Impact of Changes in Energy Input Prices on Ethanol Importation and Prices

Elizabeth Yeager[1] and Allen Featherstone[2]

[1]Graduate Research Assistant, Kansas State University, 304F Waters Hall, Manhattan, KS 66506, eyeager@agecon.ksu.edu (Contact author)

[2]Professor, Kansas State University, 313 Waters Hall, Manhattan, KS 66506, afeather@agecon.ksu.edu

Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting, Pittsburgh, Pennsylvania, July 24-26, 2011.

Impact of Changes in Energy Input Prices on Ethanol Importation and Prices

Ethanol as a fuel source has been explored since the early 1900s. However, it wasn't until the last decade that the growth in ethanol use in the United States (U.S.) occurred. Growth in ethanol use has historically not been economically profitable. The U.S. and Brazil are the largest producers of ethanol in the world. Ethanol accounts for at least 40 percent of Brazilian automobile fuel and all gasoline sold in Brazil has at least 20 percent ethanol added to it (Clean Fuels Development Coalition 2007). Additionally, Brazil is the world's largest ethanol exporter, exporting about one billion gallons of ethanol annually. The largest importer of ethanol from Brazil is the U.S. which imported 453 million gallons in 2006 and 185 million gallons in 2007 (Hofstrand 2009).

The Renewable Fuels Standard (RFS) was amended in 2007 and requires the RFS to increase to 36 billion gallons in 2022 (Renewable Fuels Association n.d.). The rationale of U.S. lawmakers for this standard is a decline in dependence on foreign oil, lower greenhouse gas emissions, and more jobs for Americans. In 2007, U.S. ethanol imports were 7 percent as a percent of U.S. production. The percent of U.S. imports from Brazil was about 2.5 times as high as from any other country at 42 percent (Hofstrand 2009). Currently, gasoline blenders who use ethanol receive a $0.45 tax credit per gallon of ethanol regardless of the ethanol origin. An ad valorem tax and secondary tariff of $0.59 is imposed on the ethanol from Brazil to limit Brazilian exporters from obtaining the tax credit though much of Brazilian ethanol gets around that requirement by moving through countries in the Caribbean and Central America (Hofstrand 2009, Renewable Fuels Association 2010). While the tariff is a point of contention, some arguments have been made that even if the tariff was removed additional ethanol would not be imported.

The objective of this study is to determine how closely ethanol prices follow changes in the price of the feedstock used in production: corn prices in the U.S. and sugar prices in Brazil. Additionally, the exchange rate between the United States dollar (USD) and Brazilian real (BRL) and ethanol prices are examined because of the importation of Brazilian ethanol.

The exchange rate may be a contributing factor to changes in imports due to currency changes from 2003 through the present. At the beginning of 2011, the USD purchased slightly over 1.6 BRL, following a mostly steady drop from the 3.5 BRL a USD could purchase in February 2003. Studies have shown that oil price fluctuations can be responsible for exchange rate changes (Amano and van Norden 1998, Chen and Chen 2007, Huang and Tseng 2010, Lizardo and Mollick 2010). However, an area yet to be fully explored is whether the USD exchange rate has an active role in determining ethanol prices. This paper studies this issue.

Data and Methods

Monthly exchange rates between the USD and BRL were obtained from the United States Department of Agriculture Economic Research Service (2011). Monthly data on ethanol and corn prices in the United States were obtained through the Agricultural Marketing Resource Center for January 2005 through February 2011 (Hofstrand and Johanns 2011). Corresponding monthly data on anhydrous ethanol and sugar prices in Sao Paulo, Brazil were obtained through the Center for Advanced Studies on Applied Economics (2011).

The U.S. ethanol prices are in dollars per gallon and the corn prices are in dollars per bushel. The Agricultural Marketing Resource Center obtains the monthly ethanol prices from the USDA Iowa Ethanol Plant Report and the corn prices from the National Agricultural Statistics Service. The ethanol prices from Brazil are in dollars per gallon and the sugar prices are in dollars per 50 kilogram bag. These prices were converted from BRL to USD by the Center for Advanced Studies on Applied Economics. Summary statistics for these variables are shown in Table 1.

Table 1. Variable Definitions and Summary Statistics, January 2005 - February 2011

Variable	Definition	Mean	Standard Deviation	Minimum	Maximum
Xrate	Exchange rate (Reals/US dollar)	2.02	0.28	1.59	2.7
Uscorn	US corn $/bushel	3.38	1.1	1.74	5.85
Brsug	Brazil sugar $/50 kilograms	21.16	9.49	10.71	45.54
Useth	US ethanol $/gallon	1.91	0.41	1.06	3.15
Breth	Brazil ethanol $/gallon	1.75	0.45	1.05	2.93

Figure 1 shows the relationship between corn prices and U.S. ethanol prices. The prices appear to move closer together beginning in August 2007. The correlation coefficient increases from 0.21 before August 2007 to 0.77 after August 2007. Figure 2 shows the relationship between sugar prices and ethanol prices in Brazil. The prices appear to move closely together during the entire time period, and the correlation between the prices is 0.86. This is likely due to the fact that many sugarcane processing facilities in Brazil can switch back and forth from sugar to ethanol based off of the current prices of each. Figure 3 presents the relationship between the ethanol prices from each country and the exchange rate. The ethanol prices appear to generally move together with a correlation coefficient of 0.38 and inversely of the exchange rate with a correlation coefficient of -0.36 for the U.S. ethanol price and the exchange rate and a correlation coefficient of -0.68 for the ethanol price in Brazil and the exchange rate.

Figure 1: Corn and ethanol prices in the U.S.

