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The Integration of Energy and Agricultural Markets

By

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The Integration of Energy and Agricultural Markets

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This paper explores the integration of energy and agricultural markets. A year ago, the paper would have been relatively simple and straight-forward. Through last summer, energy and agricultural markets were clearly closely linked. As the price of crude oil increased, so did the price of corn and other agricultural commodities. And when crude oil started to decline in the summer of 2008, so did the prices of agricultural commodities. The basic mechanism was that a higher crude oil price leads to higher gasoline price, which increases the demand for corn ethanol as a substitute for gasoline. More corn ethanol capacity comes on line demanding more corn, which, in turn leads to corn price increases (Tyner 2008). We saw that model in operation through 2006-08.

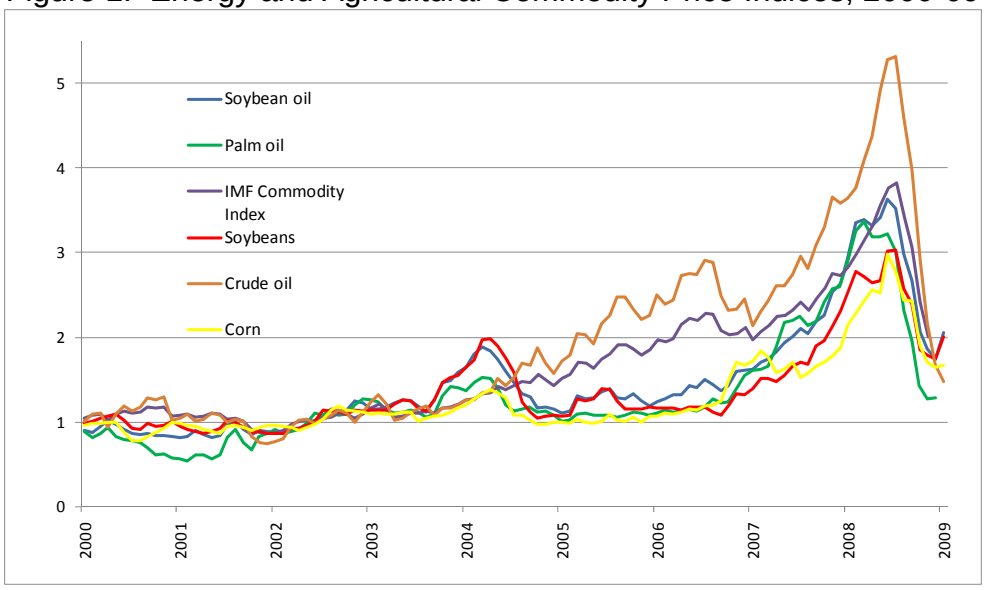
However, in 2009 things changed. Ethanol plants came under tremendous pressure as ethanol prices sank relative to gasoline. Over 2 billion gallons of US ethanol capacity (out of 12 billion) ceased operating. Instead of being priced off gasoline and crude oil as in the past, the ethanol price became more closely linked to the price of corn. What caused this shift? Is in permanent, or will we return to the energy agriculture link that existed previously.

In this paper, we will address these issues. First, we will develop the energy agriculture linkage that emerged in the 2006-08 period. Part of that story will entail examining the impact of US ethanol policies on development of the industry. Then, we will explore the recent developments and explain why the corn – ethanol link emerged. Finally, after understanding these two sets of drivers, we will explore what the future might hold in terms of energy agriculture linkages and why.

Energy – agriculture linkage

Figure 1 shows the continued strong links among the commodity prices, especially to energy/agricultural price links, both as prices rise and as they fall (Abbott, Hurt et al. 2008). The graph provides an index of prices with 2002 equal to one. The main point of this graph is that the commodity prices have moved together for the most part.

Figure 1: Energy and Agricultural Commodity Price Indices, 2000-09



Source: International Monetary Fund, *International Financial Statistics.*
* Commodity prices and indices are normalized to equal 1.0, on average, for 2002.

