U.S.' Potentials of Biofuel Trade: A World-wide Country Analysis

Osei Yeboah, PhD.
Professor and Director
L. C. Cooper, Jr. International Trade Center;
Co-Ordinator, International Agricultural Development & Engagement Certificate Program
A-25 C.H. Moore Agricultural Research Facility
North Carolina A&T State University
Greensboro, NC 27411
336-285-4727 Office
336-334-7658 Fax
Email: oyeboah@ncat.edu

Saleem Shaik, PhD
Professor & Director
Center for Policy and Trade Studies
North Dakota State University, Fargo, North Dakota
Phone 701.200.9523 Fax 701.231.7459 E-mail
Email: saleem.shaik@ndsu.edu

Ayodele Olofinsao
Research Associate
A-29 C.H. Moore Agricultural Research Facility
North Carolina A & T State University
1601 Market St Greensboro, NC 27411
Email: atolofinsao@ncat.edu

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ABSTRACT

Traditionally, the importance of trade on welfare gains for domestic or exporting country and for foreign or importing has been evaluated. Individual crop and animal commodities caught the attention of economists and policy makers. Recently, there is increased emphasis on biofuel domestically and most importantly trade. However, there is hardly any research to evaluate the potential for U.S. biofuel trade.

This paper employs both Heckman's selection model and gravity model to analyze the potential for U.S. bilateral trade in biofuels with 68 countries worldwide using an annual time series data from 2000-2018 data. The gravity model was applied to the panel data after addressing the zero trade values using Hackman selection. Besides traditional international trade variables, the model was extended to include significant biofuel policies such as the 2007 U.S. Renewable Fuel Standard (RFS), the 2013 EU's Antidumping Barrier Policy, and 2015 EU Renewable Energy Directive (RED). The result of the model showed that the economic size of Origin Country to destination Country, the passing of US Renewable Fuel Standard mandate (USrfs), and EU Antidumping policy (EU_ADP) positively influence trade volume, exchange rate negatively influences trade volume. While as expected, distance acted as a trade barrier on the U.S. biofuel bilateral trade

1.0 INTRODUCTION

Increasing interest in biofuels as an alternative source of energy in transportation has greatly increased biofuel production and trade in the past years. This trend can be attributed to policies & mandates, environmental, economic, and geopolitical factors such as countries' desire to develop new markets for agricultural products, reduction in harmful greenhouse gas emissions, increasing crude oil prices, and growing dependence on foreign oil supplies (Elobeid & Tokgoz, 2008).

Biofuels are transportation fuels produced from biomass materials such as corn, & sugar cane and are usually blended with petroleum fuels (gasoline and diesel fuel) but can also be used on their own. Using ethanol or biodiesel means less gasoline and diesel fuel is burned reducing the heavy dependence on fossil fuel, reduce greenhouse gas emission and the amount of crude oil imported from other countries.

Among biofuel producing countries, United States and Brazil have emerged to be major exporters, while other countries including Canada, India, South Korea, Netherlands, Philippines, China, Peru, Columbia, etc. have found it necessary to import biofuels to help fulfill their renewable fuel mandates, such as the EU (Beckman, 2015). Hence the need to trade. The global biofuel trade market has been influenced by various mandates, policies, and laws between trading countries.

Although, some of these policies and mandates enhance biofuel trade including the US biofuel policy which mandates sugar-based ethanol to be imported from Brazil establishing a two-way biofuel trade between US and Brazil. Other mandates including the EU Anti-dumping measure on biofuel imports. Therefore, it can be said that they are placed either push (e.g. mandates) or pull (e.g. tax incentives) biofuels into the market (Lamers, Hamelinck, Junginger, & Faaij, 2011)). Those policies that are applicable to this study would be discussed to include the 2007 US Renewable Fuel Standard (RFS), the 2013 EU's Antidumping Barrier Policy, and the 2015 EU Renewable Energy Directive (RED).

The primary focus of this paper is to analyze the potential for US bilateral trade in biofuels with 68 countries worldwide using Gravity model and Hackman selection model.

The remainder of this paper is structured into eight sections. Section two outlines the Literature review on biofuel trade and policies; Section three specifies theoretical framework of the gravity and Heckman selection model; Section four specifies the empirical model; Section five provides description of the data and their sources; Section six presents the estimation procedure while the seventh section presents the results and discussion generated from the study. Finally, Section eight outlines the conclusion.

