



The Impact of Increased Ethanol Production on Corn, Crude Oil and Beef Prices: A Threshold Vector Error Correction Model Approach

Jun Ho Seok, GwanSeon Kim, and Sayed Saghaian
Department of Agricultural Economics
University of Kentucky



Abstract

This paper investigates the impact of ethanol mandate on the price relationship between corn and beef using the monthly time-series data from January 2003 through December 2013. In addition, we examine the non-linearity in ethanol, corn, and beef markets. Based on the threshold cointegration test, we find the symmetric relationship in pairs with ethanol production-corn price and ethanol production-beef price whereas there is the asymmetric relationship between prices of corn and beef. Employing the threshold vector error correction and vector error correction models, we also find that the corn price in the U.S is caused by both ethanol production and beef price in a long-run when the beef price is relatively high. On the other hand, the corn price does not cause both ethanol production and beef price in the long run. Findings from this study imply that demanders for corn such as ethanol and beef producers have price leadership on corn producers.

Introduction

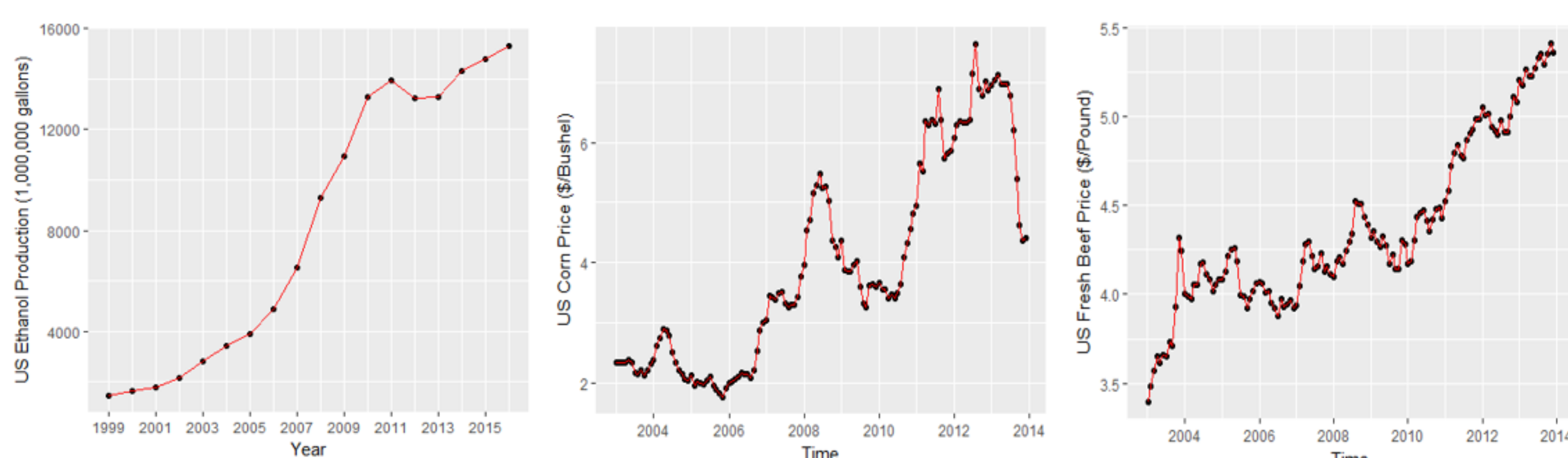
The worldwide liquid biofuel production has increased more than five times during the past decade (Condon et al., 2015). According to Renewable Fuel Association (RFA), the United States (U.S.) ethanol production has increased from 1,465 million gallons in 1999 to 14,340 million gallons in 2014. The increased biofuel production such as ethanol and biodiesel is driven by mandates, subsidies, and favorable trade policies. The Energy Policy Act (EPA) of U.S. Renewable Fuel Standard (RFS) in 2005 and the Energy Independence and Security Act (EISA) in 2007 are good examples of the mandates. In the U.S., ethanol as the main biofuel product is produced mostly (more than 90%) from corn (U.S. Department of Energy, 2011). U.S. corn production for ethanol increased from 6% in 1999 to 36% in 2014. This implies that demand for U.S. corn has increased from a rise of ethanol production. In this sense, U.S. corn prices show an increasing trend for the years 2003 to 2013, reaching the historical high of about 6.7\$/bu in 2012 according to the U.S. Department of Agriculture-National Agricultural Statistical Service of (USDA-NASS). Considering corn is one of the largest feeding crops for livestock in the U.S. covering about 55% of the feed share (Leibtag, 2008), an increase in ethanol production affect corn prices, and in turn, feedstock and meat prices.

