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Model of the US Ethanol Market

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FAPRI–MU model of the United States Ethanol Market

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I. Introduction

The United States ethanol market has become an epicenter of shocks to agricultural commodity markets and a focal point of farm policy that defies precise quantitative analysis. The modeling framework developed by researchers at the Food and Agricultural Policy Research Institute (FAPRI) at the University of Missouri–Columbia (MU) discussed here estimates the effects of public policy options and external conditions on ethanol and agricultural commodity markets, farm income and government costs. Analysis that uses this model to estimate the effects of various policies is available on the Web at: www.fapri.missouri.edu.

FAPRI–MU models represent supplies and demands of major US agricultural commodities and have been used in applied economic research for two and a half decades. These base models represent most crop and livestock markets, input costs and retail prices, farm income and government costs. The principle use of these models is to enhance decision making at a national level through experiments that test the effect of policy changes on markets and, through the market effects, on farmers and consumers. In all cases, FAPRI–MU provides objective analysis through results described strictly in terms of quantitative output of the models.

The model structure and parameterization reflect the objectives of the exercise. The focus is on forward-looking analysis. In the case of the US ethanol market, historical data may not always give sufficient insight. Such data may be scarce and, due to important changes in the market, may even be irrelevant. As a consequence, in this case in particular, the model is grounded on the most recently available data along with industry advice about economic and technical relationships. These sources may be given precedence over statistically estimated equations that are based on time series of data.

FAPRI–MU recognizes the likelihood for varying market conditions to affect the outcome of policy analysis by undertaking partially stochastic simulations. In practice, the model is simulated 500 times for 500 different sets of random shocks. Random inputs include yield shocks and trends; perturbations in key demand equations, both domestic uses and exports; and energy prices. In the case of ethanol, however, certain key assumptions are uncertain, but are not varied in partially stochastic simulation. A key unknown parameter is how consumer adoption of ethanol responds to relative ethanol-to-gasoline prices. The model summary and treatment of this particular unknown element proceeds as follows. First, the model structure is summarized. Second, the link between relative prices and consumer adoption of ethanol is varied to investigate sensitivity.

II. Model structure[1]

The following description of the model is intended to convey the general structure. The focus is on variables relating directly to ethanol and corn markets. For example, price indices that deflate terms, and consequently ensure homogeneity with respect to price changes, are omitted. The description also omits the links to the broader FAPRI–MU commodity models.

Definitions and sources of the data are provided in an appendix.

II.A. Ethanol domestic supply

Dry and wet mills produce ethanol from corn. Dry mills also produce distillers grains and solubles (DGS) as an important coproduct. Wet or dried DGS are frequently sold for use as an animal feed. Wet milling coproducts include corn oil, corn gluten feed, and corn gluten meal. Ethanol plant costs and returns are based on USDA estimates.[2] In considering the supply of ethanol, the role of capacity building, or overhang, are found to be important characteristics of possible market outcomes following a policy shock.

Supply of ethanol from dry mills at any time (*t*) depends on dry mill net returns per bushel (NRT), which are expressed on a per bushel of corn basis as

(1) $NRT_t = WETHP_t * ETYLD_t + DGP_t * DGYLD_t / 2000 - CORNP_t - NATP_t - OVC_t$.

Returns are the sum of revenues from ethanol and DGS. Ethanol revenues are the product of the wholesale ethanol price (*WETHP*) and the number of gallons of ethanol per bushel (*ETYLD*). DGS revenue is the price of dried DGS on a per-pound basis (*DGP*) multiplied by the amount of dried DGS coproduced in terms of pounds per bushel (*DGYLD*). The product is consequently coproduct revenue per bushel of corn used to make ethanol, so it can be added to the other variables of the equation. The costs of a dry mill consist of the corn price (*CORNP*), the natural gas expense per bushel of corn (*NATP*) and the other costs of conversion per bushel (*OVC*).

The capacity represents an important and largely fixed determinant of supply in any given year, no matter how large or small net returns may be. The capacity is given by

(2) $CAP_t = f(NRT_t, NRT_{t-1}, NRT_{t-2}, NRT_{t-3}, NRT_{t-4}, CAP_{t-1}, CAP_{t-10})$.

In practice, the added capacity is a linear function of net returns over five periods, including the current year.[3] The elasticity with respect to current year net returns is very low because there is limited scope to decelerate or to accelerate the schedule for plants already under

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[1] This section updates a published source. (Kruse, J., P. Westhoff, S. Meyer and W. Thompson. "Economic impacts of not extending biofuel subsidies." *AgBioForum*, 10(2), 94-103, 2007.) The representation is updated to take into account model changes conducted in advance of the 2008 FAPRI–MU baseline, in particular as regards changes to mandates introduced by new US energy legislation.

[2] United States Department of Agriculture (USDA). "The Economic Feasibility of Ethanol Production from Sugar in the United States", July 2006.

[3] The linear specification reflects the likely inappropriateness of constant elasticity representation in light of sharp and sudden changes in the market in recent years.

construction. In contrast, the elasticity with respect to one- and two-year lagged net returns is substantially higher in light of the average 18-month construction process. Longer lagged net return terms have declining effects. The lagged dependent variable reflects the fixity of a mill which, once built, represents a dedicated capital with no alternative use. Depreciation is represented by a negative coefficient associated with the ten-year lagged capacity term.

The choice to use capacity is not a foregone conclusion. The sunk cost of the capacity may or may not be put to use, depending on current net returns. Capacity utilization is
(3) $CAPUTL_t = f(NRT_t)$.
Only current period net returns drive the decision of whether or not to use existing capacity. The capacity utilization is simulated using a logit equation so the rate cannot exceed 100 percent of total existing capacity.

Production of ethanol from dry mills is the product of capacity and capacity utilization, as
(4) $PROD_t = CAP_t * CAPUTL_t$.
The specification for wet mill plant capacity, capacity utilization and production is analogous to the dry mill plant equations. However, the net returns reflect the coproducts relevant to those economic decisions. Additional production of ethanol, *PRODA,* from other grains besides corn-starch based ethanol and cellulosic-based ethanol, *PRODCL*, are included in total ethanol production and, in the case of cellulosic ethanol production, contains some ethanol price impacts which influence industry development. Also, a linear trend growth in cellulosic ethanol production is assumed irrespective of prevailing prices to reflect longer term technology improvement.

Box: Distillers Grains and Solubles

Distillers grains and solubles (DGS) are an important coproduct of dry mills that produce ethanol. This coproduct can be wet or dry and is typically used as an animal feed, although other uses may be available at lower prices, such as for energy or fertilizer. The potential to use DGS in rations is subject to technical limitations. Costs related to transportation also impose some economic limitations. In the current representation, DGS displace corn and soybean meal in animal feeds up to the technical limits depending on the dried distillers grain price, as well as the prices of corn and soymeal. Substitution among feeds is constrained, and DGS sell at a greater discount relative to corn and soymeal in the event that DGS quantities approach technical limits on their inclusion in feed. Lower bounds on the price are in place based on its fertilizer or energy burn value.

II.B. Ethanol domestic demand

Ethanol demand can be viewed as the decision of consumers standing alongside their cars, weighing the prices and usefulness of the different fuel blends available. Consumer options include ethanol in some places, in other places there is no option with ethanol, and yet in other places, all choices include ethanol.

Retail ethanol demand is disaggregated into three forms based on current consumption patterns.[4] Consumers use ethanol in:

1. mandatory uses, as when it serves as a fuel additive or to meet state mandates,
2. voluntary 10 percent ethanol blends (E10) and
3. voluntary blends of up to 85 percent ethanol (E85).

In its capacity as a fuel additive, ethanol is a complement to regular unleaded gasoline. Thus, for example, as regular unleaded gasoline prices increase, total motor fuel use declines and so does the demand for ethanol as an additive. In contrast, ethanol is a substitute for regular unleaded gasoline when used in voluntary E10 and E85 blends, so increasing regular unleaded gasoline prices will tend to increase these ethanol uses.

Ethanol has between 65 and 70 percent of the energy value of regular unleaded gasoline which implies correspondingly lower miles traveled per gallon of gasoline with today's technology, but complicating factors deter clear assessment of the relative prices at which consumers would buy ethanol. This comparison of energy content suggests that many consumers would buy ethanol only if the price (on a volume basis) is at an offsetting discount with respect to the price of regular gasoline. Seen in this light, ethanol is viewed as a substitute to traditional gasoline.

Mandatory uses

Consumer behavior may be undermined by a lack of information about ethanol that would guide their choices, or by the absence of some choices altogether. Fuel labeling at pumps varies considerably across the US. In some states, such as several in the Midwest and some in the Northeast, gas pumps need not label fuel as E10. In other locations, ethanol content is only noted to be at or below the 10 percent level. Even if consumers do know the ethanol content of different fuels, it is not certain that they are able to calculate relative prices that would reflect the energy content of various blends. Additionally, there are other factors that can influence consumer choices of fuel purchases, including a preference for the higher octane of ethanol and distribution costs of ethanol and particularly of E85. Thus, there is uncertainty about the exact relative price of ethanol and gasoline at which the bulk of consumers opt for one rather than the other.

Another factor affecting consumer behavior in ethanol purchasing is the presence of mandated uses. All fuel in some areas contains ethanol either for regulatory reasons relating to the environment or for meeting state-level mandates.[5] In these locations, consumer choice may be restricted to the amount of ethanol in the fuel, but not whether or not there is ethanol.

[4] Westhoff, P., W. Thompson, J. Kruse and S. Meyer. "Ethanol Transforms Agricultural Markets in the USA." *Eurochoices*. Volume 6 (1), p 14-21. 2007.

