Ethanol Trade between Brazil and the United States

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Abstract

The United States has used tax credit and mandate to promote ethanol production. To offset the tax credit availed by the imported ethanol, the United States instituted an import tariff. This study ascertains the appropriate U.S. ethanol import tariff corresponding to the U.S. domestic policies by setting the policy-induced ethanol price equal to the free market price. The theoretical results from a horizontally-related ethanol-gasoline partial equilibrium model of three countries (the United States, Brazil, and the Rest of the World) show that the United States should provide an import subsidy rather than impose a tariff. The empirical results quantify that this import subsidy is $0.10, instead of a $0.57 import tariff, per gallon of ethanol.

Key Words: ethanol imports, mandate, subsidy, tariff, tax credit

JEL Classifications: F13

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Introduction

The United States and Brazil are the world's largest ethanol producers, accounting for 89% of the total world production in 2008. The U.S. ethanol output of 9 billion gallons in 2008 is the largest worldwide, followed by Brazil with 6.5 billion gallons (Renewable Fuels Association (RFA), 2009). Currently, corn is the major feedstock for ethanol production in the United States and sugarcane in Brazil. The U.S. government has promoted ethanol production through several policies: tax credit, mandate, and import tariff.[1] The tax credit is a subsidy given to blenders of ethanol and gasoline. Currently, the tax credit is set at $0.46 per gallon of ethanol under the 2008 Farm Bill. The mandate requires blenders to use a specified volume of biofuel to blend with gasoline. The mandated volume for 2008 is 9 billion gallons and is set to increase to 36 billion in 2022 (RFA, 2009). Although the tax credit was meant only for domestically produced ethanol, it also applies to imported ethanol because blenders cannot distinguish the origins of ethanol. Consequently, to offset the tax credit availed by the imported ethanol, the U.S. government instituted an import tariff. The United States justifies the ethanol import tariff by claiming that since imports receive the benefits of U.S. tax credit,[2] the tariff is needed to negate these benefits, and elimination of the tariff will hurt the domestic ethanol industry (RFA, 2007). Furthermore, the tariff is permissible because U.S. tariffs on ethanol have not been contested in the Uruguay Round (Motaal, 2008), and tariffs may not face a steeper cut even if there is an agreement reached under the Doha Round (de Gorter and Just, 2008).

Currently, the U.S. import tariff on ethanol is $0.57 per gallon, which includes a $0.54 specific tariff and 2.5% ad valorem tariff (de Gorter, Just, and Tan, 2009). As a result, the import tariff is higher than the tax credit by 11 cents per gallon of ethanol. Recent studies have shown that the U.S. tariff restricts the amount of ethanol imports from Brazil even though Brazil continues to have a significant comparative advantage in ethanol production (Elobeid and Tokgoz, 2006 and 2008; Kojima, Mitchell, and Ward, 2007). The United States imported, in 2008, about 434 million gallons from Brazil, which is only 6.8% Brazilian production (RFA, 2009). Consequently, Brazil is considering filing a formal complaint at the World Trade Organization (WTO) against the U.S. ethanol tariffs (Klapper, 2008). This dispute has become even more complex because the WTO has not formulated rules to address biofuel subsidies and tariffs as policies related to energy products are largely exempted from the WTO regulations and lack of clarity on whether biofuel is an agricultural good or industrial good (Motaal, 2008; Howse, van Bork and Hebebrand, 2006).

As this dispute is unresolved, it is worth ascertaining the appropriate U.S. ethanol import tariff given the U.S. tax credit and mandate. Specifically, this study aims to determine the value of tariff corresponding to the U.S. domestic policies by setting the policy-induced ethanol price equal to the free market price. Our results show that the current U.S. tariff, which is 11 cents more than the tax credit, is punitive to Brazil, and the United States should provide an import subsidy rather than impose an import tariff. The remainder of the paper is organized as follows. The next section describes the theoretical model, analysis, and the results. Section III presents information related to parameters, data, and sources. Section IV discusses the empirical results. The final section provides concluding remarks and policy implications.

Theoretical Framework

A horizontally-related ethanol-gasoline partial equilibrium model of three countries (the United States, Brazil, and the Rest of the World) is formulated.[3] The United States produces and utilizes both fossil fuel (gasoline) and ethanol. Since the United States is the largest user of fuel, its demand for fossil fuel and ethanol exceeds supply, and thus is an importer of both fuels. The United States imports fossil fuels from the Rest of the World (ROW) oil producing countries, and U.S. excess demand equals ROW excess supply:

$$D_G^U\left(P_G^U\right)-S_G^U\left(P_G^U\right)=S_G^R\left(P_G^R\right)-D_G^R\left(P_G^R\right), \tag{1}$$

where D_G^U is the U.S. demand for gasoline, S_G^U is the U.S. supply of gasoline, S_G^R is the ROW supply of gasoline, D_G^R is the ROW demand for gasoline, P_G^U is the U.S. price of gasoline, and P_G^R is the ROW price of gasoline. The spatial price arbitrage between U.S. and ROW gasoline prices is given by:

