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Is the U.S. Import Tariff on Brazilian Ethanol Justifiable?

Stephen Devadoss and Martin Kuffel

The United States has used tax credits and mandates to promote ethanol production. To offset the tax credits received by imported ethanol, the United States instituted an import tariff. This study provides insights about the quantitative nature of a U.S. trade policy that would establish a free-market price for ethanol, given the U.S. ethanol mandate and tax credit. The theoretical results from a horizontally related ethanol-gasoline partial equilibrium model show that the United States should provide an import subsidy rather than impose a tariff. The empirical results quantify that this import subsidy is 9 cents, instead of a 57 cent import tariff, per gallon of ethanol.

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

Introduction

The United States and Brazil are the world's largest ethanol producers. In 2008, the United States produced 9 billion gallons of ethanol, while Brazil produced 6.5 billion gallons; together they accounted for 89% of total world production [Renewable Fuels Association (RFA), 2009]. In the United States, corn is the major feedstock for ethanol production; in Brazil, the major feedstock is sugarcane. The U.S. government has promoted ethanol production through several policies: a tax credit, the ethanol mandate, and an import tariff.[1] Under the 2008 Farm Bill, the tax credit, a subsidy given to blenders of ethanol and gasoline, was set at $0.46 per gallon of ethanol. The ethanol mandate requires blenders to use a specified aggregate volume of ethanol in their gasoline blends. The mandated volume for 2008 was 9 billion gallons and will increase to 15 billion gallons in 2022 (RFA, 2009).

Although the tax credit was intended only for domestically produced ethanol, it also applies to imported ethanol because blenders cannot determine the origin of the ethanol they use. Consequently, to offset the tax credit accruing to 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 the tax credit,[2] a tariff is needed to offset these benefits, and eliminating the tariff will hurt the domestic ethanol industry (RFA, 2007). Furthermore, the United States claims that the tariff is permissible under current World Trade Organization (WTO) rules because U.S. tariffs on ethanol have not been contested in the Uruguay Round (Motaal, 2008) and that tariffs may not face a steeper cut even if a new WTO agreement is reached under the Doha Round (de Gorter and Just, 2008).

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

[2] Since the 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).

Currently, the U.S. import tariff on ethanol is effectively \$0.57 per gallon and consists of a \$0.54 specific tariff and a 2.5% ad valorem tariff (de Gorter, Just, and Tan, 2009). As a result, the import tariff exceeds 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, 2008; Kojima, Mitchell, and Ward, 2007). The United States imported approximately 434 million gallons of ethanol from Brazil in 2008, representing only 6.8% of Brazilian production (RFA, 2009). Consequently, Brazil is considering filing a formal complaint with the WTO against the U.S. ethanol tariff (Klapper, 2008). This dispute has become even more complex because the WTO has not formulated rules to address biofuel policies. Subsidies and tariffs related to energy products are largely exempt from WTO regulations, and there is a lack of clarity as to whether biofuels are agricultural or industrial commodities (Motaal, 2008; Howse, van Bork, and Hebebrand, 2006).

As this dispute is unresolved, it is worth ascertaining the appropriate U.S. ethanol import policy given the U.S. tax credit and mandate. Specifically, this study's objective is to provide insights about the quantitative nature of a U.S. trade policy that would establish a free-market price for ethanol, given the U.S. ethanol tax credit and mandate. 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 in fact provide an import subsidy rather than impose an import tariff. Our findings are consistent with those reported in the literature on biofuel. For instance, de Gorter and Just (2008) conclude the U.S. policy hurts Brazilian ethanol producers and argue against the validity of the U.S. claim that an import tariff is needed to counteract the tax credit. De Gorter, Just, and Tan (2009) suggest the import tariff should be smaller than the tax credit, which would imply an import subsidy. Elobeid and Tokgoz (2008) assert that the removal of the U.S. tax credit and import tariff would significantly increase ethanol imports. The current work differs from earlier studies by providing new insights about the level of the import tariff corresponding to U.S. policies if we were to maintain the free-trade price.