[5] There are important subtle distinctions in mandates. If a state requires that each unit of motor fuel contain at least a certain percent of ethanol, then consumer choice is limited, as discussed here. In that case, all options available to most consumers include at least some ethanol. But if a mandate requires that ethanol comprises at least a certain percent of total motor fuel used, but does not specify that each unit of fuel must contain at least that percent, then the mandate may be implemented in such a way that consumer choices remain. An important example of this second case is the federal mandates discussed below. These mandates are applied to fuel blenders, not consumers, and are tradable. As such, consumers are free to choose which fuel they buy. Blenders must price ethanol low enough that consumers buy at least the mandated quantity, as discussed below.

And in some locations there may not even be that much consumer discretion. In these cases of regulatory or legislated requirements, ethanol can be viewed as mostly complementary to traditional gasoline.

The equations discussed below represent consumer demand for the various forms of ethanol demand taking into account consumer choices and limitations.

Equations governing consumer demand for ethanol are best understood by starting with the demand for liquid motor fuels in total. The use of motor fuel is
(5) $MFU_t = f (UGRP_t ,\ RETHP_t ,\ INC_t)$.
The response to changes in the unleaded gasoline retail price (*UGRP*) is negative and small while the response to income (*INC*) is positive and larger in absolute value. There is a very small effect associated with the retail price of ethanol (*RETHP*). The small effect follows from the small share of ethanol in total fuel and its role both as a complement that is added to traditional gasoline to change its properties and as a substitute that can be used in place of traditional gasoline.

Mandatory ethanol demand is
(6) $ETADD_t = f (MFU_t{*}ETADSHR_t ,\ RETHP_t)$.
The amount of ethanol that would be needed as an additive can be set at the amount required to meet regulatory requirements or higher. This amount equals the total motor fuel use, from equation 5, and the ratio of ethanol additive use to total motor fuel use (*ETADSHR*). This ratio would implicitly be the product of the share of fuels with additives in total motor fuel use and the share of ethanol in each gallon of fuel with ethanol as an additive, which is frequently 10 percent based on observations of recent events. The ratio of additive requirement to total fuel (*ETADSHR*) also takes into account state ethanol use requirements. The product of these two terms gives the total amount of mandatory demand for ethanol. There is a small price effect associated with the retail ethanol price.

Historically, this potential ethanol additive market was reduced by the amount of methyl tertiary-butyl ether (*MTBE*) used, converted into an ethanol equivalent. MTBE was the more common fuel additive, but it was phased out by 2007.

These uses are not, technically, mandatory. Consumers can choose not to buy motor fuel at all. But if they do buy motor fuel, then they must also buy ethanol. Demand for ethanol as an additive since replacing MTBE in regions with regulatory requirements is relatively inelastic to changes in the ethanol price.

Voluntary uses

The voluntary use of ethanol is disaggregated into E10 and E85, both based on current market conditions. These demands are modeled in a two-step approach that identifies market potential and penetration separately. The voluntary E10 blend can be used in the vast majority of motor vehicles on the road today so the potential market is the larger of the two. This is
(7) $E10MKT_t = f(MFU_t, ETADSHR_t)$,

where the driving force is motor fuel use less the ethanol additive share required to meet regulatory requirements primarily since 2006. This share is assumed based on the most recent data available, although separate work to identify state-level demand analysis may eventually inform this estimate. The realization of this potential market for E10, the penetration, is

(8) $E10PEN_t = f(RETHP_t/UGRP_t, \max(0, 0.73 - RETHP_t/UGRP_t))$.

This equation is relevant for those cases where there is consumer choice. That is to say, when consumers opt to buy E10 or not based on its price relative to other fuels.[6]

A logit function governs the share of E10 use based on the ratio of ethanol to regular unleaded prices. The equation includes two different levels of responsiveness with respect to the price ratio. When the ratio is larger than 73 percent only the first term in the equation applies. The significance of the 73 percent is that it reflects the energy value of ethanol relative to regular unleaded gasoline, with some allowance for higher octane level achieved as ethanol is added. So, as the price ratio falls below 73 percent, ethanol becomes more competitive with regular unleaded gasoline and consumer responsiveness should increase. Thus, the second term in the equation kinks the E10 demand from relatively inelastic to very elastic demand. The relative price where the kink occurs and how abrupt its effect on the elasticity represent important uncertainties that are discussed further in a later section. Total ethanol demand in the voluntary E10 market is the product

(9) $E10D_t = E10MKT_t * E10PEN_t$.

The equations for E85 use are similar to the representation of E10 overall, but reflect certain distinctions in the markets for these two fuels. First, the octane premium will be lower if expressed per gallon of ethanol. Of course, this presumes that the demand for higher octane is not exhausted. Second, consumers must own a flex-fuel vehicle in order to use E85. As a consequence, the equation for the potential market is restricted based on recent events and the possible evolution of flex-fuel vehicle fleet, as

(10) $E85MKT_t = f(E85MKT_{t-1}, TREND_t, \max(0, 0.75-RETHP_t/UGRP_t))$.

The logit specification of the realized penetration of that market is

(11) $E85PEN_t = f(RETHP_t/UGRP_t, \max(0, 0.69- RETHP_t/UGRP_t))$.

Here, the kink representing penetration is placed at a somewhat lower level to reflect that a lower relative price of ethanol as compared to unleaded gasoline is necessary for adoption to become widespread. Above that price ratio, there is little scope for E85 expansion, although use is unlikely to fall to zero. The price ratios are chosen with a view for plausibility of medium-term future projections, but there is little historical basis on which to make this judgment. Here, it is not assumed that all these price ratios must be identical. The E85 market potential is assumed to start to grow even if the price is higher than the E10 price adjusted for energy content. This reflects the historical use of E85 by a small share of consumers even though the cost relative to gasoline was high. But the E85 potential is not expected to be realized as quickly as actual E10 use. The E10 market potential, which is not dependent on flex-fuel vehicles, is not limited by consumer investments so consumer adoption can occur quickly if E10 becomes a cheaper source of motor fuel than gasoline, adjusting for energy

[6] This E10 use is not applicable in the cases of regulatory or the types of state-level mandates discussed in the previous section. However, this representation is applicable for a mandate of total ethanol use that depends on pricing ethanol low enough to convince consumers to buy it, such as EISA mandates discussed below.

content. Thus, serious expansion of the E10 market is assumed to start at a higher ethanol price relative to the motor fuel price. Because these ratios are critical to the determination of ethanol market expansion for given relative prices, the sensitivity of some model results to these parameters is tested in a later section.

E85 demand (E85D) is the product
(12) $E85D_t = E85MKT_t \times E85PEN_t$.

Total US demand for ethanol is
(13) $ETDMD_t = (ETADD_t+E10D_t+E85D_t)$.
The total demand includes the additive, voluntary E10 and E85 uses described above.

II.C. Ethanol blenders demands

Fuel blenders operate between ethanol supply and demand. These agents buy various fuels, likely from plants or refineries, and blend them for retail sales. The equations that represent blender behavior are derived demands, namely
(14-Other advanced) $ETBLNDA_t = f(RETHP_t, ETTAX, WETHPA_t)$, and
(14-Non-advanced) $ETBLNDC_t = f(RETHP_t, ETTAX, WETHPC_t)$.
Here, “A” represents ethanol that meets the criteria of “advanced biofuels” as set out in the legislation, but excluding biodiesel and cellulosic or agricultural waste based biofuels. Thus, this category is better termed “other advanced”, but there is no mandate for this quantity; this is the remainder of the advanced biofuel mandate after taking account of sub-mandates. “C” reflects “conventional” corn-starch base ethanol or other non-advanced ethanol. There is no mandate for conventional ethanol. This category is the remainder of the total biofuel mandate less the sub-mandate for advanced biofuels.

Blender use depends on retail price, *RETHP*, the tax credit, *ETTAX*, and the relevant wholesale price, *WETHPA* or *WETHPC*. For purposes discussed below, the blender ethanol demand is disaggregated based on the type of the feedstock in order to test whether or not various mandated consumption levels are binding and, if they are, to estimate the effect on wholesale and retail price. Thus, as discussed below, the wholesale prices by type may differ. But complications in the underlying law and its likely implementation must be summarized before introducing the model changes to represent the mandates.

II.D. Mandates and RINS

Mandates

The Energy Independence and Security Act (EISA) of 2007 increased the overall mandate for biofuel use and introduced several sub-mandates. The Renewable Fuel Standards (RFSs) are obligations placed on fuel blenders to use at least certain amounts of the specified types of biofuel. Blenders will have to show enough Renewable Identification Numbers (RINs), each representing one gallon of biofuel use, to prove they meet their share of the national mandate.

The buying and selling of RINs is permitted to meet the mandates. If blenders in one area use more ethanol than required, then they can sell their extra RINs to other blenders. Said differently, if a mandate is not binding on a national level but is binding for a sub-set of blenders, then those blenders will presumably be able to buy extra RINs from blenders who exceed their share of the mandate.

If the mandate is nationally binding, then quantity supplied and quantity demanded at the market-clearing price would be less than the mandate. At the market clearing price, suppliers would be unwilling to offer the mandated volume of biofuel and consumers would be unwilling to buy the mandated level of biofuel. Supply price would have to rise to coax greater supply and demand price would have to fall to induce greater consumption. But if prices moved in that way, then blenders would lose money buying high and selling low for each unit of biofuel. However, with the mandate requiring blenders to meet a minimum amount of use, blenders are forced in aggregate to buy enough biofuel to meet the mandate, driving wholesale prices higher. They must sell the biofuel at a lower price so that consumers choose to buy that quantity. In short, after taking into account other costs, blenders lose money on each gallon of biofuel. In this case, the RIN takes on a value that is related to the loss per gallon. A blender's share of the national mandate would be reduced by one unit for every RIN bought, so a RIN purchased allows the blender to avoid losing money on the unit of biofuel that would have to be traded otherwise. The blender is willing to pay up to the amount of money the blender avoids losing. The RIN takes a value determined by the loss per biofuel unit at the margin, after adjusting for costs.[7]

The obligation may or may not be binding on a national basis with implications for commodity markets if binding, but if it is only locally binding then there would be no market consequences. As a consequence, each mandate is considered separately on the basis of national supply of that type of ethanol and demand for ethanol.[8]

There are four overlapping mandates in total for:
1. overall biofuel use,
2. advanced biofuel use,
3. biodiesel use, and
4. cellulosic and agricultural waste based ethanol.