2.0. LITERATURE REVIEW

2.1 Biofuel Trade and Policies

The US has been making significant efforts towards reducing the current national dependence on imported oil through the development of more reliable renewable alternative energy sources to substantially substitute oil imports in the future. An increase in biofuel would imply a growth in the agricultural sectors especially for crops linked to biofuel production. There are also growing concern by many countries for possible issues of land degradation, water pollution, food security among others which are associated with the production of energy crops (Chakravorty, Hubert, & Nøstbakken, 2009; Fingerman, Torn, O'Hare, & Kammen, 2010; Popp, Lakner, Harangi-Rákos, & Fári, 2014). Therefore, the current growth trends in the demand, production, and concerns or impacts associated with the production of biofuel led to the development of policies either to stimulate or restrict biofuel production and trade in different countries.

The RFS originated from the US Energy Policy Act of 2005 known as RFS and was expanded by the Energy Independence and Security Act (EISA) of 2007 requiring that US transportation fuel should contain a minimum volume of renewable fuel (RFA, 2019). In 2013, EU imposed Antidumping Duty on US ethanol, based on the claim that the United States was able to supply EU markets at prices lower than those from EU producers leading to EU designing preferential trade agreements with Guatemala, Peru, and Pakistan to help fill the gap in ethanol imports (FAS, 2013d, Beckman, 2015).

In addition, the EU Renewable Energy Directive (RED) imposed in 2015 a 7% cap on the contribution of biofuels produced from "food" crops, while the other 3% to come from a variety of multiple counted alternatives (Olson, 2016). The Argentina B10 mandate was also implemented in April 2016 raising the required blending mandate for ethanol in regular gasoline

from 10% to 12% and diesel mixed to a minimum 10% biodiesel (Nguyen et al., 2017). As a result, there is an urgent need to review these biofuel policies and mandates in terms of the impact and implication to US Biofuel volume of trade, and potentials.

The literature on the US biofuel is increasing, ranging from examining historical trends of the market and policies to make projections on the biofuel market imposition to others focusing on empirical viewpoints such as Hall & Reed (2019).

Beckman (2015) found that the amount of biofuels trade increased resulting in countries such as Argentina and Indonesia even becoming one of several countries to become large global exporters of biofuel due to favorable market conditions and energy policies mandating the use of renewable fuels despite EU placing trade barriers on biofuel imports from the major biofuel producers.

Villoria & Hertel (2011) study on International trade patterns and the indirect land-use effects of biofuels. The result concluded that indirect land use changed owing to biofuels programs in the United States and Europe has become an important policy issue generating significant demand for agricultural economic analysis.

Hall & Reed (2019) conducted a study on US-Brazil Bilateral Fuel Ethanol Trade utilizing an autoregressive distributed lag (ARDL) model The model produced significant results for the tariff and post-tariff regimes and suggested that a one percent positive change in the Brazil-US price ratio will lead to an increase of413,800 gallons for the US in a tariff regime and a 501,500 gallons increase of ethanol net trade for the US in the post-tariff regime.

Traditionally, the importance of trade on welfare gains of the domestic or exporting country and the foreign or importing country has been evaluated for Individual crop and animal commodities because they caught the attention of economists and policymakers. Recently, there is an increased emphasis on biofuel domestically and the most important trade. However, there is hardly any research to evaluate the potential for U.S. biofuel trade. This paper develops a Heckman’s selection model to analyze the potential for U.S. bilateral trade in biofuels.

2.2 Heckman Selection Model

Due to the zero trade values observed, it is treated as a limited dependent variable. Limited dependent variable means that there is a limit or boundary on the dependent variable and some of the observations “hit” this limit. A limited dependent variable is a continuous or discrete variable with a lot of observations at the lower or upper limit (Katchowa, 2013). Such data can be censored, truncated, substituted by a small constant, or selected using the Heckman model.

Substituting the zero value with a small constant, so that the double-log model can be estimated without throwing these country pairs out of the sample has been used in literatures such as (Ball & Linnemann, 1967; Raballand, 2003; Van Bergeijk & Oldersma, 1990; Z. K. Wang, Winters, Wang, & Winters, 1991). The inserted value is however arbitrary and does not necessarily reflect the underlying expected value (Linders et al., 2006).

2.3 Gravity Model

The classical and new trade theory can successfully explain the reasons for countries to enter the World Trade, but they cannot answer the question of the size of the trade flows. Another trade theory, the gravity model, which has been used intensively in analyzing patterns and performances of international trade in recent years, can be applied to quantify the trade flows empirically(Doumbe & Belinga, 2015). The model follows the concept of Newton’s gravitational equation in physics and was first adapted into international trade analysis by Tinbergen, 1962.

