Cover Page for Paper for Inclusion in AEA 2011 Proceedings

Paper title : **Ethanol policy effects on US natural gas prices and quantities**

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Session title: Agriculture and Energy: new direct and indirect links can lead to unintended consequences

Session chair: William Meyers

Session discussant: Vincent Smith

Title: *Ethanol policy effects on US natural gas prices and quantities*

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Debate has raged about the consequences of US corn-based ethanol. Studies sought to identify how much it affected world commodity markets (Josef Schmidhuber, 2006; Dileep Birur, Thomas Hertel, and Wallace Tyner, 2008; Seth D. Meyer, Pat Westhoff and Wyatt W. Thompson, 2009). The popular press speculated on the potential for growing US ethanol production to drive up world prices, with unintended consequences for world food supplies. An unintended consequence of such an effect is to spur changes in land use outside the US, possibly leading to greenhouse gas emissions (Angelo Gurgel, John M. Reilly, and Sergey Paltsev, 2007; Martin Banse, Hans van Meijl, and Geert Woltjer, 2008). But these discussions focus narrowly on one set of related markets, namely those for agricultural commodities. Other studies have estimated that greater ethanol availability reduces gasoline prices to the benefit of US motor fuel consumers (Xiaoyang Wang, 2008; Xiaodong Du and Dermot J. Hayes, 2009).

We focus on the direct effects on the US natural gas market of US biofuel policies, specifically tax credits, ethanol tariff, and mandates. Increased ethanol production based on current technologies and policies is likely to lead to greater corn demand and indirectly to more land allocated to growing corn. Both these activities use natural gas either directly for firing an ethanol plant or indirectly through the fertilizers and other chemical inputs used to grow corn. These effects will tend to drive up natural gas prices. We estimate the magnitude of effects and test its sensitivity to market conditions given the presence of a quantity policy lever in the form of biofuel use mandates. We also assess whether or not the link from petroleum to natural gas is strengthened by the presence of a new product, ethanol, that substitutes for gasoline and is made in part from natural gas.

I. Background and intuition

All three key elements of US biofuel policy can increase US ethanol production over levels that would likely occur without these policies in place. The tax credit given to fuel blenders for each gallon of biofuel that they use in blended fuels for domestic consumption encourages them to buy more. This will tend to drive US ethanol and biodiesel production higher, particularly if there are any natural or policy barriers to trade. Indeed, a specific tariff on ethanol imports is somewhat paired with the tax credit, with the apparent purpose of redirecting any effect of the tax credit towards domestic ethanol producers. The tax credit and tariff have been in place for some time, albeit with changes in the per-gallon level from time to time, thus our assumption that they will be continued indefinitely in our baseline case seems appropriate.

Biofuel use mandates can also drive US ethanol higher, but only under certain conditions. If biofuel use would have been higher than the mandated volume anyway, then this policy may have little or no direct effect on markets. For example, if a high petroleum price led many consumers to replace petroleum-based gasoline and diesel with ethanol and biodiesel and if the consequent marketed volumes were higher than the mandate, then it would not be binding. Likewise, high corn or soybean yields or poor international demand for these agricultural commodities could lower biofuel production costs enough relative to even a modest petroleum price that biofuel use would exceed the mandated volumes.

The mandates do have direct effects on markets if the mandated volumes exceed the amount that would have been used otherwise. Thus, a combination of a low petroleum price, low crop yields, and strong foreign agricultural commodity demand would tend to be associated with a binding mandate. Moreover, the underlying legislation sets out rising mandate volumes and places growing emphasis on new forms of biofuels. The contribution of corn-based ethanol is capped at 15 billion gallons by 2015, as compared to about 11 billion in the 2009/10 marketing year. The total mandate continues to rise, reaching 36 billion gallons by 2022 with a larger share drawn from sugar-based ethanol and biofuels made from cellulosic feedstocks or agricultural waste.

The mandates affect markets if they are binding but have no direct effects if they are not binding, thus leading to a certain dependence of results on the surrounding context. Moreover, the effects of tax credits and ethanol tariff should not be assessed independently of the mandates. If the mandates are not binding, then tax credits and tariff will affect quantities as normal. If the mandates are binding, then the tax credits might not cause there to be any additional biofuel quantities used and the tariff might affect where the mandated volume is sourced but not the overall level. Thus, if the mandates affect volumes used, then the credit and tariff probably do not; and if the mandate is not binding and has little or no direct effect on volumes used, then the credit and tariff do have an effect.