The maximum use of ethanol made from corn starch that can be counted toward the mandates is the difference between the overall biofuel use mandate and the advanced biofuel mandate. Ethanol made from sugarcane (whether imported or not) and some other forms of ethanol can be counted towards the overall mandate and also the advanced mandate. In all cases, biofuels will have to meet greenhouse gas emission reduction targets as well.

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[7] A summary such as this one does little justice to the potential for speculation. Because of various provisions of the EISA, the RIN value will also reflect speculative value about the degree to which mandates are binding in the subsequent year. Also, it should be noted that this interpretation of EISA implementation is based heavily on proposed regulations to implement its predecessor. At the time of writing, rules to implement the EISA have not yet been published.

[8] We assume that the penalties for non-compliance are prohibitively high. Rules for implementing the previous version of the mandates state that "any person who is liable for a violation … is subject to a civil penalty of up to $32,500 … for every day of each such violation and the amount of economic benefit or savings resulting from each violation" (Federal Register, 1 May, 2007, 80.1163, p. 24004). We interpret this to mean that a blender who does not supply RINs to cover its share of the mandate would be required to pay for the value of the RINs nonetheless by way of "economic benefit and savings", plus the daily fine.

A key point to representing these mandates is that different mandates can be binding to different degrees. To assess the possibility that each one is binding, a separate market-clearing identity is generated for that mandate.

The mandate for biofuels made from cellulosic feedstocks and agricultural wastes is the exception. The model structure is based on a waiving of this mandate and its replacement with a per gallon subsidy as determined by the EISA. This subsidy is added to the wholesale price of corn-based ethanol to determine returns to ethanol production from cellulosic feedstocks.

The mandate for biodiesel is assumed not to be waived. The contribution of biodiesel to the broader mandates for advanced biofuel and overall biofuel use is assumed to be increased for the energy value. The ratio assumed is 1.5 to 1; a gallon of biodiesel counts for 1.5 gallons of ethanol towards meeting the broader mandates.[9]

Ethanol blender demands revisited

Blenders are required to buy at least the mandated level in aggregate.[10] This is reflected in the model by adjusting the blender demand equations, which take the form

(14-Other advanced)′ $ETBLNDA_t = MAX\{ f(RETHP_t, ETTAX, WETHPA_t),\ RFSA_t - 1.5*BDBLND_t - RFSCELL_t \}$, and

(14-Non-advanced)′ $ETBLNDC_t = MAX\{ f(RETHP_t, ETTAX, WETHPC_t),\ (RFS_t - ETBLNDA_t - 1.5*BDBLND_t - RFSCELL_t \}$.

The blender demand for other advanced biofuels is the greater of the economic equation described above or the applicable mandate volume. The relevant mandate is the advanced biofuel mandate, *RFSA*, less its sub-mandates. First, the amount of biodiesel blenders demand, *BDBLND*, is subtracted. This is endogenous in the model and similarly the greater of the relevant mandate or the behavioral decision by biodiesel blenders. If blenders opt to use more than the mandated level of biodiesel, then there is less need for other advanced biofuels to be used in order to meet the broader advanced biofuel mandate. The second term is the mandate for cellulosic and agricultural waste-based biofuel, *RFSCELL*.[11]

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[9] This expectation of EISA implementation is based on rules designed to implement its predecessor, as described in the Federal Register, but also takes into account the fact that sub-mandates seem to replace many of the other "equivalence values" described there. A more complicated array of equivalence values was introduced in the previous energy policy. But the EISA does not reiterate these equivalence values. Instead, the new law imposes various sub-mandates based on biofuel feedstocks. However, preliminary information indicates that there will be a determination of equivalence value based on energy content in order to harmonize biofuels on an ethanol-equivalent basis. The 1.5 here is not the only equivalence value likely to be used if this interpretation is correct. The equivalence value is assumed not to apply within the biodiesel mandate. This mandate states an "applicable volume of biomass-based diesel (in billions of gallons)" (EISA, sec 202, a211). An alternative assumption would be that the equivalence value operates within this mandate, thus reducing the amount of biodiesel actually required from 1 billion gallons to 667 million gallons or less by 2012. However, 1 billion gallons of biodiesel would count as at least 1.5 billion gallons of biofuel in advanced and overall mandates.

[10] Rollover and deficit provisions represented in the model are not summarized here.

[11] It is assumed that the cellulosic mandate will be waived, and that the advanced mandate will be reduced accordingly so that the amount of other advanced biofuel required will not increase as one sub-mandate falls. Thus, the overall mandate is also assumed to be reduced by the same amount.

Blender demand for non-advanced ethanol is the greater of the economic equation above or the mandate that applies to this fuel. This mandate is the total RFS (RFS_t), less all of its other components. As before, it is typically appropriate to use the blender demand which may exceed the mandated amount. This structure reflects the potential that a sub-mandate is exceeded, leading to a reduction in the amount of biofuel that blenders must necessarily use to achieve the higher level mandate.

II.E. Market-clearing identities, stocks, and imports

Clearing markets and mandates

The advanced fuel mandate can be expressed as

(15-Other advanced) $$ETPRODA_t + ETNIMP_t \geq ETBLNDA_t \quad .$$

If the mandate if binding, equality holds in the market-clearing for other advanced, *15-Other advanced*, but if the mandate is not binding, then production plus imports exceed the advanced mandate. The advanced biofuel mandate and its components are incorporated in the blender demand for other advanced fuels, as shown above. Imports are assumed to be of sugar-based ethanol that meets the criteria of advanced biofuels. Domestic production of advanced biofuel, *ETPRODA*, is assumed to be a majority of US ethanol not produced from corn.[12]

The market clearing identity for non-advanced ethanol is similarly defined as

(15-Conventional) $$ETSTK_{t-1}+ETPRODC_t + ETPRODA_t + ETNIMP_t = ETBLNDC_t + ETBLNDA_t + ETSTK_t.$$

All stocks, *ETSTK*, are assumed to be of corn-based ethanol. Production of conventional ethanol, *ETPRODC*, and advanced ethanol, *ETPRODA*, are included. So, too, are imports, *ETNIMP*. The RFS is incorporated through the blender demand equations, *ETBLNDC* and *ETBLNDA*, as discussed above. The inclusion of variables that represent the broader mandates are because the conventional mandate is the remainder of the overall mandate after these fuels are taken into account. Thus, in theory, the overall mandate could be met by a advanced biofuels alone, so there would be no need for conventional biofuels to count against any mandate. However, the mandates are minimums, so that hypothetical case would not support the assumption that there would not be any conventional biofuels at all.

The wholesale ethanol market closes on the two equations above to determine the wholesale price(s). The wholesale price of non-advanced ethanol, *WETHPC*, will be used as the price that drives net returns to dry and wet mills that use corn (described above). The wholesale price of advanced ethanol is associated with a sub-mandate, placing the restriction that it cannot be lower than the non-advanced ethanol price. If the overall mandate is binding and the advanced mandate is not, then the price of advanced ethanol will be equal to the non-

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[12] In practice, implementation is somewhat more complicated. The price of other advanced ethanol at which the blenders demand would equal the mandate is generated. This price is only relevant when the mandate is binding and it exceeds the market-clearing price. Otherwise, this price is a mere artifact of the model that is useful given the software environment.

advanced ethanol price. If the advanced mandate is binding for a given non-advanced price, then the advanced ethanol price will be higher than the non-advanced ethanol price. And, if neither mandate is binding then the prices will be the same. Thus, the wholesale price of advanced ethanol is the higher of its own market-clearing price, or the non-advanced ethanol price.

Ethanol ending stocks depend on the wholesale ethanol price and ethanol production to reflect speculative and transaction components, as

(16) $ETSTK_t = f(WETHPC_t, PROD_t)$.

The wholesale price will reflect the value of non-advanced ethanol, *WETHPC*, in practice. Net imports of ethanol are specified as

(17) $ETNIMP_t = f(WETHPA_t, XETHP_t, ETHTAR_t, 3\% * ETDMD_t)$.

A Brazilian ethanol price is used as the indicator of the world ethanol price, *XETHP*. The comparison of world and domestic ethanol prices is adjusted for the $0.54 import tariff, *ETHTAR*. The preferential access afforded certain countries is added. Based on historical data, imports under preferential access are assumed to amount to 3 percent of domestic demand, well below the maximum 7 percent of US domestic demand that is permitted. Assuming imports are advanced biofuels under US legislation, the appropriate wholesale price will be the advanced ethanol price, *WETHPA*.

Retail price is determined by retail price clearing.

(18) $ETBLNDC_t + ETBLNDA_t + PRODCL_t = ETDMD_t$.

The amount of ethanol provided to the retail market is the sum of blenders demands for non-advanced and other advanced ethanol, plus cellulosic and agricultural waste-based ethanol. Retail demand is the sum of mandatory and voluntary uses.

There is only one retail ethanol price. Consumers do not differentiate based on the raw feedstock, so the retail price of ethanol will not vary according to whether it was purchased to meet one mandate or another. Consumers would never opt to buy the more expensive version if retail prices differed. The national mandate does not affect consumers directly, so in those cases that they would not be willing to buy the mandated quantity consumers must be induced to buy the mandated quantity by a lower price.[13] The national mandate affects actions of blenders. If mandates bind in aggregate, then each blender must either buy high and sell low or else buy a RIN from another blender who is doing so.

