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## CRUDE OIL PRICE VARIABILITY AND ITS IMPACT ON BREAK-EVEN CORN PRICES

For the 2006 – 2007 marketing year, 2.15 billion bushels of corn, accounting for 11 percent of total U.S. corn consumption, will be used to make ethanol. More corn is projected to be used in ethanol production over the next several years. If corn remains the predominant feed stock, nearly 4.5 billion bushels of corn could be used annually in ethanol production beginning in 2007-08 or early 2008-09 marketing years.

Increasing use of corn in ethanol production holds the promise of increasing corn prices such that average corn prices in the future will be higher than average historical prices. However, ethanol production may not reduce corn price variability. As corn use in ethanol production increases, corn prices will be more influenced by oil prices. Like corn, crude oil and gasoline are commodities and are subject to price swings as a result of supply and demand changes.

Once Federal mandates for use of biofuels are reached, ethanol's primary use will be as a substitute for gasoline. As such, the ethanol price will have to be competitive with the gasoline price so that consumers will buy ethanol-blended fuels. Because corn is the major production cost for ethanol, the price an ethanol producer will be willing to pay for corn, hereafter referred to as the break-even corn price, will be directly related to the ethanol price. As the ethanol price increases, the break-even corn price increases. Moreover, ethanol price will be directly related to crude oil price. Therefore, break-even corn prices will be positively related to crude oil prices. As crude oil price increases, the price of gasoline will increase leading to higher ethanol and break-even corn prices. Conversely, decreases in crude oil price will lead to a lower gasoline price, a lower ethanol price, and a lower break-even corn price.

Impacts of crude oil price variability on break-even corn prices are presented in this paper. This is accomplished by first calculating break-even corn prices for a range of crude oil prices. Then, historic oil prices are examined. Finally, crude oil uncertainty is quantified using futures and options contracts traded on the New York Mercantile Exchange.

### Crude Oil and Break-even Corn Prices

For a range of crude oil prices, two corn break-even prices are calculated. The first break-even price is the price that would allow the ethanol producer to just recover variable costs of production. As long as corn can be purchased below this price, existing ethanol plants will find it economically advantageous to produce ethanol. The second break-even corn price is the price that would allow the ethanol producer to just recover all economic costs of production. As long as corn can be purchased below this price, there would be incentive to expand ethanol production capacities.

Steps used to calculate the break-even prices are illustrated in Table 1 and begin with the price of a barrel of crude oil. Because crude oil is the major input of gasoline, there is a strong positive relationship

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between crude oil and gasoline prices. For each crude oil price, a corresponding wholesale unleaded gasoline price is calculated based on a relationship estimated using historical data by researchers at Purdue University (see footnotes for Table 1). The relationship explains the majority of variability in historic wholesale gasoline prices. For a $65 per barrel crude oil price, a $2.14 per gallon wholesale gasoline price results (see second column of Table 1). This gasoline price is a wholesale price and will be below the price consumers pay for gasoline. Taxes and marketing margins need to be added to the wholesale price to arrive at a retail gasoline price.

A wholesale ethanol price is calculated based on the assumption that ethanol will substitute for gasoline. Therefore, gasoline and ethanol prices should equate their relative fuel values. The equation used to calculate an ethanol price for each gasoline price is:

.67 x gasoline price +
$.51 blender's credit +
$.20 additive value

**Table 1. Relationships Between Crude Oil , Gasoline, Ethanol and Break-even Corn Prices.**

| Crude Oil Price | Wholesale Unleaded Gasoline Price[1] | Wholesale Ethanol Price[2] | Break-even Corn Price After | |
|---|---|---|---|---|
| | | | Variable Costs[3] | All Costs[4] |
| $/barrel | $/gallon | $/gallon | $/bu. | $/bu. |
| 20 | 0.73 | 1.20 | 2.64 | 2.09 |
| 25 | 0.89 | 1.31 | 2.97 | 2.42 |
| 30 | 1.05 | 1.41 | 3.30 | 2.75 |
| 35 | 1.20 | 1.52 | 3.64 | 3.09 |
| 40 | 1.36 | 1.62 | 3.97 | 3.42 |
| 45 | 1.51 | 1.72 | 4.30 | 3.75 |
| 50 | 1.67 | 1.83 | 4.63 | 4.08 |
| 55 | 1.83 | 1.93 | 4.96 | 4.41 |
| 60 | 1.98 | 2.04 | 5.29 | 4.74 |
| 65 | 2.14 | 2.14 | 5.62 | 5.07 |
| 70 | 2.30 | 2.25 | 5.95 | 5.40 |
| 75 | 2.45 | 2.35 | 6.28 | 5.73 |
| 80 | 2.61 | 2.46 | 6.61 | 6.06 |
| 85 | 2.77 | 2.56 | 6.94 | 6.39 |
| 90 | 2.92 | 2.67 | 7.27 | 6.72 |
| 95 | 3.08 | 2.77 | 7.60 | 7.05 |
| 100 | 3.23 | 2.88 | 7.93 | 7.38 |