$$P_G^U = P_G^R + T_G, \tag{2}$$

where T_G is the transport cost of gasoline between the ROW and the United States. The United States imports ethanol from Brazil, and U.S. excess demand equals Brazil's excess supply:

$$D_E^U\left(P_E^{U,C}\right)-S_E^U\left(P_E^{U,P}\right)=S_E^B\left(P_E^B\right)-D_E^B\left(P_E^B\right), \tag{3}$$

where D_E^U is the U.S. demand for ethanol, S_E^U is the U.S. supply of ethanol, S_E^B is the Brazilian supply of ethanol, D_E^B is the Brazilian demand for ethanol, $P_E^{U,C}$ is the U.S. consumer/demand price of ethanol, $P_E^{U,P}$ is the U.S. producer/supply price of ethanol, and P_E^B is the Brazilian price of ethanol. The United States imposes tariff (t) on ethanol imports from Brazil, and the price-linkage equation is

$$P_E^{U,P} = P_E^B + t + T_E, \tag{4}$$

where T_E is the cost of transportation of ethanol from Brazil to the United States. The United

States provides tax credit (s) to the blenders for blending ethanol and gasoline. This tax credit causes a wedge between producer and consumer/blender ethanol prices:

$$P_E^{U,C} = P_E^{U,P} - s. \tag{5}$$

The United States mandates a fixed volume of ethanol to be blended with gasoline under the Renewable Fuel Standard (RFS) program of the Energy Independence and Security Act of 2007. For instance, 9 billion gallons of renewable fuel were required to be blended with gasoline in 2008, and this requirement will continue to increase to 36 billion gallons by 2022. Even though this Act requires a fixed volume of biofuel to be mixed with gasoline, i.e., consumption mandate, the Environmental Protection Agency, which is responsible for implementing the RFS, requires that ethanol and gasoline are to be mixed in a fixed proportion (*m*), i.e., blend mandate. This blend mandate implies that the share of ethanol (gasoline) in the final fuel is *m* (1-*m*):

$$D_E^U = mD_F^U \text{ and } D_G^U = (1-m)D_F^U, \tag{6}$$

where D_F^U is the U.S. demand for final fuel. Thus,

$$D_F^U = D_E^U + D_G^U = mD_F^U + (1-m)D_F^U.$$

Since final fuel is a weighted average of ethanol and gasoline, the producer price of final fuel $(P_F^{U,P})$ is

$$P_F^{U,P} = mP_E^{U,C} + (1-m)P_G^U.$$

The United States imposes excise tax (t_F) on final fuel, which causes the wedge between consumer and producer price:

$$P_F^{U,C} = P_F^{U,P} + t_F.$$

Combining the above two equations yields

$$P_F^{U,C} = mP_E^{U,C} + (1-m)P_G^U + t_F. \quad (7)$$

Substitution of the equation (5) into (7) leads to

$$P_F^{U,C} = m\left(P_E^{U,P} - s\right) + (1-m)P_G^U + t_F. \quad (8)$$

Substitution of equations (2), (4), (6), and (8) into the gasoline and ethanol trade equilibrium equations (1) and (3) and rearrangements yield

$$(1-m)D_F^U\left(m\left(P_E^{U,P} - s\right) + (1-m)P_G^U + t_F\right) = S_G^U\left(P_G^U\right) + S_G^R\left(P_G^U - T_G\right) - D_G^R\left(P_G^U - T_G\right) \quad (9)$$

$$mD_F^U\left(m\left(P_E^{U,P} - s\right) + (1-m)P_G^U + t_F\right) = S_E^U\left(P_E^{U,P}\right) + S_E^B\left(P_E^{U,P} - t - T_E\right) - D_E^B\left(P_E^{U,P} - t - T_E\right). \quad (10)$$

The above system of two equations in two unknowns $\left(P_E^{U,P} \text{and } P_G^U\right)$ is the core equations used for the analysis below. If the specific functional forms of supply and demand are known, equations (9) and (10) can be solved for equilibrium U.S. ethanol and gasoline price. This equilibrium price can be substituted into the supply, demand, and price linkage equation to obtain other prices and quantities. Similarly, the equilibrium prices and quantities under free trade can be solved. By equating ethanol prices under distortive policies to free trade ethanol price, we can compute the tariff corresponding to the U.S. ethanol policies.