EISA implications

Rising federal mandates may or may not be binding, depending on circumstances such as the oil price and the corn yield. The model outcomes reflect the effects of this policy. (Specific cases are summarized in the text box, below.)

If a mandate is binding, the blenders must buy more ethanol in aggregate than they would otherwise. At the margin, each blender would consider the options (1) to buy a RIN from a

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[13] As noted above, some state-level mandates operate differently by requiring at least some ethanol in all fuels. In those cases, the mandate is imposed at the consumer level and removes some consumer choice. That is not the case of the current federal mandate.

peer and (2) to trade one more unit of ethanol. Those who choose the second case would start to bid higher the wholesale ethanol price and the greater through-put would lead to more ethanol in the retail market. Mapped against consumer demand, the retail price would have to fall to induce consumers to buy a greater volume. Some blenders would choose to buy and sell ethanol even beyond their share of the mandate. For these blenders, the marginal unit would be profitable because the losses on each gallon of ethanol would be more than offset by the value of the RIN that they could sell. Thus, blenders who have less trouble meeting or even exceeding their share of the mandate would sell RINs to blenders who have more trouble meeting their share of the mandate. Such marginal decision-making would continue until the national mandates are met.

A consequence of a binding mandate is a lower retail price than would occur without the mandate. But how much lower is a subject of uncertainty. The mandated volumes are greater than the quantity of ethanol use, but can the extra amount of the mandates be met by voluntary E10 use? The E10 market potential is limited in that the volume of ethanol in this market cannot exceed 10 percent of the total motor fuel demand after subtracting the additive market.[14] If blenders must sell more ethanol than the mandatory market and voluntary E10 market potential allow, then the price would have to fall more quickly to induce greater consumption of E85. Consumers are likely not to move as readily into E85 purchases given the necessary purchase of an E85-capable vehicle and the potential for additional costs associated with extending the E85 retail infrastructure that may well be passed on to E85 consumers.

Finally, any cost to blenders of the mandates is assumed to be passed on to final consumers of motor fuels. Blender behavior is assumed to be competitive, overall, so any additional costs of operation caused by the mandates will lead eventually to higher selling prices. In other words, we assume that mandates that raise the costs for blenders to stay in business will lead to a higher margin between input and output fuel prices. We expect that these costs will be passed on to all motor fuel consumers. Thus, the aggregate cost of the mandate is divided by total motor fuel use to calculate a per-unit cost. This cost is added to the links that determine the motor fuel price as a function of the petroleum price. The fundamental point is that the cost of the mandate is not ignored, nor is it assumed to be paid by taxpayers. Instead, the cost of a binding mandate is spread among all motor fuel consumers who pay to keep more than they would otherwise to keep blenders in business despite the extra cost. In net, consumer prices of ethanol will be lowered by the mandate, and consumer prices of petroleum-based motor fuels will be higher.

[14] The possibility for wide-scale use of blends with more than 10 percent ethanol in cars that are not flex fuel vehicles is not represented. The chosen specification reflects current facts as regards technological and regulatory possibilities. Some adjustments to the structure would follow if E20 or other blends prove widely accessible to consumers.

Box: Cases of mandates and price wedges

The retail price may differ from the wholesale price even after taking into account margins. If the mandate is binding, then blenders are paying more for ethanol than they would otherwise given the retail price at which they can sell it. In this case, a retail price calculated as a wholesale price equivalent by adjusting for margins would be lower than the wholesale price blenders pay.

Case: the advanced mandate is binding, but the overall mandate is not

The market-clearing conditions could be such that, without the mandate, then the equilibrium price would lead to more use of conventional ethanol than mandated, but too little other advanced ethanol use relative to the advanced biofuel mandate. In other words, the retail price is not high enough relative to the other advanced ethanol wholesale price for blenders to cover costs, but blenders must meet the mandate so they cannot reduce the quantity of through-put. However, the retail price is high enough relative to the non-advanced ethanol wholesale price for blenders to cover costs. The other advanced ethanol price at wholesale is bid higher than the wholesale price of non-advanced ethanol. This outcome reflects the fact that conventional ethanol cannot be used to count against the advanced mandate, so it can trade at a lower price if the advanced mandate is binding.

The RIN for advanced biofuels take on a value that reflects at least the gap between the wholesale price for other advanced ethanol and the retail ethanol price.

Case: the overall mandate is binding, but the advanced mandate is not binding

The retail price is not high enough to cover the wholesale price non-advanced ethanol plus other costs, but blenders cannot reduce the quantity because of the mandate so they must lose money on each gallon. The RINs for the overall mandate take on a value based on this price gap.

Because the ethanol that meets the advanced biofuel requirement also counts towards the overall mandate, the wholesale price of other advanced ethanol is no lower than the price for non-advanced ethanol.

Case: the overall and advanced mandates are binding

The retail price is not high enough to cover the wholesale prices of non-advanced or other advanced ethanols, plus other costs. Blenders cannot reduce quantities because of mandates. As both are binding, it is certain that the wholesale price of other advanced ethanol will be greater than the wholesale price of non-advanced ethanol, and that both wholesale prices exceed the retail price (after adjusting for other costs to set it in a wholesale equivalent basis).

The RINs for the overall mandate and for the advanced mandate take on values that are at least as large as the related price gaps.

Case: no mandate is binding

Non-advanced and other advanced wholesale ethanol prices are equal. The retail ethanol price is high enough to cover wholesale ethanol price plus other blender costs.

The RINs take on no greater value than suffices to cover transaction costs plus any speculative value relating to conditions in the next year.

II.F. Wholesale-to-retail ethanol price margin

The margin between wholesale and retail ethanol prices plays a critical role. If consumers opt to buy ethanol based on its price relative to the regular gasoline price – if voluntary uses dominate at the margin – then the short and long run relationships between wholesale ethanol and oil prices depends on local consumer prices of these two fuels. As the wholesale prices of ethanol and oil are observed and widely quoted, there is a tendency to think in terms of these benchmark prices instead of retail prices, of which the ethanol retail price is largely unobserved. There is no body of ethanol retail price data that is considered to represent reliably the prices facing US consumers, much less the prices that will face consumers if ethanol use expands. Published reports that tie corn prices to oil prices hinge critically on the assumed margins between wholesale and retail prices.

Recently observed data and preliminary projections are illustrative (Table 1). The retail price of gasoline of $2.61 per gallon and wholesale price of $2.00 in 2006/07 imply a margin of $0.61 per gallon. If the same margin is assumed for ethanol, then the wholesale ethanol price of $2.32 per gallon and the blender tax credit imply a retail price of $2.42 per gallon of ethanol, which is 92 percent of the retail gasoline price as compared to 116 percent ethanol-to-gasoline price ratio at wholesale. In the absence of the tax credit or if it were not passed on to consumers, the fixed absolute margin implies that the price ratios are different at wholesale and retail levels in most cases. Looking ahead to 2009/10, the price ratio at wholesale level could be 80.9 percent, as compared to 85.1 percent at retail without taking account of the tax credit and 67.4 percent at retail taking account of the tax credit. Inference leads to the belief that relative prices in 2006/07 were not determined by energy equivalence, but instead driven by its value in the additive market which expanded rapidly as ethanol replaced MTBE in most US markets in that year. In contrast, based on current events, near-term relative retail prices are expected to be determined by consumer willingness to buy the fuel service of ethanol which implies a comparison of energy values.

Table 1. Ethanol-gasoline price relationships at wholesale and retail

	2006/07	2009/10
Gas retail	2.61	2.88
- Gas wholesale	-2.00	-2.25
= Difference	0.61	0.64
Conventional ethanol wholesale	2.32	1.82
- Tax credit	-0.51	-0.51
+ Gas retail-wholesale diff.	0.61	0.63
= Implied ethanol retail pr.	2.42	1.94
% of gasoline retail price	92.4%	67.4%

Source: FAPRI preliminary January 2008 baseline

The belief that relative price will be driven by energy value in the future is supported by retail price ratios implied by futures market prices (Table 2). After taking into account the tax credit and an assumed margin, the January 2009 and January 2010 retail prices ratios are 70 percent, which is almost within the range of the estimated energy value of ethanol. The ratio of ethanol price as posted on the Chicago Board of Trade (CBOT) to the reformulated gasoline blendstocks for oxygenated blending (RBOB) price, however, is at about four-fifths and consequently much higher than the energy value of ethanol.

Table 2. Ethanol-gasoline price relationships

	Jan 2009	Jan 2010
RBOB gas	3.324	3.264
CBOT ethanol	2.660	2.640
Ethanol/ RBOB	80.0%	80.9%
Ethanol-credit	2.15	2.13
(Ethanol-credit)/ RBOB	64.7%	65.3%
(Ethanol-credit +0.61)/(RBOB+0.61)	70.2%	70.7%

NYMEX & CBOT close, 6/11/2008.

A fundamental question is not only the size of the margin between wholesale and retail ethanol prices, but also its specification. Is the margin best approximated as a constant amount expressed in dollars per gallon, or as a constant percent of the price? Presumably, this margin is a combination of costs, some of which do not depend on the ethanol price and some of which do. In an effort to understand better this margin and retail prices, historical data about federal and state taxes and tax reductions are useful. The vast majority of taxes are expressed in terms of a fixed amount per gallon, not as a relative tax rate. The federal tax plus the simple average of state taxes is almost $0.40 per gallon of gasoline. The total margin including taxes and other costs of distribution is about $0.60 per gallon. Thus, two-thirds of the margin is a fixed constant, not a relative mark-up, based on fuel taxes alone.