[1] Equals .1076 + .03127 x crude oil price. The relationship is taken from Tyner, W.E. and F. Thaeripour, "Farm Biofuel Policy Alternatives", Paper presented at a conference on Biofuels, Food, and Feed Tradeoffs, St. Louis, MO., April 12-13, 2007.

[2] Equals .67 x wholesale gasoline price + $.51 subsidy plus $.20 additive value. The .67 results because ethanol has 67% of the BTUs of unleaded gasoline.

[3] Equals 2.8 x ethanol price plus 18 x distillers grain price of $.0575 per pound - $1.65 variable costs.

[4] Equals break-even corn price after variable costs minus .55 fixed costs.

Since ethanol contains 67 percent of the BTUs of gasoline, the gasoline price is multiplied by .67 to adjust for the lower number of BTUs in ethanol compared to gasoline. Currently, the Federal government offers a $.51 credit on Federal taxes for each gallon of ethanol used as fuel. Hence, $.51 is added when calculating the ethanol price. Also added is $.20 to account for additional values offered by ethanol not captured by ethanol's BTU content, such as ethanol's value as an oxygenate and octane enhancer.

At a $65 per barrel crude oil price, the wholesale gasoline price is $2.14 per gallon and the wholesale ethanol price also is $2.14 per gallon (see third column of Table 1). The gasoline and ethanol prices are equal only at a $2.14 price. For gasoline prices below $2.14, the equivalent ethanol price is above the gasoline price. For gasoline prices above $2.14 per gallon the ethanol price is below the gasoline price.

The break-even corn price to recover after variable costs is calculated based on a newly constructed dry mill ethanol plant with 100,000,000 gallon capacity. Older, less efficient plants will have lower break-

even prices than shown here.  Break-even prices are based on obtaining 2.8 gallons of ethanol per bushel of corn and 18 pounds of distiller's grain per bushel of corn.  The variable costs of converting corn into ethanol equal $1.65 per bushel of corn processed into ethanol.  The equation for calculating the break-even corn price to recover variable costs is:

   2.8 x ethanol price ($ per gallon) + 18 x distillers grain price ($ per lb.) – 1.65 variable costs

The distillers grain price is a function of the break-even corn price.  The relationship defining the break-even corn price is taken from a report by Purdue researchers (see footnote 1 of Table 1).  This price per ton of distillers equals

       11.7 + 12.57 x break-even corn price ($ per bushel) + .254 x SBOM price ($ per ton)

where the SBOM price is set at $230 per ton.

The break-even corn price to recover all costs equals the break-even corn price to recover variable costs minus $.55.  The $.55 is an estimate of the overhead costs associated with ethanol production.

Currently, the price of crude oil is near $65 per barrel.  This $65 per barrel price translates into a $5.62 break-even corn price after variable costs and a $5.07 break-even price after all costs (see Table 1).  Currently, corn prices are around $3.50 per bushel, indicating that ethanol production currently is profitable.  Current price forecasts suggest that corn prices will exceed break-even prices; therefore, there are incentives to expand ethanol production.