Behind the increased biofuels production were both government policy drivers and high oil prices. Government policies were important in all cases, and in particular were critical in launching the ethanol and biodiesel industries in earlier years. Since 2006, however, the increasing oil price was an especially important driver in the United States. Agricultural commodity prices followed crude oil both up and down. In the E.U., government policy remained the dominant driver, as biodiesel is less competitive than ethanol without government intervention.

Since 2006, the ethanol market in the United States has established a link between the prices of crude oil and corn—a link that did not exist historically (Abbott, Hurt et al. 2008). Table 1 contains price correlations for the 1988-2005, 2006-2008, and 2008-09 periods. Crude oil and gasoline correlations are high in all three periods as would be expected. In the period 1988-2005, there is little apparent correlation between crude oil and corn prices—it is, in fact, low and negative. If one had chosen a different period, it might be low and positive, but the point is that historically it has been quite low. For the period 2006-08, the crude/corn price correlation is high and positive at 0.80. It is also high for the recent period. Thus, there continues to be a strong link between crude oil and corn. The third set of correlations is between ethanol and corn. In the 1988-2005 period, this correlation is low and negative. In the 2006-08 period, it is low

and positive. However, for the 2008-09 period, the correlation between ethanol and corn is high (0.84) and positive. We return to the significance of this change later.

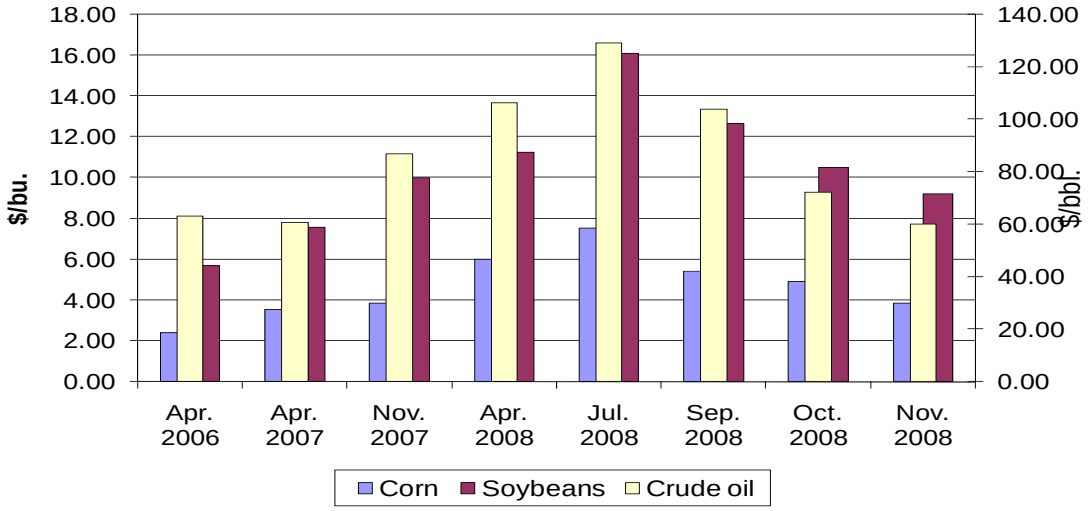
Table 1: Crude, Gasoline, and Corn Price Correlations

Period	Correlation type	Correlation
1988-2005	Crude - gasoline	0.97
	Crude – corn	-0.26
	Ethanol - corn	-0.08
2006-08	Crude - gasoline	0.92
	Crude – corn	0.80
	Ethanol - corn	0.04
2008-09	Crude - gasoline	0.99
	Crude - corn	0.95
	Ethanol - corn	0.84

The crude oil – corn link is further illustrated in Figure 2. This figure contains selected monthly observations on crude oil, corn, and soybean prices. Soybeans and corn prices are on the left axis in $/bu. and crude oil is on the right axis in $/bbl. The first set of bars for early 2006 shows a weaker linkage than the others. But after that month, corn, soybeans, and crude prices clearly moved together both up and down the price ladder.

