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Future Biofuels Policy Alternatives

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Introduction

Within the past two years, there has been a significant movement in political consensus towards an energy future with a substantially larger renewable energy component. One of the major drivers is the perception that importing over 60% of our oil reduces our national security. There is a perceived high national security cost associated with continuing to rely on foreign sources for a resource as vital to our economy as oil. The more than 50% increase in oil price also has contributed to the interest in alternatives. At the same time, the subsidy system we have had in place for ethanol for the past 30 years remains essentially unchanged even with the huge jump in oil prices. That meant that ethanol became highly profitable with the combination of the subsidy and high oil prices – although ethanol and oil prices are not perfectly correlated. This paper is motivated, in part, by the huge increase in ethanol production capacity in the United States in the past two years and the impact that increase is having on corn and other commodity prices. The current fixed ethanol subsidy was established in an era of cheap oil, but at this writing, with oil around $60/barrel (bbl), the subsidy has provided very large profits to ethanol producers and thereby a substantial incentive for the industry to grow. With this industry growth, demand for corn grows in parallel and thus its price. This paper examines the history of US ethanol policy, evaluates the economics of ethanol production in today's market environment, and reviews some policy alternatives that could be considered for the future.

US Ethanol Policy History

Ethanol has been produced for fuel in the United States for at least 26 years. The industry launch was initiated by a subsidy of $0.40/gallon (gal) provided in the *Energy Policy Act of 1978*. Between 1978 and today, the ethanol subsidy has ranged between $0.40/gal and $0.60/gal. The history of subsidy changes is provided in Table 1. The federal subsidy today is $0.51/gal. Throughout its almost 30 year history, the subsidy has always been a fixed amount that is invariant with oil or corn prices (Tyner and Quear, 2006).

In addition to the federal blending credit subsidy, there are also some other federal and state subsidies. In fact, Koplow (2006) calculated the total subsidy available for ethanol in 2006 to range between $1.05/gal and $1.38/gal of ethanol or between $1.42/gal and $1.87/gal of gasoline equivalent. Many would regard these figures as being high, but they do demonstrate that the ethanol industry has been one with substantial subsidies. However, the ethanol industry is not alone. The US government has a long history of energy subsidies encompassing oil and natural gas production, rural electrification, nuclear energy, and others.

Ethanol Economics

Ethanol gets its value from the energy it contains and its additive value. Ethanol has value as a gasoline additive because it contains more oxygen than gasoline (and therefore causes the blend to burn cleaner) and because it has a much higher octane than gasoline (112 compared with 87 for regular gasoline). Table 2 contains an estimate of the additive value after taking into consideration only the federal subsidy. That is, the additive value is given by the following equation:

Additive value = Ethanol price - (Gasoline price $\times$ 0.7 + subsidy).

In other words, the gasoline price is converted to an energy equivalent using 70%, the subsidy is added, and the difference between the sum of these two values and the ethanol price is the additive value. The subsidy increases what blenders are willing to pay because it is a credit they get for every gallon of ethanol blended with gasoline. The value from these data has ranged from a low of $0.02 in 2002 to a high of $0.70 in 2006, with an average over the entire period of $0.25/gal of ethanol.

The spread increased substantially in the summer of 2006 because of a change in federal rules that took effect May 8, 2006. As of that date, the federal requirement for blending a certain percentage of oxygen ended. One of the major sources of oxygen had been a compound named methyl tertiary butyl ether (MTBE). However, this compound is highly toxic and had been found in the water supplies in several areas and banned by many states. With there no longer being a requirement to blend a certain amount of oxygen, many companies feared legal prosecution if they continued to use MTBE and switched to ethanol, which substantially increased the demand and price of ethanol. Thus, at least in the short run, there was also a scarcity rent in the additive value for ethanol since ethanol supplies could not initially meet the MTBE replacement demand.

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Table 1: History of Ethanol Subsidy Legislation.