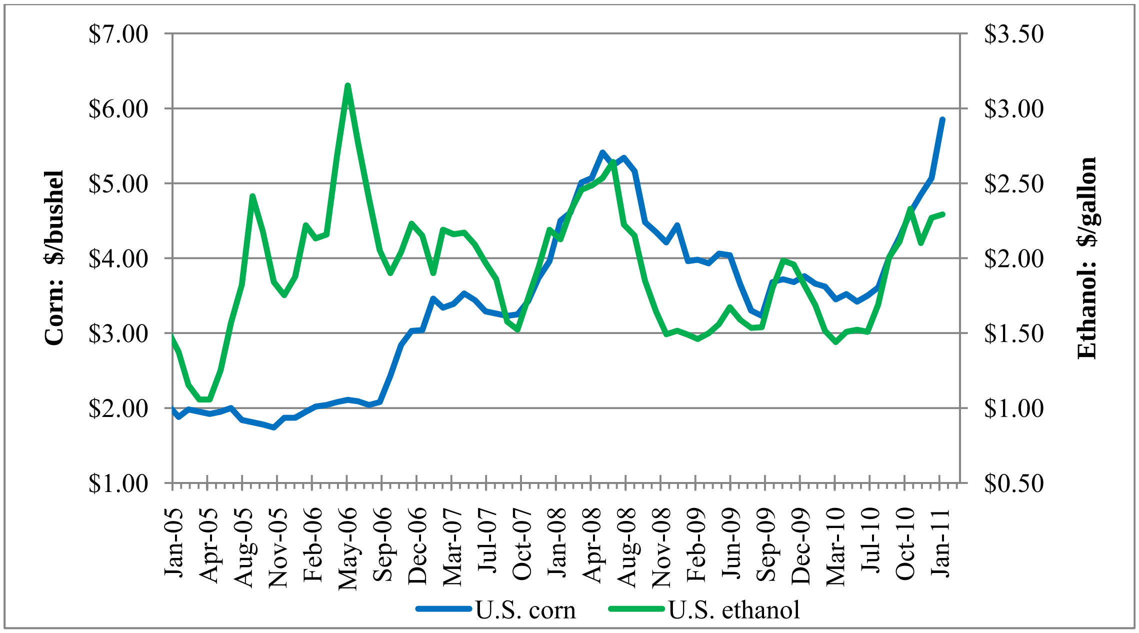


Figure 2: Sugar and ethanol prices in Brazil.

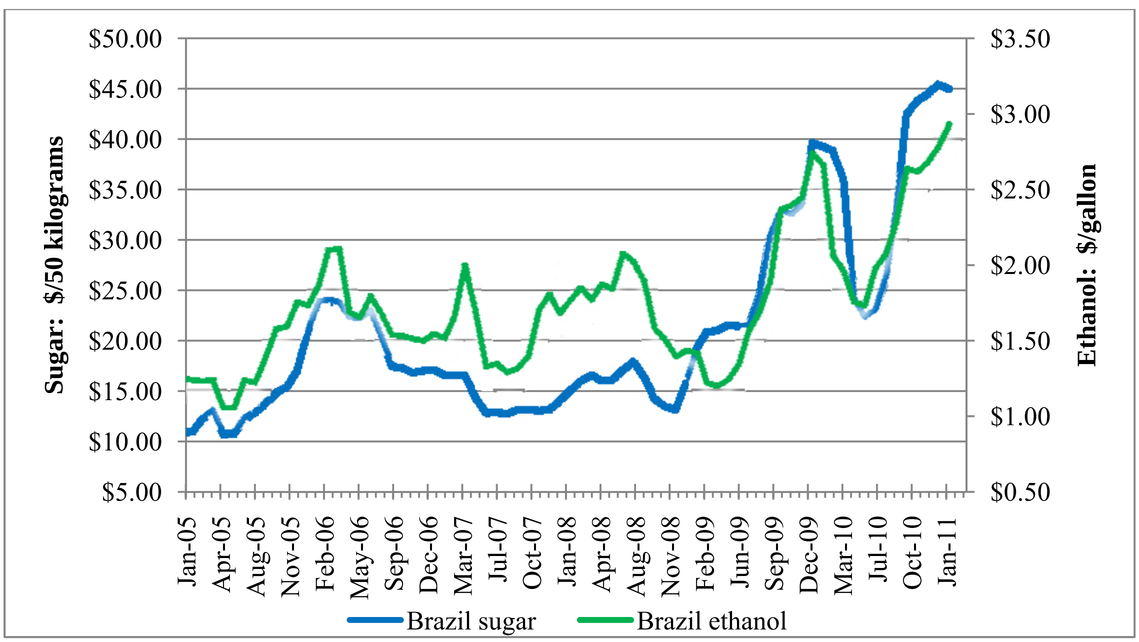
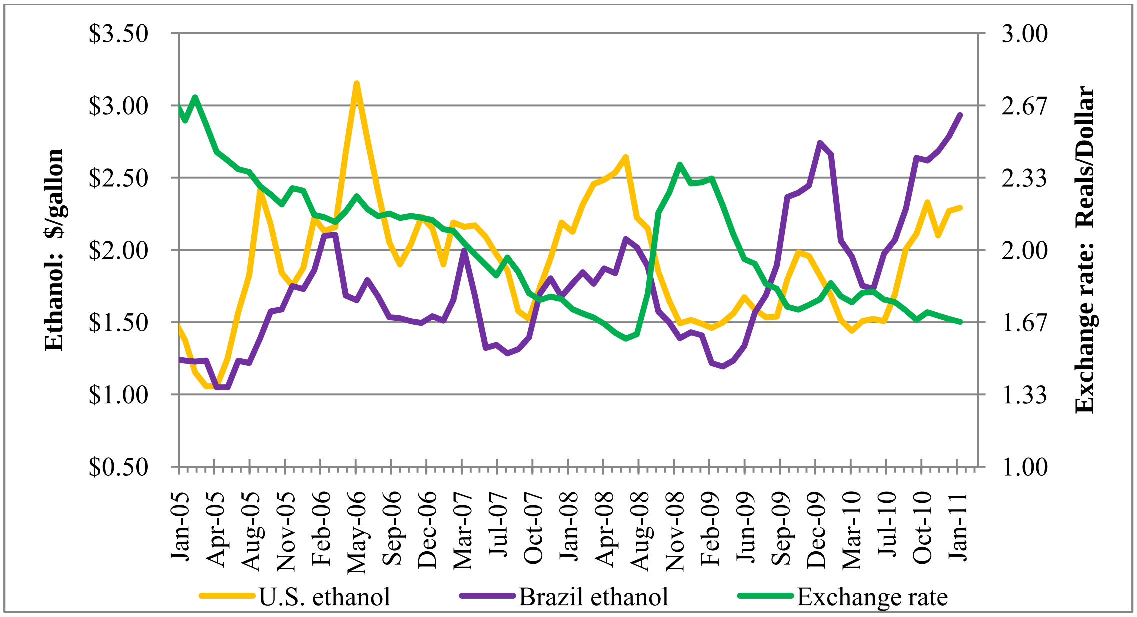


Figure 3: Ethanol prices and the exchange rate.