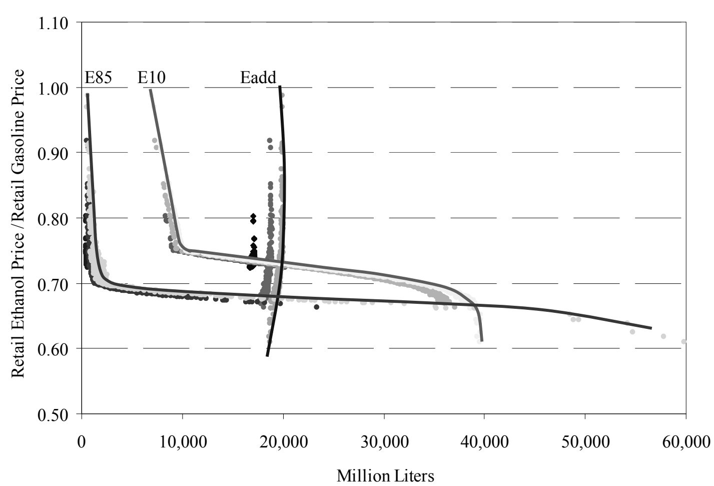
III. Sensitivity

The kinks that represent a highly nonlinear trade-off between ethanol and regular gasoline are not certain, but are defining. As such, we explore the sensitivity of model results to these kinks in this section.

The mandates of the EISA of 2007 are not represented in the scenario results reported here. The exclusion directs attention to the sensitivity of ethanol markets to the relative price level at which consumer adoption occurs. But the results do not relate to current policies.

Consumer willingness to buy ethanol is not assumed to evolve smoothly as prices change (Figure 1). As the ethanol price falls from a high level as compared to a given oil price or, conversely, as oil price rises from a low level relative to the ethanol price, E10 use gradually rises until the retail ethanol price is 73 percent of the regular gasoline price. At that point, ethanol becomes a more competitive source of motor fuel and consumer adoption rises sharply. If the relative price continues to fall, then at some point, E85 becomes a cost competitive source of motor fuel and consumers adopt that fuel instead of alternatives.

Figure 1. Curves representing ethanol use, simulation results for 2007, 2011 and 2016.



Source: FAPRI–MU model experiment. Note: each year represents the 500 partially stochastic simulations in which oil price, among other variables, changes. Output is simulated, not calibrated to actual data. Non-linear lines are fitted to these data to represent possible outcomes over a wide range of theoretically possible prices ratios.

In this representation, the y-axis variable is not the own-price of each fuel, but is instead the relative prices of two components. The mixture of ethanol and gasoline may differ between additive and E10 use, and the share of ethanol is certainly higher in E85. It is hardly surprising that a falling ratio of ethanol to gasoline price induces less consumption of ethanol as an additive. Consumers respond to a falling ethanol price by buying fuels with more ethanol blended in them, not fuels with less ethanol.

Other work may lead us to moderate the sharp discontinuity based on new findings relating to the variation of margins between wholesale and retail ethanol prices caused by transportation and infrastructure, as well as varying taxes. Nevertheless, less precision in the model does not reflect substantially greater certainty about the relative prices at which consumers opt to change fuels. Thus, in the following section, we explore the sensitivity of certain results with respect to the parameterization of this kink in consumer response.

III.A. Sensitivity of policy results to the location of the consumer demand kinks

To test the sensitivity of policy analysis to the chosen kink in consumer response, we conduct an experiment with five baselines and ten scenarios.

1. The baselines are identical except for the "kink" point in the E10 penetration equation (as defined above). The value used in the August 2008 baseline was 73 percent; a 10 percent blend use becomes much more price responsive when the "implied retail" price of ethanol falls below 73 percent of the retail gasoline price. The four alternative baselines use 75, 80, 85 and 95 percent.
2. The first scenario against each baseline removes the ethanol tax credit from 2011.
3. The second scenario against each baseline removes the ethanol tax credit from 2011, and also the ethanol tariff and the biodiesel tax credit from 2009.

Results are presented for only three key variables: corn ethanol use (Table 3), the price of ethanol (Table 4) and the price of corn (Table 5). Key results are as follows.

- For the various baselines, changing the kink point mostly affects the early years of the baseline. A higher kink implies that consumers opt to use ethanol even for higher relative prices, so the ethanol prices and production are higher. In later years, the effects of increased ethanol production (triggered primarily by the additional capacity built in response to initial higher profits) offset most of any price-enhancing effect of stronger E10 demand. This happens because of the baseline. The E10 market is largely saturated by the middle of the period in that the quantity approaches 10 percent of total motor fuel use net of additive fuels. Hence, there is no scope for more E10 demand no matter the price. To increase overall ethanol demand, whether due to falling ethanol price relative to gasoline price or due to an increasing mandate, there would have to be substantial E85 use. But consumers adopt E85 less readily. So, greater E85 use requires a price below 70 percent of the gasoline price regardless of the price that triggers more E10 demand.
- In the tax credit scenarios, the change from baseline is very sensitive to the kink for E10 demand. Even a modest retail price increase will cause consumers to forego E85. Thus, the question is at what price will E10 use establish a floor for the price (up to the point that market is saturated)? When measured using the baseline model (where the E10 kink point is only a little above the E85 kink), the answer is a very low price, such as $1.30 per gallon. More of the $0.51 tax credit removal is born by producers when the kink is lower and more is born by consumers as the kink moves higher. For example, when the kink is at 80 percent, the removal of the tax credit lowers the ethanol

price by an average of 31 cents over 2011-17, but if the kink is at 85 percent, the ethanol price drops 21 cents.

- Adding the tariff elimination to the tax credit discontinuation does not lead to large changes in the results. The effects are small even in 2008/09 and 2009/10, when the ethanol tariff is eliminated but the ethanol tax credit is still in place, at least in the current specification. The reason is that available capacity is ample and output does not test capacity constraints, so domestic production is cheap at the margin and competitive with imports.
- In the current model of ethanol, calendar year and marketing year data are used, although these are not represented in the summary tables. For example, in the ethanol tax credit scenarios, calendar year 2010 ethanol production, use and prices change because the 2010 figures are a weighted average of 2009/10 (where there are no changes) and 2010/11 (which gets 2/3 of a full effect from a tax credit eliminated on January 1, 2011).

Table 3. Sensitivity of policy analysis, corn used for ethanol production

September-August year	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2011-2017 avg
						(million bushels)						
August baseline--kink at 73%	3,263	4,209	4,764	4,945	4,983	5,001	5,050	5,076	5,087	5,092	5,071	5,051
No ethanol credit in 2011	3,263	4,209	4,764	3,796	2,988	2,971	3,041	3,080	3,099	3,108	3,094	3,054
Absolute difference from baseline	0	0	1	-1,149	-1,995	-2,030	-2,009	-1,996	-1,988	-1,984	-1,977	-1,997
Proportional difference	0.0%	0.0%	0.0%	-23.2%	-40.0%	-40.6%	-39.8%	-39.3%	-39.1%	-39.0%	-39.0%	-39.5%
Also no tariff, biodiesel credit in 2009	3,263	4,205	4,765	3,791	2,983	2,965	3,035	3,074	3,093	3,103	3,089	3,049
Absolute difference from baseline	0	-4	2	-1,154	-2,001	-2,036	-2,015	-2,002	-1,993	-1,989	-1,982	-2,003
Proportional difference	0.0%	-0.1%	0.0%	-23.3%	-40.1%	-40.7%	-39.9%	-39.4%	-39.2%	-39.1%	-39.1%	-39.6%
Alternative baseline--kink at 75%	3,285	4,304	4,861	5,046	5,099	5,123	5,173	5,199	5,209	5,213	5,192	5,172
Absolute difference from August base	22	94	97	101	116	122	123	122	122	121	121	121
Proportional difference	0.7%	2.2%	2.0%	2.0%	2.3%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%	2.4%
No ethanol credit in 2011	3,285	4,304	4,861	4,008	3,223	3,196	3,268	3,307	3,323	3,330	3,313	3,280
Absolute difference from 75% baseline	0	0	1	-1,039	-1,876	-1,926	-1,904	-1,892	-1,885	-1,883	-1,879	-1,892
Proportional difference	0.0%	0.0%	0.0%	-20.6%	-36.8%	-37.6%	-36.8%	-36.4%	-36.2%	-36.1%	-36.2%	-36.6%
Also no tariff, biodiesel credit in 2009	3,285	4,299	4,860	4,003	3,217	3,190	3,262	3,301	3,318	3,325	3,308	3,274
Absolute difference from baseline	0	-4	0	-1,044	-1,882	-1,933	-1,910	-1,898	-1,891	-1,888	-1,884	-1,898
Proportional difference	0.0%	-0.1%	0.0%	-20.7%	-36.9%	-37.7%	-36.9%	-36.5%	-36.3%	-36.2%	-36.3%	-36.7%
Alternative baseline--kink at 80%	3,317	4,494	5,098	5,243	5,318	5,357	5,403	5,423	5,424	5,420	5,392	5,391
Absolute difference from August base	54	284	334	298	334	356	353	346	337	328	321	339
Proportional difference	1.7%	6.8%	7.0%	6.0%	6.7%	7.1%	7.0%	6.8%	6.6%	6.4%	6.3%	6.7%
No ethanol credit in 2011	3,317	4,494	5,100	4,514	3,833	3,794	3,869	3,903	3,914	3,916	3,892	3,874
Absolute difference from 80% baseline	0	0	1	-729	-1,485	-1,563	-1,534	-1,520	-1,510	-1,504	-1,500	-1,517
Proportional difference	0.0%	0.0%	0.0%	-13.9%	-27.9%	-29.2%	-28.4%	-28.0%	-27.8%	-27.8%	-27.8%	-28.1%
Also no tariff, biodiesel credit in 2009	3,317	4,491	5,086	4,505	3,827	3,786	3,861	3,895	3,907	3,908	3,885	3,867
Absolute difference from 80% baseline	0	-3	-12	-738	-1,491	-1,571	-1,542	-1,528	-1,517	-1,512	-1,507	-1,524
Proportional difference	0.0%	-0.1%	-0.2%	-14.1%	-28.0%	-29.3%	-28.5%	-28.2%	-28.0%	-27.9%	-28.0%	-28.3%
Alternative baseline--kink at 85%	3,334	4,609	5,199	5,342	5,440	5,490	5,538	5,555	5,549	5,535	5,498	5,515
Absolute difference from August base	71	400	435	397	457	489	488	479	462	443	427	464
Proportional difference	2.2%	9.5%	9.1%	8.0%	9.2%	9.8%	9.7%	9.4%	9.1%	8.7%	8.4%	9.2%
No ethanol credit in 2011	3,334	4,609	5,200	4,931	4,429	4,394	4,466	4,492	4,498	4,494	4,467	4,463
Absolute difference from 85% baseline	0	0	1	-412	-1,011	-1,095	-1,072	-1,063	-1,051	-1,041	-1,031	-1,052
Proportional difference	0.0%	0.0%	0.0%	-7.7%	-18.6%	-20.0%	-19.4%	-19.1%	-18.9%	-18.8%	-18.7%	-19.1%
Also no tariff, biodiesel credit in 2009	3,334	4,607	5,171	4,917	4,421	4,384	4,455	4,480	4,486	4,482	4,456	4,452
Absolute difference from 85% baseline	0	-2	-27	-426	-1,020	-1,106	-1,083	-1,075	-1,063	-1,053	-1,043	-1,063
Proportional difference	0.0%	0.0%	-0.5%	-8.0%	-18.7%	-20.1%	-19.6%	-19.4%	-19.2%	-19.0%	-19.0%	-19.3%
Alternative baseline--kink at 95%	3,357	4,730	5,238	5,493	5,655	5,714	5,784	5,820	5,822	5,804	5,754	5,765
Absolute difference from August base	94	520	474	548	672	713	734	744	735	712	683	713
Proportional difference	2.9%	12.4%	9.9%	11.1%	13.5%	14.3%	14.5%	14.7%	14.4%	14.0%	13.5%	14.1%
No ethanol credit in 2011	3,357	4,730	5,237	5,213	5,178	5,190	5,188	5,179	5,171	5,165	5,159	5,176
Absolute difference from 95% baseline	0	0	0	-280	-477	-524	-596	-641	-651	-638	-596	-589
Proportional difference	0.0%	0.0%	0.0%	-5.1%	-8.4%	-9.2%	-10.3%	-11.0%	-11.2%	-11.0%	-10.4%	-10.2%
Also no tariff, biodiesel credit in 2009	3,357	4,728	5,214	5,185	5,154	5,165	5,161	5,152	5,144	5,139	5,133	5,150
Absolute difference from 95% baseline	0	-2	-23	-308	-501	-550	-623	-668	-678	-665	-622	-615
Proportional difference	0.0%	0.0%	-0.4%	-5.6%	-8.9%	-9.6%	-10.8%	-11.5%	-11.6%	-11.5%	-10.8%	-10.7%