Thi Thanh Binh, Viet Duong, & Manh Cuong (2013) analyzed the trade activities of Vietnam with 60 Countries using the gravity model. The results revealed that the economic size of Vietnam, economic size and market size of foreign partners, distance and culture have huge effects on bilateral trade flows between Vietnam and these 60 countries, while a change in exchange rates of Vietnam's currency does not significantly support for commercial. Also, Doumbe & Belinga (2015) performed an international bilateral trade analysis between Cameroon and Twenty-Eight European Union Countries and they find that Cameroon’s bilateral trade with European Union countries is affected positively by economic size and per capita GDP, and influenced negatively by the distance between the trading partners.

Wang, Wei, & Liu, (2010) investigated the determinants of bilateral trade flows in OECD Countries using Gravity Panel Data Models. The result concluded that the levels and similarities of market size, domestic R&D stock, and inward FDI stock are positively related to bilateral trade, while the distance, measured by both geographical distance and relative factor endowment, between trade partner countries has a negative impact.

Likewise, Rahman & Dutta (2012) attempts to investigate trade potential for Australia using the augmented gravity models and cross-section data of 50 countries. His results reveal that Australia's bilateral trade is affected positively by economic size, GDP per capita, openness and common language, and negatively by the distance between the trading partners.

Despite its popularity, G van Bergeijk & Brakman (2010) argue that one of the limitations of the gravity model is that it focuses on bilateral trade, and in fact only explains an increase or decrease in bilateral trade flow. Bikker et al., (2007) finds that the gravity model cannot describe substitutions between flows, and it lacks a cogent theoretical foundation. The empirical analysis also proves that the gravity model widely overestimates the influence of the determinants of international trade (Bikker & Vos, 1992). C Santos Silva & Tenreyro (2006) have also focused on econometric problems resulting from heteroskedastic residuals and the prevalence of zero bilateral trade flows associated with gravity model analysis.

Given this firm theoretical issue of the zero trade provided in recent papers such that (Chaney, 2008; Eaton & Kortum, 2002; Helpman, Melitz, & Rubinstein, 2007; Kabir, Salim, & Al-Mawali, 2017; Melitz & Ottaviano, 2008), it seems important to examine the performance of limited dependent variable estimator as a way of dealing with the zero trade. The most common response to the problem of zero trade is to truncate the sample by deleting the observations with zero trade which is inefficient because it ignores the information in the limit observations.

3 THEORETICAL MODEL

3.1 Gravity Model

The model follows the concept of Newton's gravitational equation in physics and was first adapted into international trade analysis by Tinbergen, 1962. In physics, Newton's universal law of gravitation states that two objects are subjected to a force of attraction that depends positively

on the product of their masses and negatively on their distance (Esmaeili & Pourebrahim, 2011). Newton's gravity model is generally expressed as follows:

$$GF_{ij} = \frac{M_i M_j}{D_{ij}} \quad , i \neq j \qquad (i)$$

Where,

GF_{ij} is Newton's law of gravitational force between two objects *i* and *x*. M_i and M_j are the masses of the objects *i* and *j* and D_{ij} is the distance between the two objects (*i and j)*.

Equation (1) could be explained as "the gravitational force is directly proportional to the masses of the objects and indirectly proportional to the distance between them".

Incorporating the basic gravity model in equation (i) in international trade can be expressed as:

$$T_{ij} = \frac{GDP_i GDP_j}{D_{ij}} \qquad (ii)$$

Where

T_{ij} is the total bilateral trade flow from country *i* to country *j* and from country *j* to country *i*, GDP_i and GDP_j represents the gross domestic products of countries *i* and *j* respectively, D_{ij}represents the geographical distance separating the ports of the two trading partners (country *i* and *j)*.

Equation (ii) explains that Trade among countries is explained by their economic sizes, their populations, direct geographical distances. This equation can be modified to include other variables like exchange rates, agricultural GDP, and even dummy variables.

Equation 2 can be rewritten as:

$$\ln(T_{ij}) = \propto_0 + \propto_1 \ln(GDP_i \cdot GDP_j) + \propto_2 \ln(D_{ij}) \qquad (iii)$$

For the purpose of this study, modifications to the Gravity model have been made to accommodate the zero trade values through the Heckman selection model as shown in equation (vi) and (vii). There is a total of 1305 zero trade value out of total trade observation of 2582.