However, when the supply and demand functions are in general forms, it is not possible to solve the system of two equations explicitly for endogenous variables. In this case, the trade equilibrium conditions (9) and (10) need to be differentiated to compute the appropriate tariff level. The equilibrium ethanol price depends on the exogenous policy parameters: $\tilde{P}_E^{U,P} = P_E^{U,P}(\bullet; t, s)$. The tariff ($t$) corresponding to the tax credit for domestic and imported ethanol should be such that $P_E^{U,P}(\bullet; t, s) = \overline{P}_E^{U,P}$, the free trade price of ethanol in the United States. Thus, the problem is to find t for a given level of subsidy s such that the U.S. ethanol producer price after the subsidy and tariff is the same as the free market ethanol price. Taking first order Taylor series approximation of $P_E^{U,P}(\bullet;t,s)$ around the free market policies $(t = s = 0)$ and making use of $P_E^{U,P}(\bullet;0,0) = \overline{P}_E^{P,U}$ yields

$$\frac{\partial P_E^{U,P}}{\partial s}s + \frac{\partial P_E^{U,P}}{\partial t}t = 0.$$

The above equation can be solved to express U.S. tariff as a proportion of U.S. tax credit.

$$t = -\frac{\frac{\partial P_E^{U,P}}{\partial s}}{\frac{\partial P_E^{U,P}}{\partial t}}s = \phi s, \tag{11}$$

where $\phi = -\left(\partial P_E^{U,P} / \partial s\right) / \left(\partial P_E^{U,P} / \partial t\right)$ is the countervailing coefficient that (i.e., the ratio of *t* to *s*) determines the magnitude of the specific tariff resulting from one unit of production tax credit.

The countervailing coefficient ϕ can be solved by conducting a comparative static analysis of trade equilibrium equations (9) and (10) and finding $\frac{\partial P_E^{U,P}}{\partial s}$ and $\frac{\partial P_E^{U,P}}{\partial t}$, or we can solve for $dP_E^{U,P}$ to find $\frac{\partial P_E^{U,P}}{\partial s}$ and $\frac{\partial P_E^{U,P}}{\partial t}$ (since $dP_E^{U,P} = \frac{\partial P_E^{U,P}}{\partial s}ds + \frac{\partial P_E^{U,P}}{\partial s}dt$) and then compute ϕ. The second approach is followed, and equations (9) and (10) are totally differentiated to obtain:

$$\begin{bmatrix} m^2\frac{\partial D_F^U}{\partial P_F^{U,C}}-\frac{\partial S_E^U}{\partial P_E^{U,P}}-\frac{\partial S_E^B}{\partial P_E^B}+\frac{\partial D_E^B}{\partial P_E^B} & m(1-m)\frac{\partial D_F^U}{\partial P_F^{U,C}} \\ m(1-m)\frac{\partial D_F^U}{\partial P_F^{U,C}} & (1-m)^2\frac{\partial D_F^U}{\partial P_F^{U,C}}-\frac{\partial S_G^U}{\partial P_G^U}-\frac{\partial S_G^R}{\partial P_G^R}+\frac{\partial D_G^R}{\partial P_G^R} \end{bmatrix}\begin{bmatrix} dP_E^{U,P} \\ dP_G^U \end{bmatrix}$$

$$=\begin{bmatrix} m^2\frac{\partial D_F^U}{\partial P_F^{U,C}}ds+\left(\frac{\partial D_E^B}{\partial P_E^B}-\frac{\partial S_E^B}{\partial P_E^B}\right)dt \\ m\left((1-m)\frac{\partial D_F^U}{\partial P_F^{U,C}}\right)ds \end{bmatrix}.$$

Applying Cramer's rule and with further simplification, we can solve for $dP_E^{U,P}$:

$$dP_E^{U,P}=\frac{1}{|A|}\begin{bmatrix} \left(-\frac{\partial S_G^U}{\partial P_G^U}-\frac{\partial S_G^R}{\partial P_G^R}+\frac{\partial D_G^R}{\partial P_G^R}\right)\left(m^2\frac{\partial D_F^U}{\partial P_F^{U,C}}\right)ds \\ \left((1-m)^2\frac{\partial D_F^U}{\partial P_F^{U,C}}-\frac{\partial S_G^U}{\partial P_G^U}-\frac{\partial S_G^R}{\partial P_G^R}+\frac{\partial D_G^R}{\partial P_G^R}\right)\left(\frac{\partial D_E^B}{\partial P_E^B}-\frac{\partial S_E^B}{\partial P_E^B}\right)dt \end{bmatrix}, \tag{12}$$

where $|A|$ is the determinant of the coefficient matrix.

