementation of Mac Sharry reforms had a significant, positive impact on Greece and Portugal; while France and Denmark experienced a decrease in imports due to these reforms in 1992. The Agenda 2000 Reforms have largely had a negative impact on imports with them being statistically significant in France, Germany, Ireland and Italy. Under Agenda 2000 Reforms, Portugal increased the amount of corn it imported.

Except for three countries (Denmark, Ireland and Greece), SPS regulations had a negative impact on imports of corn into the EU. This result supports the notion that SPS regulations effectively serve as technical barriers to trade as imports of the commodity in question decreased when SPS regulations were implemented. The negative impact on corn imports from US was expected as SPS regulations work as an import levy while being WTO compliant. In France, Austria, Germany, Italy Spain and UK these effects were statistically significant.

Supply Equation

Supply of corn depends on domestic prices, production refunds that farmers were paid, expendable income (GDP), and the two dummies for the policy changes in the CAP. An increase in domestic price should increase the amount of corn supplied since it is profitable for farmers to produce more. Our empirical analysis demonstrates this as all the coefficients show a positive relation to quantities supplied. Except the UK, all EU countries had a statistically significant, positive relationship (Table 2 and Table 7).

Production refunds also create incentives for increased production and increased quantity supplied of corn. Results from our analysis demonstrate that production refunds have a positive effect on corn production in all EU nations. In Belgium, Germany, Ireland, Italy and the Netherlands this relationship was significant and positive.

As household income (GDP) increases, one would anticipate that the consumption of goods would increase and this was found in all EU countries, with Belgium, Germany, Spain, The Netherlands, Greece and Portugal all having significant, relationships. Except for the Netherlands, all countries had inelastic supply for corn. The elastic supply case of the Netherlands suggests that a slight change in the household income could increase the amount of corn supplied by a significant amount.

The two dummy variables which captured significant changes in supply due to the implementation of the policies showed mixed results. France, Germany and Denmark showed that the Mac Sharry Reforms actually helped increase corn production in these countries, though they were not statistically significant. On the other hand, the rest of the countries showed a negative effect on the production of corn due to Mac Sharry Reforms being implemented. Belgium, Spain and Greece showed that the effect of the reforms were significant. All the EU countries decrease corn production under the reforms of the Agenda 2000 of the CAP, and in Belgium, Denmark, Italy, Spain and Greece such reductions were statistically significant.

Welfare Implications

Our partial equilibrium model approach is useful in understanding the welfare implications to the interest groups (producers and consumers) of the EU member countries. It accounts for substitution in demand (foreign and domestic corn) while allowing for adjustments to a new price level without the regulation in place. Partial equilibrium models provide for an explicit specification of supply and demand functions that can be used to evaluate the welfare effects of these restrictions on the producers and consumers in each EU country.

To generalize, consider an algebraic representation presented in the following equations. In equation (13), supply of corn in the EU depends on the domestic price in the EU, the world price, the production refunds and a restriction factor (*R*). The restriction factor, as seen in equation (14), is a function of a factor (γ) which represents the maximum EU allowed GM residue in corn (0.9%) and the ratio of the total imports from the U.S. ($IMPL_{us}$) to all corn imports ($IMPL_{TOT}$) into the EU.

$$(13) \quad Q_s = S_c\left(DMPR_{ijt}, WP_c, PROD_{ijt}, R\right)$$

$$(14) \quad R = \gamma * \frac{IMPL_{US}}{IMPL_{TOT}}$$

Now, as seen in equation (15), the demand for corn in EU countries would be a function of the domestic price, import restrictions, and consumers' disposable income.

$$(15) \quad Q_D = D_c\left(DMPR_{ijt}, WP_c, IMPL_{ijt}\right)$$

Equating these equations and using the derived elasticities for each of the countries from our model we can calculate the welfare effects for producers and consumers of the EU and gauge the deadweight loss caused by these policies. Net welfare effects are shown in Table 8. Results are presented as a percent change in quantity from the baseline due to the one percent change in the price. Producer surplus is positive and highly so in France, Germany, and Greece – some of the main corn producers in the EU-15. On the other hand, consumer surplus is negative in all the EU nations – indicating that consumers are potentially negatively affected by the SPS policy restrictions. Estimated net welfare changes are negative for all EU countries; reflecting the inclusion of government transfers and deadweight losses in the net welfare estimate (Table 8).