A vector autoregression (VAR) model was used to explore the relationship between domestic and imported ethanol price fluctuations and the United States dollar (USD) exchange rate. Additionally, a VAR model was used to capture the interdependencies between the input price (corn) or the competing output from sugarcane (sugar) and the price of ethanol in the United States and Brazil.

VAR estimation treats all variables as endogenous and allows the lags of every variable to influence every other variable in the system (Featherstone and Baker 1987). The equations below illustrate the three-equation system for exchange rate (Xrate), ethanol prices in the United States (Useth), and ethanol prices in Brazil (Breth):

(1) $Xrate_t = k_1 + a_1 t + \sum_{i=1}^{n} b_{1i} Xrate_{t-i} + \sum_{i=1}^{n} c_{1i} Useth_{t-i} + \sum_{i=1}^{n} d_{1i} Breth_{t-i} + e_{1t},$

(2) $Useth_t = k_2 + a_2 t + \sum_{i=1}^{n} b_{2i} Xrate_{t-i} + \sum_{i=1}^{n} c_{2i} Useth_{t-i} + \sum_{i=1}^{n} d_{2i} Breth_{t-i} + e_{2t},$

(3) $Breth_t = k_3 + a_3 t + \sum_{i=1}^{n} b_{3i} Xrate_{t-i} + \sum_{i=1}^{n} c_{3i} Useth_{t-i} + \sum_{i=1}^{n} d_{3i} Breth_{t-i} + e_{3t},$

where t is time in months; n is number of lags; $k, a, b, c,$ and d are estimated parameters; $e_{1t,} e_{2t,}$ and e_{3t} are the error terms for each equation. This model was chosen because the exchange rate between the USD and BRL, the ethanol price in the U.S., and the ethanol price in Brazil are all involved in the decision to import Brazilian ethanol into the U.S. This model was estimated using the package **vars** in R (Pfaff 2008, R Development Core Team 2011). The number of lags was estimated using the Hannan-Quinn (1979) information criteria that trades-off fit for parsimony in parameters and allowing up to 12 lags. The estimated lag length or order of the system for each equation above was two. The data used for equations (1) – (3) were levels and the data was stationary, in other words the Eigen values were all less than one.

The following equations illustrate the initial VAR estimation for the four-equation system for corn prices in the United States (Uscorn), sugar prices in Brazil (Brsug), ethanol prices in the United States (Useth), and ethanol prices in Brazil (Breth):

$$(4)\quad Uscorn_t = k_4 + a_1t + \sum_{i=1}^{n} b_{1i}Uscorn_{t-i} + \sum_{i=1}^{n} c_{1i}Brsug_{t-i} + \sum_{i=1}^{n} d_{1i}Useth_{t-i} + \sum_{i=1}^{n} f_{1i}Breth_{t-i} + e_{4t},$$

$$(5)\quad Brsug_t = k_5 + a_1t + \sum_{i=1}^{n} b_{1i}Uscorn_{t-i} + \sum_{i=1}^{n} c_{1i}Brsug_{t-i} + \sum_{i=1}^{n} d_{1i}Useth_{t-i} + \sum_{i=1}^{n} f_{1i}Breth_{t-i} + e_{5t},$$

$$(6)\quad Useth_t = k_6 + a_1t + \sum_{i=1}^{n} b_{1i}Uscorn_{t-i} + \sum_{i=1}^{n} c_{1i}Brsug_{t-i} + \sum_{i=1}^{n} d_{1i}Useth_{t-i} + \sum_{i=1}^{n} f_{1i}Breth_{t-i} + e_{6t},$$

$$(7)\quad Breth_t = k_7 + a_1t + \sum_{i=1}^{n} b_{1i}Uscorn_{t-i} + \sum_{i=1}^{n} c_{1i}Brsug_{t-i} + \sum_{i=1}^{n} d_{1i}Useth_{t-i} + \sum_{i=1}^{n} f_{1i}Breth_{t-i} + e_{7t},$$

where t is time in months; n is number of lags; $k, a, b, c, d,$ and f are estimated parameters; $e_{4t}, e_{5t}, e_{6t},$ and e_{7t} are the error terms for each equation. This model was chosen to examine the relationships between the prices of the feedstock used in production of ethanol and the ethanol prices. The first difference, or change in price from period to period in this case, was used to obtain stationarity in the time series data for equations (4) – (7). The estimated number of lags using the Hannan-Quinn criteria was one.

Results

The coefficients for the estimated VAR system of equations (1) – (3) are shown in Table 2. The coefficient estimates are difficult to interpret in a VAR system, therefore, other items will be examined including causality tests, impulse responses, and forecast error decomposition.

Table 2. Estimated VAR Coefficients, Test Statistics, and Matrices of Residuals for Exchange Rate, Ethanol Price in the United States, and Ethanol Price in Brazil.