3.2 Dealing with Zero Trade Flows and Heckman Selection Model

Given that the conventional gravity model does not predict zero-valued bilateral trade nor desired negative trade, and in the absence of rounding below some positive value, zero flows have to be interpreted otherwise. The appropriate way to proceed then will be applying Heckman's selection model. This can be done by modeling the decision of whether or not to trade as a Probit model. The outcome of that decision determines whether or not we observe actual trade flows in the sample, and the size of potential trade is determined by the gravity model.

In this paper, using the Heckman selection model, the following two endogenous variables are estimated: trade flows (Yes or No) – selection equation (Probit) and magnitude of trade flows – outcome equation (Tobit).

The sample selection model of bilateral trade is specified as:

$$Y_{ijt}^{*}=\beta_0+\beta_i X_t + \varepsilon_{ijt} \qquad \text{(iv)}$$

$$\ln Y_{ijt}^{*}=\beta_0+\beta_i lnX_t + \varepsilon_{ijt} \qquad \text{(v)}$$

X_t are the independent variables observed

Y_{ijt}^{*} is a discrete choice between 0 and 1 and estimated using Probit model, with

$$Yijt*=\begin{cases} Yit*, \ if\ Yit > 0 \equiv \ln Yijt* \\ \\ \quad 0, \ if\ Yit \leq 0 \end{cases}$$

While is $\ln Y_{ijt}^{*}$ estimated using a lower zero censored Tobit model. The model in equation (v) is estimated using Maximum Likelihood (ML).

4 EMPIRICAL MODEL

There are two dependent variables i.e. the biofuel dummy variable for the Probit model and the biofuel trade flow between the US and 68 countries for the Tobit model

The independent variables consist of both continuous and discrete variables.

Continuous variables are real GDP, real agricultural GDP, exchange rate, population, while the discrete variables include the 2007 US Renewable Fuel Standard, the 2013 EU Anti-dumping policy, the 2015 RED, and the 2016 B1O Argentina Mandate captured by 1 if the policy or mandate regime otherwise 0.

$$BioDummy_{ijt} = \beta_0 + \beta_1 lnEXrate_{ijt} + \beta_2 lnDistance_{ijt} + u_{ijt} \quad \text{(vi)}$$

$$LnBiofuelEX_{ijt} = \beta_3 + \beta_4\ lnEXrate_{ijt} + \beta_5 lnOD\_RGDP_{ijt} + \beta_6\ lnO\_ratio_{it} + \beta_7\ lnD\_ratio_{jt} + \beta_8\ USrfs + \beta_9 EU\_ADP + \beta_{10}\ EU\_RED + \beta_{11} Argentina\_Bio + \varepsilon_{ijt} \quad \text{(vii)}$$

Where:

i is the origin county

j is the exporting country

The t is the time period is from 2000, 2001, 2002..., 2019

$BioDummy_{ijt}$=1 for positive trade flow. 0 otherwise

$BiofuelEX_{ijt}$=biofuel trade volume

$EXrate_{ijt}$ =real exchange rate per US dollars in year t

$Distance_{ijt}$ =distance between origin and destination Countries in year t (miles)

OD_RGDP_{ijt} =the ratio of Origin Country's GDP to destination Country's GDP in year t ($1000)

O_ratio_{it} =the ratio of Origin Country's Agricultural GDP to its GDP in year t ($1000)

D_ratio_{jt} =the ratio of Destination Country's Agricultural GDP to its GDP in year t ($1000)

USrfs =Dummy variable for 2007 US RFS. 1 for the policy era, otherwise 0

EU_ADP = Dummy variable for EU 2013 Anti-dumping policy. 1 for the policy era, otherwise 0

EU_RED = Dummy variable for EU 2015 RED directive. 1 for the directive era, otherwise 0

Argentina_Bio = Dummy variable for Argentina 2016 B1O Mandate. 1 for the mandate era, otherwise 0

u_{ijt}&ε_{ijt} =Error term

5 DESCRIPTION OF DATA

The dependent variable is the biofuel volume of trade (in 1,000 barrels) between the U.S. and other 69 countries from 2000 to 2018 were collected from the U.S.I.T.C website https://dataweb.usitc.gov/). Data of the independent variables covering the same periods were collected from different sources. Agricultural GDP and Real GDP data (in 1,000 dollars) obtained from (https://data.worldbank.org/) is used as a proxy to capture the size of the exporting countries by using the GDP of the sector related to the commodity under consideration. The distance (in miles) between the economic centers of the exporting and importing countries for the same period of study was also sourced from (https://www.geodatos.net/en/distances/country/united-states). The annual exchange rate per US dollar was sourced from (https://www.worldbank.org). The different dummy variables are used to represent regime (1 during the regime, 0 otherwise).