Conclusions

This study develops a partial equilibrium model that incorporates the simultaneity of supply and demand, and implications of Sanitary and Phytosanitary regulations on the two major corn players in the world. While there are many disagreements between the EU and the U.S. on trade issues, SPS regulations have created new challenges that need to be addressed for trade liberalization. This paper attempts to quantify the negative effects of these trade regulations that are considered WTO compliant. Welfare analysis helps identify the costs of the regulations and assess whether they are in proportion to the externality they seek to address, or whether they are mainly implemented for protecting domestic producers. Findings from our analysis indicated positive producer welfare effects and negative consumer welfare effects. However, if EU consumers have willingly embraced SPS regulations to mitigate externalities related to perceived or real adverse effects of GM corn, then these values could be considered estimates of the welfare consumers are willing to forego to restrict GM corn from entering the EU market.

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Table 1. Definition of Variables and Measurement Units

Variable Name	Definition	Units
LNDMPR	Log of Domestic Price	U.S. Dollars per Ton
(LNPROD+LNIMPQ)/LNCONP	Log of Ratio of Apparent production to Apparent consumption	1000 Tons
LNCONP	Log of Consumption	1000 Tons
MREF	Dummy Variable for Mac Sharry Reforms	
SPS	Dummy Variable for SPS regulations	
AREF	Dummy Variable for Agenda 2000 Reforms	
LNOPSTK	Log of Opening Stocks	1000 Tons
LNGDP	Log of Gross Domestic Product	Million U.S. Dollars
LNWORLDP	Log of World Price	U.S. Dollars per Ton
LNEXPR	Log of Export Refund	U.S. Dollars per Ton
LNEXRT	Log of Exchange Rates	Domestic Currency per U.S. Dollar
LNIMPL	Log of Import Levies	U.S. Dollars per Ton
LNIMPQU/LNIMPQ	Log of Ratio of Imports from United States to Total Imports	1000 Tons
LNPRODR	Log of Production Refunds	U.S. Dollars per Ton
LNEXPQ	Log of Export Quantity	1000 Tons
LNIMPQ	Log of Import Quantity	1000 Tons
LNPROD	Log of Domestic Production	1000 Tons

Table 2. Parameter Definitions and Expected Signs

Coef.	Parameter	Explanation	No. of Countries	Expected Sign*
a2	*LNDMPR*	Domestic Price	8	-
a3	*(LNPROD+LNIMPQ)/ LNCONP*	Ratio of Apparent Consumption and Production	9	+
b2	*LNCONP*	Consumption	3	-
b3	*MREF*	Dummy for Mac Sharry Reforms	12	-
b4	*AREF*	Dummy for Agenda 2000 Reforms	12	-
b5	*LNOPSTK*	Opening Stocks	7	-
b6	*LNGDP*	GDP	8	+
c2	*LNDMPR*	Domestic Price	4	-
c3	*LNWORLDP*	World Price	5	+
c4	*LNEXPR*	Export Refunds	7	+
c5	*LNEXRT*	Exchange Rates	8	+
c6	*MREF*	Dummy for Mac Sharry Reforms	3	-
c7	*AREF*	Dummy for Agenda 2000 Reforms	6	-
c8	*SPS*	Dummy for SPS Regulations	6	-
d2	*LNDMPR*	Domestic Price	9	+
d3	*LNWORLDP*	World Price	1	-
d4	*LNEXRT*	Exchange Rates	6	-
d5	*LNIMPL*	Import Levies	4	-
d6	*MREF*	Dummy for Mac Sharry Reforms	4	-
d7	*AREF*	Dummy for Agenda 2000 Reforms	5	-
d8	*LNGDP*	GDP	7	+
d9	*SPS*	Dummy for SPS Regulations	6	-
e2	*LNDMPR*	Domestic Price	11	+
e3	*LNPRODR*	Production refunds	5	+
e4	*MREF*	Dummy for Mac Sharry Reforms	3	-
e5	*AREF*	Dummy for Agenda 2000 Reforms	5	-
e6	*LNGDP*	GDP	6	+

* The expected sign on the parameter estimates represents the hypothesized relationship (positive or negative) of the independent variables and their explanatory effect on the dependent variable.

