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Grain Ethanol - Why Consider Food for Fuel?

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In a scant eighteen months, grain ethanol production has doubled, and this year ethanol plants will consume about 30% of the country's corn crop. This dramatic emergence has sent shock waves through agricultural markets, and has generated both public acclaim as a clean energy alternative and public excoriation as a colossally expensive, polluting, policy boondoggle. The purpose of this presentation is to marshal some facts about the industry to help place it perspective so as to help in evaluate its potential impacts.

Because public policies are at the heart of debates about grain ethanol, I will first recount arguments for and against ethanol policies to increase ethanol production, then outline some industry trends and prospects, and finally, offer some evaluation of claims made for and against ethanol.

ARGUMENTS *FOR* POLICIES TO INCREASE ETHANOL PRODUCTION

Ethanol was sold in some Midwest gas stations during the 1930's, promoted as a way to improve farm incomes by increasing the demand for corn that was selling for virtually nothing. The current ethanol promotion policies have more recent roots – the oil crises of the 1970's. Changes in policies since 2000 would not have been enacted without the concern about climate change - carbon dioxide building up in the atmosphere. These concerns remain today, which we can summarize as arguments offered in support of policies to increase ethanol production:

1. Reduce greenhouse gas (GHG) emissions
2. Increase energy security - reduce petroleum imports
3. Promote rural development
4. Reduce federal farm supports - support farm prices

ARGUMENTS *AGAINST* POLICIES TO INCREASE ETHANOL PRODUCTION

Two years ago, very few of us anticipated the effects of the ethanol boom, nor had the debate about the merits of ethanol been at all in the public eye. As of one year ago, the public began to be aware of the potential benefits of ethanol, as described above. During 2008, however, those who perceived potential hazards of expanded grain ethanol

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began to get their messages out to the public, also. These concerns can be summarized as follows:

1. Converting grain to ethanol will drive up food prices
2. Intensified crop production will deteriorate environmental resources
3. Grain ethanol won't reduce greenhouse gasses very much, if at all
4. Ethanol will increase smog in heavy traffic environments
5. There are more efficient policies to achieve the objectives listed above

POLICIES THAT INCREASE ETHANOL PRODUCTION

The most significant US policy supporting increased grain ethanol production is the Volumetric Ethanol Excise Tax Credit (VEET), a federal tax credit of $0.51 per gallon of ethanol blended for vehicle fuel. A number of smaller federal subsidies are available, both for production, such as the $.20/gal small ethanol producer subsidy (available only to plants producing 60 million gallons per year (mgy), and only for the first 20 mgy), and loans and grants to assist the organization and construction of new plants. In addition, ethanol imports except those from Carribbean countries are subject to a $0.54/gal import tax.

A number of Midwestern states have offered direct production subsidies, such as Nebraska's EPIC program that offered first $0.20/g and then $0.18/g subsidies for limited amounts of production for specified periods to plants that qualified.

Another type of policy consists of mandated uses of ethanol. Federal clean air standards mandate the use of ethanol blends to combat air pollution in some congested areas at some times during the year. Even more significantly, both state and federal mandates have prohibited the use of MTBE as an oxygenate, and ethanol has been the fuel of choice to replace it. The MTBE bans and related market disruptions, in fact, were responsible for the very high prices of ethanol during 2006, when ethanol production capacity was insufficient to replace MTBE reductions. Now that the MTBE phase-out is essentially complete, however, ethanol competes with gasoline on the basis of its energy value alone, which is only 67% of that of gasoline. We should not expect to see ethanol priced higher than 67% of premium gasoline unless production is insufficient in the future to meet state-mandated low-carbon fuel requirements.

We can summarize policies that have stimulated increased grain ethanol production in the US as follows:

1. A $0.51/gallon federal VEET subsidy
2. A $0.20/gallon federal small ethanol producer subsidy
3. Tariff protection - $0.54/gallon (except Caribbean area)
4. State subsidies
5. Federal and state mandates

In the remainder of this paper, we will focus on VEET costs, as it has the most significant budget impact, though it is by no means the only policy. It hardly needs to be added, but petroleum prices in the vicinity of $100 per barrel have had stimulating effects as well, but my concern here is to outline the public policy debate.