1978	*Energy Tax Act of 1978*	\$0.40/gal of ethanol tax exemption on the \$0.04 gasoline excise tax
1980	*Crude Oil Windfall Profit Tax Act and the Energy Security Act*	Promoted energy conservation and domestic fuel development
1982	*Surface Transportation Assistance Act*	Increased tax exemption to \$0.50/gal of ethanol and increased the gasoline excise tax to \$0.09/gal
1984	*Tax Reform Act*	Increased tax exemption to \$0.06/gal
1988	*Alternative Motor Fuels Act*	Created research and development programs and provided fuel economy credits to automakers
1990	*Omnibus Budget Reconciliation Act*	Ethanol tax incentive extended to 2000 but decreased to \$0.54/gal of ethanol
1990	*Clean Air Act Amendments*	Acknowledged contribution of motor fuels to air pollution
1992	*Energy Policy Act*	Tax deductions allowed on vehicles that could run on E85
1998	*Transportation Efficiency Act of the 21st Century*	Ethanol subsidies extended through 2007 but reduced to \$0.51/gal of ethanol by 2005
2004	*Jobs Creation Act*	Changed the mechanism of the ethanol subsidy to a blender tax credit instead of the previous excise tax exemption. Also extended the ethanol tax exemption to 2010.
2005	*Energy Policy Act*	Established the Renewable Fuel Standard starting at 4 billion gal in 2006 and rising to 7.5 billion gal in 2012.

Source: North Dakota Chamber of Commerce, 2006.

Table 2: Yearly Average Ethanol Additive Value.

Year	Ethanol Additive Value (cents/gal of ethanol)
2000	16
2001	32
2002	2
2003	12
2004	29
2005	13
2006	70
2007	55
Average	25

Source: Nebraska Energy Office, 2007.

Components of Ethanol Value

As indicated above, there are three components to the market value of ethanol: energy, additive, and subsidy. It is interesting to portray these values in terms of the relationship between crude oil price and the maximum a corn dry mill could afford to pay for corn at each crude price. To estimate such a relationship many assumptions were needed. These assumptions are detailed in Appendix A.

Figure 1 displays the relationships between crude oil price and break-even corn price on the basis of energy equivalence, energy equivalence plus additive value (assumed to be \$0.35/gal for this illustration), and energy equivalence plus additive value plus the current federal blending subsidy of \$0.51/gal. The energy equivalence line was developed assuming a figure of 70%, slightly more than the direct energy equivalent. Using Figure 1, one can trace out the break-even corn price for any given crude oil price. For example, with crude oil at \$60/bbl, the break-even corn price is \$4.72/bushel (bu) including both the additive premium and the fixed federal subsidy. This figure is for a new plant and includes 12% return on equity and 8% debt interest. If we consider an existing plant with capital already recovered, we add \$0.78/bu to yield a break-even corn price of \$5.50/bu. It is important to note that additive value is currently \$0.20 higher than the value assumed

Table 3: Sensitivity Analysis for Corn Breakeven Prices.

Sensitivity Case	Corn Breakeven with $60/bbl Crude Oil
Subsidy pass-through equal to $0.40 instead of $0.51	$4.37/bu
Additive value equal to $0.20 instead of $0.35	$4.25/bu
Additive value equal to $0.55 instead of $0.35	$5.35/bu
Ethanol priced equal to gasoline on a volumetric basis instead of energy basis with no supplemental additive value	$5.76/bu
Ethanol priced equal to gasoline on a volumetric basis instead of energy basis with $0.10 supplemental additive value	$6.08/bu

here, so ethanol producers can afford to pay another $0.53/bu under current market conditions.

Sensitivity Analysis

Any number of sensitivity analyses could be performed on the calculations contained in this paper. Table 3 provides results on some important sensitivity analyses, all assuming $60/bbl crude oil. First, suppose that not all the subsidy gets passed through to dry millers and to the corn price. The first sensitivity assumes the subsidy is effectively $0.40/gal instead of $0.51/gal. In other words, this assumes that not all the subsidy gets passed back to ethanol producers. The breakeven corn price with the fixed subsidy becomes $4.37/bu instead of $4.72/bu. Next suppose that the additive value is $0.20/gal instead of $0.35/gal. The corn breakeven price becomes $4.25/bu. With an additive value of $0.55, the corn breakeven becomes $5.35/bu. There is no doubt that ethanol has an additive value as an oxygenate and for octane, but it is impossible to predict what it will be as ethanol production increases beyond the needs for octane and added oxygen.

Another type of sensitivity would be to assume that ethanol might be priced equivalent to gasoline on a volumetric basis instead of energy basis. Some argue that in the long term refiners will choose to modify their refining process to produce a lower octane gasoline, say 84 octane, which could be blended at 10% ethanol to produce the standard 87 octane regular gasoline. We conducted two sensitivity analyses – one with the supplemental additive value at zero and one with the additive value at $0.20. With volumetric equivalent pricing and no additional additive value, the corn breakeven becomes $5.76/bu. With volumetric pricing and $0.10 additional additive value, the corn breakeven becomes $6.08/bu. In all these cases except the lower subsidy pass through and lower additive value, dry millers could afford to pay more for corn than in the base case. Other combinations of these cases could be done as well, but the approximate outcomes can be inferred from these results.