Statistic	Exchange Rate Equation	U.S. Ethanol Equation	Brazil Ethanol Equation
Adjusted R-squared	0.933	0.796	0.865
Granger causality for exchange rate[a]	1.3898		
Granger causality for U.S. ethanol[b]		1.643	
Granger causality for Brazil ethanol[c]			0.7862
Independent Variable	Regression Coefficients		
Intercept	0.2	1.171*	0.435
Time trend	-0.001	-0.005*	0.002
$Xrate_{t-1}$	1.243***	-0.431	-0.27
$Xrate_{t-2}$	-0.346**	0.144	0.173
$Useth_{t-1}$	-0.052	1.116***	0.235*
$Useth_{t-2}$	0.048	-0.430***	-0.222*
$Breth_{t-1}$	0.006	0.031	1.087***
$Breth_{t-2}$	0.025	0.08	-0.279*
	Covariance Matrix of Residuals		
	Xrate	Useth	Breth
Xrate	0.005	-0.001	-0.002
Useth	-0.001	0.034	0.003
Breth	-0.002	0.003	0.027
	Correlation Matrix of Residuals		
	Xrate	Useth	Breth
Xrate	1.000	-0.093	-0.201
Useth	-0.093	1.000	0.082
Breth	-0.201	0.082	1.000

***, **, and * indicate signicance at the less than 0.1% level, 1% level, and 5% level, respectively.

[a] F-value for testing H_0: Xrate do not Granger-cause Useth Breth

[b] F-value for testing H_0: Useth do not Granger-cause Xrate Breth

[c] F-value for testing H_0: Breth do not Granger-cause Xrate Useth

Granger causality tests were conducted and the results indicated the variables did not cause any of the other variables besides themselves. The lack of causality among the variables may be a result of the nature of the ethanol markets in the two considered countries. The United States places taxes on the relatively small amount of ethanol imported from Brazil in an attempt to protect the domestic market. This may damper what otherwise would be a stronger relationship between the markets.

The impulse response identifies the responses over time in all the variables to a one-standard-deviation increase in one of the variables (Featherstone and Baker 1987). Figures 4, 5, and 6 illustrate the impact of a shock in one variable on the other variables. Figure 4 shows that a shock in the exchange rate results in an opposite shock in ethanol prices. Figures 5 and 6 indicate that a positive shock in either ethanol price results in a small positive response by the other ethanol price and a very minimal response by the exchange rate.

Figure 4: Response of Exchange Rate, U.S. Ethanol Price, and Brazil Ethanol Price to a Shock in Exchange Rate

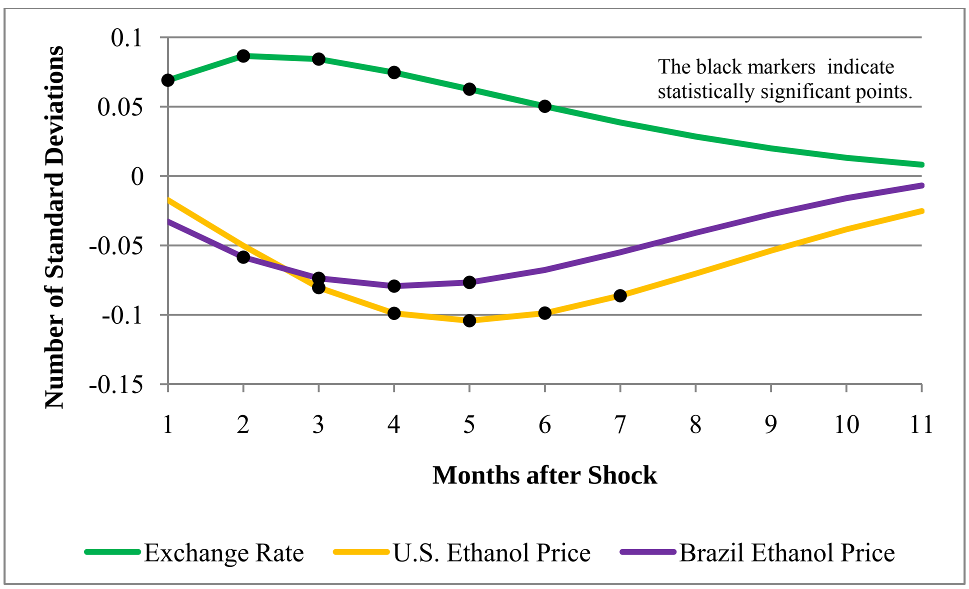


Figure 5: Response of Exchange Rate, U.S. Ethanol Price, and Brazil Ethanol Price to a Shock in U.S. Ethanol Price

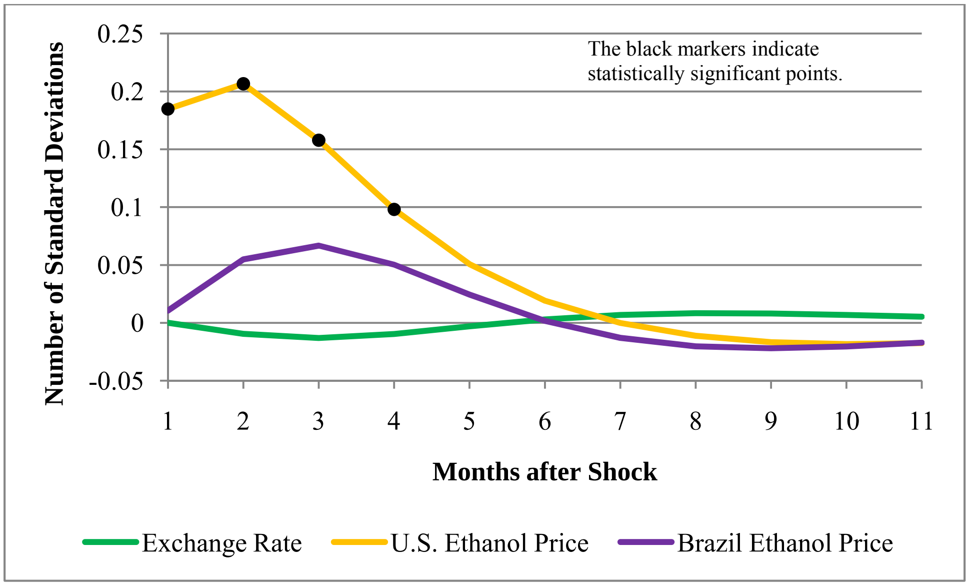
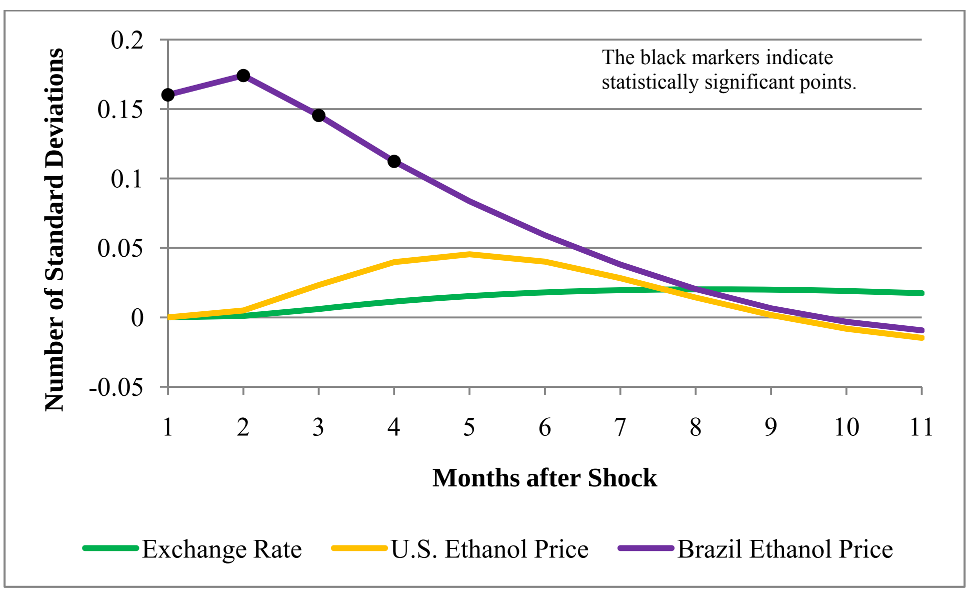