ETHANOL INDUSTRY TRENDS AND PROSPECTS

The development of the industry in response to these policies is charted in Figures 1 and 2 below (projections are based on current plants plus plants currently under construction.) There was only a slight increase in capacity between 1980 and 2000, but then low corn prices and ethanol subsidies began to show their effect. Then between 2003 and 2004, oil prices doubled, and the Energy Act of 2005 liberalized the VEET subsidy and mandated that 7.5 billion gallons of renewable fuels must be used by 2012. These events plus the state MTBE replacement mandates set the stage for the steep expansion in capacity that is still coming on line in 2008.

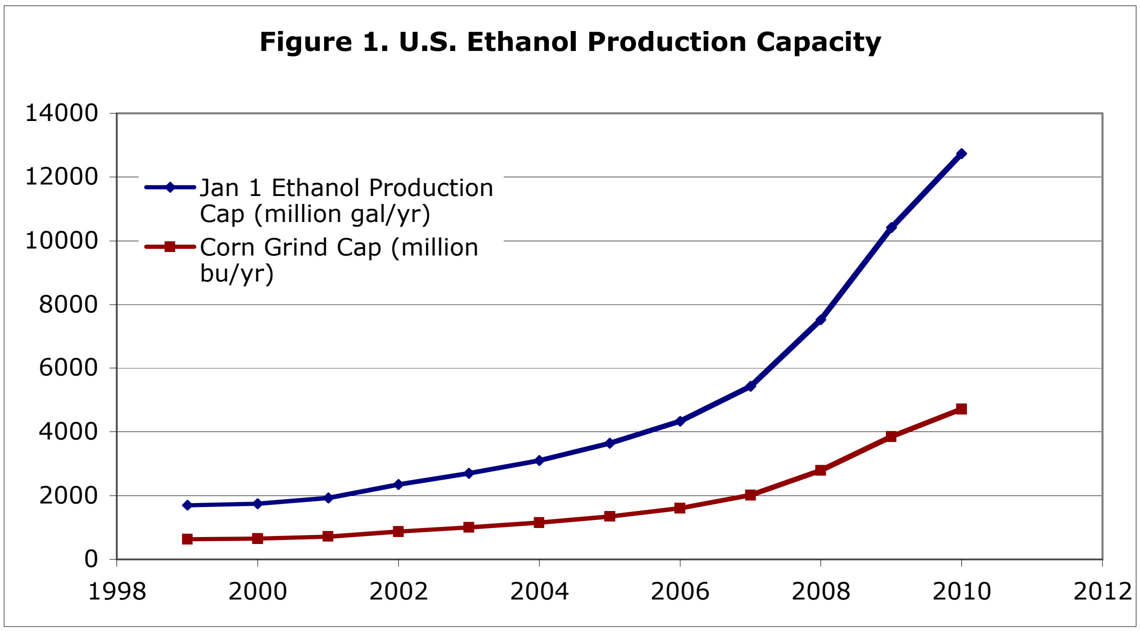
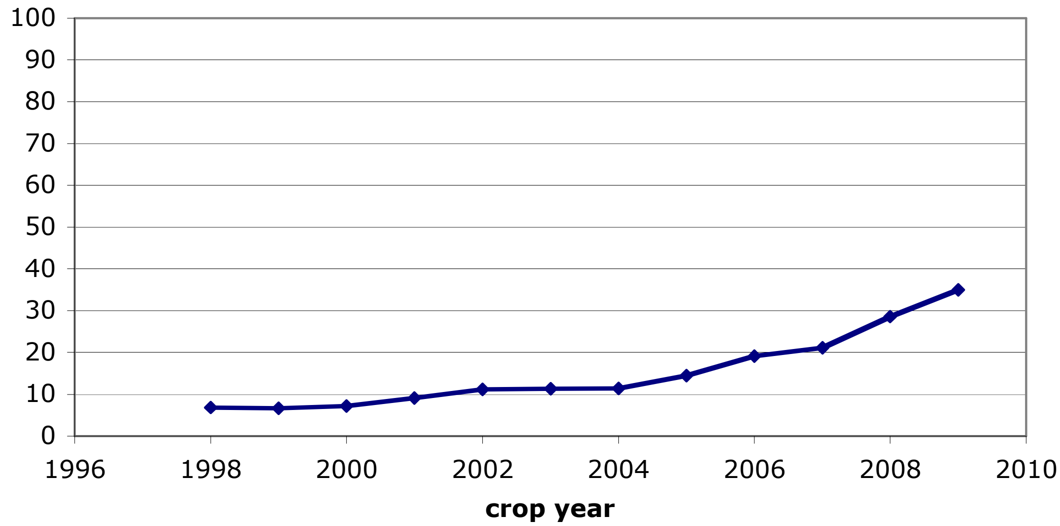
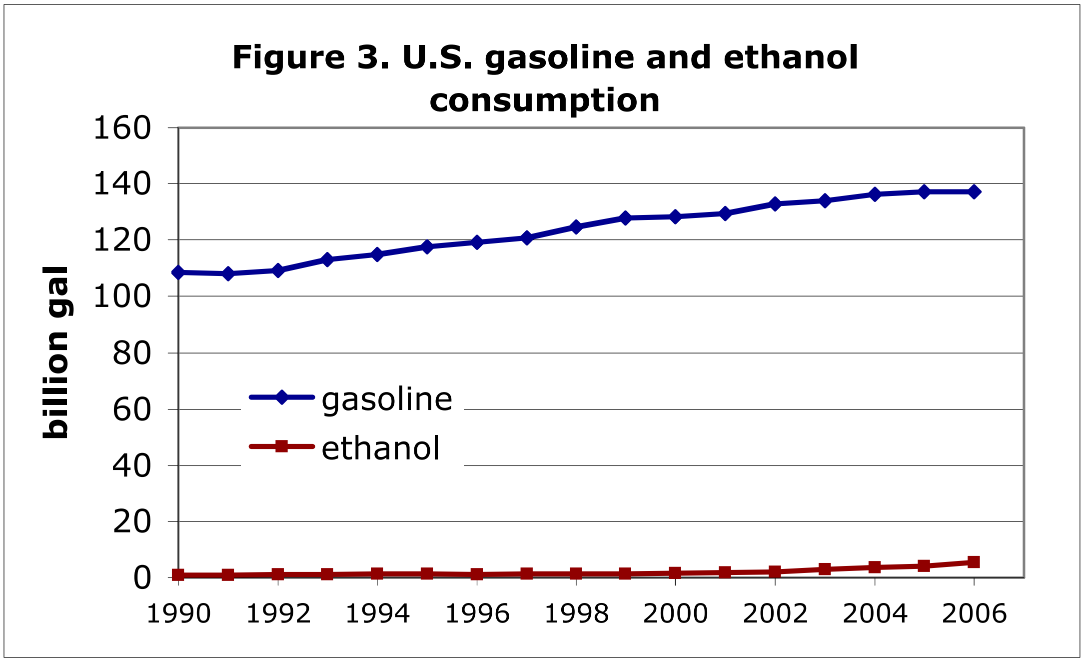