Clearly the oil price driver continues to be very important. The policy drivers also remain important. In the EU, the strong political support for biofuels has waned somewhat for two reasons—concern over greenhouse gas emissions (GHG) that may be associated with biofuels and food-fuel price concerns that arose in 2008. In the EU, policy was a more important driver than oil prices because biodiesel from plant sources is not as economically viable without subsidies or mandates (Food and Agricultural Organization (FAO) 2008). While subsidies in the E.U. have fallen, the future of mandates is unclear at this writing. Most countries are behind in achieving their targets, but the targets are not yet legally binding. It appears that the ambitious targets previously established will not be realized.

Figure 2: Crude Oil, Corn, and Soybean Prices



Sources: DOE/EIA for crude oil, and USDA for corn and soybean prices.

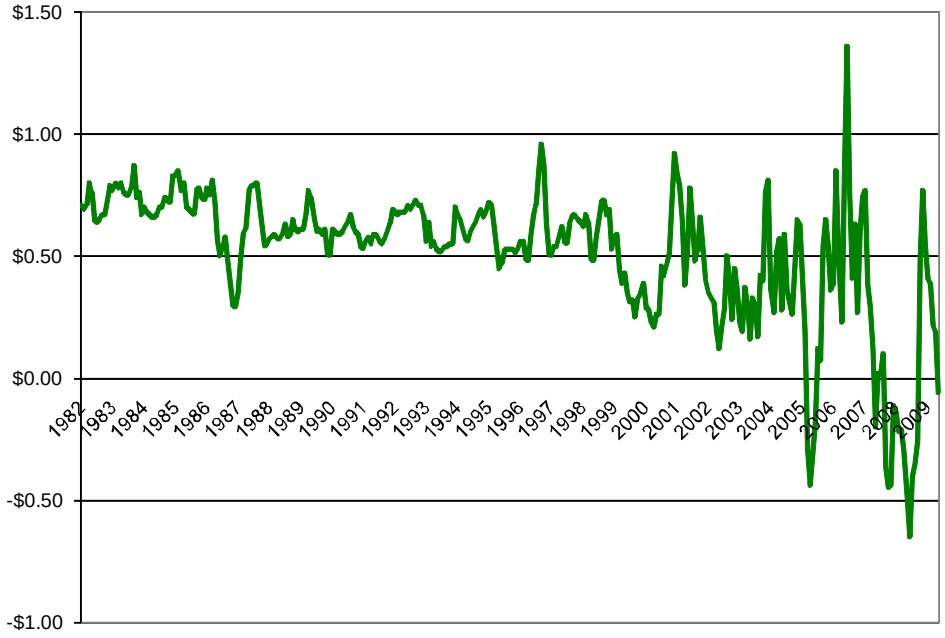
In the United States, the main policy instruments are the subsidy, the Renewable Fuel Standard (RFS), and the import tariff (Taheripour and Tyner 2008). Changing market conditions can best be illustrated by Figure 3, showing the difference between market prices for ethanol and gasoline. The graph runs from 1982 to 2009. It shows clearly that from 1982 through about 2002, the ethanol price was above gasoline, usually by more than the federal subsidy, which averaged around 50 cents/gal. Ethanol had value as an oxygenate and for its higher octane. From about 2002 through early 2007, the margin averaged about the same level, but the variability increased substantially. From early 2007 through September 2008, the gap narrowed and even became negative, with gasoline priced above ethanol until fourth quarter 2008. During that period, it appeared that ethanol pricing was moving to an energy-equivalent basis instead of a per-gallon (volumetric) basis.[1] However, in the fourth quarter, as gasoline prices plummeted, the difference between ethanol and gasoline returned to levels more

[1] Energy value pricing means that the ethanol price was approximately equal to 0.68 times the gasoline price plus the federal subsidy of 51 cents per gallon. Ethanol has about 68% of the energy of gasoline and therefore delivers about that percentage of mileage per gallon. Volumetric pricing means price equivalence per gallon.

akin to historic norms. But in 2009, the difference again began to fall and became negative.