Figure 6: Response of Exchange Rate, U.S. Ethanol Price, and Brazil Ethanol Price to a Shock in Brazil's Ethanol Price



The forecast error decompositions for a 12-month period are presented in Table 3. Up to 24 months were examined; however, the changes were minimal after the 12 month period and are not presented in the table. The order of the variables is important and based upon predictions of most to least exogenous to the system. It is evident by in the first section of Table 3 that the exchange rate is likely the most exogenous of the variables because after 12 months almost 91% of the variation in the exchange rate is explained by its own forecast error. The own forecast error explains about two-thirds of the variation in each of the ethanol prices and the exchange rate while the exchange rate explains about 32% for the ethanol price in the United States and 22% for the ethanol price in Brazil. The price of crude oil is not included in this study, but the relationship between exchange rates and crude oil prices may have something to do with the relationship between ethanol price and the exchange rate.

Table 3. Proportions of *k*-Months-Ahead Forecast Error Attributed to Innovations in Respective Series.

		Proportion of Error Explained by:		
	Months Ahead (*k*)	Xrate	Useth	Breth
Xrate	1	1.0000	0.0000	0.0000
	2	0.9926	0.0074	0.0001
	3	0.9847	0.0134	0.0019
	4	0.9794	0.0140	0.0066
	5	0.9741	0.0123	0.0136
	6	0.9661	0.0115	0.0224
	7	0.9556	0.0122	0.0322
	8	0.9438	0.0137	0.0425
	9	0.9324	0.0152	0.0524
	10	0.9224	0.0162	0.0614
	11	0.9145	0.0168	0.0688
	12	0.9086	0.0170	0.0744
Useth	1	0.0087	0.9913	0.0000
	2	0.0354	0.9643	0.0003
	3	0.0831	0.9118	0.0051
	4	0.1438	0.8399	0.0163
	5	0.2022	0.7693	0.0285
	6	0.2484	0.7151	0.0365
	7	0.2805	0.6800	0.0395
	8	0.3005	0.6600	0.0395
	9	0.3115	0.6497	0.0388
	10	0.3165	0.6447	0.0387
	11	0.3180	0.6423	0.0397
	12	0.3178	0.6408	0.0414
Breth	1	0.0403	0.0041	0.9556
	2	0.0708	0.0490	0.8802
	3	0.1051	0.0799	0.8150
	4	0.1399	0.0869	0.7732
	5	0.1707	0.0825	0.7468
	6	0.1940	0.0777	0.7284
	7	0.2089	0.0763	0.7148
	8	0.2168	0.0778	0.7053
	9	0.2201	0.0805	0.6994
	10	0.2208	0.0829	0.6962
	11	0.2205	0.0847	0.6948
	12	0.2200	0.0857	0.6943

In order to obtain stationary variables in the VAR model for corn, sugar, and ethanol prices, equations (4) – (7), first differences of the prices were used. Johansen's procedure was used to test for cointegration (Johansen 1988). A cointegration rank of 3 was determined to exist between the variables. This is interpreted as there being 3 long-run relationships among the variables (Pfaff 2008). Knowledge of the number of cointegration relationships allows for the vector error correction model (VECM) to be converted to a level VAR representation using the vec2var function in R (Pfaff 2010, R Development Core Team 2011). This is beneficial because the **var** package can then be used. The coefficients for equations (4) – (7) are presented in Table 4.

Table 4. Estimated VECM Coefficients Using the Transformed level-VAR Representation for Change in the Price of U.S. Corn, Change in the Price of Brazilian Sugar, Change in the Price of U.S. Ethanol, and Change in the Price of Brazilian Ethanol.

	Change in U.S. Corn Equation	Change in Brazil Sugar Equation	Change in U.S. Ethanol Equation	Change in Brazil Ethanol Equation
Independent Variable	Regression Coefficients			
Intercept	-0.001	0.287	0.002	0.013
$\Delta Uscorn_{t-1}$	0.482	0.107	0.262	0.135
$\Delta Uscorn_{t-2}$	0.532	-1.415	-0.082	-0.054
$\Delta Brsug_{t-1}$	0.011	0.520	0.014	0.021
$\Delta Brsug_{t-2}$	-0.012	-0.385	-0.017	-0.024
$\Delta Useth_{t-1}$	-0.008	2.694	0.327	0.247
$\Delta Useth_{t-2}$	-0.132	-0.290	-0.206	0.012
$\Delta Breth_{t-1}$	0.141	0.154	-0.058	0.129
$\Delta Breth_{t-2}$	-0.012	5.587	0.269	-0.034

Figures 7, 8, 9, and 10 illustrate the impact of a shock in one variable on the other variables. A somewhat surprising result is that the change in sugar price seems to be the most responsive to a shock in all variables. This may be attributable to the fact that the change in sugar price had a larger standard deviation than the other prices. Figure 9 illustrates the responses to a one-standard-deviation increase in the change in price of corn. This resulted in a sustained higher response of change in corn price. The corn price has seen relatively constant positive increases in the recent years, so this may be picking up that fact.