The links from biofuel policy to natural gas are intuitively quite clear. The biofuel policies can increase the use of ethanol. More ethanol use will drive higher US production. Most of US biofuel production is corn-based ethanol, at present, so greater production of these fuels will increase demands for that feedstock. Agricultural commodity prices will change, leading to shifts in area and changes in yield, presumably driving higher US corn production with other effects depending on relative price signals. Because natural gas is an important input into ethanol, corn, and other crop production, these policy effects will be manifested in natural gas markets as greater natural gas use for these purposes and a higher price.

These expectations must be rendered with some caution. The sensitivity of effects to the broader context, as noted above, is one reason. Another is the difficulty of drawing strong conclusions about the future based on historical data given the pace of change in the biofuel sector. Ethanol use, for example, rose from less than two billion gallons until 2000 and is three-fold higher than it was five years ago. Direct time series estimation linking these markets over historical data seems an unreliable predictor of future relationships, particularly as the mandates will require further growth in use even if the petroleum price or other conditions would suggest otherwise. Instead, we represent the links from ethanol and crop production to natural gas using a structural model, as summarized below, and test how shocks to ethanol and crop production pass through those links to affect natural gas markets.

II. Data and Method

We arrive at our estimates in the following steps. First, we identify source data that project US agricultural and biofuel commodity markets with and without the three key biofuel support policies. We exploit existing work on the direct effects of biofuel policies on agricultural and biofuel markets by extending the effects on ethanol production and land use to their implications for natural gas demand. Meyer, Westhoff and Thompson (2009) generated 500 sets of potential effects of discontinuing US biofuel tax credits, use mandates, and specific ethanol tariff on biofuel and agricultural commodity markets. Results represent the sensitivity of these policies' impacts over a ten-year, forward-looking period to various combinations of petroleum prices, yield shocks, and commodity demand perturbations.

Second, we feed these data into a structural model of natural gas. Other US natural gas demands, domestic supply, and trade will be represented using a partial equilibrium structural model (Jarrett Whistance, 2009). The estimated elasticities are well in line with other studies (for example, Hillard Huntington, 2007; George Lady, 2007), but in some few cases elasticities were imposed because of poor estimation results and, in those instances, the values were dictated by findings reported in previous studies (Energy Information Administration (EIA), 2009). This model is based mostly on data from the EIA. To test the sensitivity of results to market conditions in the agricultural and biofuel sectors, we use all 500 sets of biofuel and agricultural market outcomes as exogenous data representing different possible combinations that are consistent with the underlying policy assumption (discussed next). We broaden our experiment even more by drawing randomly on the errors of the natural gas model to see if the results of our experiment are robust with respect to natural gas model error.

We repeat the experiment twice to reflect two different policy assumptions. In the first, the “baseline” case, we feed to the natural gas model a set of biofuel and agricultural commodity results that are based on the assumption that biofuel policies are maintained or extended indefinitely. Thus, in the baseline results, the ethanol and crop production demands for natural gas are consistent with the presence of biofuel use tax credit, ethanol tariff, and rising mandates. In the second experiment, the “scenario” case, we remove these three biofuel policies. The second experiment tests the case of no policy in the future, but it is not a test of what happens if there are no biofuels nor if there never were any biofuel policy. We do not change the fact that there already exists ethanol production capacity that will be engaged as long as variable net returns are positive and we allow continued ethanol use either as an additive to gasoline to change its properties or as a substitute for gasoline if the petroleum price is high or the ethanol price low. Thus, our exercise is relevant in a forward-looking sense: we use a structural model that can reflect the scale of future use, not much smaller past levels, and we take as given the starting point and consumer realities that are immutable from a policy perspective.

III. Results

The results of eliminating US biofuel support are measured as the change from the baseline case with policies in place to the scenario case with policies eliminated. In each of these two cases, a 9-year projection period is solved in 500 stochastic simulations over random terms, including petroleum price and errors, to gain a sense of the range or effects that, as discussed above, are likely to be sensitive to market conditions. Results are expressed in terms of average effect of eliminating the policy or to indicate the distribution of these simulated effects such as by comparing the standard deviations. The sensitivity to market context is investigated by looking at the correlation between variables and the correlation between changes in key indicators with the levels of key driving factors. These measures are calculated for the average over the 9-year projection period and for a few particular years.

The average results over the period and over all simulations show that eliminating US biofuel support has important consequences for the use of natural gas in ethanol production, lesser effects on its use in corn production, and minimal implications for broader natural gas markets. The volume of natural gas used for ethanol production is reduced by a third if support is discontinued. The period-average reduction in natural gas used for corn production is 6%, with less sizeable and positive relative impacts on natural gas use for other crop production. The natural gas price effect is a more modest -0.3%, reflecting the fact that even though the volumes of natural gas used for ethanol production in the future are expected to be much more than levels used in the past given current policy, it still remains a very small share of total natural gas markets. The effects tend to be largest in 2018, when the mandates would be larger, with natural gas use for ethanol production off by almost half and natural gas use for corn 8% lower, on average. Even by 2018, the average effect on natural gas price is -0.4%.