Since $dP_E^{U,P}=\frac{\partial P_E^{U,P}}{\partial s}ds+\frac{\partial P_E^{U,P}}{\partial t}dt,$ we can decipher from (12) and from the definition of ϕ in (11):

$$\phi=-\frac{\left(-\frac{\partial S_G^U}{\partial P_G^U}-\frac{\partial S_G^R}{\partial P_G^R}+\frac{\partial D_G^R}{\partial P_G^R}\right)\left(m^2\frac{\partial D_F^U}{\partial P_F^{U,C}}\right)}{\left((1-m)^2\frac{\partial D_F^U}{\partial P_F^{U,C}}-\frac{\partial S_G^U}{\partial P_G^U}-\frac{\partial S_G^R}{\partial P_G^R}+\frac{\partial D_G^R}{\partial P_G^R}\right)\left(\frac{\partial D_E^B}{\partial P_E^B}-\frac{\partial S_E^B}{\partial P_E^B}\right)}.$$

The terms on the right hand side of the above equations are converted into elasticities by multiplying and dividing (price/quantity) and using the identities $(1-m)D_F^U=D_G^U$ and $mD_F^U=D_E^U$:

$$\phi = \frac{\overbrace{\left(\varepsilon_{GG}^{U}\frac{S_G^U}{P_G^U} + \varepsilon_{GG}^{R}\frac{S_G^R}{P_G^R} - \eta_{GG}^{R}\frac{D_G^R}{P_G^R}\right)}^{(+)}\left(\overbrace{m\left(\eta_{FF}^{U}\frac{D_E^U}{P_F^{U,C}}\right)}^{(-)}\right)}{\left(\underbrace{\left(\varepsilon_{GG}^{U}\frac{S_G^U}{P_G^U} - (1-m)\eta_{FF}^{U}\frac{D_G^U}{P_F^{U,C}}\right)}_{(+)} + \underbrace{\left(\varepsilon_{GG}^{R}\frac{S_G^R}{P_G^R} - \eta_{GG}^{R}\frac{D_G^R}{P_G^R}\right)}_{(+)}\right)\underbrace{\left(\varepsilon_{EE}^{B}\frac{S_E^B}{P_E^B} - \eta_{EE}^{B}\frac{D_E^B}{P_E^B}\right)}_{(+)}}, \tag{13}$$

where ε_{GG}^{U} is gasoline supply elasticity in the United States, ε_{GG}^{R} is gasoline supply elasticity in the ROW, η_{GG}^{R} is gasoline demand elasticity in the ROW, η_{FF}^{U} is the fuel demand elasticity in the United States, ε_{EE}^{B} is ethanol supply elasticity in Brazil, and η_{EE}^{B} is ethanol demand elasticity in Brazil. For positively sloped supply $\left(\varepsilon_{GG}^{U}, \varepsilon_{GG}^{R}, \varepsilon_{EE}^{B} \geq 0\right)$ and negatively sloped demand $\left(\eta_{FF}^{U}, \eta_{GG}^{R}, \eta_{EE}^{B} \leq 0\right)$, we can ascertain from (13) that ϕ is negative, and thus, from (11), t is also negative. This result implies that the U.S. should be providing an import subsidy rather than imposing the import tariff to maintain the policy-distorted U.S. ethanol producer price at the free market price. The rationale for this result is that the U.S. ethanol tax credit props up the U.S. producer price artificially; if this price were to come down to free market level, ethanol supply would also need to increase. However, domestic production will decline because of falling producer price. Hence, the only way to expand total ethanol supply is to increase imports, which can be accomplished by subsidizing imports, not taxing imports.

Though the sign of the countervailing coefficient ϕ is readily determined as negative, the magnitude of ϕ is not easily ascertainable. However, we can ascertain the effects of the magnitude of parameters on ϕ by conducting comparative statics, i.e., differentiating ϕ with the respect to various parameters. Note that in this analysis, ϕ and demand elasticities $(\eta_{GG}^{U},\ \eta_{EE}^{B},$

and η_{FF}^{U}) are negatives. $\partial\phi/\partial\varepsilon_{GG}^{U} < 0$, $\partial\phi/\partial\varepsilon_{GG}^{R} < 0$, and $\partial\phi/\partial\eta_{GG}^{U} > 0$: the more elastic the gasoline supply in the United States and the ROW and the gasoline demand in the ROW, the larger the import subsidy. $\partial\phi/\partial\varepsilon_{EE}^{B} > 0$ and $\partial\phi/\partial\eta_{EE}^{B} < 0$: the more elastic the Brazilian ethanol supply and demand, the smaller the import subsidies. $\partial\phi/\partial\eta_{FF}^{U} > 0$: the more elastic the U.S. fuel demand, the larger the import subsidy. $\partial\phi/\partial m < 0$: as *m* increases, the import subsidy also increases. In addition, the range of values that ϕ could take can be determined by conducting sensitivity analysis for small and large values of the parameters, which we examine in the empirical analyses.

If only the single sector model, i.e., only the ethanol market (equation 10 without gasoline price) is considered, then

$$\phi = \frac{\overbrace{\left(\eta_{EE}^{U}\frac{D_E^U}{P_E^{U,C}}\right)}^{(-)}}{\underbrace{\left(\varepsilon_{EE}^{B}\frac{S_E^B}{P_E^B} - \eta_{EE}^{B}\frac{D_E^B}{P_E^B}\right)}_{(+)}}, \tag{14}$$

which is also negative, implying that the U.S. trade policy should be an import subsidy policy.