Figure 3: Historic Ethanol and Gasoline Price Differences

Omaha, NE



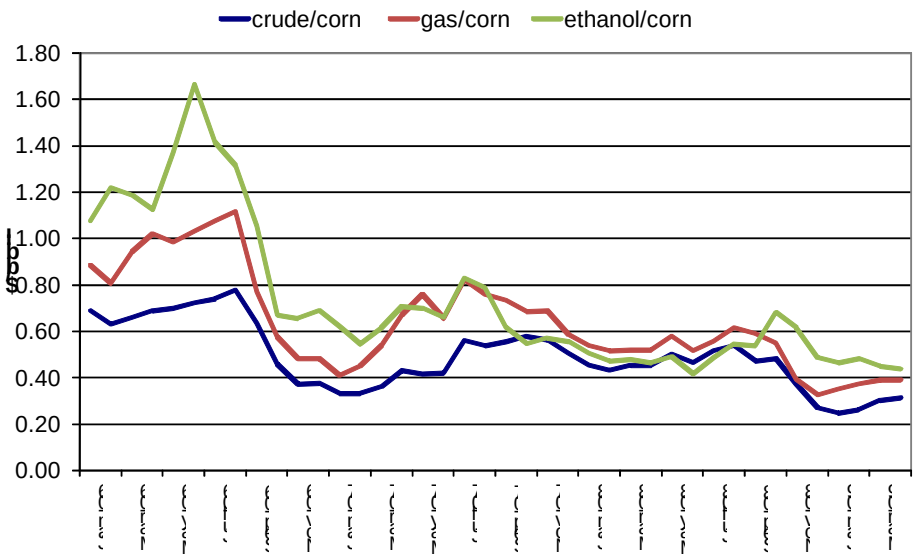
Source: State of Nebraska: http://www.neo.ne.gov/statshtml/66.html

During much of 2008, the ethanol industry faced difficulty with rising corn prices not completely offset by rising ethanol prices.[2] In the last half of 2008, many ethanol plant construction plans were delayed or abandoned. More than 2 billion gallons of existing capacity (out of 12 billion total) was shut down temporarily or permanently. Because of these conditions, it appears the RFS became binding towards the end of 2008 for a very short period, even though production capacity was more than the RFS level. The price relationship between ethanol and corn became very important as plants opened or closed depending on margins driven mainly by these two prices. In essence, the ethanol/corn link remained strong—any time that price relationship changed, ethanol production would start or stop.

[2] See Tyner, W. and F. Taheripour (2008). "Biofuels, Policy Options, and Their Implications: Analyses Using Partial and General Equilibrium Approaches." Journal of Agricultural & Food Industrial Organization **6**(2): Article 9. for an analysis of ethanol profitability over time.

During the last half of 2008, there were other important market differences. First, the refining margins for crude oil changed as the crude price plummeted and gasoline demand was quite low. In December 2008, refining margins were sometimes less than $3/bbl. as gasoline plummeted even faster than crude oil. This is illustrated in Figure 3, which shows the crude/corn, ethanol/corn, and gasoline/corn price ratios from January 2006 to November 2008. Until 2007, the ethanol ratio had always been the highest, followed by gasoline and crude. Starting in 2007, the ethanol/corn ratio began to fall below the gasoline/corn ratio reflecting the apparent move to energy-based pricing of ethanol. In the fourth quarter of 2008, the ethanol price became significantly higher than gasoline, and the ethanol/corn price ratio was again higher than the other two. By January 2009, refining margins increased above historic norms to around $12/bbl. Gasoline prices increased substantially while the price of crude oil remained fairly constant. The crude oil/corn price link is still very strong, but with more short-run volatility.

Figure 4: Crude, Gasoline, and Ethanol Price Ratios to Corn



Sources: Crude oil – composite refiner acquisition cost, EIA; gasoline and ethanol – Nebraska Web site, http://www.neo.ne.gov/statshtml/66.html; corn USDA/ERS.