Break-even corn prices do not translate into prices that farmers will receive for corn.  Actual corn prices will be determined by supply and other demands for corn.  Currently, for example, ethanol producers do not have to pay break-even corn prices to obtain enough corn to operate their plants at capacity.  In the longer-run, having break-even prices above market price encourages the increase in ethanol production capacity.
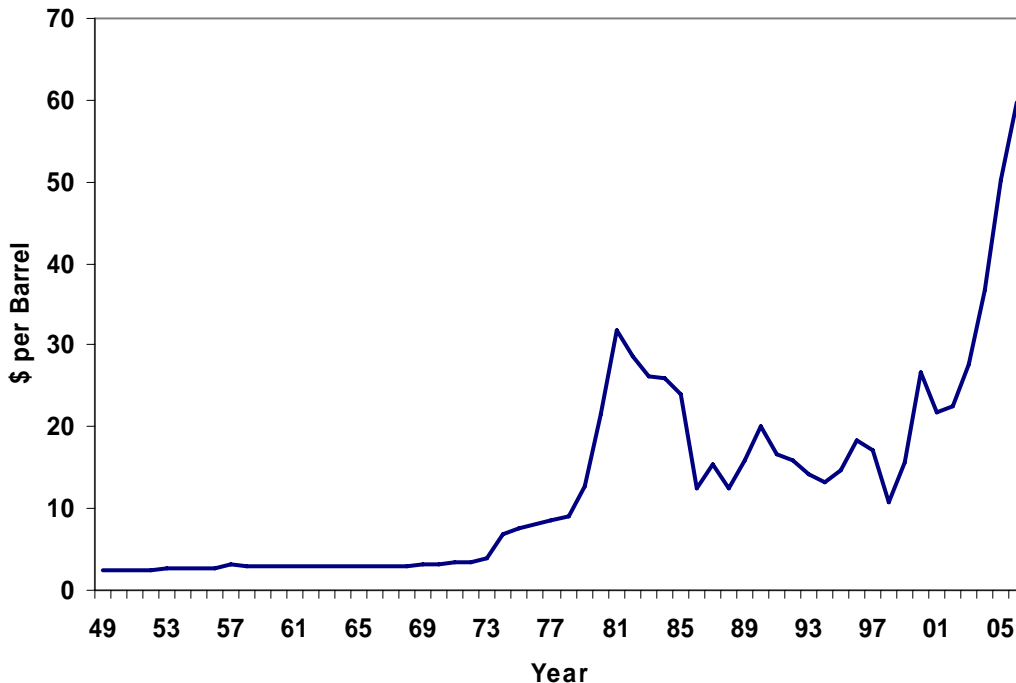
**Historic Crude Oil Prices**

From 1949 through 1980, crude oil prices were relatively low, averaging $4.06 per barrel (see Figure 1).  In the 1980s, crude oil prices increased, reaching a high of $31.77 per barrel in 1981.  From the 1981 level, crude oil prices declined to $12.51 per barrel in 1986.  From 1986 through 1999, crude oil prices exhibited variability but did not trend up or down.  During this period, the average crude oil price was $15.22 per barrel.  In 2000, crude oil prices increased.  Crude oil prices reached $26.72 per barrel in 2000 and then declined to the low $20 range in 2001 and 2002.  Since 2002, crude oil prices have increased each year, reaching a high of $59.69 per barrel in 2006.

From 1986 through 1999, the low average crude oil price meant that ethanol was costly as a fuel source.  Applying the same methodology used to calculate the break-even corn prices in Table 1 to the $15.22 crude oil price results in a break-even corn price after all variable costs of $1.78 per bushel, well below the U.S. average for the 1986 through 1999 period of $2.33 per bushel.  The actual break-even price is likely below $1.78 since the $1.78 break-even price is based on newer technology than existed in the 1990s. Given that the break-even corn price was below the average corn price, ethanol production as a gasoline substitute was unprofitable.

Currently, the profitability of ethanol production and ethanol use of corn stems from high crude oil prices.  At present, future markets point toward crude oil prices averaging $65 per barrel over the next several years.  At $65 per barrel, ethanol will be competitive as a source of fuel as long as corn prices do not exceed $5.35, the break-even corn price to recover all costs.  Declines in oil prices could reduce this profitability and hence use of corn in ethanol production.  At this point, lower oil prices seem unlikely.

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However, the experience during the 1980s when oil prices declined after reaching new highs suggests that declines in oil prices are possible.

**Figure 1. U.S. Yearly Crude Oil Prices, Nominal.**



Source: U.S. Department of Energy,
http://tonto.eia.doe.gov/dnav/pet/pet_pri_dfp1_k_a.htm

**Variability in Oil Prices**

Futures and options contracts for crude oil are traded on the New York Mercantile Exchange. Prices on option contracts are used in options models to determine the probabilities of crude oil prices for different time periods in the future.