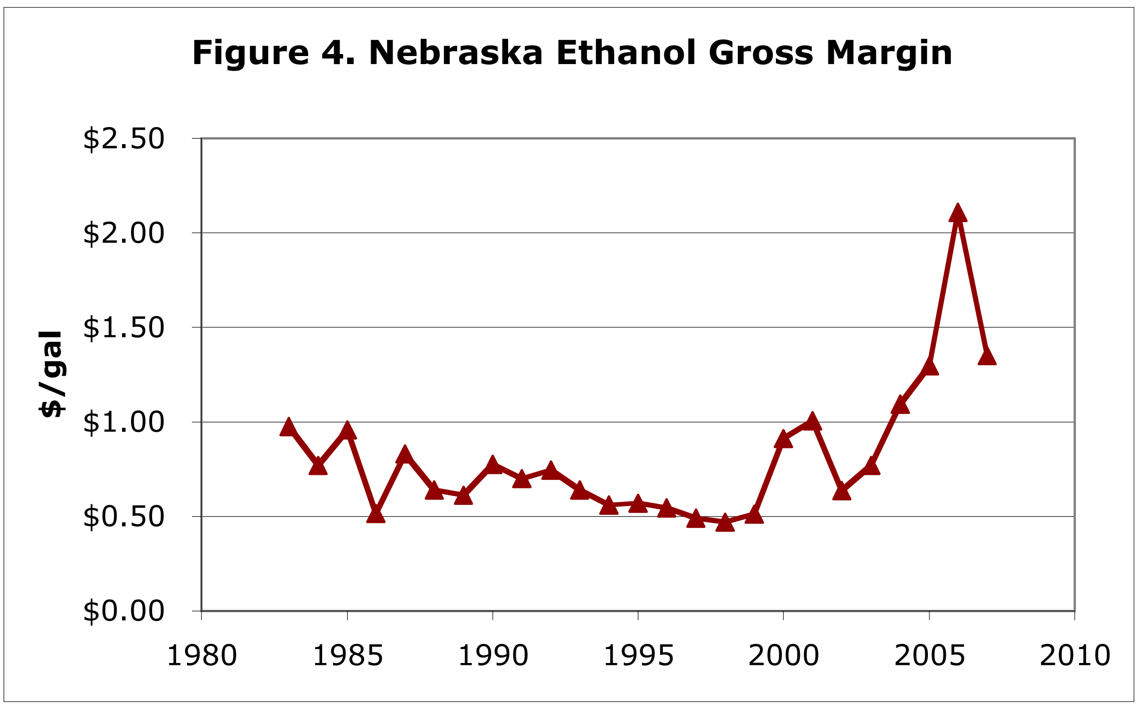
Figure 2. U.S. Grind Capacity as Percent of Corn Crop