During most of the history of the federal ethanol subsidy, crude oil prices ranged between $20/bbl and $30/bbl. With crude oil price in that range, the fixed federal subsidy did not put significant pressure on corn prices. However, with crude oil today around $60/bbl, there is significant pressure on corn prices. Ethanol investments in the United States during the past two years have been highly profitable with

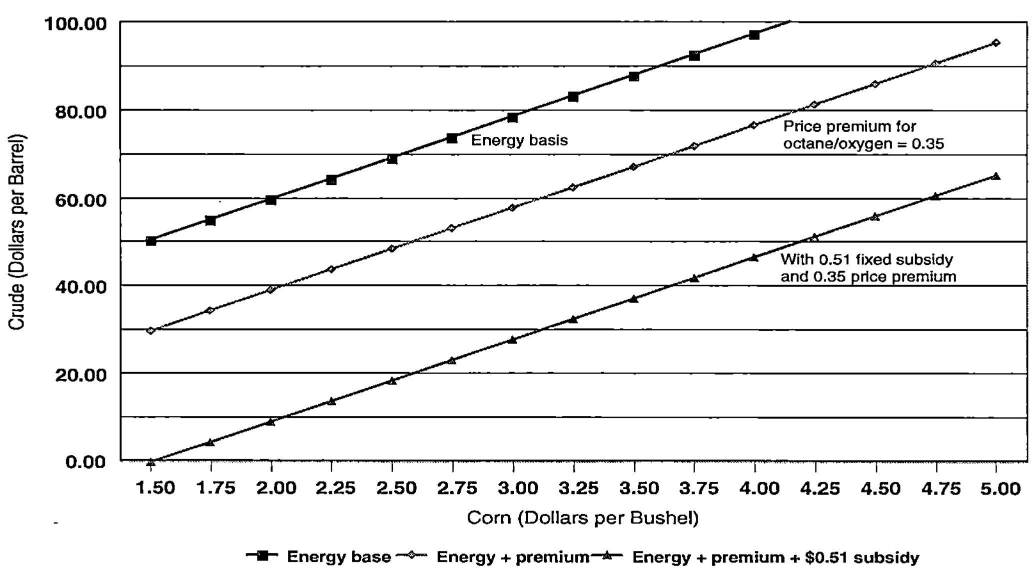

Figure 1: Breakeven Corn and Crude Prices with Ethanol Priced on Energy and Premium Bases Plus $0.51 Ethanol Subsidy.

payback periods as short as one year. This high profitability has attracted significant new investment in the industry as shown in Figure 2. Ethanol production grew 1 billion gal in 2005 and 2006 and is expected to grow 3 billion gal in 2007, a doubling in two years. It is expected to reach 11 billion gal in 2008. Because of this current and expected future growth in ethanol production, corn prices have skyrocketed in late 2006 and early 2007. In just a few months, prices are up from about \$2.25/bu to around \$4.00/bu, an increase of about 75%. This leap in corn prices is leading to an emerging opposition to ethanol subsidies on the part of animal agriculture, export markets, and other corn users. Some are also concerned about the \$4 billion cost of the subsidy in 2007.

Future Policy Alternatives

In essence, we are living an unintended consequence of the fixed ethanol subsidy. When it was created, no one could envision \$60/bbl oil, but today \$60/bbl oil is reality, and many believe oil prices are likely to remain high. So given this reality, what future federal policy options could be considered that would support the ethanol industry but provide less incentive for rapid growth in the industry leading to abnormally high corn prices? There are several possible policy alternatives that could be considered:

- Make no changes and let the other corn using sectors (particularly livestock) adjust as needed.