Data and Sources

Implementation of the theoretical model to estimate the countervailing coefficient in equation (13) requires parameter values. Since the ethanol market is still in its infancy stage and undergoing structural change, reliable econometric estimates for elasticity parameters are not readily available (Gardner, 2003; Elobeid and Tokgoz, 2008). Consequently, elasticity values used by the past studies are utilized to estimate the value for ϕ. This approach is taken because earlier studies have used these elasticity values to obtain credible results in their analyses (Elobeid and Tokgoz, 2008; de Gorter, Just, and Tan, 2009).

Table 1 reports values of elasticity parameters and their sources, which were obtained from extensive search of the agricultural economics and energy literature pertinent to the U.S., Brazilian, and ROW oil and ethanol markets. The own-price demand elasticity for fuel, ethanol, and gasoline are generally inelastic. The supply elasticities for gasoline in the United States and for ethanol in Brazil are also inelastic. However, the supply elasticity of gasoline in the ROW is elastic because it is based on OPEC countries' supply response as reported by de Gorter, Just, and Tan (2009). The blend ratio *m* is determined by the RFS regulations, and the current ethanol blend in gasoline is 10%.

Estimation of the countervailing coefficient ϕ also requires, as evident from equation (13), supply, demand, and price data. Ethanol and gasoline consumption and production data were obtained from the Online International Energy Statistics Database of the Energy Information Administration (EIA) (2009c); Country Analysis Briefs: Brazil Energy Data Statistics and Analysis of the EIA (2009b); Monthly Energy Review, September 2009 EIA (2009d); the Plano Decenal de Expansao de Energia 2008/2017 – Capitulo VIII (in Portuguese) of the Empresa de Pesquisa Energetica (EPE) em estreita vinculacao com o Ministerio de Minas e Energia (MME); the Anuário Estatístico Brasileiro do Petróleo, Gás Natural e Biocombustíveis 2009 (in Portuguese) of the Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP) (2009); and the World Oil Outlook 2009 of the Organization of the Petroleum Exporting Countries (OPEC) (2009).

Ethanol and gasoline retail and wholesale price data were obtained from the Online International Energy Statistics Database of the Energy Information Administration (EIA) (2009c); the Annual Energy Review 2008 of the EIA (2009a); the Monthly Energy Review of the of the EIA (2009d); the Energy Prices & Taxes 2nd Quarter 2009 of the International Energy

Agency (IEA) (2009); the Ethanol and Unleaded Gasoline Average Rack Prices F.O.B., Omaha, Nebraska, 1882-2009 of the Nebraska Ethanol Board (2009); the Brazil Biofuel Annual Ethanol Report 2009 of the U.S. Department of Agriculture (USDA) (2009); and the Anuário Estatístico Brasileiro do Petróleo, Gás Natural e Biocombustíveis 2009 (in Portuguese) of the Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP) (2009).

Results and Discussions

The value of the countervailing coefficient for the year 2008 was computed by substituting the values for elasticities, mandate, consumption, production, and retail and wholesale prices in equation (13). The year 2008 was chosen because that was the year the mandate was first implemented. Once ϕ is determined, the appropriate value of the import tariff is calculated by multiplying ϕ with the tax credit as per equation (11). The computed value of ϕ is -0.19, and the negative value of ϕ, as ascertained in the theoretical analysis, implies that the tariff is negative, i.e., it is an import subsidy. For 2008, the tax credit was \$0.46, which translates into an import subsidy of \$0.09 (\$0.46* (-0.19) = -\$0.09; this negative import tariff amounts to a positive import subsidy of \$0.09). This means that every gallon of ethanol imported by the United States from Brazil should receive a subsidy of \$0.09, rather than the currently imposed import tariff of \$0.57. In 2008, the United States imported 434 million gallons of ethanol from Brazil (The Brazilian Sugarcane Industry Association (UNICA), 2009). These imports availed the tax credit of \$0.46 per gallon but incurred the tariff of \$0.57 per gallon. As a result, the United States paid \$199.6 million in tax credits but generated \$247.4 million in tariff revenues from the imports of Brazilian ethanol. The net value of \$47.8 million is a gain to the United States but a loss to Brazil. Instead of collecting \$47.8 million net import tariff revenues, the United States should be subsidizing the ethanol imports from Brazil to the tune of $39.1 million (434 million gallons times the per unit import subsidy of $0.09).

The results of this analysis are consistent with the findings of the previous studies. de Gorter and Just (2008) find that Brazil benefits from U.S. free market policies but incurs loss with a tax credit and import tariff. They also note that the U.S. argument that an import tariff is needed to offset the tax credit, otherwise the U.S. ethanol industry would be harmed, is unfounded. Elobeid and Tokgoz (2008) observe that removing the U.S. ethanol import tariff without modifying the tax credit should increase ethanol imports and lower U.S. ethanol prices. Furthermore, the removal of both policies should decrease U.S. ethanol prices and production, increase consumption, and increase imports by almost 200%. Brazilian ethanol production and exports are predicted to increase to satisfy the U.S. demand. de Gorter, Just, and Tan (2009) conclude that a reduction of the U.S. ethanol import tariff on a level lower than the tax credit would increase and stimulate ethanol trade, which implies that the United States should be subsidizing the ethanol imports as supported by our study.