Table 4. Sensitivity of policy analysis, Ethanol price, FOB Omaha

September-August year	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2011-2017 avg
						(dollars per gallon)						
August baseline--kink at 73%	1.85	1.80	1.76	1.74	1.72	1.71	1.72	1.71	1.71	1.71	1.71	1.72
No ethanol credit in 2011	1.85	1.80	1.76	1.45	1.31	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Absolute difference from baseline	0.00	0.00	0.00	-0.29	-0.41	-0.41	-0.41	-0.42	-0.42	-0.42	-0.42	-0.41
Proportional difference	0.0%	0.0%	0.0%	-16.5%	-23.8%	-23.9%	-24.1%	-24.3%	-24.4%	-24.4%	-24.3%	-24.2%
Also no tariff, biodiesel credit in 2009	1.85	1.80	1.76	1.45	1.31	1.30	1.30	1.30	1.29	1.29	1.30	1.30
Absolute difference from baseline	0.00	0.00	0.00	-0.29	-0.41	-0.41	-0.41	-0.42	-0.42	-0.42	-0.42	-0.42
Proportional difference	0.0%	0.0%	-0.1%	-16.6%	-23.9%	-24.0%	-24.2%	-24.3%	-24.4%	-24.4%	-24.4%	-24.2%
Alternative baseline--kink at 75%	1.90	1.84	1.78	1.76	1.74	1.73	1.73	1.73	1.72	1.72	1.72	1.73
Absolute difference from August base	0.05	0.04	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Proportional difference	2.8%	2.3%	1.1%	0.9%	0.8%	0.8%	0.7%	0.7%	0.6%	0.6%	0.6%	0.7%
No ethanol credit in 2011	1.90	1.84	1.78	1.49	1.35	1.34	1.34	1.34	1.33	1.33	1.33	1.34
Absolute difference from 75% baseline	0.00	0.00	0.00	-0.26	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39
Proportional difference	0.0%	0.0%	0.0%	-15.1%	-22.4%	-22.4%	-22.5%	-22.6%	-22.7%	-22.7%	-22.6%	-22.6%
Also no tariff, biodiesel credit in 2009	1.90	1.84	1.78	1.49	1.35	1.34	1.34	1.33	1.33	1.33	1.33	1.34
Absolute difference from baseline	0.00	0.00	0.00	-0.27	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39	-0.39
Proportional difference	0.0%	-0.1%	-0.1%	-15.2%	-22.4%	-22.4%	-22.6%	-22.7%	-22.8%	-22.8%	-22.7%	-22.6%
Alternative baseline--kink at 80%	2.03	1.96	1.83	1.77	1.75	1.74	1.73	1.73	1.73	1.73	1.73	1.73
Absolute difference from August base	0.18	0.15	0.07	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Proportional difference	9.8%	8.6%	4.1%	1.7%	1.4%	1.3%	1.1%	1.0%	1.0%	1.0%	1.1%	1.1%
No ethanol credit in 2011	2.03	1.96	1.83	1.58	1.44	1.43	1.43	1.43	1.42	1.42	1.43	1.43
Absolute difference from 80% baseline	0.00	0.00	0.00	-0.19	-0.31	-0.30	-0.30	-0.31	-0.31	-0.31	-0.31	-0.31
Proportional difference	0.0%	0.0%	0.0%	-10.7%	-17.6%	-17.5%	-17.5%	-17.6%	-17.7%	-17.7%	-17.7%	-17.6%
Also no tariff, biodiesel credit in 2009	2.03	1.95	1.82	1.58	1.44	1.43	1.43	1.43	1.42	1.42	1.42	1.43
Absolute difference from 80% baseline	0.00	0.00	-0.01	-0.19	-0.31	-0.30	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31
Proportional difference	0.0%	-0.1%	-0.4%	-10.8%	-17.7%	-17.5%	-17.6%	-17.7%	-17.8%	-17.8%	-17.7%	-17.7%
Alternative baseline--kink at 85%	2.16	2.07	1.83	1.76	1.74	1.73	1.73	1.73	1.73	1.73	1.73	1.73
Absolute difference from August base	0.31	0.27	0.07	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01
Proportional difference	16.8%	15.3%	4.2%	1.2%	0.9%	0.8%	0.7%	0.7%	0.7%	0.8%	0.9%	0.8%
No ethanol credit in 2011	2.16	2.07	1.83	1.66	1.53	1.52	1.52	1.51	1.51	1.51	1.51	1.52
Absolute difference from 85% baseline	0.00	0.00	0.00	-0.10	-0.21	-0.21	-0.21	-0.21	-0.21	-0.22	-0.21	-0.21
Proportional difference	0.0%	0.0%	0.1%	-5.9%	-12.0%	-11.9%	-12.1%	-12.3%	-12.4%	-12.5%	-12.4%	-12.3%
Also no tariff, biodiesel credit in 2009	2.16	2.07	1.82	1.65	1.53	1.52	1.52	1.51	1.51	1.51	1.51	1.51
Absolute difference from 85% baseline	0.00	0.00	-0.01	-0.11	-0.21	-0.21	-0.21	-0.21	-0.22	-0.22	-0.22	-0.21
Proportional difference	0.0%	-0.1%	-0.6%	-6.1%	-12.1%	-12.0%	-12.2%	-12.4%	-12.5%	-12.6%	-12.5%	-12.3%
Alternative baseline--kink at 95%	2.42	2.32	1.79	1.75	1.72	1.71	1.71	1.71	1.71	1.71	1.72	1.71
Absolute difference from August base	0.57	0.52	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Proportional difference	31.0%	29.0%	1.7%	0.3%	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	0.1%	0.2%	0.0%
No ethanol credit in 2011	2.42	2.32	1.79	1.68	1.64	1.62	1.61	1.60	1.59	1.59	1.60	1.61
Absolute difference from 95% baseline	0.00	0.00	0.00	-0.06	-0.09	-0.09	-0.11	-0.12	-0.12	-0.12	-0.12	-0.11
Proportional difference	0.0%	0.0%	0.0%	-3.7%	-5.0%	-5.3%	-6.3%	-6.8%	-7.1%	-7.2%	-6.9%	-6.4%
Also no tariff, biodiesel credit in 2009	2.42	2.31	1.78	1.68	1.63	1.62	1.60	1.59	1.59	1.59	1.59	1.60
Absolute difference from 95% baseline	0.00	-0.01	-0.01	-0.07	-0.09	-0.09	-0.11	-0.12	-0.13	-0.13	-0.12	-0.11
Proportional difference	0.0%	-0.6%	-0.5%	-4.0%	-5.2%	-5.5%	-6.5%	-7.1%	-7.3%	-7.4%	-7.1%	-6.6%