Theoretical Framework

We develop a horizontally linked partial equilibrium model of ethanol and gasoline for three regions: the United States, Brazil, and the rest of the world (ROW).[3] The United States produces and utilizes fossil fuel (gasoline) and ethanol. Since the U.S. demand for fossil fuel and ethanol exceeds supply, it imports both fuels. The United States imports fossil fuel from oil-producing countries in the ROW, and U.S. excess demand equals ROW excess supply:

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

where D_G^U is U.S. demand for gasoline, S_G^U is U.S. supply of gasoline, S_G^R is ROW supply of gasoline, D_G^R is ROW demand for gasoline, P_G^U is U.S. price of gasoline, and P_G^R is ROW price of gasoline. Spatial price arbitrage between U.S. and ROW gasoline prices requires that:

(2) $$P_G^U = P_G^R + T_G,$$

[3] See de Gorter and Just (2008, 2009) for a two-country (the United States and Brazil) model that incorporates U.S. biofuel policies and ethanol imports.

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

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

where T_E is the transport cost of ethanol from Brazil to the United States. The United States provides a tax credit (s) to U.S. blenders of ethanol and gasoline, which creates the following 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 be blended with gasoline under the Renewable Fuel Standard (RFS) program of the Energy Independence and Security Act (EISA) of 2007. For instance, 9 billion gallons of ethanol were required to be blended with gasoline in 2008, and this requirement is scheduled to increase to 15 billion gallons by 2022. Even though the EISA requires a fixed volume of biofuel to be mixed with gasoline (i.e., a consumption mandate), the Environmental Protection Agency (EPA), which is responsible for implementing the RFS, requires that ethanol and gasoline be blended in a fixed proportion (m). This amounts to a blend mandate. The blend mandate implies that the share of ethanol (gasoline) in the final fuel is m $(1-m)$; hence,

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

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

$$D_F^U = D_E^U + D_G^U = mD_F^U + (1-m)D_F^U. \tag{7}$$

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

$$P_F^{U,P} = mP_E^{U,C} + (1-m)P_G^U. \tag{8}$$

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

$$P_F^{U,C} = P_F^{U,P} + t_F. \tag{9}$$

Combining equations (8) and (9) yields:

$$P_F^{U,C} = mP_E^{U,C} + (1-m)P_G^U + t_F. \tag{10}$$

Substituting equation (5) into (10) yields:

$$P_F^{U,C} = m\left(P_E^{U,P} - s\right) + (1-m)P_G^U + t_F . \tag{11}$$

Substituting equations (2), (4), (6), and (11) into the gasoline and ethanol trade equilibrium equations (1) and (3) and rearranging terms yields the following results:

$$\begin{aligned}(1-m)D_F^U\left(m\left(P_E^{U,P}-s\right)+(1-m)P_G^U+t_F\right)\\ = S_G^U\left(P_G^U\right)+S_G^R\left(P_G^U-T_G\right)-D_G^R\left(P_G^U-T_G\right),\end{aligned} \tag{12}$$

$$\begin{aligned}mD_F^U\left(m\left(P_E^{U,P}-s\right)+(1-m)P_G^U+t_F\right)\\ = S_E^U\left(P_E^{U,P}\right)+S_E^B\left(P_E^{U,P}-t-T_E\right)-D_E^B\left(P_E^{U,P}-t-T_E\right).\end{aligned} \tag{13}$$

Equations (12) and (13) contain two unknowns ($P_E^{U,P}$ and P_G^U) and form the core equations used in this analysis. If the specific functional forms of supply and demand are known, equations (12) and (13) can be solved for the equilibrium U.S. ethanol and gasoline prices. We can substitute these equilibrium prices into the supply, demand, and price linkage equations to obtain other prices and quantities. Similarly, we can solve for the equilibrium prices and quantities under free trade. By equating ethanol prices under distortive policies to the ethanol price that would exist under a free-trade regime, we can identify the trade policy that would establish the free-trade ethanol price under the current U.S. domestic policy regime.

When the supply and demand functions are specified in general terms, it is not possible to solve the system of two equations explicitly for endogenous variables. In this case, the trade equilibrium conditions (12) and (13) can 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 the tariff, 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 $P_E^{U,P}(\bullet; 0, 0) = \overline{P}_E^{U,P}$ yields:

$$\frac{\partial P_E^{U,P}}{\partial s}\, s + \frac{\partial P_E^{U,P}}{\partial t}\, t = 0. \tag{14}$$