Table 3. Three-stage Least Square Estimation of Inventory Demand of Corn for EU Countries

		lndmpr	(lnprod+lnimpq)/lnconp
France	2.4291	*-1.1308	*6.8775
Austria	0.4548	*-1.4601	*1.6391
Belgium	-0.1143	*-1.3639	*8.0129
Germany	-0.3687	*-1.3698	*10.2927
Denmark	1.1797	-1.9071	*7.9908
Ireland	2.4331	*-15.4992	*2.3128
Italy	10.6049	*-2.0666	*0.3465
Netherlands	1.5919	0.7084	0.1787
Spain	-4.3926	-0.7786	*14.6784
UK	-3.7344	*-2.1782	*2.0325
Greece	0.1915	*-5.2283	*15.3625
Portugal	1.5815	-9.0079	7.4503

Note: Single asterisks (*) for parameter estimates indicates significance at 10 percent level.

Table 4. Three-stage Least Square Estimation of Domestic Demand of Corn for EU Countries

		lnconp	mref	aref	lnopstk	lngdp
France	1.5864	-0.9571	*-0.2615	*-0.5059	*-0.3987	*0.2841
Austria	0.1518	*-0.2278	*-0.3019	*-0.4499	*-0.1930	*0.4211
Belgium	0.0022	-0.0280	*-0.5493	*-0.8450	*-2.9499	*0.4117
Germany	0.1125	-0.1109	*-0.3814	*-0.5319	*-0.1698	*0.3985
Denmark	0.0782	*0.1012	*-0.3553	*-0.7118	*-1.3429	*0.3548
Ireland	5.1448	-0.1078	*-0.3198	*-0.5977	-5.5549	0.0961
Italy	0.0823	-0.0261	*-0.5861	*-0.8022	0.2306	0.2961
Netherlands	0.0710	-0.1623	*-0.3966	*-0.6705	0.2485	*0.3608
Spain	1.5152	-0.0354	*-0.4130	*-0.6469	-0.0710	0.0448
UK	0.1052	-0.2633	*-0.3094	*-0.4530	-0.0095	*7.3998
Greece	12.4165	-0.1141	*-0.5759	*-0.9699	*-0.2662	*-0.8370
Portugal	0.0387	*-5.6676	*-0.4179	*-0.6859	*-10.5490	*0.3414

Note: Single asterisks (*) for parameter estimates indicates significance at 10 percent level.

Table 5. Three-stage Least Square Estimation of Export Demand of Corn for EU Countries

		lndmpr	lnworldp	lnexpr	lnexrt	mref	aref	sps
France	0.0452	-0.4647	*1.1147	*7.6408	*1.2940	-0.2933	*0.9896	*-0.4532
Austria	0.8300	*-24.0806	*3.7138	*2.1208	1.8722	-0.3158	*-1.3599	*-1.3650
Belgium	8.0153	-2.6844	0.0760	0.0765	1.7163	-0.5593	*-3.1796	-0.3785
Germany	0.0545	-0.2497	0.2113	*7.9629	*2.0066	*-4.4726	*-0.3959	*-0.5976
Denmark	3.7721	-1.1454	0.1557	0.0938	*5.1419	0.3526	-0.6012	-1.7652
Ireland	0.9714	-7.1385	0.2133	*1.9822	*3.2134	0.1019	*3.2134	0.1134
Italy	-3.3167	*-17.4387	*0.9316	0.0147	*3.8825	-0.3245	-0.1237	*-0.4765
Netherlands	0.0222	*-1.2656	*1.0173	*17.2986	*2.0703	-0.2814	-0.2945	-0.3467
Spain	50.9711	-4.3452	*1.8219	0.0107	0.9419	-1.3810	-0.2315	*-0.6742
UK	8.6676	-0.6436	0.2514	0.0822	*1.9472	*-1.5781	-0.5876	*-1.1599
Greece	2.4081	-24.4435	0.2882	*0.8527	*5.7596	*-2.2067	*-3.4022	2.3451
Portugal	14.1762	*-6.4258	1.4014	*0.6455	0.0882	-0.9874	-1.5492	-1.2904

Note: Single asterisks (*) for parameter estimates indicates significance at 10 percent level.