The Binding RFS

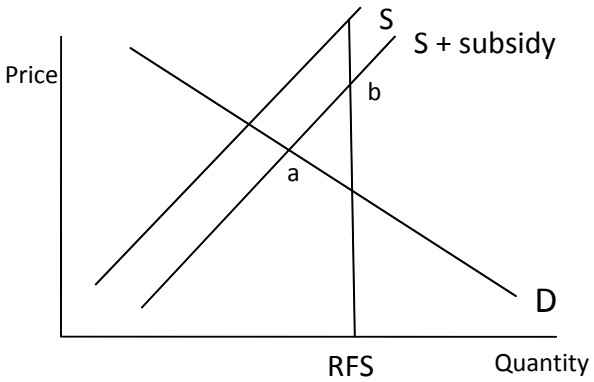
Why did the price of ethanol rise relative to gasoline at the end of 2008? One explanation is that because of ethanol plant closings, some blenders found themselves near the end of the year without enough ethanol to meet their RFS quotas. They needed volume quickly to make their quota. Another piece of evidence supporting this hypothesis is the fact that Renewable Fuel Identification Numbers (RINs), the tradable ethanol certificates, doubled in price in the fourth quarter. Blenders can meet their quota either by buying and blending ethanol or by buying a RIN from a blender who has blended more than their own quota. Thus, it appears that in the fourth quarter, the RFS became binding for the first time due to ethanol plant closings.

The analytics of a binding RFS are shown in Figure 5. Point a in Figure 5 represents the market equilibrium price and quantity with a subsidy and non-binding RFS. Point b represents the market price and quantity with a binding RFS. Since the RFS is assumed to bind, the quantity produced and consumed is higher than the market equilibrium, and the higher price reflects the economic rent associated with the binding RFS. In other words, the change in pricing regime could be due to the binding of the RFS and the rent associated with that binding constraint. With either pricing paradigm for ethanol, however, there is still a strong link between crude oil and corn prices, just with a change in the way it functions.

Figure 6 illustrates how the blenders' credit and the RFS would operate. The fixed subsidy is 45 cents per gallon, and the RFS is set at 15 billion gallons. Another possible policy option would be a variable subsidy which makes the level of the subsidy a function of the price of crude oil. In this example, there is no subsidy if crude is higher than $70 per barrel, and the subsidy increases as crude falls below $70. Figure 6 shows the estimated ethanol production level for each policy and oil price. The numbers at the top of each set of bars represent the implicit subsidy (rent) paid to ethanol producers/blenders by consumers ($/gal. of ethanol). At high oil prices, the implicit consumer tax is zero because the RFS is no longer binding. Note that below $80 per barrel oil, the RFS dominates the subsidy, and above $80, the subsidy stimulates more ethanol production than the RFS. Looking at the difference between

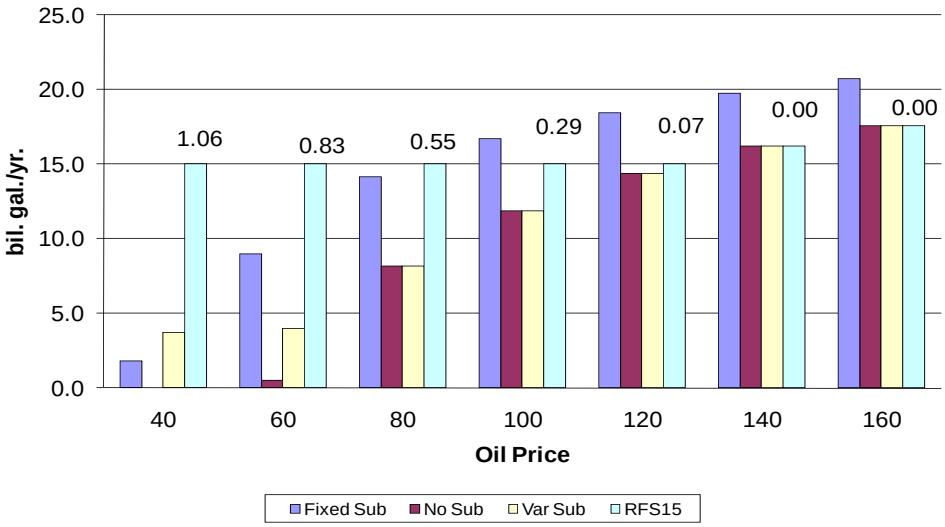
$80 and $100 oil prices, the subsidy dominates once the implicit subsidy/tax falls below the level of the 45-cent fixed subsidy.

Figure 5: Subsidy and RFS Operation



Source: Author

Figure 6: Ethanol Production



Source: Author's estimations. See (Tyner and Taheripour 2008) for a complete description of the model and analysis that was done in comparing these policy options.