Figure 7: Response of Change in the Price of U.S. Corn, Change in the Price of Brazilian Sugar, Change in the Price of U.S. Ethanol, and Change in the Price of Brazilian Ethanol to a Shock in the Price Change of U.S. Corn

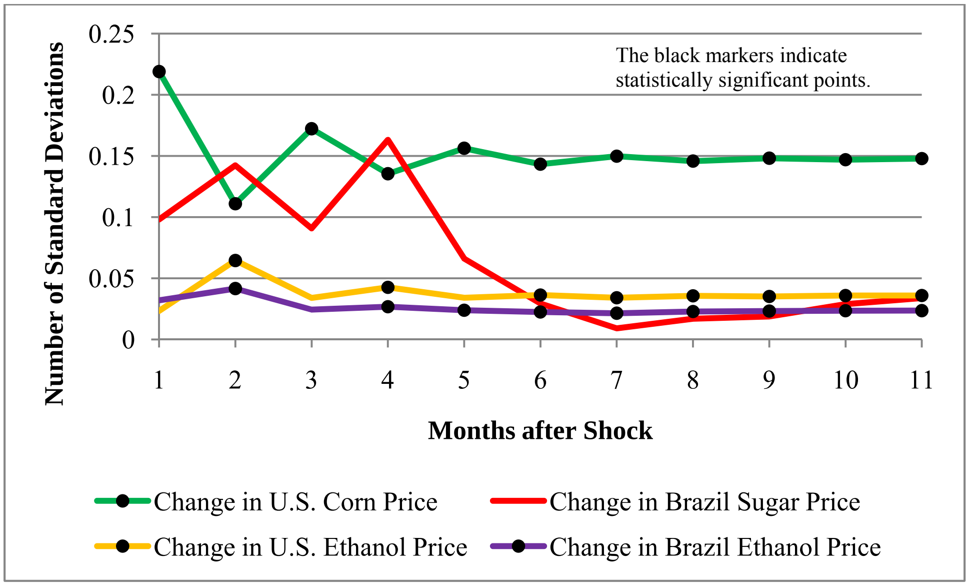


Figure 8: Response of Change in the Price of U.S. Corn, Change in the Price of Brazilian Sugar, Change in the Price of U.S. Ethanol, and Change in the Price of Brazilian Ethanol to a Shock in the Price Change of Brazilian Sugar

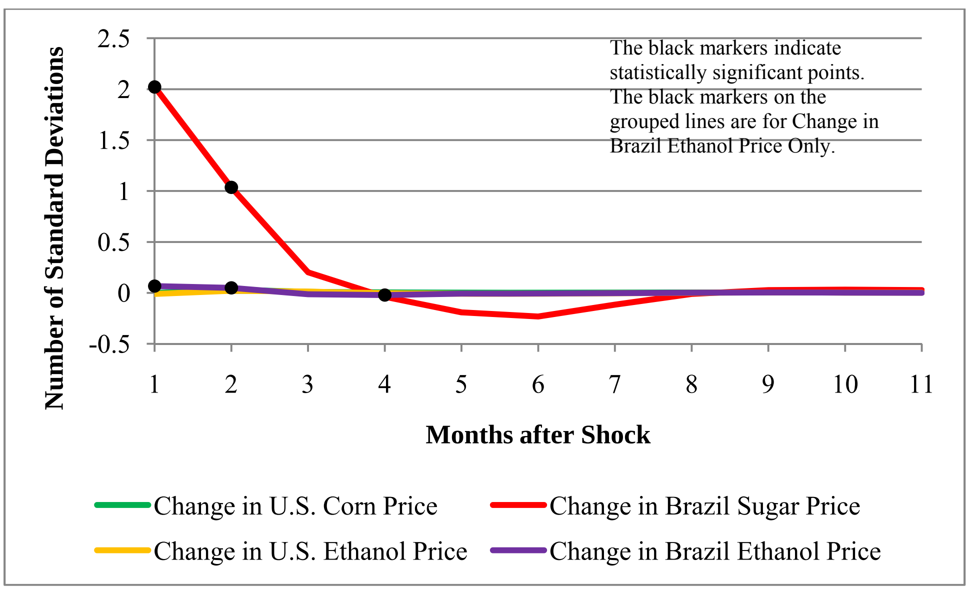


Figure 9: Response of Change in the Price of U.S. Corn, Change in the Price of Brazilian Sugar, Change in the Price of U.S. Ethanol, and Change in the Price of Brazilian Ethanol to a Shock in the Price Change of U.S. Ethanol