Table 5. Sensitivity of policy analysis, corn price

September-August year	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2011-2017 avg
						(dollars per bushel)						
August baseline--kink at 73%	3.10	3.38	3.35	3.34	3.28	3.25	3.21	3.17	3.13	3.10	3.04	3.17
No ethanol credit in 2011	3.10	3.38	3.35	2.93	2.76	2.75	2.72	2.68	2.65	2.61	2.57	2.68
Absolute difference from baseline	0.00	0.00	0.00	-0.41	-0.52	-0.50	-0.49	-0.49	-0.49	-0.48	-0.48	-0.49
Proportional difference	0.0%	0.0%	0.0%	-12.3%	-16.0%	-15.4%	-15.4%	-15.4%	-15.5%	-15.6%	-15.6%	-15.6%
Also no tariff, biodiesel credit in 2009	3.10	3.38	3.34	2.92	2.75	2.74	2.71	2.68	2.64	2.61	2.56	2.67
Absolute difference from baseline	0.00	0.00	0.00	-0.42	-0.53	-0.50	-0.50	-0.49	-0.49	-0.49	-0.48	-0.50
Proportional difference	0.0%	0.1%	-0.1%	-12.5%	-16.1%	-15.5%	-15.6%	-15.6%	-15.7%	-15.8%	-15.8%	-15.7%
Alternative baseline--kink at 75%	3.11	3.41	3.37	3.36	3.31	3.28	3.24	3.20	3.16	3.13	3.07	3.20
Absolute difference from August base	0.01	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Proportional difference	0.3%	1.0%	0.6%	0.8%	0.9%	0.9%	0.9%	0.9%	0.9%	0.9%	1.0%	0.9%
No ethanol credit in 2011	3.11	3.41	3.37	2.99	2.81	2.80	2.77	2.74	2.70	2.67	2.62	2.73
Absolute difference from 75% baseline	0.00	0.00	0.00	-0.38	-0.50	-0.47	-0.47	-0.46	-0.46	-0.46	-0.45	-0.47
Proportional difference	0.0%	0.0%	0.0%	-11.2%	-15.1%	-14.4%	-14.4%	-14.4%	-14.6%	-14.7%	-14.7%	-14.6%
Also no tariff, biodiesel credit in 2009	3.11	3.41	3.36	2.98	2.81	2.80	2.77	2.73	2.70	2.66	2.62	2.73
Absolute difference from baseline	0.00	0.00	-0.01	-0.38	-0.50	-0.48	-0.47	-0.47	-0.47	-0.46	-0.46	-0.47
Proportional difference	0.0%	0.1%	-0.2%	-11.3%	-15.2%	-14.6%	-14.6%	-14.6%	-14.8%	-14.8%	-14.9%	-14.8%
Alternative baseline--kink at 80%	3.12	3.48	3.42	3.41	3.37	3.33	3.29	3.25	3.21	3.18	3.12	3.25
Absolute difference from August base	0.02	0.10	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Proportional difference	0.6%	3.0%	2.3%	2.1%	2.5%	2.6%	2.6%	2.6%	2.6%	2.6%	2.5%	2.6%
No ethanol credit in 2011	3.12	3.48	3.42	3.14	2.96	2.95	2.92	2.88	2.84	2.81	2.76	2.88
Absolute difference from 80% baseline	0.00	0.00	0.00	-0.26	-0.41	-0.38	-0.37	-0.37	-0.37	-0.37	-0.36	-0.37
Proportional difference	0.0%	0.0%	0.0%	-7.8%	-12.1%	-11.3%	-11.4%	-11.3%	-11.5%	-11.5%	-11.6%	-11.5%
Also no tariff, biodiesel credit in 2009	3.12	3.48	3.41	3.14	2.95	2.95	2.91	2.88	2.84	2.80	2.75	2.87
Absolute difference from 80% baseline	0.00	0.00	-0.01	-0.27	-0.41	-0.38	-0.38	-0.37	-0.37	-0.37	-0.37	-0.38
Proportional difference	0.0%	0.1%	-0.3%	-7.9%	-12.3%	-11.4%	-11.5%	-11.5%	-11.7%	-11.7%	-11.7%	-11.7%
Alternative baseline--kink at 85%	3.13	3.52	3.44	3.43	3.40	3.36	3.32	3.28	3.24	3.20	3.15	3.28
Absolute difference from August base	0.03	0.14	0.09	0.09	0.11	0.11	0.11	0.11	0.11	0.10	0.10	0.11
Proportional difference	0.8%	4.2%	2.7%	2.8%	3.4%	3.4%	3.5%	3.5%	3.4%	3.4%	3.3%	3.4%
No ethanol credit in 2011	3.13	3.52	3.44	3.28	3.11	3.11	3.06	3.03	2.99	2.95	2.90	3.02
Absolute difference from 85% baseline	0.00	0.00	0.00	-0.14	-0.29	-0.25	-0.26	-0.25	-0.25	-0.25	-0.25	-0.26
Proportional difference	0.0%	0.0%	0.1%	-4.2%	-8.5%	-7.5%	-7.7%	-7.7%	-7.8%	-7.9%	-7.9%	-7.9%
Also no tariff, biodiesel credit in 2009	3.13	3.53	3.42	3.28	3.10	3.10	3.06	3.02	2.98	2.94	2.89	3.01
Absolute difference from 85% baseline	0.00	0.00	-0.01	-0.15	-0.30	-0.26	-0.26	-0.26	-0.26	-0.26	-0.25	-0.26
Proportional difference	0.0%	0.1%	-0.4%	-4.4%	-8.7%	-7.7%	-7.9%	-7.9%	-8.0%	-8.1%	-8.1%	-8.1%
Alternative baseline--kink at 95%	3.13	3.56	3.43	3.48	3.44	3.41	3.37	3.33	3.30	3.26	3.20	3.33
Absolute difference from August base	0.03	0.19	0.08	0.15	0.16	0.16	0.16	0.17	0.16	0.16	0.15	0.16
Proportional difference	1.1%	5.5%	2.5%	4.4%	4.8%	4.9%	5.1%	5.2%	5.2%	5.2%	5.1%	5.1%
No ethanol credit in 2011	3.13	3.56	3.43	3.39	3.33	3.29	3.24	3.19	3.15	3.11	3.07	3.20
Absolute difference from 95% baseline	0.00	0.00	0.00	-0.10	-0.11	-0.11	-0.14	-0.14	-0.14	-0.14	-0.13	-0.13
Proportional difference	0.0%	0.0%	0.0%	-2.8%	-3.2%	-3.3%	-4.1%	-4.3%	-4.4%	-4.4%	-4.2%	-4.0%
Also no tariff, biodiesel credit in 2009	3.13	3.57	3.41	3.37	3.32	3.28	3.23	3.18	3.14	3.10	3.06	3.19
Absolute difference from 95% baseline	0.00	0.00	-0.01	-0.11	-0.12	-0.12	-0.15	-0.15	-0.16	-0.15	-0.14	-0.14
Proportional difference	0.0%	0.1%	-0.4%	-3.2%	-3.6%	-3.7%	-4.4%	-4.6%	-4.7%	-4.7%	-4.5%	-4.3%