Despite these dramatic increases, ethanol still remains a small portion of the motor fuel market, however, as is illustrated by Figure 3.



The gross processing margin for ethanol (Figure 4) reflects the results of policies and other factors on expansion incentives. The gross margin is defined here as the



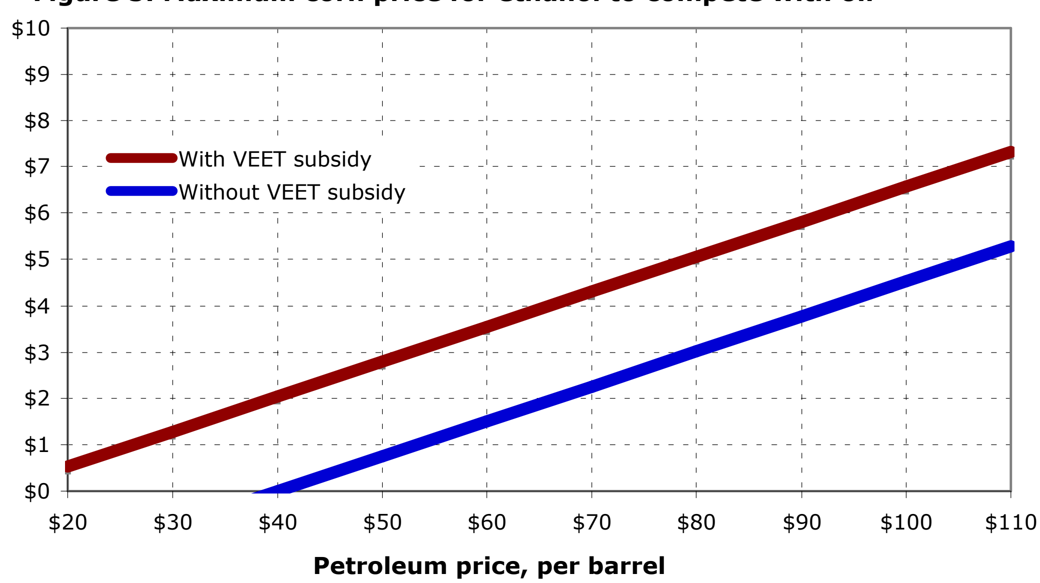
wholesale value of ethanol (the rack price) minus the cost of ¼ bushel of corn. The rationale behind this is that while one bushel of corn produces about 2.8 gallons of ethanol (0.357 bu/gal), one third of this corn is returned to the feed market at about the same value as corn itself, so the plant must withdraw and pay for only 0.249 bu/gal.

As shown in Figure 4, the margin exceeded $2.00/gal in 2006. To put that level in perspective, the construction costs at that time were considered to be about $1.25 per gallon of annual capacity, and processing costs were in the vicinity of $0.55/gal. Thus, a plant in full operation during 2006 would very likely have been able to pay off the full costs of constructing and operating the plant during just that one year of operation. This was a powerful incentive for further expansion. Due to much lower prices of ethanol and much higher prices for corn, the gross margin fell back below $1.50 in 2007.