The mandates reduce variability in the volume of ethanol used and, consequently, limit the down-side swings that might otherwise be induced if a low petroleum price undermined consumer demand for substitute biofuels or if high agricultural commodity prices shifted back biofuel supply curves. Removing these three biofuel policies causes changes in the period-average standard deviation (e.g. the standard deviations of 500 simulations for each year averaged over the 9-year period). The standard deviation of the natural gas used for ethanol is 2.7 times higher without support than it is with mandates, credits, and tariff in place. The impact on natural gas use for corn production is much more modest, reflecting the limited role of ethanol in corn markets and the mitigation of price shifts brought about by the usual market responses. The eventual impact on natural gas prices is vanishingly small as compared to the immediate impact on ethanol, particularly when set in comparison to the sorts of ranges of results generated by sizeable shocks to the error terms of the natural gas market.

There is some evidence of correlation between the changes in natural gas used for ethanol or corn production caused by discontinuing biofuel policies and corn yields and more correlation between petroleum price and these effects. For example, the correlation between the corn yield level and the (negative) change in the wholesale natural gas price caused by removing the policy is 0.05, on average, and the correlation between petroleum price level and the change in the natural gas price is 0.80. The mandate is more likely to affect markets if the corn crop is poor and particularly if petroleum price is weak, leading to larger decreases in natural gas use for ethanol and corn when either determining factor is below average.

Ethanol could represent a new link from petroleum markets to natural gas markets. If a higher petroleum price leads to more ethanol use and consequently more demand for natural gas as an input to making ethanol, then the budding ethanol market could cause greater integration of these two energy markets in the future. Moreover, this link is likely to be stronger in the absence of quantity limits, than with the mandates in place. However, in correlations among these variables we see very little evidence of any contemporaneous links or even over the period averages, and removing biofuel support has only small effects on that relationship.

Finally, US consumer expenditures on natural gas are estimated by taking the product of wholesale price for each broad use category (residential, industrial, and so on) times relevant volume, then summing over all domestic uses. This proxy would be accurate if the change in expenditures at the wholesale level is passed on to consumers. Removing biofuel support reduces consumer expenditures in 2018 by USD 2 billion, or 0.9%, on average in the 500 simulations. The change in the natural gas price ranges from -0.5% to -0.2% and tends to be more pronounced (larger in absolute value) if the petroleum price is lower.

IV. Conclusions

The objective of this paper is to estimate the natural gas price increase caused by different US biofuel policies, thereby offsetting some of the presumed benefits to consumers associated with any decreases in motor fuel prices. In simulating over many possible market contexts and possible errors in estimated equations, we find that changes in biofuel and agricultural markets caused by discontinuing US biofuel tax credits, ethanol tariff, and use mandates on natural gas markets are small. While discontinuing these policies reduces natural gas use for ethanol by almost one-half, on average, and reduces the use of natural gas for crop production, the magnitude of these changes relative to the broader natural gas market are quite small and the reduction in natural gas prices is quite small. Discontinuing US biofuel support increases the variability in natural gas used for ethanol and crop production. The changes in natural gas markets tend to be larger if the crop yield or particularly the petroleum price is lower.

Similarly, the reduction in consumer expenditures change of eliminating the policy on costs, which averages about $2 billion or 0.9%, also depends in part on these conditioning factors. We identify no contemporaneous link through ethanol between natural gas and petroleum prices, with or without policies, possibly owing to delays in crop production and capacity building.

This exercise is based on certain assumptions that would ideally be adjusted in future analyses on the question of US biofuel policy effects on natural gas markets. First, the causality was one-way, from crop and biofuel markets to natural gas markets, whereas it should be two-way with natural gas prices feeding back to affect costs of crop and biofuel production. Second, the exogeneity of the petroleum price, and mostly recursive determination of petroleum product prices, ignores the potential for substitution between natural gas and petroleum in electricity, industrial, and other demands as well as feedback through competition in motor fuel markets with biofuels. Clearly, a useful step would be to endogenize petroleum and petroleum product markets. Third, drawing the boundaries at the US border, albeit with trade equations to represent import supplies and export demands, might be replaced with broader market definition, particularly if other countries' biofuel policies are to be assessed.

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