Sugarcane in Brazil is a low-cost input for ethanol production, which can compete on a production cost basis with gasoline even without subsidies. Sugar ethanol in Brazil costs only $2.62 per gallon in 2008; in contrast, corn ethanol in the United States costs $3.44. In addition, sugar ethanol offers higher energy benefits than corn ethanol energy (Rajagopal and Zilberman, 2007). Furthermore, Brazilian ethanol is competitive between $29.00 and $35.00 per barrel of crude oil, but U.S. ethanol is competitive only between $44.00 and $50.00 per barrel of crude oil (Motaal, 2008; Von Lampe, 2006). Consequently, Brazil has a comparative advantage in producing ethanol from sugarcane and is competitive in spite of high U.S. import tariff. These findings support the view that the U.S. ethanol import tariff is designed to protect U.S. biofuel producers and corn farmers who cannot produce the ethanol as cost effectively as the Brazilian sugarcane growers.

To examine the influence of various parameter values on the countervailing coefficient and thus on import subsidy, we conduct sensitivity analyses by letting the values of elasticities to range from very inelastic to elastic and the mandate to range from 0 to 1. We present the empirical results in Table 2 and the comparative static results of the theoretical analysis in the appendix. The value of the countervailing coefficient is not overly sensitive to U.S. gasoline supply elasticity, and ROW gasoline supply and demand elasticities. For example, as these elasticities become elastic, the value of ϕ converges to -0.21 which is very close to the ϕ value of -0.19 obtained from the benchmark elasticities given in Table 1. When U.S. gasoline supply elasticity and ROW gasoline demand elasticity are very inelastic, the ϕ value is -0.19, which is identical to the ϕ value for the benchmark elasticities, which implies that for a given tax credit, the import subsidy does not change much. As the ROW gasoline supply elasticity becomes inelastic, the ϕ value approaches -0.08.

As the Brazilian ethanol supply and demand elasticities become very elastic, the value of ϕ approaches 0. The reason for this result is the elastic Brazilian supply and demand make the excess supply also very elastic and when the United States faces an elastic excess supply it operates as a small country and its policies have no effect on Brazil. Thus, the Brazilian price is not impacted, and the ethanol imports from Brazil do not need any import subsidy. As the Brazilian ethanol demand elasticity becomes inelastic, it does not have a significant impact on the ϕ value. This is because the excess supply elasticity reflects the Brazilian domestic supply elasticity, and thus the ϕ value is similar to the results obtained for the benchmark Brazilian supply elasticity. However, an inelastic Brazilian supply has a larger effect on ϕ because the excess supply also becomes inelastic and the U. S. policies depress the Brazilian price significantly. Consequently, to increase the Brazilian price, the United States needs to give a large import subsidy; thus, the ϕ value is a large negative.

As the U.S. demand elasticity for fuel becomes more elastic, the ϕ coefficient tends to a large negative. The rationale for this result is that the U. S. excess demand for gasoline and ethanol also becomes very elastic, which makes Brazil a small exporting country in the ethanol market. Consequently, Brazil bears the full effect of U.S. ethanol policy changes, which means the tariff needs to decline and become a large negative for the U.S. ethanol price to reach the free market price. If U.S. fuel demand elasticity is very inelastic, then ϕ tends to zero. This result implies that irrespective of the magnitude of the tax credit, the tariff/import subsidy will be close to zero, and U.S. ethanol policies do not have any bearing on the import tariff.

If *m* is close to zero, the role of the mandate is less important because the ethanol is not a significant component of the fuel market, and the U.S. will not be a major player in the world ethanol market. In this case, the value of ϕ is close to zero, which indicates that for a given tax credit, the import subsidy would also be near zero. In contrast, as *m* increases (i.e., $m \to 1$), the ethanol market becomes large relative to the gasoline market, and the United States will be an even larger player in the world ethanol market. As a result, U.S. policies will have a greater impact on the world ethanol market, which implies, for a given tax credit, the ethanol import subsidy will increase as *m* rises to maintain the free-market policy U.S. domestic ethanol price.

The ϕ value for the ethanol market in isolation computed using equation (14) is -1.14, and the corresponding import subsidy is \$0.52. The import subsidy is larger if only the ethanol market is considered because the effect of the huge gasoline market is ignored.