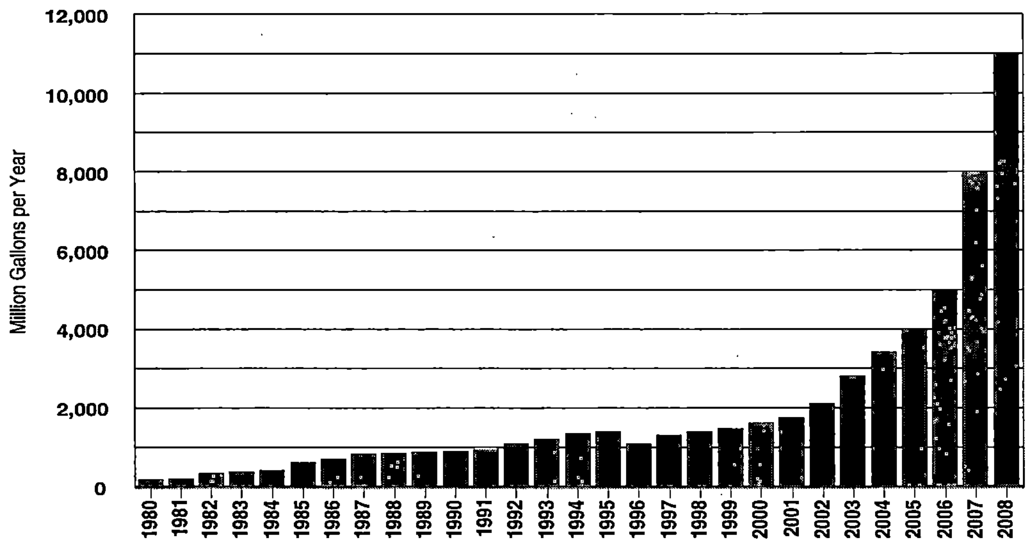

Figure 2: Ethanol Production, 1980-2008.

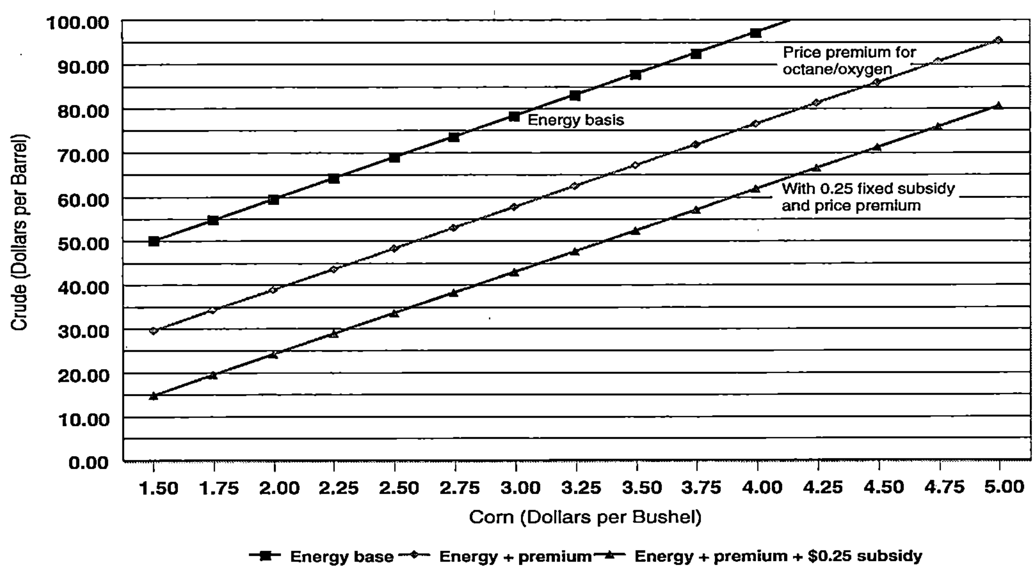

Figure 3: Breakeven Corn and Crude Prices with Ethanol Priced on Energy and Premium Bases Plus \$0.25 Ethanol Subsidy.

- Keep the subsidy fixed but reduce it to a level more in line with crude oil prices around $60/bbl.
- Convert the subsidy from a fixed subsidy to one that varies with the price of crude oil.
- Use an alternative fuel standard instead of subsidies to stimulate growth in production and use of alternative fuels.
- Use a combination of an alternative fuel standard and a variable subsidy.
- Provide higher subsidies for cellulose based ethanol in hopes of accelerating development and implementation of that technology.

No Changes

Certainly, one option is to do nothing – to let the other corn using sectors adjust to higher corn prices. But as can be seen from the results in the ethanol economics and sensitivity analyses sections above, that option could lead to substantially higher corn prices than we have seen historically. It certainly would lead to higher costs for the livestock industry (is happening already) and ultimately for consumers of livestock products. It also would lead to reduced corn exports. The breakeven corn prices provided above are maximums the ethanol industry could pay to retain profitability.

Whether these prices would be reached would depend on the rate of growth of the ethanol industry compared with the rate of growth of corn supply. The March planting intentions report revealed an expected corn planted acreage of 90.5 million acres, and increase of 15% over 2006. With that report, the high corn prices moderated somewhat. However, we can certainly expect to see continued pressure on corn prices if no change is made in federal subsidy policy.