Table 6. Three-stage Least Square Estimation of Import Demand of Corn for EU Countries

		lndmpr	lnworldp	lnexrt	lnimpl	mref	aref	lngdp	sps
France	15.0454	*0.7830	-0.4174	*-0.7218	*-0.4535	*-0.8040	*-0.5426	*0.5033	*-0.2987
Austria	13.8964	*1.1894	-0.0574	-1.9580	-0.3493	-1.6638	-1.7132	1.7894	*-0.9621
Belgium	11.2358	0.6609	0.1947	-0.0504	*-0.6429	0.4353	-0.0691	0.3382	-0.5692
Germany	17.3134	*1.3946	0.0535	*-0.7015	-0.0186	0.1646	*-0.5660	*0.3877	*-0.6391
Denmark	0.5115	*27.1891	-0.1565	-0.3519	-0.1378	*-1.7848	-0.1218	*0.8723	0.5498
Ireland	0.3791	*5.2281	-0.4390	-0.4410	0.0425	0.1620	*-0.2423	*0.7158	0.5987
Italy	0.1686	*19.2091	0.2489	-1.1304	0.0173	0.0417	*-0.4851	0.4620	*-0.1392
Netherlands	0.1024	*19.4245	-0.1532	*-0.8736	*-0.4263	-0.0831	-0.0551	0.0696	-0.4581
Spain	0.8354	1.1364	-0.0855	*-9.7622	-0.0308	0.0971	0.6342	*1.8301	*-0.9136
UK	0.3043	*9.2080	*-0.4408	*-0.7743	-0.0252	0.1374	0.2290	0.0789	*-0.3982
Greece	24.0424	1.3439	-0.9687	-0.1289	*-0.5208	*1.1264	-0.6342	*1.9946	0.7640
Portugal	5.1399	*1.5322	-0.1289	*-0.4067	-0.0390	*0.8615	*1.2825	*1.1144	-1.7439

Note: Single asterisks (*) for parameter estimates indicates significance at 10 percent level.

Table 7. Three-stage Least Square Estimation of Total Supply of Corn for EU Countries

		lndmpr	lnprodr	mref	aref	lngdp
France	0.2410	*6.4567	0.1071	0.1349	-0.1632	0.1700
Austria	0.0800	*3.9043	0.0641	-0.1777	-0.0311	0.2075
Belgium	0.0780	*0.6805	*1.2909	*-0.8815	*-5.2495	*0.8355
Germany	-5.3971	*0.5739	*0.1148	0.1771	-0.1192	*0.8396
Denmark	1.7870	*12.5899	0.5839	1.2494	*-1.8924	1.3409
Ireland	-3.6055	*30.1242	*7.9685	-1.2913	-0.2696	0.1422
Italy	-0.3413	*29.4847	*0.2101	-0.0410	*-0.5989	0.0729
Netherlands	-0.1300	*6.2647	*7.4018	-0.4306	-0.1530	*5.5761
Spain	-0.2747	*0.4349	0.0446	*-0.5627	*-0.6438	*0.4651
UK	-38.4882	4.4465	1.0243	-0.4703	-1.4000	2.9793
Greece	3.0158	*0.2799	0.0136	*-0.8465	*-0.9805	*0.4247
Portugal	-2.1576	*3.8979	0.3632	-0.0288	-0.1186	*0.1412

Note: Single asterisks (*) for parameter estimates indicates significance at 10 percent level.

Table 8. Estimates of Welfare Effects (Percentage Change from Baseline) from Sanitary and Phytosanitary Regulations on Imported Corn in the EU

	Producer Surplus	Consumer Surplus	Net Welfare*
France	5.762	-1.198	-0.794
Austria	2.503	-1.736	-1.386
Belgium	2.761	-0.885	-0.972
Germany	3.487	-1.165	-1.067
Denmark	1.042	-0.650	-0.893
Ireland	1.102	-0.387	-0.091
Italy	2.309	-1.067	-1.162
Netherlands	2.861	-0.800	-1.071
Spain	3.100	-1.276	-1.120
UK	2.980	-0.892	-1.852
Greece	3.486	-0.792	-0.848
Portugal	1.687	-0.961	-0.692

*Net Welfare includes estimates of government transfers and dead weight losses from SPS regulations.

Figure 1. Domestic and World Price of Corn in the United Kingdom (UK)