Equation (14) can be solved to express the U.S. tariff as a proportion of the U.S. tax credit:

$$t = -\left(\frac{\partial P_E^{U,P}}{\partial s} \bigg/ \frac{\partial P_E^{U,P}}{\partial t}\right) s = \phi s, \tag{15}$$

where $\phi = -(\partial P_E^{U,P}/\partial s)/(\partial P_E^{U,P}/\partial t)$ is the countervailing coefficient (i.e., the ratio of t to s) which 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 the trade equilibrium equations (12) and (13) and finding $\partial P_E^{U,P}/\partial s$ and $\partial P_E^{U,P}/\partial t$, or we can solve for $dP_E^{U,P}$ to find $\partial P_E^{U,P}/\partial s$ and $\partial P_E^{U,P}/\partial t$, 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. We use the second approach here. Equations (12) and (13) are totally differentiated to obtain:

$$\begin{bmatrix} m^2 \frac{\partial D_F^U}{\partial P_F^{U,C}} - \frac{\partial S_E^U}{\partial P_E^{U,P}} - \frac{\partial S_E^B}{\partial P_E^B} + \frac{\partial D_E^B}{\partial P_E^B} & m(1-m)\frac{\partial D_F^U}{\partial P_F^{U,C}} \\ m(1-m)\frac{\partial D_F^U}{\partial P_F^{U,C}} & (1-m)^2 \frac{\partial D_F^U}{\partial P_F^{U,C}} - \frac{\partial S_G^U}{\partial P_G^U} - \frac{\partial S_G^R}{\partial P_G^R} + \frac{\partial D_G^R}{\partial P_G^R} \end{bmatrix} \begin{bmatrix} dP_E^{U,P} \\ dP_G^U \end{bmatrix} \tag{16}$$

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

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

$$dP_E^{U,P} = \frac{1}{|A|} \begin{bmatrix} \left(-\frac{\partial S_G^U}{\partial P_G^U} - \frac{\partial S_G^R}{\partial P_G^R} + \frac{\partial D_G^R}{\partial P_G^R} \right) \left(m^2 \frac{\partial D_F^U}{\partial P_F^{U,C}} \right) ds \\ \left((1-m)^2 \frac{\partial D_F^U}{\partial P_F^{U,C}} - \frac{\partial S_G^U}{\partial P_G^U} - \frac{\partial S_G^R}{\partial P_G^R} + \frac{\partial D_G^R}{\partial P_G^R} \right) \left(\frac{\partial D_E^B}{\partial P_E^B} - \frac{\partial S_E^B}{\partial P_E^B} \right) dt \end{bmatrix}, \tag{17}$$

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

$$dP_E^{U,P} = \frac{\partial P_E^{U,P}}{\partial s} ds + \frac{\partial P_E^{U,P}}{\partial t} dt,$$

using equation (17) and the definition of ϕ in (15), we can solve for ϕ:

$$\phi = -\frac{\left(-\frac{\partial S_G^U}{\partial P_G^U} - \frac{\partial S_G^R}{\partial P_G^R} + \frac{\partial D_G^R}{\partial P_G^R} \right) \left(m^2 \frac{\partial D_F^U}{\partial P_F^{U,C}} \right)}{\left((1-m)^2 \frac{\partial D_F^U}{\partial P_F^{U,C}} - \frac{\partial S_G^U}{\partial P_G^U} - \frac{\partial S_G^R}{\partial P_G^R} + \frac{\partial D_G^R}{\partial P_G^R} \right) \left(\frac{\partial D_E^B}{\partial P_E^B} - \frac{\partial S_E^B}{\partial P_E^B} \right)}. \tag{18}$$

The terms on the right-hand side of the above equations are converted to elasticities by multiplication and division using prices and quantities and the identities $(1-m)D_F^U = D_G^U$ and $mD_F^U = D_E^U$ to obtain the following expressions:

$$(19)\quad \phi = \frac{\overbrace{\left(\varepsilon_{GG}^{U}\frac{S_G^U}{P_G^U}+\varepsilon_{GG}^{R}\frac{S_G^R}{P_G^R}-\eta_{GG}^{R}\frac{D_G^R}{P_G^R}\right)}^{(+)}\left(m\overbrace{\left(\eta_{FF}^{U}\frac{D_E^U}{P_F^{U,C}}\right)}^{(-)}\right)}{\left(\underbrace{\left(\varepsilon_{GG}^{U}\frac{S_G^U}{P_G^U}-(1-m)\eta_{FF}^{U}\frac{D_G^U}{P_F^{U,C}}\right)}_{(+)}+\underbrace{\left(\varepsilon_{GG}^{R}\frac{S_G^R}{P_G^R}-\eta_{GG}^{R}\frac{D_G^R}{P_G^R}\right)}_{(+)}\right)\underbrace{\left(\varepsilon_{EE}^{B}\frac{S_E^B}{P_E^B}-\eta_{EE}^{B}\frac{D_E^B}{P_E^B}\right)}_{(+)}},$$

where ε_{GG}^{U} is the U.S. gasoline supply price elasticity, ε_{GG}^{R} is the ROW gasoline supply price elasticity, η_{GG}^{R} is the ROW gasoline demand elasticity, η_{FF}^{U} is the U.S. fuel demand elasticity, ε_{EE}^{B} is the Brazilian ethanol supply elasticity, and η_{EE}^{B} is the Brazilian ethanol demand elasticity.