6 ESTIMATING PROCEDURE

The panel data was estimated by applying Hackman's selection model and Gravity model to the data in SAS. Extra calculations were done on the data. The GDP of the origin country was divided by the GDP of the destination country to capture the change in the origin country's economy size relative to that of the destination country; The agricultural GDP of the origin country was divided by its GDP while the agricultural GPD of the destination country was divided by its GDP to observe agricultural GDP growth relative to GDP.

7 RESULTS AND DISCUSSION

Table 1 presents the estimated results using equation (vi) & (vii). GDP of origin Country relative to GDP of destination Country, and the dummy policy variables US Renewable Fuel Standard (USrfs), & EU Antidumping policy (EU_ADP) positively influence trade volume, while exchange rate negatively impacts trade volume. Distance in equation (vi) is the only variable that influences a country's decision to trade in biofuel with the US.

Despite the EU Antidumping policy strategy in place to protect themselves from US ethanol exports, trade increased by 0.97% during the regime. Also, during US Renewable Fuel Standard regime, the volume of trade increased by 0.6%. This result is similar to the result of Beckman's study in 2015 which found that the amount of biofuels trade increased substantially due to

favorable energy policies mandating the use of renewable fuels despite EU placing trade barriers on biofuel imports from the major biofuel producers.

The negative effect of the exchange rate as expected indicates that as US dollars appreciate by 1% relative to the trading country's currency, the trade volume will decrease by 0.07%. Furthermore, as the GDP of the exporting countries increases relative to those of the importing countries, exports from the origin/exporting country to the importing/destination country decreases by 0.17%.

Geographical distance is statistically significant and estimated to impair biofuel bilateral trade between the US and trading countries. This is because the longer the distance between US and trading country the higher the transportation cost involved.

8 CONCLUSION

The main purpose of this study is to estimate the potential for U.S. biofuel trade by determining factors that influence biofuel trade flow between the US and 68 other countries. Heckman's selection model and gravity model was used to estimate the data from 69 countries in the period from 2000 to 2018. Results indicate that bilateral trade flows between the US and the 68 countries are mainly affected by the economic size of the exporting country relative to that of the importing country, geographical distance, exchange rate, the 2007 US Renewable Fuel Standard mandate, and 2013 EU Antidumping policy regimes, while distance is the only variable that influences the decision of a country to trade in a biofuel with the US.

The study proves that exchange rate and distance is vital in US biofuel bilateral trade. Also despite biofuel restricting trade policies from the EU, the biofuel trade flow between the US and other countries continues to increase indicating a strong demand for biofuel in the international market.

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Appendix

Table 1 Result of Heckman Selection model and Gravity moddel

Parameter Estimates					
Parameter	**DF**	**Estimate**	**Standard Error**	**t Value**	**Approx. Pr > |t|**
L_BiofuelEX.Intercept	1	7.443292	0.706617	10.53	<.0001
L_BiofuelEX.L_EXrate	1	-0.078523	0.038565	-2.04	0.0417
L_BiofuelEX.L_OD_RGDP	1	-0.171665	0.025254	-6.80	<.0001
L_BiofuelEX.L_O_ratio	1	0.171935	0.117034	1.47	0.1418
L_BiofuelEX.L_D_ratio	1	-0.078201	0.072717	-1.08	0.2822
L_BiofuelEX.USrfs	1	0.589721	0.213585	2.76	0.0058
L_BiofuelEX.EU_ADP	1	0.970739	0.263985	3.68	0.0002
L_BiofuelEX.EU_RED	1	-0.089506	0.404589	-0.22	0.8249
L_BiofuelEX.Argentina_Bio	1	-0.038036	0.388089	-0.10	0.9219
_Sigma.L_BiofuelEX	1	3.067633	0.122683	25.00	<.0001
BioDummy.Intercept	1	3.346811	0.430737	7.77	<.0001
BioDummy.L_EXrate	1	-0.009220	0.010028	-0.92	0.3579
BioDummy.L_Distance	1	-0.390522	0.050267	-7.77	<.0001
_Rho	1	-0.413665	0.118028	-3.50	0.0005