Conclusion

The United States and Brazil are currently the two largest biofuel producers in the world. The U.S. goals are to become energy independent and reduce carbon emission. However, studies have shown that the U.S. biofuel policies do more to increase farm income from corn production than to reduce GHG emissions. For instance, Miranowski (2007) concludes that even with the farm supports, the U.S. corn-ethanol production would have never been feasible without biofuel subsidies. In contrast, Brazil has a comparative advantage in producing sugar-based ethanol, which is more energy efficient and eco-friendly than corn-based ethanol (Kojima, Mitchell, and Ward, 2007). Furthermore, sugar-based ethanol can directly compete with gasoline without subsidies as a renewable energy alternative. Nevertheless, U.S. trade barriers restrict environmentally beneficial sugar-based ethanol. Therefore, the U.S. import tariff contradicts its goal of less reliance on imported petroleum and environmental improvements through reductions in GHG emissions (Johnson and Runge, 2007). Though the U.S. corn-based ethanol is promoted as a clean alternative for fossil fuel, recent research exposed possible negative environmental impacts as well as the rise in food prices (Searchinger et al. 2008; Escobar et al. 2009). These factors breed doubts as to the feasibility of U.S. corn ethanol.

Our study provides evidence that the current U.S. ethanol import tariff in excess of the tax credit is unjustifiable, and the United States should be providing an import subsidy. Furthermore, global emissions will decline if there is a freer trade in ethanol due to Brazil's comparative advantage in producing energy efficient and environmentally beneficial sugar ethanol (de Gorter, Just, and Tan, 2009). In addition, elimination of U.S. import tariff should increase competition and bring innovation in efficiency and production to the global ethanol industry. The United States should focus on increasing investments and gaining a comparative advantage in the "next generation" biofuel production.

Endnote

[1] Brazil does not currently subsidize its sugar-based ethanol, even though it did provide government support at the infancy stage of the ethanol industry (van den Wall Bake et al., 2008).

[2] Since tax credit is given to domestic production and imports, and thus does not discriminate against imports, it does not violate the WTO's Agreement on Subsidies and Countervailing Measures (de Gorter and Just, 2008).

[3]See de Gorter and Just (2008) and de Gorter and Just (2009) for a model that incorporates U.S. biofuel policies and ethanol imports.

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Appendix

$$\varepsilon_{GG}^{U} \to \infty, \varepsilon_{GG}^{R} \to \infty, \eta_{GG}^{R} \to -\infty, \quad \phi \to \frac{m\left(\eta_{FF}^{U} \frac{D_E^U}{P_F^{U,C}}\right)}{\left(\varepsilon_{EE}^{B} \frac{S_E^B}{P_E^B} - \eta_{EE}^{B} \frac{D_E^B}{P_E^B}\right)}$$

$$\varepsilon_{GG}^{U} \to 0, \quad \phi \to \frac{\left(\varepsilon_{GG}^{R} \frac{S_G^R}{P_G^R} - \eta_{GG}^{R} \frac{D_G^R}{P_G^R}\right)\left(m\left(\eta_{FF}^{U} \frac{D_E^U}{P_F^{U,C}}\right)\right)}{\left(\left(-(1-m)\eta_{FF}^{U} \frac{D_G^U}{P_F^{U,C}}\right) + \left(\varepsilon_{GG}^{R} \frac{S_G^R}{P_G^R} - \eta_{GG}^{R} \frac{D_G^R}{P_G^R}\right)\right)\left(\varepsilon_{EE}^{B} \frac{S_E^B}{P_E^B} - \eta_{EE}^{B} \frac{D_E^B}{P_E^B}\right)}$$

$$\varepsilon_{GG}^{R} \to 0, \quad \phi \to \frac{\left(\varepsilon_{GG}^{U} \frac{S_G^U}{P_G^U} - \eta_{GG}^{R} \frac{D_G^R}{P_G^R}\right)\left(m\left(\eta_{FF}^{U} \frac{D_E^U}{P_F^{U,C}}\right)\right)}{\left(\left(\varepsilon_{GG}^{U} \frac{S_G^U}{P_G^U} - (1-m)\eta_{FF}^{U} \frac{D_G^U}{P_F^{U,C}}\right) + \left(-\eta_{GG}^{R} \frac{D_G^R}{P_G^R}\right)\right)\left(\varepsilon_{EE}^{B} \frac{S_E^B}{P_E^B} - \eta_{EE}^{B} \frac{D_E^B}{P_E^B}\right)}$$

$$\eta_{GG}^{R} \to 0, \quad \phi \to \frac{\left(\varepsilon_{GG}^{U} \frac{S_G^U}{P_G^U} + \varepsilon_{GG}^{R} \frac{S_G^R}{P_G^R}\right)\left(m\left(\eta_{FF}^{U} \frac{D_E^U}{P_F^{U,C}}\right)\right)}{\left(\left(\varepsilon_{GG}^{U} \frac{S_G^U}{P_G^U} - (1-m)\eta_{FF}^{U} \frac{D_G^U}{P_F^{U,C}}\right) + \left(\varepsilon_{GG}^{R} \frac{S_G^R}{P_G^R}\right)\right)\left(\varepsilon_{EE}^{B} \frac{S_E^B}{P_E^B} - \eta_{EE}^{B} \frac{D_E^B}{P_E^B}\right)}$$