Given positive supply elasticities $(\varepsilon_{GG}^{U}, \varepsilon_{GG}^{R}, \varepsilon_{EE}^{B} \geq 0)$ and negative demand elasticities $(\eta_{FF}^{U},\ \eta_{GG}^{R}, \eta_{EE}^{B} \leq 0)$, equation (19) implies that ϕ is negative. Thus, t must also be negative. This suggests the United States should provide an import subsidy rather than levy an import tariff to maintain the policy-distorted U.S. ethanol producer price at the free-market price. The rationale is that the U.S. ethanol tax credit props up the U.S. producer price artificially; if the ethanol price were to decline to the free-market level, total ethanol supply for domestic use would need to increase. However, domestic production would fall because of the decline in the U.S. producer price. Hence, the only way to expand total ethanol supply is to increase imports, which can only be accomplished by subsidizing imports, not taxing them.

Though the sign of the countervailing coefficient ϕ is negative, the magnitude of ϕ is not easily determined. However, we can ascertain the effects of the magnitudes of key parameters on ϕ by differentiating ϕ with respect to those parameters. Note that in this analysis, ϕ and the demand elasticities $(\eta_{GG}^{U}, \eta_{EE}^{B}, \text{and } \eta_{FF}^{U})$ are negative. The comparative static results are as follows. First, $\partial\phi/\partial\varepsilon_{GG}^{U} < 0$, $\partial\phi/\partial\varepsilon_{GG}^{R} < 0$, and $\partial\phi/\partial\eta_{GG}^{U} > 0$; i.e., when gasoline supply in the United States and the ROW and gasoline demand in the ROW become more price elastic, the import subsidy increases. Second, $\partial\phi/\partial\varepsilon_{EE}^{B} > 0$ and $\partial\phi/\partial\eta_{EE}^{B} < 0$; i.e., when Brazilian ethanol supply and demand are more price elastic, the import subsidy decreases. Third, $\partial\phi/\partial\eta_{FF}^{U} > 0$; i.e., when U.S. fuel demand becomes more price elastic, the import subsidy increases. Finally, $\partial\phi/\partial m < 0$; i.e., as m increases, the import subsidy also increases. In addition, the range of values that ϕ could potentially take on can be evaluated by conducting a sensitivity analysis for smaller and larger values of the key elasticity parameters. This issue is examined in the empirical analysis provided below.

If we only model the ethanol market [i.e., equation (13) without the gasoline price], then:

$$(20)\qquad \phi = \frac{\overbrace{\left(\eta_{EE}^{U}\frac{D_E^U}{P_E^{U,C}}\right)}^{(-)}}{\underbrace{\left(\varepsilon_{EE}^{B}\frac{S_E^B}{P_E^B}-\eta_{EE}^{B}\frac{D_E^B}{P_E^B}\right)}_{(+)}},$$

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

Data and Sources

Implementation of the theoretical model to estimate the countervailing coefficient in equation (19) requires parameter values. Since the ethanol market is still in its infancy and undergoing structural change, reliable econometric estimates for elasticity parameters are not readily available (Gardner, 2003; Elobeid and Tokgoz, 2008). Consequently, elasticity values used in previous studies (e.g., Elobeid and Tokgoz, 2008; de Gorter, Just, and Tan, 2009) are utilized to estimate the value of ϕ.

Table 1 reports values of elasticity parameters and their sources, which were obtained from an 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 elasticities for fuel, ethanol, and gasoline are generally inelastic. Supply elasticities for gasoline in the United States and for ethanol in Brazil are also relatively small (less than 0.2). However, the supply elasticity of gasoline in the ROW is relatively large (2.25) because it is based on OPEC countries' supply response, as reported by de Gorter, Just, and Tan (2009). The blend ratio (m) for ethanol in gasoline, determined by RFS regulations, is currently 10%.