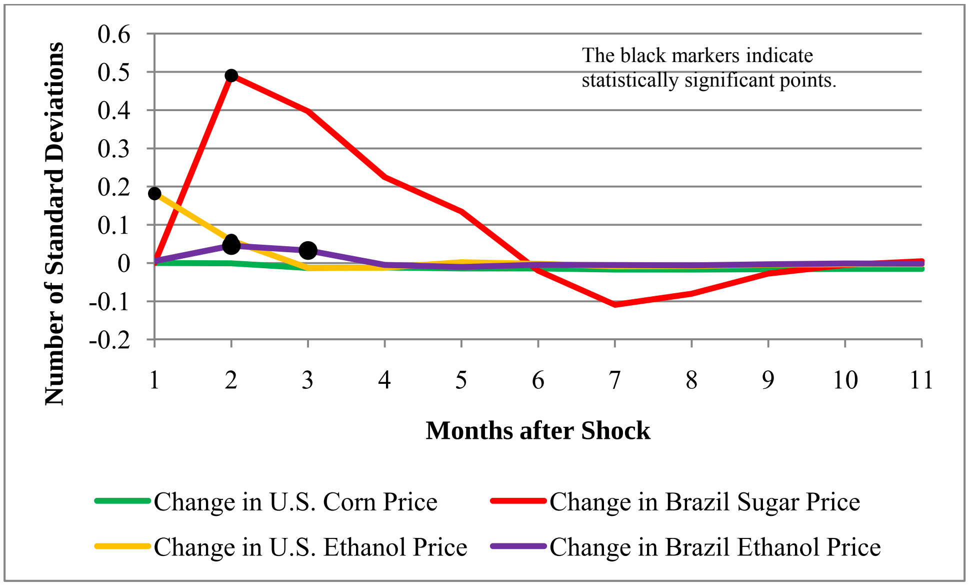
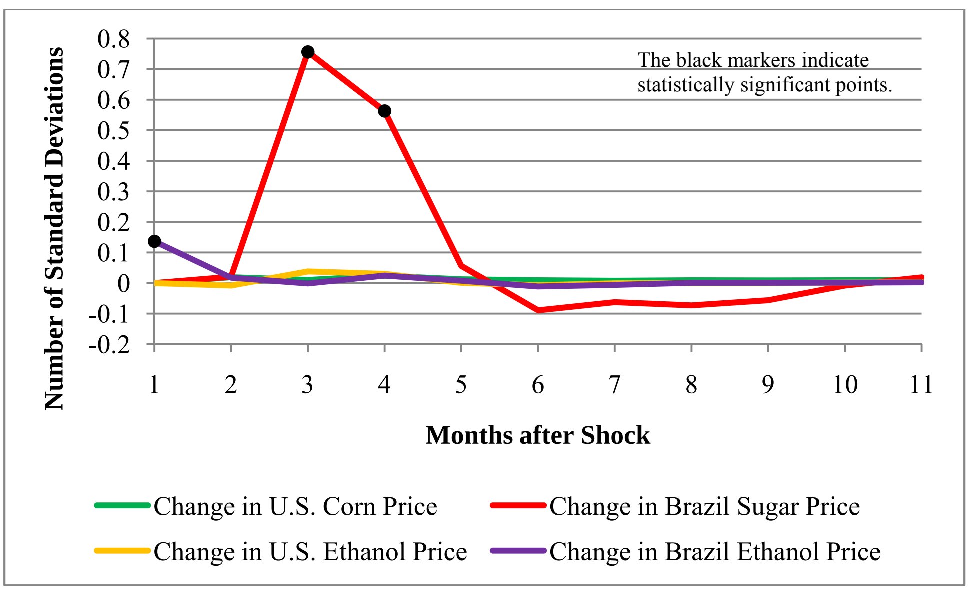


Figure 10: Response of Change in the Price of U.S. Corn, Change in the Price of Brazilian Sugar, Change in the Price of U.S. Ethanol, and Change in the Price of Brazilian Ethanol to a Shock in the Price Change of Brazilian Ethanol



The forecast error decompositions for a 12-month period are presented in Table 5. The change in the corn price is almost entirely exogenous to the system and after 12 months over 98% of the variation in the change in corn price is explained by its own forecast error. The change in the sugar price was mostly explained by its own forecast error, but about 13.5% of the variation was explained by the change in the ethanol price in Brazil. The own forecast error of the change in ethanol price in the United States explained about two-thirds of the change in ethanol price with the change in corn price explaining 30.5%. The own forecast error explains about half of the variation in the change in ethanol price in Brazil while the change in the corn and sugar prices each explain about 20%. The importance of both prices may reflect the fact that the United States does import more ethanol from Brazil when the price of corn is high and that ethanol and sugar are competing goods in Brazil because they both rely on sugarcane for production.

Table 5. Proportions of *k*-Months-Ahead Forecast Error Attributed to Innovations in Respective Series.

		Proportion of Error Explained by:			
	Months Ahead (*k*)	ΔUscorn	ΔBrsug	ΔUseth	ΔBreth
ΔUscorn	1	1.0000	0.0000	0.0000	0.0000
	2	0.9768	0.0172	0.0000	0.0060
	3	0.9803	0.0127	0.0018	0.0053
	4	0.9768	0.0109	0.0027	0.0096
	5	0.9784	0.0089	0.0037	0.0090
	6	0.9795	0.0077	0.0044	0.0084
	7	0.9801	0.0068	0.0054	0.0076
	8	0.9803	0.0061	0.0063	0.0073
	9	0.9807	0.0056	0.0068	0.0069
	10	0.9809	0.0052	0.0072	0.0066
	11	0.9812	0.0049	0.0075	0.0065
	12	0.9813	0.0046	0.0077	0.0063
ΔBrsug	1	0.0024	0.9977	0.0000	0.0000
	2	0.0055	0.9501	0.0443	0.0001
	3	0.0061	0.8375	0.0641	0.0923
	4	0.0098	0.7875	0.0679	0.1348
	5	0.0104	0.7857	0.0700	0.1340
	6	0.0104	0.7863	0.0694	0.1339
	7	0.0104	0.7849	0.0708	0.1339
	8	0.0104	0.7835	0.0716	0.1345
	9	0.0104	0.7830	0.0717	0.1348
	10	0.0106	0.7830	0.0717	0.1348
	11	0.0107	0.7828	0.0717	0.1348
	12	0.0109	0.7826	0.0717	0.1348
ΔUseth	1	0.0162	0.0027	0.9811	0.0000
	2	0.1128	0.0123	0.8733	0.0015
	3	0.1312	0.0152	0.8193	0.0343
	4	0.1615	0.0143	0.7729	0.0514
	5	0.1812	0.0152	0.7535	0.0501
	6	0.2022	0.0167	0.7316	0.0496
	7	0.2198	0.0164	0.7154	0.0484
	8	0.2383	0.0161	0.6984	0.0472
	9	0.2556	0.0159	0.6824	0.0461
	10	0.2729	0.0156	0.6664	0.0451
	11	0.2892	0.0153	0.6512	0.0443
	12	0.3050	0.0150	0.6365	0.0434
ΔBreth	1	0.0425	0.1851	0.0011	0.7713
	2	0.0900	0.2245	0.0684	0.6170
	3	0.1033	0.2168	0.0977	0.5823
	4	0.1189	0.2180	0.0933	0.5698
	5	0.1325	0.2147	0.0942	0.5586
	6	0.1441	0.2115	0.0930	0.5514
	7	0.1547	0.2086	0.0925	0.5442
	8	0.1666	0.2055	0.0921	0.5358
	9	0.1785	0.2028	0.0909	0.5278
	10	0.1904	0.2000	0.0896	0.5200
	11	0.2021	0.1971	0.0883	0.5125
	12	0.2135	0.1942	0.0872	0.5052