Lower Fixed Subsidy

Since the current pressure on corn prices comes from the combination of $60/bbl oil and the $0.51/gal subsidy, one option would be to maintain a fixed subsidy but lower it to a level more in line with the higher oil price. Figure 3 depicts the corn breakeven prices with a $0.25/gal subsidy instead of the current $0.51/gal subsidy. The corn breakeven price for $60/bbl oil becomes $3.90/bu instead of $4.72/bu under current policy. However, the fixed subsidy still has the disadvantage of not responding to possible future changes in oil prices. If oil fell to $40/bbl, the corn breakeven would be $2.84/bu, and it would be $4.43/bu for $70/bbl oil.

Variable Subsidy

In designing a variable subsidy, there are two key parameters: the price of crude oil at which the subsidy begins, and the rate of change of the subsidy as crude oil price falls. We will illustrate the variable subsidy using $60/bbl crude as the point at which the subsidy begins. That is, when crude is higher than $60/bbl, there is no subsidy, but some level of subsidy exists for any crude oil price lower than $60/bbl. In this illustration, we will use a subsidy change value of $0.025/gal of ethanol for each dollar crude oil falls below $60/bbl. Thus, if crude oil were $50/bbl, the subsidy for ethanol would be $0.25 cents/gal. If crude oil were $40/bbl, the ethanol subsidy would be $0.50/gal. Therefore, for any crude oil price above $40/bbl, the ethanol subsidy would be lower than the current fixed subsidy. For any crude price less than $40/bbl, the subsidy would be greater than the current fixed subsidy of $0.51/gal.

Figure 4 illustrates the corn break-even price for different crude oil prices if this variable subsidy were in effect. In this

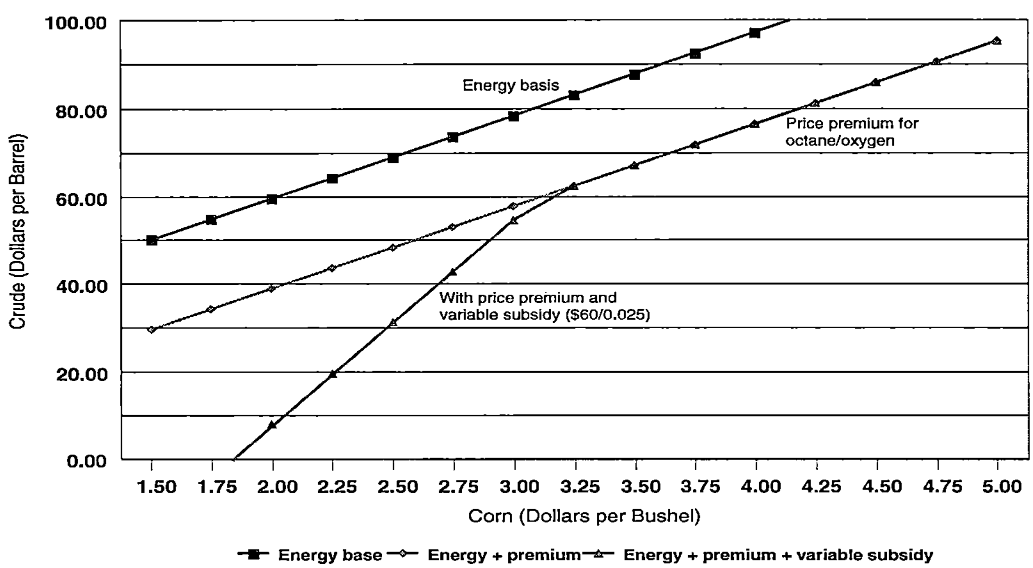

Figure 4: Breakeven Corn and Crude Prices with Ethanol Priced on Energy and Premium Bases Plus Variable Ethanol Subsidy.

case, the corn break-even price at $60/bbl oil for a new ethanol plant would be $3.12/bu, compared to $4.72/bu with the fixed subsidy shown in Figure 2. With oil at $50/bbl, the corn break-even would be $2.90/bu for a new plant with the variable subsidy. $40/bbl oil would support a corn price of $2.69/bu for a new plant and $3.47/bu for an existing plant with capital recovered. $70/bbl oil would yield a breakeven corn price of $3.65/bu with no ethanol subsidy. So the variable subsidy provides a safety net for ethanol producers without putting inordinate pressure on corn prices.