Future expansion will continue to depend upon the outlook for the gross margin. Because corn ethanol will always be a small component of the motor fuel market (the ethanol from the *entire* corn crop would replace only about 17% of gasoline consumption), ethanol price will be determined by gasoline price, not the other way around. Since ethanol's energy value is but 67% of gasoline, and its price will reflect that, as it does in Brazil where ethanol use is more mature. Gasoline price, in turn, will be determined by world petroleum price. Thus the maximum price that ethanol plants can pay for corn will be determined by petroleum price. If the price of corn were to persist below its value for fuel, ethanol production will be profitable and thus more plants will be built until the price is driven up close to that value. Over the next decade, then, petroleum price will tend to determine the price of corn.

The arithmetic of this logic allows us to chart the long-run relationship between the price of petroleum and the price of corn, as shown in Figure 5.

Figure 5. Maximum corn price for ethanol to compete with oil



The arithmetic of this chart is as follows. The maximum price plants can pay for a bushel of corn is 4 times the value of a gallon of ethanol (since each gallon requires ¼

bushel of corn), less about $0.80/gal production cost. (Processing and capital costs are about $0.55 and $0.30 per gallon, respectively.) Ethanol rack price should be about 66% of premium gasoline (premium because ethanol has a high octane rating), plus the VEET of $.51/g, since the VEET subsidy is paid to the person who purchases the ethanol at the rack for blending with gasoline. We have found by regression analysis of past average annual prices that the wholesale price of premium gasoline has been equal to $0.145+0.0286 times the price of petroleum. Putting these numbers together, with and without VEET, yields Figure 5.

Hence we should expect that if oil were to persist in the vicinity of $90-$100, plants will be built until corn price is driven to the level of $6/bu, or $4/bu if VEET were eliminated. Currently, ethanol is using 30% of the crop. How much of the corn crop would it take for ethanol to sustain corn prices at levels of $4 or $6? It is difficult to say, but given that current prices are around $4 the capacity already in place is probably sufficient to support sustained corn prices at $4/bu. But how much more of the crop it would take to drive the price to $6/bu, we really are unable to predict.

COST EFFECTIVENESS OF ETHANOL POLICIES

We do not have any clear criteria to evaluate whether the benefits and side costs of more ethanol are worth the treasury cost to implement them. What I will do here is consider what we have achieved with policies, then calculate the simple VEET treasury cost per unit of achievement so far as I can. This is a very rudimentary cost-effectiveness analysis. First, it is a bit clumsy because we cannot allocate the VEET cost among the various objectives listed above – but we can attribute the entire cost to each objective sequentially to get a sense of cost effectiveness. Second, the VEET budget cost is a very incomplete measure of true social costs of the policies. For one reason, the subsidy includes transfers from taxpayers to people in the ethanol industry, which is a transfer but not a true loss to society. Secondly, current consumers of grain suffer losses due to higher grain prices, but the dollar value of those losses must in theory always be smaller than the gains to producers (basically, food users of grain pay a higher price for only a portion of the crop, while producers receive the higher price for the entire crop.) However, we cannot really say that the value of a dollar lost by a consumer (who may be poor) is offset by a dollar gained by a producer (who may be rich – or vice-versa.)

Greenhouse gas cost effectiveness

Greenhouse gasses are those that contribute to global warming. The most important of these is the carbon dioxide (CO_2) that we pump from the ground into the air when we burn fossil fuels - oil, coal and natural gas. Therefore it is common to measure the effectiveness of greenhouse gas policies in terms of the reduction in the number of tons of fossil CO_2 emitted. This is not easy to measure. All of the CO_2 released when ethanol is burned is CO_2 that was taken out of the atmosphere by plants, so in that sense ethanol is carbon-neutral. However, we do burn fossil fuels in the process of producing ethanol, natural gas in the ethanol plant, the fertilizer we put on corn, etc., so what we must measure is the "life-cycle" carbon neutrality of ethanol. This is done by estimating the amount of fossil CO_2 used in the entire ethanol production chain. Because this amount varies depending upon corn production practices and ethanol plant technology,

estimates vary and are hotly disputed.