Estimation of the countervailing coefficient (ϕ) also requires supply, demand, and price data. Ethanol and gasoline consumption and production data were obtained from the online "International Energy Statistics" database of the U.S. Energy Information Administration (EIA) (2009c); "Country Analysis Briefs: Brazil Energy Data, Statistics and Analysis" (EIA, 2009b); "Monthly Energy Review, September 2009" (EIA, 2009d); the "Plano Decenal de Expansão de Energia 2008/2017—Capítulo VIII" (in Portuguese) of the Empresa de Pesquisa Energética (EPE) em estreita vinculação com o Ministério de Minas e Energia (MME) (2009); the "Anuário Estatístico Brasileiro do Petróleo, Gás Natural e Biocombustíveis" (2009, in Portuguese) of the Agência Nacional do Petróleo, Gás Natural e Biocombustíveis; 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 U.S. Energy Information Administration (EIA, 2009c); the "Annual Energy Review 2008" (EIA, 2009a); the "Monthly Energy Review, September 2009" (EIA, 2009d); the "Energy Prices and 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 Discussion

The value of the countervailing coefficient for the year 2008 was computed by substituting the values for the elasticities, mandate, consumption, production, and retail and wholesale prices in equation (19). The year 2008 was chosen because that was the year in which the mandate was first implemented. Once ϕ is determined, the appropriate value of the import tariff is calculated by multiplying ϕ by the tax credit using equation (15). The computed value of ϕ is -0.19, and, as the theoretical analyses suggest, implies that the United States should

Table 1. Elasticity Values and Sources

Definition	Parameter	Elasticity Value	Source
Demand Elasticities:			
U.S. own-price elasticity of fuel	η_{FF}^{U}	−0.80	Gallagher et al., 2003
Brazilian own-price elasticity of ethanol	η_{EE}^{B}	−0.10	Elobeid & Tokgoz, 2008
ROW own-price elasticity of gasoline	η_{GG}^{R}	−0.205	Eltony & Al-Mutairi, 1995
U.S. own-price elasticity of ethanol	η_{EE}^{U}	−0.43	Elobeid & Tokgoz, 2008
Supply Elasticities:			
U.S. own-price elasticity of fuel	ε_{GG}^{U}	0.15	Elobeid & Tokgoz, 2008
Brazilian own-price elasticity of ethanol	ε_{EE}^{B}	0.20	Gallagher et al., 2003
ROW own-price elasticity of gasoline	ε_{GG}^{R}	2.25	de Gorter, Just & Tan, 2009

implement an import subsidy. For 2008, the tax credit was \$0.46, which translates into an import subsidy of \$0.09 per gallon [$\$0.46 * (-0.19)$]. This means every gallon of ethanol imported by the United States from Brazil should receive a subsidy of \$0.09, rather than be subject to the current import tariff of \$0.57. In 2008, the United States imported 434 million gallons of ethanol from Brazil (Brazilian Sugarcane Industry Association, 2009). These imports received the \$0.46 per gallon tax credit but incurred the \$0.57 per gallon tariff. 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 multiplied by a per unit import subsidy of \$0.09 per gallon).

The results of this analysis are consistent with the findings of previous studies. As reported by de Gorter and Just (2008), Brazil benefits from U.S. free-market policies but incurs losses as a result of the tax credit and import tariff. They also note the U.S. argument that an import tariff is needed to offset the tax credit and protect the U.S. ethanol industry is unfounded. Elobeid and Tokgoz (2008) assert that removing the U.S. ethanol import tariff without modifying the tax credit should increase ethanol imports and lower U.S. ethanol prices; furthermore, removing 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, implying the United States should be subsidizing the ethanol imports as supported by our study.

To examine the influence of the various parameter values on the countervailing coefficient and thus on import subsidy, we conduct a sensitivity analysis by letting the values of elasticities range from very inelastic to elastic and the mandate 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.

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

Parameter	Parameter Values	Countervailing Coefficient ϕ
U.S. gasoline supply price elasticity (ε^U_{GG})	0.01 10	−0.19 −0.21
ROW gasoline demand elasticity (η^R_{GG})	−0.01 −10	−0.19 −0.21
ROW gasoline supply price elasticity (ε^R_{GG})	0.01 10	−0.08 −0.21
Brazilian ethanol supply elasticity (ε^B_{EE})	0.01 10	−0.85 −0.00
Brazilian ethanol demand elasticity (η^B_{EE})	−0.01 −10	−0.22 −0.01
U.S. fuel demand elasticity (η^U_{FF})	−0.01 −10	−0.00 −0.85
Blend mandate (m)	0 1	−0.00 −2.21

Notes: This table presents the results of sensitivity analyses by letting various parameters in text equation (19) to vary. These parameters are given in column 1. The elasticity parameters range in absolute values from inelastic (0.01) to elastic (10), and the blend mandate ranges from 0 to 1. The values of the parameters are given in column 2. The computed values of ϕ corresponding to these parameters are reported in column 3.