Conclusion

This research is important for policy makers in the United States, refineries, and investors. The results indicate that the price of ethanol in Brazil is not significantly impacted by a shock in the price of U.S. ethanol; therefore, it is unlikely that the tax currently placed on ethanol imported from Brazil is impacting the market. Similarly, the price of ethanol in the U.S. was not significantly impacted by a shock in the price of ethanol in Brazil. A shock to the change in prices was significant for a few months following a shock in the price changes in U.S. corn or ethanol. Recent business ventures have been undertaken by two major U.S. agribusinesses. Monsanto purchased a Brazilian company that will allow them to focus more on sugarcane breeding and applied genomics. ADM has formed a joint venture to build sugarcane plantations, mills, and ethanol distilleries in Brazil (Hofstrand 2009). The business ventures may allow the U.S. agribusiness to diversify some of their risk away from the U.S. market.

The correlation coefficient between the two ethanol prices was 0.38; however, the relationship did not appear to be very strong based on the impulse response functions. Graphically, it is visible the prices were responding to each other, but the change was not significant. This may partially be the result of other factors not included within the model such as the impacts of the Renewable Fuels Standard and oil or unleaded fuel prices. Ethanol production has been targeted as a primary contributor to the increased corn prices in recent years. This study sheds light on the fact that an increase in the price of ethanol has a minute effect on the change in the price of corn.

Future work in this area could include a longer time span if data is available and more relationships. The exchange rate and corn price were most exogenous to the systems. It may be interesting to explore the exchange rate and price of corn with other variables.

References

Amano, Robert A., and Simon van Norden. "Exchange Rates and Oil Prices." *Review of International Economics* 6, no. 4 (1998): 683-694.

Center for Advanced Studies on Applied Economics. *CEPEA - Centro de Estudos Avancados em Economia Aplicada.* 2011. http://www.cepea.esalq.usp.br/english/products/ (accessed April 22, 2011).

Chen, Shiu-Sheng, and Hung-Chyn Chen. "Oil prices and real exchange rates." *Energy Economics* 29, no. 3 (2007): 390-404.

Clean Fuels Development Coalition. "The Ethanol Fact Book A Compilation of Information About Fuel Ethanol." *American Coalition for Ethanol.* 2007. http://ethanol.org/pdf/contentmgmt/2007_Ethanol_Fact_Book.pdf (accessed January 4, 2011).

Featherstone, Allen M., and Timothy G. Baker. "An Examination of Farm Sector Real Asset Dynamics: 1910-85." *American Journal of Agricultural Economics* 69, no. 3 (August 1987): 532-546.

Hannan, E.J., and B.G. Quinn. "The Determination of the Order of an Autoregression." *Journal of the Royal Statistical Society. Series B (Methodological)* 41, no. 2 (1979): 190-195.

Hofstrand, Don. "Brazil's ethanol exports." *Ag Decision Maker Iowa State University.* May 2009. http://www.extension.iastate.edu/agdm/articles/hof/HofMay09.html (accessed January 4, 2011).

Hofstrand, Don, and Ann Johanns. "Fuel and Grain Price Historic Comparisons." *Agricultural Marketing Resource Center.* April 2011.

http://www.agmrc.org/renewable_energy/ethanol/ethanol__prices_trends_and_markets.cfm (accessed April 22, 2011).

Huang, Alex YiHou, and Yi-Heng Tseng. "Is Crude Oil Price Affected by the US Dollar Exchange Rate?" *International Research Journal of Finance and Economics*, no. 58 (2010): 109-120.

Johansen, Soren. "Statistical Analysis of Cointegration Vectors." *Journal of Economic Dynamics and Control* 12 (1988): 231-254.

Lizardo, Radhames A., and Andre V. Mollick. "Oil price fluctuations and U.S. dollar exchange rates." *Energy Economics* 32, no. 3 (2010): 399-408.

Pfaff, Bernhard. "Package 'vars': VAR Modelling." August 27, 2010. http://cran.r-project.org/web/packages/vars/vars.pdf (accessed April 27, 2011).

Pfaff, Bernhard. "VAR, SVAR and SVEC Models: Implementation Within R Package vars." *Journal of Statistical Software* 27, no. 4 (July 2008): 1-32.

R Development Core Team, . "R: A language and environment for statistical computing." *R Foundation for Statistical Computing.* Vienna, 2011. http://www.R-project.org/.

Renewable Fuels Association. "Renewable Fuels Standard." *Renewable Fuels Association.* http://www.ethanolrfa.org/pages/renewable-fuels-standard (accessed January 4, 2011).

—. "Using More Brazilian Ethanol Would RAISE Gasoline Prices for D.C. Drivers - With or Without the Tariff." *Renewable Fuels Association.* May 24, 2010. http://www.ethanolrfa.org/page/-/rfa-association-site/studies/Brazil%20US%20Price%20Comparison.pdf?nocdn=1%22 (accessed January 3, 2011).

United States Department of Agriculture. "Agricultural Exchange Rate Data Set." *United States Department of Agriculture Economic Research Service The Economics of Food, Farming, Natural Resources, and Rural America.* February 2011. http://www.ers.usda.gov/Data/ExchangeRates/ (accessed April 22, 2011).