This study has four main objectives:

1. Examine the effect of U.S. ethanol policy on corn prices
2. Investigates a causal relationship between corn and beef prices in the U.S.
3. Test a relationship between ethanol production and beef price in the U.S.
4. Examine a possible asymmetric relationship between U.S. ethanol production, corn prices, and beef prices.

Data

This paper uses monthly time-series data for U.S. ethanol production, corn prices, and beef prices from January 2003 to December 2013. The data source for U.S. ethanol production is U.S. energy information administration (EIA), U.S. corn prices come from the NASS of USDA, and U.S. beef prices come from the USDA Economic Research Service (ERS). This study only focuses on the period from 2003 to 2013 that U.S. ethanol production had a rapid growth. This ethanol growth is originated from the Energy Policy Act of 2005 that requires a minimum volume of renewable fuels to help greenhouse gas reduction. In addition, prices of U.S. corn and beef show an increasing trend during the period from 2003 to 2013. Two possible explanations may support this phenomenon. First, a rise in the U.S. corn prices may cause an increase in production costs for U.S. beef since corn is dominant in feeding sources for U.S. cattle. Second, a rise in the U.S. beef price may cause an increase in demand for U.S. corn since beef prices are one of the factors to decide the number of cattle produced.



The Historical Trend for U.S. Fuel Ethanol Production, U.S. Corn, and Fresh Beef Prices

Sources: U.S. ethanol production from U.S. energy information administration (EIA) and U.S. Corn Price from USDA NASS and U.S. Beef Prices from USDA ERS

Empirical Model

TVECM is extended from the VECM and is presented by the following equation:

$$\begin{bmatrix} \Delta X_t \\ \Delta Y_t \end{bmatrix} = \begin{cases} \begin{bmatrix} \mu_{XL} \\ \mu_{YL} \end{bmatrix} + \begin{bmatrix} \alpha_{XL} \\ \alpha_{YL} \end{bmatrix} ECT_{L,t-1} + \Pi_{1L} \begin{bmatrix} \Delta X_{t-1} \\ \Delta Y_{t-1} \end{bmatrix} + \dots + \Pi_{pL} \begin{bmatrix} \Delta X_{t-p} \\ \Delta Y_{t-p} \end{bmatrix} + \varepsilon_{L,t}, ECT_{t-1} \leq v \\ \begin{bmatrix} \mu_{XH} \\ \mu_{YH} \end{bmatrix} + \begin{bmatrix} \alpha_{XH} \\ \alpha_{YH} \end{bmatrix} ECT_{H,t-1} + \Pi_{1H} \begin{bmatrix} \Delta X_{t-1} \\ \Delta Y_{t-1} \end{bmatrix} + \dots + \Pi_{pH} \begin{bmatrix} \Delta X_{t-p} \\ \Delta Y_{t-p} \end{bmatrix} + \varepsilon_{H,t}, ECT_{t-1} > v \end{cases}$$

where $\Pi = \Pi_1 + \Pi_2 + \dots + \Pi_k - I$ and $\Gamma_k = -\sum_{j=k+1}^p \Pi_j$, L is the lower-regime, H is the higher-regime, v is the threshold value for the error correction term, The long-run matrix Π can be defined as $\alpha\beta'$, where α is the vector of adjustment parameter ($i \times r$) and β is cointegration vector ($r \times i$).

To check the threshold in the VECM, *sup-LM* test suggested by Hansen and Seo (2002) is used as follows:

$$\begin{aligned} \text{supLM} &= \text{supLM}(\tilde{\gamma}, v) \\ v_u &\leq v \leq v_L \end{aligned}$$

where $\tilde{\gamma}$ is the estimated cointegration vector, v_u is the θ percentile of the error correction term, and v_L is the $(1 - \theta)$ percentile of the error correction term.