IV. Appendix: data definitions and sources

Variable	Name	Units	Source	Average values 1996-2000	2001-2005
Corn fuel alcohol use	CRDGAS	million bushels	USDA feed grains data base, updated with Feed Outlook, Table 5; sum of dry and wet milling for ethanol for 2004/05	525.80	1158.97
Corn HFCS use	CRDHFC	million bushels	USDA feed grains data base, updated with Feed Outlook,	520.99	530.38
Corn glucose & dextrose	CRDGLD	million bushels	USDA feed grains data base, updated with Feed Outlook,	224.20	223.10
Corn starch use	CRDSTR	million bushels	USDA feed grains data base, updated with Feed Outlook,	244.45	265.39
Corn beverage alcohol	CRDBEV	million bushels	USDA feed grains data base, updated with Feed Outlook,	129.97	132.36
Corn cereals & other	CRDCER	million bushels	USDA feed grains data base, updated with Feed Outlook,	181.66	187.90
Corn, ethanol dry mill	CRDGDM	million bushels	Computed for 1991-2003; equation for projection period	239.16	788.49
(Share dry milled)	CRDGDM/CRDGAS	proportion	Various sources for 1991-2003; 2004 figure from www.ethanolrfa.org is 0.75; computed during projection period	0.45	0.66
Corn, ethanol wet mill	CRDGWM	million bushels	Computed for 1980-2003; equation for projection period	286.64	370.48
Corn, other wet mill	CRDOWM	million bushels	Computed, sum of HFCS, glucose & dextrose, starch,	1119.61	1151.22
Corn other dry mill costs	CROTCDM	dollars per gallon	USDA sugar ethanol report for 2002-2005	0.22	0.27
Corn dry mill net ret. (MY)	CRNRBDM	dollars per bushel	Calculated, crop year	0.96	1.71
Corn, other wet mill costs	CROTCWM	dollars per gallon	USDA sugar ethanol report for 2002-2005	0.36	0.44
Corn wet mill net ret. (MY)	CRNRBWM	dollars per bushel	Calculated, crop year	0.97	1.80
HFCS wet mill gross mar.	CRGMWH	dollars per bushel	Calculated	2.48	3.01
Motor gas. supplied, cal. yr.	MGSTOTCL	million gallons	http://www.eia.doe.gov/emeu/mer/pdf/pages/sec3_17.pdf	126039.67	136994.84
Unl. gas. pr., Omaha, cal. yr.	UGPFBCL	dollars per gallon	Calendar year price from	0.64	1.12
Unl. gas. retail price, cal. yr.	UGPRTCL	dollars per gallon	http://www.eia.doe.gov/emeu/mer/pdf/pages/sec9_6.pdf	1.24	1.72
Ethanol price, Omaha, cal. yr.	ETPFBCL	dollars per gallon	Calendar year price from	1.18	1.49
Ethanol implied retail pr., cal. yr.	ETPRTCL	dollars per gallon	Calculated	1.24	1.57
Ethanol, BZ anhyd. price, cal. yr.	ETPBZCL	dollars per gallon	Iowa State from Licht	0.98	1.02
Ethanol total capacity, Jan	ETCAPTO	million gallons	http://www.ethanolrfa.org/industry/statistics/	1638.65	2744.10
Ethanol prod., cal. yr.	ETSPRDCL	million gallons	http://tonto.eia.doe.gov/dnav/pet/pet_pnp_oxy_dc_nus_mbbl_	1350.61	2802.34
Ethanol imports, cal. yr.	ETSIMPCL	million gallons	http://tonto.eia.doe.gov/dnav/pet/hist/mfeimus1A.htm	5.60	64.59
Ethyl alcohol net imports, cal. yr.	ETSIMNCL	million gallons	Calculated from ISU data historically	97.35	128.11
Ethyl alcohol imports, cal. yr.	NA	thousand liters	FATUS 2207	586560.00	708058.20
Ethyl alcohol exports, cal. yr.	NA	thousand liters	FATUS 2207	218105.80	223157.60
Ethanol disapp., cal. yr.	ETDISCL	million gallons	Calculated	1419.40	2912.28
Ethanol end stocks, cal. yr.	ETDTESCL	million gallons	http://tonto.eia.doe.gov/dnav/pet/hist/mfestus1m.htm	132.89	235.54
Fed. ethanol tax credit, cal. yr.	ETTAXEX	cents per gallon	Assumed	0.54	0.52
Ethanol import tariff, cal. yr.	ETTAR	cents per gallon	Assumed	0.54	0.54
Renewable fueld mandate, cal. yr.	RFMAN	million gallons	Energy Policy Act of 2005	0.00	0.00
Ethanol additive dummy	ETADD	proportion	Assumed--ethanol as "additive" share of motor gasoline	0.03	0.03
Ethanol yield--dry mill, Sep-Aug	ETYLDDM	gallons per bu.	Assumed	2.68	2.69
Ethanol yield--wet mill, Sep-Aug	ETYLDWM	gallons per bu.	Assumed	2.66	2.67
Motor gas. supplied, Sep-Aug	MGSTOTSA	million gallons	http://www.eia.doe.gov/emeu/mer/pdf/pages/sec3_17.pdf	127408.66	138296.46
Unl. gas. pr., Omaha, Sep-Aug	UGPFBSA	dollars per gallon	Simple average of Sep-Aug prices from	0.67	1.27
Unl. gas. retail price, Sep-Aug	UGPRTSA	dollars per gallon	http://www.eia.doe.gov/emeu/mer/pdf/pages/sec9_6.pdf	1.28	1.87
Ethanol price, Omaha, Sep-Aug	ETPFBSA	dollars per gallon	Simple average of Sep-Aug prices from	1.21	1.64
Ethanol implied ret. pr., Sep-Aug	ETPRTSA	dollars per gallon	Calculated	1.28	1.73
Dry mill capacity, Sep-Aug avg.	ETCAPDM	million gallons	Assumed	798.43	2248.62
Wet mill capacity, Sep-Aug avg.	ETCAPWM	million gallons	Assumed	933.95	1083.25
Eth. dry mill cap. use, Sep-Aug	ETCUSDM	proportion	Calculated	0.82	0.93
Eth. wet mill cap. use, Sep-Aug	ETCUSWM	proportion	Calculated	0.87	0.91
Ethanol non-corn prod, Sep-Aug	ETSPNCSA	million gallons	Assumed	3.17	100.08
Ethanol cellulosic prod, Sep-Aug	ETSPCESA	million gallons	Assumed	0.00	0.00
Ethanol prod., Sep-Aug	ETSPRDSA	million gallons	http://tonto.eia.doe.gov/dnav/pet/pet_pnp_oxy_dc_nus_mbbl_	1456.84	3196.46
Ethanol imports, Sep-Aug	ETSIMPSA	million gallons	http://tonto.eia.doe.gov/dnav/pet/pet_move_imp_dc_NUS-	5.94	150.70
Ethyl alcohol net imp., Sep-Aug	ETSIMNSA	million gallons	Calculated from USDA data historically	97.13	201.05
Ethyl alcohol imports, Sep-Aug	NA	thousand liters	http://www.ers.usda.gov/Data/feedgrains/StandardReports/YBt	585636.95	963830.35
Ethyl alcohol exports, Sep-Aug	NA	thousand liters	http://www.ers.usda.gov/data/feedgrains/StandardReports/YBt	218002.25	202864.31
Ethanol disapp., Sep-Aug	ETDISSA	million gallons	Calculated	1527.20	3356.29
Ethanol addit. market, Sep-Aug	ETDADSA	million gallons	Assumed	68.80	1765.35
Ethanol E10 market, Sep-Aug	ETME10SA	million gallons	Calculated	3661.92	9680.75
Ethanol E10 pen. rate, Sep-Aug	ETE10PEN	proportion	Calculated	0.07	0.16
Ethanol E10 use, Sep-Aug	ETDE10SA	million gallons	Calculated	625.64	1540.94
Ethanol E85 market, Sep-Aug	ETME85SA	million gallons	Assumed	168.30	1293.96
Ethanol E85 pen. rate, Sep-Aug	ETE85PEN	proportion	Calculated	0.01	0.04
Ethanol E85 use, Sep-Aug	ETDE85SA	million gallons	Assumed	6.00	50.00
Ethanol ending stocks, Sep-Aug	ETDTESSA	million gallons	http://tonto.eia.doe.gov/dnav/pet/pet_stoc_typ_d_nus_SAE_m	170.78	284.37
MTBE production, Sep-Aug	NA	million gallons	http://tonto.eia.doe.gov/dnav/pet/pet_pnp_oxy_dc_nus_mbbl_	3170.33	2360.09
MTBE imports, Sep-Aug	NA	million gallons	http://tonto.eia.doe.gov/dnav/pet/pet_move_imp_dc_NUS-	1069.98	614.59
MTBE exports, Sep-Aug	NA	million gallons	http://tonto.eia.doe.gov/dnav/pet/pet_move_exp_dc_NUS-	317.03	413.39
MTBE ending stocks, Sep-Aug	NA	million gallons	http://tonto.eia.doe.gov/dnav/pet/pet_stoc_typ_d_nus_SAE_m	339.17	160.53
MTBE disapp., Sep-Aug	MTDISSA	million gallons	Calculated	3942.36	2613.17
HFCS yield, wet mill	HFYLDWM	pounds per bu.	Calculated based on USDA-reported corn used for HFCS and HFCS deliveries; fixed at average of 2002/03 and 2003/04 for	34.92	34.82
HFCS prod., Oct.-Sep.	HFSPRDOS	thousand tons	http://www.ers.usda.gov/Briefing/Sugar/data/table29.xls	9096.89	9234.20
HFCS dom. deliveries, Oct.-Sep.	HFDDOMOS	thousand tons	http://www.ers.usda.gov/Briefing/Sugar/data/table28.xls	8900.58	9135.40
HFCS net exports, Oct.-Sep.	HFDEXNOS	thousand tons	Pre-2006: Production - deliveries	196.31	98.80
HFCS exports, Oct.-Sep.	HFDEXTOS	thousand tons	http://www.ers.usda.gov/Briefing/Sugar/data/table32a.xls	320.80	246.77
HFCS exports to Mexico, O-S	HFDEXMOS	thousand tons	http://www.ers.usda.gov/Briefing/Sugar/data/table32b.xls	174.46	79.93
HFCS prod., cal. yr.	HFSPRDCL	thousand tons	http://www.ers.usda.gov/Briefing/Sugar/data/table30.xls	8942.20	9195.60
HFCS dom. use, cal. yr.	HFDDOM	thousand tons	Sugar and Sweeteners yearbook, Table 30, projections =	8750.00	9139.40
HFCS net exports, cal. yr.	HFDEXN	thousand tons	http://www.ers.usda.gov/Briefing/Sugar/data/table30.xls	192.20	56.60
HFCS-42 price, Midwest, O-S	HFPRMW	cents per pound	http://www.ers.usda.gov/Briefing/Sugar/data/Table09.xls	11.37	13.64
Raw sugar price, Oct.-Sep.	SUPRAW	cents per pound	Sugar model	21.13	21.30
Refined beet sugar price, O-S	SUPREF	cents per pound	Sugar model	24.95	27.56
HFCS consumption trend	HFTRND	units	Assumed	17.70	17.00
DDG yield, dry mill	DGYLDDM	pounds per bu.	Assumed	17.00	17.00
Dist. grains production	DGSPRD	thousand tons	Computed based on dry milling and assumed yield	2032.83	6702.14
Brewers grain production	BGSPRD	thousand tons	Computed based on assumed yield from barley food use	1127.13	1084.01
DDG/Brewers dom. use	DGDDOM	thousand tons	Computed from production and net trade	2516.88	6907.62
DDG/Brewers net exports	DGDEXN	thousand tons	FATUS-reported trade; projections from equation	643.07	878.52
DDG price, Lawrenceburg	DGPMKT	dollars per ton	Feed Situation and Outlook Yearbook, April 2004, p. 55, updated with Feed Outlook, May 2004, Table 4; projection	100.25	86.73
Brewer/dist. grain exports	BDGDEXP	1000 metric tons	FATUS, 2303300000	710.44	908.54
Brewer/dist. grain imports	BDGSIMP	1000 metric tons	FATUS, 2303300000	127.05	111.56