Table 1 below uses some commonly-accepted estimates for measuring

Table 1. CO2 from fossil sources

	unit	
	liter	gallon
1. Fossil CO2 released in burning gasoline (kg)	2.93	11.30
2. Fossil CO2 released in producing a unit of ethanol (kg)*	1.61	6.20
3. adjusted(.676) for energy in gasoline (kg)	2.38	9.18
4. Fossil CO2 reduction, substituting ethanol for a unit of gasoline, (1)-(3)	0.55	2.13
5. VEET cost per Mg fossil CO2 reduced, $0.51*1000/(4)		$355

*Farrell, et al. intermediate ("Today") level

the carbon-intensity of ethanol. Gasoline as burned is estimated to release 11.30kg of CO_2 per gallon. The amount of ethanol required to replace its energy (1.5 gal) estimated to have required 9.18kg of CO_2, so when 1.5 gallons of ethanol replaces 1 gallon of gasoline, 2.13kg less fossil CO_2 is released, a reduction of about 20%. Given the VEET treasury cost of $0.51/gal, this converts to about $355 per metric ton of fossil CO_2 reduced.

To put this number in perspective, it has been estimated by the Intergovernmental Panel on Climate Chang that a carbon price of as little as $20/ton of CO_2 would be sufficient to reduce greenhouse gasses to acceptable levels, while current carbon exchange markets value it at $2/ton in the US and up to $20/ton in the EU. We can conclude that treasury cost of VEET for just the purpose of reducing fossil CO_2 is exorbitantly high. But other objectives are met as well, so we now consider them.

Energy security cost effectiveness

Petroleum imports in recent years have been about 5 billion bbl/yr. As noted above, current ethanol production capacity is about 7.5 billion gallons, or 178 million bbl/yr. Thus, current ethanol production replaces about 3.5% of petroleum imports. If the entire corn crop were converted to ethanol, it would allow us to reduce imports by only about 10%, so ethanol alone will not do much for energy independence.

The VEET cost of ethanol is equivalent to about $21/bbl. Is this a reasonable price? I don't think we know what the social value of energy independence is, but at this rate, to eliminate all imports it would cost us about $100 billion per year (perhaps cheaper than war.) Bear in mind that in addition to VEET, we must also pay the cost of producing the ethanol, which with $4/bu corn, is about $75/bbl. Calculated in this way, the total cost of a barrel of ethanol is about the same as we are paying for a barrel of imported oil. If ethanol costs us no more than imported oil, it’s a good proposition except for the fact that total ethanol quantities can barely make a dent on imports.

Rural development cost effectiveness

Most ethanol plants have been located in small communities. The new jobs

created, approximately one plant job for every two million gallons per year of capacity, can make a very significant contribution to rural development. Construction jobs are even more significant, but the construction period lasts only 2-3 years. The VEET cost for two million gallons of ethanol per year is $1 million per year, not a very cost effective way to create a job. But additional considerations can be introduced to either increase or decrease this measure of impact.

On the impact enhancement side, the existence of the plant does increase corn prices, thus increasing farm incomes which has some effect on rural development. More significantly, the persons who hold the new ethanol plant jobs will spend their incomes on haircuts, groceries and other local services, and these expenditures create additional new jobs and economic activity. Peters estimates that that under current economic conditions a 100 mgy plant adds 168 new jobs and generates $31.7 million in new value added economic activity to the local economy. Under this scenario, the VEET cost falls to "only" about $300,000 per year per job – still not very cost effective.

On the impact reduction side, one must ask about the previous status of the workers in these new jobs. If they were totally unemployed, then calculations of the type in the previous paragraph are appropriate. But if they left other jobs to take the new jobs, then the calculated number of new jobs is too high – one job is lost, one job is gained, and it is theoretically possible (not likely in practice) that the net number of new jobs is zero. Furthermore, since some employees may commute from another community, a substantial portion of the economic impact may occur well beyond the bounds of the local community. To my knowledge, there have not yet been any studies that have attempted to calculate empirically the economic impact of an ethanol plant on the local economy. But it seems clear that one cannot possibly justify the VEET policy on the basis of rural development alone.