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 value of −0.19 obtained from the benchmark elasticities reported in table 1. When U.S. gasoline supply elasticity and ROW gasoline demand elasticities are very inelastic, a value of −0.19 is obtained for ϕ, which is identical to its value for the benchmark elasticities. This finding suggests that for a given tax credit, the import subsidy does not change much. As the ROW gasoline supply elasticity becomes inelastic, ϕ approaches −0.08.

As Brazilian ethanol supply and demand elasticities become very elastic, the value of ϕ approaches zero. This is because the Brazilian excess supply curve becomes increasingly elastic; when the United States faces a very elastic (horizontal) excess supply curve, it operates as a small country and its policies have no effect on ethanol prices in Brazil. Since the Brazilian price is not impacted, 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 value of ϕ because the elasticity of the Brazilian excess supply curve is largely determined by the Brazilian domestic supply elasticity. However, as the Brazilian domestic supply curve becomes less price elastic, the impact on ϕ is relatively large because the Brazilian excess supply function becomes more price inelastic. Consequently, to increase Brazilian prices, the United States needs to provide a larger import subsidy and the value of ϕ is a large negative.

As U.S. demand for fuel becomes more price elastic, ϕ increases in absolute terms. The rationale for this result is that the U.S. excess demand for gasoline and ethanol also becomes more price elastic, which makes Brazil more like 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 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 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, indicating that for a given tax credit the import subsidy would also be near zero. For instance, an ethanol content of 6.97% (based on 2008 EIA data) results in a ϕ value of −0.13. In contrast, as m increases (i.e., $m \rightarrow 1$), the ethanol market becomes large relative to the gasoline market, and the United States becomes an even larger player in the world ethanol market. As a result, U.S. policies have a greater impact on the world ethanol market, which implies, for a given tax credit, the ethanol import subsidy will increase as m increases to maintain the free-trade price for U.S. ethanol.

When the ethanol market is viewed as independent of the gasoline market, the value for ϕ is computed using equation (20), which increases to −1.14; the corresponding import subsidy is $0.52. When only the ethanol market is considered, the import subsidy is larger because the effect of the gasoline market is ignored.

Conclusion

The United States and Brazil are currently the two largest ethanol producers in the world. The United States has articulated two energy policy goals: (*a*) to become energy independent and (*b*) to reduce carbon emissions. However, studies have shown that U.S. biofuel policies do more to increase farm income from corn production than to reduce GHG emissions. For instance, Miranowski (2007) concludes that under the U.S. domestic farm subsidy program, U.S. corn-ethanol production would never have 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. Sugar ethanol in Brazil cost only $2.62 per gallon in 2008; in contrast, the price of corn ethanol in the United States was $3.44 per gallon. In addition, sugar ethanol offers higher energy benefits than corn ethanol (Rajagopal and Zilberman, 2007). Moreover, Brazilian ethanol is competitive with gasoline when crude oil is priced at between $29 and $35 per barrel, but U.S. ethanol is competitive only between $44 and $50 per barrel (Motaal, 2008; Von Lampe, 2006). Consequently, Brazil has a comparative advantage in producing ethanol from sugarcane and is competitive in spite of a high U.S. import tariff. Nevertheless, U.S. trade barriers restrict the use of the more environmentally beneficial sugar-based ethanol.

These findings support the view that the U.S. ethanol import tariff is designed to protect U.S. ethanol producers—who cannot produce ethanol as cost-effectively as Brazilian producers—and increase the demand for U.S. corn. Therefore, the current U.S. import tariff policy is inconsistent with the U.S. goals of reducing reliance on imported petroleum and reducing GHG emissions (Johnson and Runge, 2007). Though U.S. corn-based ethanol is promoted as a clean alternative for fossil fuel, recent research has identified possible negative environmental impacts; in addition, the U.S. ethanol mandate has had adverse effects on food prices (Searchinger et al., 2008; Escobar et al., 2009).

This study presents evidence that the current U.S. ethanol import tariff in excess of the tax credit is not justified and the United States should consider providing an import subsidy. Furthermore, global emissions will decline if there is 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, eliminating the U.S. import tariff should increase competition and bring innovations in efficiency and production to the global ethanol industry.

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Appendix: Comparative Static Results of the Parameters in Equation (19)

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

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

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

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

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

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

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

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

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

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