For any crude oil price above $60/bbl, there is no ethanol subsidy with the variable subsidy, so ethanol plant investment decisions are made based on market forces alone instead of being driven by the federal subsidy. For any crude price between $40/bbl and $60/bbl, the variable subsidy is less than the fixed subsidy thereby providing less incentive to invest and less pressure on corn prices, but maintaining a safety net. However, with the fixed subsidy, ethanol plant investment decisions continue to be heavily influenced by the government subsidy even at crude oil prices that render ethanol very profitable in the absence of a subsidy.

Alternative Fuel Standard

In his 2007 State of the Union message, President George W. Bush proposed a relatively large alternative fuel standard of 35 billion gal by 2017. That is roughly seven times current ethanol production. A fuel standard works very differently from a subsidy. It says to the industry that you must acquire a certain percentage of your fuel from alternative domestic sources. In President Bush's proposal, the sources could be renewable fuels, clean coal liquids or other domestic sources. With a fuel standard that is perceived to be iron-clad, the industry is required to procure these alternative fuels no matter what their cost in the market. Most of the change in cost of the fuels is passed on to consumers either through cheaper or more expensive fuel at the pump.[2] In other words, if crude oil is much cheaper than alternative fuels, consumers would pay more at the pump than they would in the absence of the standard. If it turns out that alternative fuels are less expensive than crude oil down the road, consumers would actually pay less at the pump. So, in a sense, an alternative fuel standard is a different form of variable subsidy – one in which consumers see a different price at the pump than they would without the standard. For either a fixed or variable subsidy, the cost of the incentive is paid through the government budget. For a standard, consumers do not pay through taxes but pay directly at the pump.

Figure 5 illustrates the functioning of an alternative fuel standard. The two lines represent $60/bbl and $80/bbl crude oil. The horizontal axis is the cost of the alternative fuel (unknown at this point), and the vertical axis is the percentage change in consumer fuel cost compared to the no standard case. Clearly in the left side of the graph with low alternative fuel costs, consumers see little or no change in fuel cost. But with high costs of alternative fuels (current state of technology), consumers could see significantly higher pump prices.

Alternative Fuel Standard Plus Variable Subsidy

In the event that crude oil prices turned out to be quite low, consumers could see significantly higher pump prices than without a standard. One option to limit the consumer exposure would be to combine a variable subsidy with a fuel

[2] Recent studies of the demand elasticity for gasoline (Hughes *et al.*, 2006) conclude that gasoline demand elasticity is very low (-0.03 – -0.08) and is lower than in previous time periods. With very low demand elasticity, most of the price change due to supply shifts would be passed on to consumers.

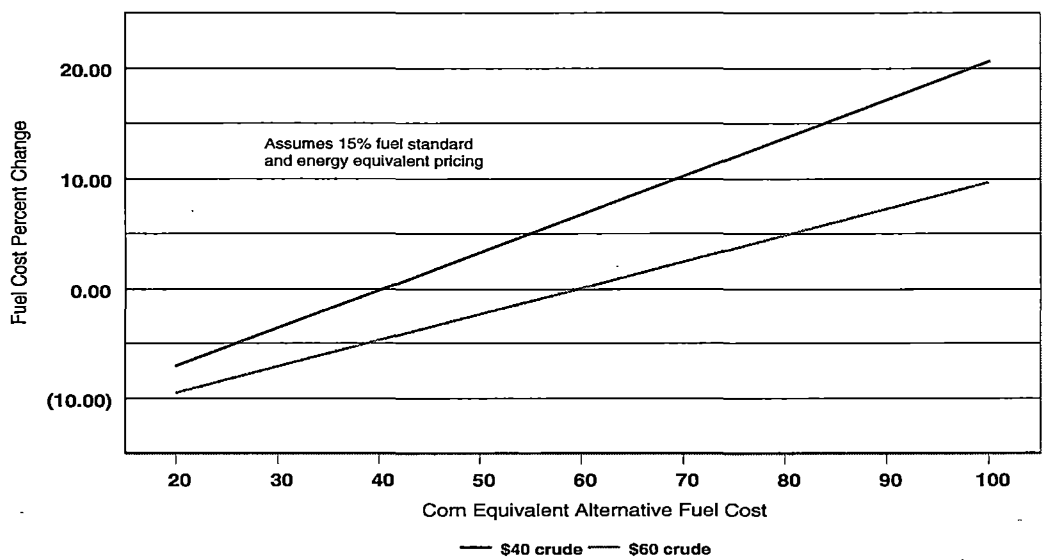

Figure 5: Fuel Cost Change from Fuel Standard.

standard. Essentially, there would be no subsidy unless crude oil prices fell below some predetermined level, say $45/bbl. Then a variable subsidy would kick in, which would limit the price increase consumers would see at the pump. In a sense it is a form of risk sharing so that in the event of very low oil prices, the government budget would take part of the hit instead of pump prices. This option is illustrated in Figure 6. In this case, the horizontal axis is crude oil price and the curve is done for a $60/bbl alternative fuel cost. The line on the left side that begins at $45/bbl crude illustrates the impact of the variable subsidy combined with the fuel standard.