Ethanol import tariff

Another U.S. policy issue is the ethanol import tariff, which is 54 cents per gallon plus 2.5% of the import value. For an import value of about $1.50, the total import tariff becomes 58 cents per gallon compared with the current subsidy of 45 cents per gallon. Since imported ethanol also receives the 45-cent federal subsidy, imported ethanol faces a net penalty of 13 cents per gallon. The *raison d'être* for the import tariff was to balance off the subsidy that also applied to ethanol imports. Since there is now a large gap between the two, there will be increasing pressure to at least reduce the import tariff.

If the import tariff went to zero or to any level less than the difference between the implicit subsidy/tax with the RFS and the blender credit, there would be a strong incentive to use imported ethanol. In other words, at low oil prices, imported ethanol would benefit from the implicit subsidy/tax (rent) of the binding RFS as would domestic ethanol. For example, at $60 per barrel oil the implicit subsidy/tax from the 15 billion gallons RFS is 83 cents per gallon (Figure 6). As long as the import tariff is less than that level, imported ethanol might be attractive. At high oil prices, the RFS is no longer binding, and the fixed subsidy dominates. However, to the extent that foreign ethanol became more competitive because sugar did not increase in price as much as corn, foreign ethanol could be competitive on the high end as well.

Ethanol blending wall

The last issue to be covered here is the blending wall—the maximum amount of ethanol that could be blended at the current national blending level of 10% (E10). Since the United States consumes about 140 billion gallons of gasoline annually, the theoretical maximum amount of ethanol that could be blended as E10 is 14 billion gallons. The practical limit, at least in the near term, is more like 12 billion gallons (Tyner, Dooley et al. 2008) because of inadequate distribution infrastructure and summer blending constraints in southern states due to high evaporative emissions with ethanol blends. Already in place or under construction are over 13 billion gallons of ethanol capacity. At present E85 is tiny, and it would take quite a while to build that market. Since gasoline consumption is a function of gasoline price in our model, the

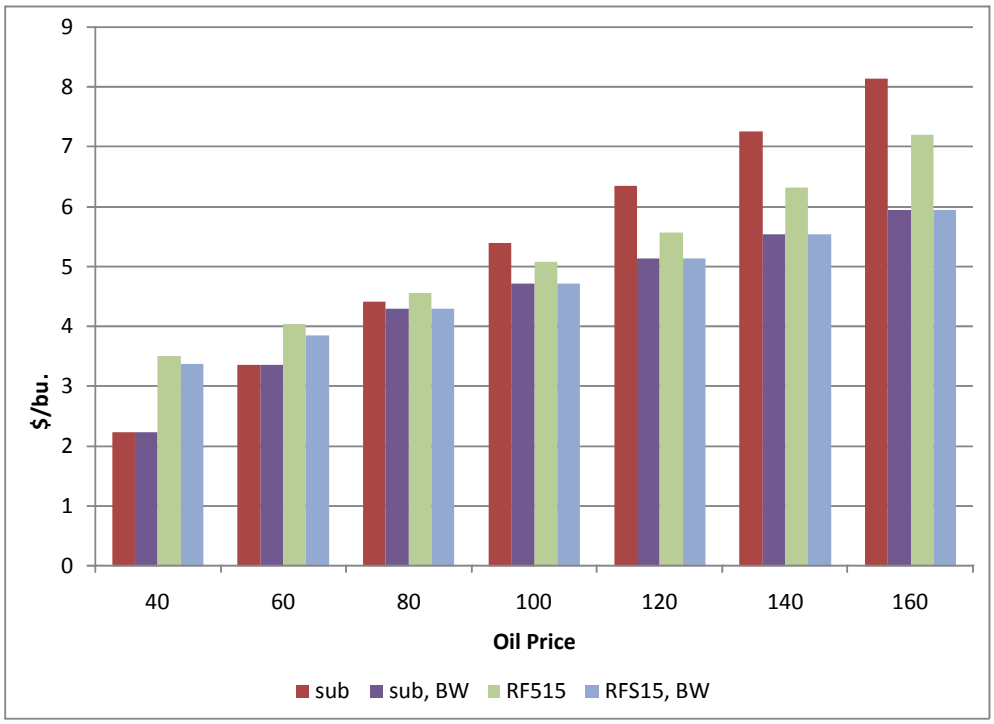
blending wall is modeled here at 9% of gasoline consumption, or 12.6 bil. gal. when total gasoline-type fuel demand is 140 bil. gal.[3]