$$\varepsilon_{EE}^{B} \to \infty, \eta_{EE}^{B} \to -\infty, \quad \phi \to 0$$

$$\varepsilon_{EE}^{B} \to 0, \quad \phi \to \frac{\left(\varepsilon_{GG}^{U} \frac{S_G^U}{P_G^U} + \varepsilon_{GG}^{R} \frac{S_G^R}{P_G^R} - \eta_{GG}^{R} \frac{D_G^R}{P_G^R}\right)\left(m\left(\eta_{FF}^{U} \frac{D_E^U}{P_F^{U,C}}\right)\right)}{\left(\left(\varepsilon_{GG}^{U} \frac{S_G^U}{P_G^U} - (1-m)\eta_{FF}^{U} \frac{D_G^U}{P_F^{U,C}}\right) + \left(\varepsilon_{GG}^{R} \frac{S_G^R}{P_G^R} - \eta_{GG}^{R} \frac{D_G^R}{P_G^R}\right)\right)\left(-\eta_{EE}^{B} \frac{D_E^B}{P_E^B}\right)}$$

$$\eta_{EE}^{B} \to 0, \quad \phi \to \frac{\left(\varepsilon_{GG}^{U} \frac{S_G^U}{P_G^U} + \varepsilon_{GG}^{R} \frac{S_G^R}{P_G^R} - \eta_{GG}^{R} \frac{D_G^R}{P_G^R}\right)\left(m\left(\eta_{FF}^{U} \frac{D_E^U}{P_F^{U,C}}\right)\right)}{\left(\left(\varepsilon_{GG}^{U} \frac{S_G^U}{P_G^U} - (1-m)\eta_{FF}^{U} \frac{D_G^U}{P_F^{U,C}}\right) + \left(\varepsilon_{GG}^{R} \frac{S_G^R}{P_G^R} - \eta_{GG}^{R} \frac{D_G^R}{P_G^R}\right)\right)\left(\varepsilon_{EE}^{B} \frac{S_E^B}{P_E^B}\right)}$$

$$\eta_{FF}^{U} \to -\infty, \quad \phi \to \frac{\left(\varepsilon_{GG}^{U}\frac{S_G^U}{P_G^U} + \varepsilon_{GG}^{R}\frac{S_G^R}{P_G^R} - \eta_{GG}^{R}\frac{D_G^R}{P_G^R}\right)\left(m\left(\frac{D_E^U}{P_F^{U,C}}\right)\right)}{\left(-(1-m)\frac{D_G^U}{P_F^{U,C}}\right)\left(\varepsilon_{EE}^{B}\frac{S_E^B}{P_E^B} - \eta_{EE}^{B}\frac{D_E^B}{P_E^B}\right)}$$

$$\eta_{FF}^{U} \to 0, m \to 0, \quad \phi \to 0$$

$$m \to 1, \quad \phi \to \frac{\left(\eta_{FF}^{U}\frac{D_E^U}{P_F^{U,C}}\right)}{\left(\varepsilon_{EE}^{B}\frac{S_E^B}{P_E^B} - \eta_{EE}^{B}\frac{D_E^B}{P_E^B}\right)}$$

Table 1. Elasticity Values and Sources

Definitions	Parameters	Elasticity Values	Sources
Demand Elasticities			
U.S. own-price elasticity of fuel	η_{FF}^{U}	-0.8	Gallagher et al., 2003.
Brazilian own-price elasticity of ethanol	η_{EE}^{B}	-0.10	Elobeid and Tokgoz, 2008.
ROW own-price elasticity of gasoline	η_{GG}^{R}	-0.205	Eltony and Al-Mutairi, 1995.
U.S. own-price elasticity of ethanol	η_{EE}^{U}	-0.43	Elobeid and Tokgoz, 2008.
Supply Elasticities			
U.S. own-price elasticity of fuel	ε_{GG}^{U}	0.15	Elobeid and Tokgoz, 2008.
Brazilian own-price elasticity of ethanol	ε_{EE}^{B}	0.2	Gallagher et al., 2003.
ROW own-price elasticity of gasoline	ε_{GG}^{R}	2.25	de Gorter et al., 2009.

Table 2. Effects of the Magnitude of Parameters on the Countervailing Coefficient

Parameter Values		Countervailing Coefficient ϕ
ε_{GG}^{U}	0.01	-0.19
	10	-0.21
η_{GG}^{R}	-0.01	-0.19
	-10	-0.21
ε_{GG}^{R}	0.01	-0.08
	10	-0.21
ε_{EE}^{B}	0.01	-0.85
	10	-0.00
η_{EE}^{B}	-0.01	-0.22
	-10	-0.01
η_{FF}^{U}	-0.01	-0.00
	-10	-0.85
m	0	-0.00
	1	-2.21