Farm support cost effectiveness

At first glance, one might expect the farm lobby to be supportive of ethanol policies, and politically, this has been true. However, the livestock industry is heavily penalized by high grain prices, at least in the short run. Most federal farm program expenditures, on the other hand, have been made on behalf of grain producers, and it is clear that they have benefited immensely, as US crop prices are up 75-100% from two years ago, and are taking an additional significant jump at this writing. Most market analysts concur that current high prices are not the result of the ethanol boom alone, but ethanol clearly has played a major role.

It does seem likely that ethanol alone would have increased prices sufficiently to eliminate counter-cyclical and load deficiency payments to grain producers, which averaged $5.2 billion per year from 2003 to 2006. The 2007 treasury cost of VEET was about $3 billion, so a $5 billion reduction in other treasury costs results in a benefit of $1.60 per dollar of VEET expenditure. But as VEET costs increase to a likely level of $6-7 billion in the next few years, cost effectiveness falls from $1.60 benefit to $0.75 benefit per dollar of VEET expenditure. The benefits of ethanol subsidies in terms of reduced farm program payments is substantial, because ethanol-induced price increases of only 15-20% would be sufficient to eliminate the $5 billion in federal farm payments described.

The cost to food consumers

Obviously, when ethanol demand drives up the price of grain, the price consumers pay for food must eventually go up, as well. But, by how much? That depends partly on how much the price of grain is driven up, and partly on the value share of the raw grain in the consumers' food basket.

USDA analysis (USDAa) suggests that corn prices will be 65% higher when enough corn is used to produce 12 billion gallons of ethanol per year. Iowa State's CARD analysis (Tokgoz) indicates that corn price will be up by 75% if 14.8 billion gallons per year are produced, and that this will cause US consumer prices of all food to rise by 2%, and the price of meat to rise by 5-10%. (Grain prices in January, 2008, are more than 100% higher than summer, 2006, prior to the ethanol boom, but this probably indicates that other factors are in play to drive prices so high.)

While there is much speculation and a few anecdotes about the effect of grain ethanol on food prices elsewhere in the world, I have not seen any careful analyses of that. But some arithmetic can help estimate this, as shown in Table 2.

Table 2. Effects of grain price increases on US vs third-world consumers

	USA	world's most food insecure
grain as % of all food	5%	30%
food as % of income	10%	70%
grain as % of income	0.5%	21%
income equivalent of a grain price increase of: 100%	0.5%	21%

Sources: USDA(b), Ahmed.

Considering the US first, the farm value of grain used to produce the consumers' food basket is about 5% of the basket value, and food expenditures average about 10% of consumer income. Therefore a 100% increase in grain price would increase food cost by about 5%, and this would be equivalent to about 0.5% of consumer income – not really very significant to US consumers. Considering the worlds' food insecure population, however, the value of grain in the consumers' food basket is about 30% , and food expenditures are about 70% of consumer income. In this case, doubling grain prices would increase food cost about 30%, which is equivalent to about 21% of those consumers' incomes.

Clearly, a doubling of grain prices means little to developed-country consumers, but could be a very difficult blow for the world's most food insecure consumers. On the other hand, many of the world's poor are grain *producers*, and as opposed to urban poor, they will *gain* from higher prices. The extent to which the world's poorest are producers versus consumers of grain will determine whether they are gainers or losers from any ethanol-induced grain price increases.

The cost in environmental degradation

As the ethanol industry drives up grain prices, farmers respond by increasing acres devoted to grain crops and by increasing inputs on each acre to raise grain yields.

Both of these responses pose threats to the environment. Higher fertilizer and pesticide levels will be used, which will likely, but not necessarily, result in more of such chemicals in the groundwater and in rivers. In the US, new land converted to grain production will be lands that are marginal row-crop lands because of slopes that are too steep, soil that is too rocky or otherwise undesirable, too little moisture, etc. Potential environmental impacts of converting these lands to grain production include increased soil erosion, increased chemical runoff and greater extraction of ground and surface waters for irrigation. In other parts of the world, new cropland will be carved from tropical forests, which will entail the same kinds of environmental threats as in the US, but will have more serious consequences for fragile ecosystems and will likely reduce the amount of CO_2 that is sequestered in those ecosystems, thus offsetting some of the greenhouse gas benefits of grain ethanol.