Incentives for Cellulosic Ethanol

One of the issues with any of the subsidy systems discussed thus far is that they do not differentiate the source of the ethanol. However, cellulosic forms of ethanol promise to have favorable characteristics for both energy production and for environmental preservation (including carbon balance). Use of cellulose instead of corn kernels would also reduce the implications of ethanol production for corn exports and animal feed. If the state or federal government wants to provide incentives for the industry to move towards cellulose sources instead of corn, then targeted incentives might be appropriate. One method would be what is called a reverse auction. In that approach, the government requests that firms supply some fixed quantity of cellulosic ethanol for the next 10-15 years. Companies then bid for the contract to supply the ethanol with the lowest bidder winning the contract. Another option would be to provide a tax credit to cellulose processors for each dry ton of cellulose converted into fuels. With either of these alternatives, the government could assist in launching the cellulose-based industry. So long as corn-based ethanol is highly profitable, it will be difficult to stimulate investment in cellulose technology, because it is much more uncertain and at present more costly than corn-based ethanol production. Thus, targeted incentives might be needed.

Conclusions

Ethanol has been subsidized in the US since 1978, and the subsidy has ranged from $0.40/gal to $0.60/gal over that period. Currently the subsidy is $0.51/gal, and combined with $60/bbl oil, ethanol production has become highly profitable. This profitability has stimulated a huge increase in ethanol production capacity with 6 billion gal of new capacity under construction as of January 2007. This increase in ethanol production is increasing corn demand and prices. Under the current policy, ethanol producers could still invest profitably in new production with corn price as high as $4.72/bu. Other assumptions could yield substantially higher corn prices.

One option, clearly, is to make no change in current policy. With this alternative, the other corn using sectors such as livestock production and corn exports would be forced to make the needed adjustments. Less corn would be used in these sectors, and prices for all livestock products likely would increase.

If government is interested in reducing upward pressure on corn prices, alternatives to the current fixed $0.51/gal subsidy could be considered. One option would be to lower the fixed subsidy. This alternative would reduce the pressure on corn prices but would still provide ethanol subsidies under higher oil prices when they are not needed. It is also invariant to underlying market conditions.

A second option would be a variable subsidy that provided an ethanol subsidy, which changes with the crude oil

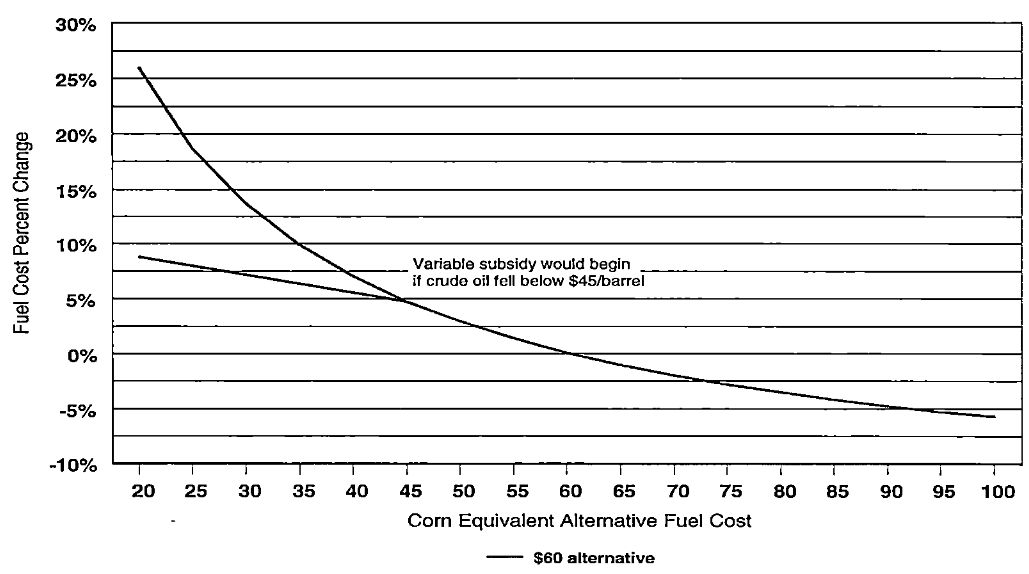

Figure 6: Cost of A Fuel Standard with a Variable Subsidy.

price. The option evaluated in this paper provided no subsidy for crude oil price above $60/bbl, and a subsidy that increased $0.025/gal for each dollar the crude price is below $60/bbl. This option yields a breakeven corn price for $60/bbl oil of $3.12/bu compared with $4.72/bu under the current policy.