Results and Discussion

The results of the linear cointegration based on the VECM in Table 4, we found that ethanol production causes the corn price in the long-run. This finding is not surprising because increasing ethanol production pushes the demand for corn outward.

Based on the TVECM results in Table 5, we find two different regimes for the threshold parameter value of 1.8896 ($= US \text{ Corn Price} - 0.9091 \times US \text{ Beef Price}$). In regime 2, when corn prices are relatively high, we find the existence of a long-run relation between prices of U.S. beef and corn. More specifically, U.S. beef prices cause corn prices in the long-run based on the significant coefficient of the ECT term in regime 2. In other words, increasing in beef price results in increasing in corn price, but not vice versa in regime 2. This result indicates that feeding cost for cow is not a major factor for explaining the beef price in the U.S. However, beef market in the U.S. is large enough to impact on corn prices as demander of corn especially when beef price is relatively high.

Table 4. Linear VECM: U.S. Ethanol Production and Corn Price

	$\Delta Ethanol_t$	$\Delta Corn_t$
ECT_{t-1}	0.0093 (0.0171)	0.0251 *** (0.0115)
Intercept	0.1191 *** (0.0346)	0.0035 (0.0233)
$\Delta Ethanol_{t-1}$	-0.5109 *** (0.0933)	0.0684 (0.0628)
$\Delta Ethanol_{t-2}$	-0.0031 (0.0928)	-0.0075 (0.0625)
$\Delta Corn_{t-1}$	-0.0961 (0.1313)	0.2905 *** (0.0884)
$\Delta Corn_{t-2}$	-0.0682 (0.1329)	0.1332 (0.0895)
Cointegration Vector	(1, -1.816)	
<i>supLM</i> test	14.425	

Table 5. Linear and Threshold VECM: Corn and Beef Prices in the U.S.

Observations (%)	Linear VECM		Threshold VECM			
	$\Delta Corn_t$	$\Delta Beef_t$	Regime 1 (ECT \leq 1.8869) 84.5%		Regime 2 (ECT $>$ 1.8869) 15.5%	
ECT_{t-1}	-0.0223 (0.0165)	0.0064 (0.0051)	-0.0109 (0.0004)	0.0062 (0.3758)	-0.5688 (0.0062)	-0.0060 (0.9301)
Intercept	0.0120 (0.0227)	0.0141 (0.0070)	-0.0197 (0.4087)	0.0130 (0.1077)	1.3935 (0.0031)	-0.0395 (0.7998)
$\Delta Corn_{t-1}$	0.2692 (0.0878)	-0.0039 (0.0271)	0.2674 (0.0125)	-0.0177 (0.6185)	0.3611 (0.0356)	-0.0553 (0.3351)
$\Delta Corn_{t-2}$	0.1420 (0.0888)	0.0175 (0.0274)	0.2925 (0.0059)	-0.0207 (0.5573)	-0.2566 (0.1440)	-0.0840 (0.1551)
$\Delta Beef_{t-1}$	0.2700 (0.2871)	0.1758 (0.0887)	0.2993 (0.2810)	0.2271 (0.0161)	-2.5796 (0.0109)	-0.4385 (0.1936)
$\Delta Beef_{t-2}$	-0.5828 (0.2867)	-0.1656 (0.0886)	-0.3703 (0.1855)	-0.1940 (0.0404)	-2.7073 (0.0026)	-0.0305 (0.9180)
Cointegration Vector	(1, -0.9091)					
<i>supLM</i> Test	26.2666***					
Threshold Paramet	1.88689					

Notes: ***, **, * Significant at the 1%, 5%, and 10% level, respectively. () is robust standard error.

Conclusions and Implications

Our findings provide some contributions and implications.

1. Most existing studies focus on the relationship between biofuel price and food price (especially crop price). Therefore, findings in this study will fill a gap in previous and existing studies.
2. We find that beef price causes corn price in long-run, implying that beef market has price leadership on corn market; in other words, U.S. beef market has a market power on the corn market.
3. U.S. ethanol market has a price leadership on the corn market based on the unidirectional long-run Granger causation. Thus, U.S. corn market could be considered as a responsive market for corn demanders such as ethanol and beef producers.
4. U.S. ethanol policy for environment has a direct effect on a source of ethanol (corn) but does not have an indirect impact on a price change of corn.