For the next five years, futures prices suggest that the most likely price for crude oil is around $65 per barrel. However, the range of possible prices increases over time. Table 2 shows the probabilities of different crude oil price ranges for each December beginning in 2007 and ending in 2011. In December 2007, there is a 0 percent chance of prices being less than $35 per barrel. The chance of having prices between $35 and $45 per barrel is 1 percent, between $45 and $55 per barrel is 12 percent, between $55 and $65 is 28 percent, between $65 and $75 is 29 percent, between $75 and $85 is 18 percent, between $85 and $95 is 8 percent, and above $95 per barrel is 4 percent.

Options markets indicate that oil prices become more uncertain into the future. For example, the chance of oil prices being below $45 per barrel is 1 percent in December 2007. This increases to 8 percent in December 2008, 12 percent in December 2009, and 16 percent in December 2010. By December 2011, there is a 20 percent chance of per barrel crude oil prices being below $45 per barrel. There also is a 16 percent chance of crude oil prices being greater than $95 in December 2011. This 2011 distribution implies that crude oil prices likely will average around $65 per barrel. However, monthly crude oil prices will vary considerably around this average.

Crude oil price variability will translate to break-even corn price variability. Based on the 2011 implied crude oil price distribution, a distribution of break-even corn prices to cover all economic costs is

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calculated. This distribution has a mean of $5.09, suggesting that ethanol will provide higher corn prices than in previous years. This distribution has a standard deviation of 1.74. By way of comparison, monthly corn prices in the U.S. had a standard deviation of .47 from 1974 through 2006. Based on standard deviations, the break-even price distribution is projected to be 3.7 times more variable than historical monthly corn prices.

**Table 2. Estimates of the Probability of Differing Crude Oil Prices, Based on New York Mercantile Exchange Options Prices, May 2007.**

| | Period into the Future | | | | |
|---|---|---|---|---|---|
| Crude Oil Price | Dec 2007 | Dec 2008 | Dec 2009 | Dec 2010 | Dec 2011 |
| $/barrel | Probability of Price | | | | |
| Less than $35 | 0.00 | 0.01 | 0.03 | 0.05 | 0.07 |
| $35 to $45 | 0.01 | 0.07 | 0.09 | 0.11 | 0.13 |
| $45 to $55 | 0.12 | 0.16 | 0.17 | 0.17 | 0.16 |
| $55 to $65 | 0.28 | 0.21 | 0.19 | 0.18 | 0.16 |
| $65 to $75 | 0.29 | 0.19 | 0.17 | 0.15 | 0.13 |
| $75 to $85 | 0.18 | 0.15 | 0.13 | 0.11 | 0.10 |
| $85 to $95 | 0.08 | 0.10 | 0.09 | 0.08 | 0.08 |
| Greater than $95 | 0.04 | 0.12 | 0.13 | 0.15 | 0.16 |

Break-even corn prices will not necessarily equal corn prices that farmers will receive; however, the linkage will become more direct as ethanol constitutes a larger use of U.S. corn. The above analysis suggests that crude oil will not lead to more stable corn prices. Rather, dependence as a fuel source will cause corn to have more variable prices.

**Summary**

Given current projections of $65 per barrel crude oil prices, ethanol production will remain profitable. This likely will lead to growth in the capacity of the ethanol industry and to additional use of corn in ethanol production. Increasing demand for corn likely will cause corn prices to remain above historical averages.

While corn prices may be higher than historical averages, there is little reason to believe that they will be less variable. Oil prices will have increasing impacts on corn prices. Historically, crude oil prices have exhibited variability. Moreover, options contracts indicate that oil prices will be variable. This variability may cause more corn price variability than has occurred in the past. This variability may be further exacerbated by corn production risks and low levels of stocks which may further contribute to corn price variability.

This suggests that risk management will be of continued importance for farmers into the future. Higher corn prices will lead to higher costs on grain farms, as cash rents and land prices adjust to those higher prices. Cost adjustments could lead to the same per acre margins as before potential ethanol-induced commodity price increases. Given the same margins, farmers will still need to protect themselves against price declines.

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