Instead of continuing subsidies, another policy path would be to switch entirely to alternative fuel mandates. The mandate approach takes the cost of stimulating production and use of alternative fuels off the government budget and, instead, puts it directly on the pump price of liquid fuels. If the risk of high pump prices in the face of possible low oil prices is deemed unacceptable, another policy alternative would be an alternative fuel mandate combined with a variable subsidy that kicked in at very low oil prices. In that way, higher pump prices could be avoided if oil prices were quite low.

One of our policy challenges is to make the transition from corn based ethanol to cellulose based ethanol. To accomplish that, some incentives targeted exclusively at cellulose based ethanol may be needed.

What is very clear is that much work is needed in delineating the impacts of alternative policy pathways. This paper attempts to illustrate some of the alternatives that will need to be considered.

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Appendix

The link between crude oil price and breakeven corn price requires numerous assumptions. Following are the most important assumptions updated to November 2006:

1) **Relationship between crude oil price and gasoline price** – This relationship is given by the equation below:

   Wholesale gasoline price ($/gal.) = 0.1076 + 0.03127 × crude oil price ($/bbl).

   The data for this equation was monthly data 2000-2006 from EIA/DOE. However, longer and shorter time periods were tested, and the results are remarkably stable. The adjusted R^2 for the equation is 0.96, meaning that 96% of the variability in gasoline price over time is explained by changes in the crude oil price.

2) **Relationship between gasoline price and ethanol price** – The energy equivalent price of ethanol is assumed to be 70% of the gasoline price. That is slightly higher than the pure energy equivalence.

3) **Relationship between corn price and DDGS price** – DDGS price is a function of the prices of corn and soybean meal as follows:

   DDGS price ($/ton) = 11.70 + 0.254 × soybean meal price ($/ton) + 12.57 × corn price ($/bu).

   Substituting a price for soybean meal of $230/ton into this equation yields the equation used in the model:

   DDGS price ($/ton) = 70.12 + 12.57 × corn price ($/bu).

   All data is from USDA, monthly 2004-06. Illinois prices were used for corn and soybean meal, and Lawrenceburg, IN, for DDGS.

   It is assumed that 18 pounds of DDGS is produced per bushel of corn used.

4) **Ethanol yield per bushel of corn is assumed to be 2.65 gallons.** Newer plants may have higher yield, but this figure is close to the industry average.

5) **Capital cost for the plant is assumed to be $1.80/gal of capacity, which translates to about $0.29/gal produced.** Older plants had considerably lower capital cost, and much of the capital probably has already been paid off. The plant is assumed to operate at full capacity.

6) **Financial assumptions:**

   The plant is 40% equity and 60% debt finance.

   The debt interest rate is 8%, and the equity return is 12%.

7) **No value was assigned to the CO_2 produced.**

8) **Energy costs:**

   Natural gas price was estimated from a relationship with crude oil price given by the equation below:

   Industrial natural gas price ($/milion Btu) = 2.619 + 0.1 × crude oil price ($/bbl)

   The data for this equation was monthly data from DOE/EIA for 2001-06. The adjusted R^2 for this equation is 0.51.

LP	$1.20/gal
Electricity	$0.06/kWh
Total energy	$0.370/gal of ethanol for $60/bbl crude oil

9) **Other costs (assuming $60/bbl crude oil):**

Chemical and enzyme costs	$0.23/gal of ethanol
Other processing costs	$0.09/gal of ethanol

   Non-corn operating costs total $0.69/gal of ethanol for $60/bbl crude oil.

Given these assumed relationships and values, the Tiffany/Eidman (University of Minnesota) spreadsheet model (Tiffany and Eidman, 2003) of a dry-mill ethanol plant was used to calculate profitability and thus derive the breakeven prices. Breakeven was assumed to be the point of zero economic profit; that is, it includes the payment of debt and stipulated return on equity. Clearly, any of these assumptions and values could be modified in the future as conditions change.

Sources: (Hurt *et al.*, 2006) and authors calculations.