Figure 7 provides one set of results with the blending wall in place. The results shown for each oil price are the subsidy with and without the blending wall and the 15 bil. gal. RFS with and without the blending wall. The most important point that emerges from these results is that the blending wall effectively breaks the link between crude oil and corn prices at high crude oil prices. The blending wall restricts ethanol use and therefore reduces demand for corn for ethanol. At low crude prices, the blending wall has little impact. But at high crude prices ethanol production is limited by the level of the blending wall, and the corn price increase is significantly dampened. Thus the crude-corn price link that has been established could be significantly weakened at high crude oil prices because of the blending wall limit.

In fact, in the summer of 2009, it appears that the blending wall has become binding. Blending in the Midwest is already at the 10% limit. In California, there is a legal limit at present of 5.7%. In other markets, there are infrastructure barriers preventing blending at the 10% level. The importance of this fact is that the industry size today is greater than the amount that can be physically blended. That means more ethanol is on offer than can be accommodated by the market. This over-supply of ethanol forces the price down to the plant shut-down level because of the severe competition to capture the blending wall determined market. In other words, what this means is that the major determinant of production cost – the cost of corn – now determines the ethanol price. That is why the corn – ethanol correlation in the 2008-09 period is so high (0.84).

[3] DOE and EPA are examining the possible implications of increasing the ethanol blending percentage from 10% to something higher. Automobile companies are concerned about the implications for fuel systems in the existing automobile fleet. Fuel pumps could be another issue. Corrosion, wear, and performance tests are being conducted to get more information on the implications of a switch to a higher level. The outcome of these tests is unknown at this point.

Figure 7: Corn Price for RFS and Subsidy Cases Without & With the Blending Wall



Source: Author's estimates – based on the model described in (Tyner and Taheripour 2008).

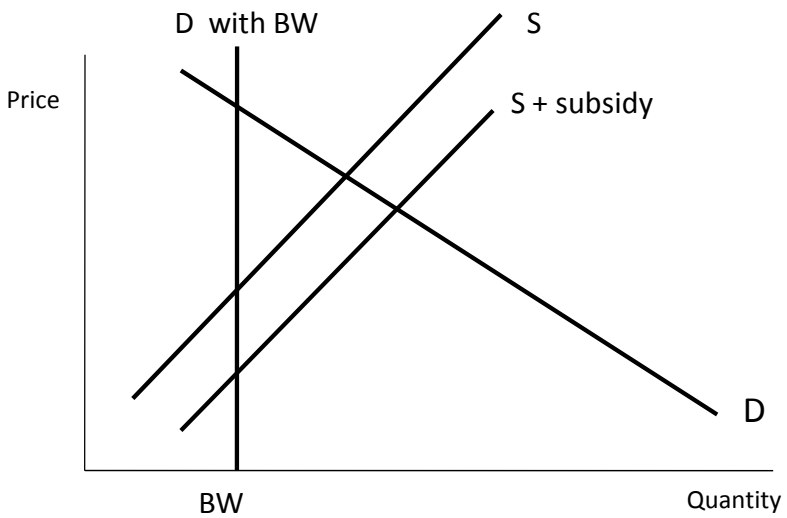
Note: Sub is the current 45 cent per gallon subsidy; sub,BW is that subsidy with the blending wall binding; RFS15 is the 15 bil. gal. mandate; and RFS15,BW is that RFS with the binding blending wall.

The economics are such that in a market that is surplus in ethanol as in summer 2009, the price of ethanol is driven more by the price of corn as the surplus production capacity drives the price of ethanol down to the breakeven price given the corn price. This market situation is illustrated in Figure 8. The blend wall is an effective constraint on demand, so the effective demand curve is the standard demand curve down to the blend wall and then the vertical blend wall. Under that condition, the subsidy goes mainly to blended fuel consumers. The RFS anywhere to the right of the blend wall is totally irrelevant because EPA cannot require blenders to blend any quantity of ethanol they are not legally permitted to blend.