These environmental costs may be quite significant without policy steps to ameliorate them. But the costs are difficult to evaluate quantitatively, and I have not seen an attempt to do so. These costs can be limited with appropriate agronomic practices, such as conservation tillage, precision application of chemicals, etc., but to the extent that these practices are more expensive for farmers to employ, they are not likely to be widely adopted without some incentives or regulations to encourage them.

The cost in ground-level air pollution

A recent study by Jacobsen (2007) suggests that ground-level air quality might suffer with widespread use of ethanol as a motor fuel. This study is based on measurements that have shown that flex-fuel vehicles burning E85 produce higher emissions of some smog-producing compounds than the gasoline the ethanol would replace. The study used an atmospheric computer simulation model to evaluate the likely chemical effect of 100% use of E85 in the US. Results from epidemiological studies were used to estimate the impact of these chemical changes on health. The results indicated an increase of 4% in ozone-related mortality in the US. While this research represents a heroic computational effort, one must question its relevance, since even under the new federal mandates for biofuel use, only 35% of gasoline is to be replaced by biofuels, with less than half of that to be ethanol from grain.

Alternatives to grain ethanol policy

We have listed a number of objectives supported by increased ethanol use: greenhouse gas reduction, energy independence, rural development and support of farmers. The most obvious alternative policies to reduce greenhouse gases and energy imports are to penalize their use directly with taxes on fossil carbon and petroleum imports. These taxes would increase fuel costs for Americans, and politicians so far have decided that it is more popular to increase indirect taxes and costs instead, even though virtually all economists agree that the direct taxes would be more efficient. European consumers have for decades been paying fuel taxes that double their fuel price as compared to ours, and they have responded by purchasing vehicles with fuel efficiencies that are also approximately double those of US consumers. If we had done the same, and had by now achieved a doubling of our fleet mileage, the reduction in gasoline consumption would be almost exactly equal to the current level of imports.

A carbon tax would also stimulate ethanol production, with rural development and

farm support benefits as described above. If a carbon tax doubled gasoline prices, it would also double the price that consumers are willing to pay for ethanol (now approximately $1.70/gal) which is a greater price incentive than the $0.51/gallon VEET now provides. Such a high carbon tax would not be enacted, but this calculation establishes the potential impact.

Alternative policies that would effectively stimulate rural development are difficult to identify. As for supporting farmers or farm prices, the $6-7 billion cost of VEET seems to be a bargain if it is responsible for even half of the recent increase in farm prices, because that extra farm income would far exceed the $5 billion transferred to farmers via the counter-cyclical and loan deficiency components of the current farm program.

SUMMARY

Why should US policy support the use of grain for ethanol? Grain ethanol production is very limited relative to total energy consumption, so it cannot have a very big greenhouse gas impact, and it cannot contribute much to energy security. The VEET cost per rural job created is prohibitively high. Diverting 40% to 50% of U.S. corn production to ethanol will drive up world food prices, perhaps at considerable pain to the poorer consumers of the world. And expanded grain production will pose additional environmental hazards in terms of erosion, water use and water quality.

On the other hand, VEET, the primary component of ethanol policy, has low treasury cost – the current cost of about $3 billion per year will grow at most to $7-8 billion per year if ethanol production reaches 14-16 billion gallons per year (using 40-45% of the current level of corn production.) Federal farm program payments of $5 billion per year to grain producers under the current farm program have been eliminated for the foreseeable future, even though I think the current level of grain prices is not the result of ethanol alone. Thus the ultimate net treasury cost of VEET can be argued to be only $2 billion. Carbon reductions due to ethanol, valued at $20 per metric ton, are only worth $0.3 billion.

It is hard to place a value on rural jobs and reducing petroleum imports, but at a net treasury cost of $2 billion, the cost is still over $200,000 per plant job, or about $8 per barrel of reduced imports. Increased food costs to the poor, even though they are exceeded in dollar value by increased revenues to producers, represent another cost difficult to quantify. Given these calculations and observations, the VEET program is barely defensible, even considering the treasury benefits of reduced farm program payments. It is not defensible at all as compared to carbon and import taxes that would directly and more efficiently reduce fossil carbon emissions and petroleum imports. But these taxes seem not to be politically feasible at the moment, so perhaps VEET is a second-best solution for making some headway on climate change and energy security objectives.

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