Today the blending wall is the biggest policy issue faced by the U.S. corn ethanol industry. The industry cannot grow; indeed, it cannot even return to profitability until that issue is resolved. It appears likely that the blending limit may be extended above

10 percent, although perhaps not entirely to the proposed 15 percent. If that happens, the historic linkage between crude oil and corn likely would be re-established.

Figure 8: Subsidy, Blend Wall, and RFS Operation

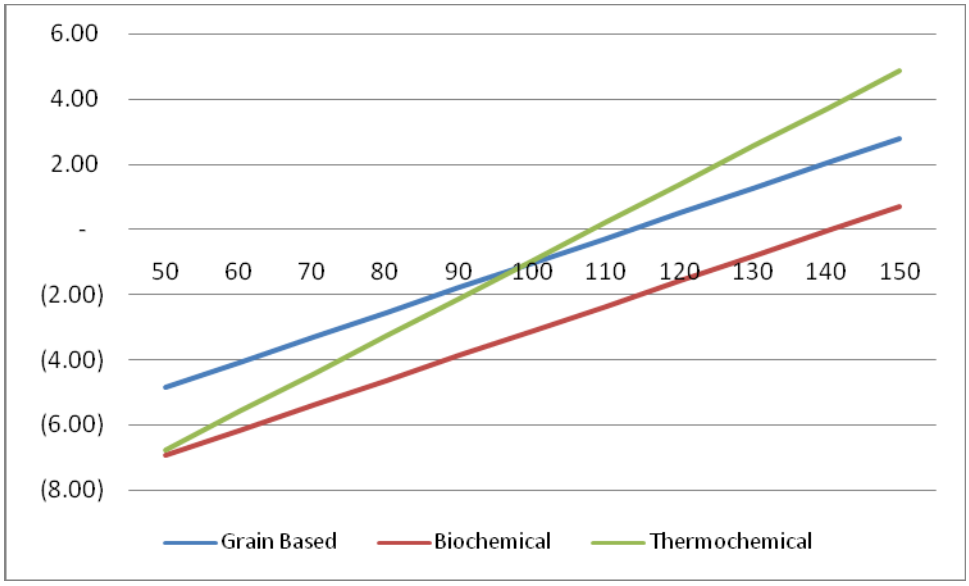


Future prospects

In the U.S., corn ethanol likely will not grow beyond the 15 billion gallon level of the RFS allocated to it even if the blending wall issue is resolved. So corn ethanol in the U.S. is a mature industry. The renewable fuels future in the U.S. depends on the development of cellulosic biofuels. There are thermochemical processing technologies that can take cellulosic feedstocks directly to bio-based gasoline and diesel. Successful development of these technologies would avoid the blending wall issues. Our assessment of the likely economics of cellulose conversion indicate that it is expensive even with the best technologies available today, but plausible if oil prices return to previous levels or if the cellulose RFS is deemed to be credible by industry investors. Figure 9 provides our best estimates of the cost of biofuels from thermochemical conversion, biochemical conversion, and corn ethanol all converted to crude oil equivalent on an energy basis. The thermochemical process produces bio-hydrocarbons directly while the biochemical and grain based processes produce

ethanol. The breakeven prices are $108, $114, and $141 for thermochemical, grain based, and biochemical processing respectively.

Figure 9: Profitability ($/gal.) at Various Oil Prices using Energy Equivalent Prices



Source: Author's Calculations (2009).

Clearly, development of a cellulosic biofuels industry will depend upon government subsidies and mandates until such time as markets become convinced $100+ crude oil is here to stay. Cellulosic biofuels have lower net greenhouse gas emissions than corn based biofuels. Many argue that they also do not compete with food and feed, so there is no food/fuel issue. However, at the margin, there would be some competition between food/feed uses of lands and biofuels uses – especially at the large scales that would be implied by ambitious U.S. and E.U. biofuels programs. This topic needs further research.

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