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U.S. Biofuels Policy: Few Environmental Benefits but Large Trade Gains

Gal Hochman, Geoff Barrows, and David Zilberman

The introduction of ethanol has significant but subtle impacts, which include substantially improving the U.S. energy trade balance and contributing to the United States becoming a net exporter of petroleum products.

Since the advent of motor vehicles the search has been on for affordable fuels. Petroleum products have been the dominant fuel because of their cost advantages. Even though petroleum is considered a non-renewable resource, discoveries were ahead of its use for the time, and its price tended to decline. But that changed in the beginning of the new millennium, where ethanol in Brazil and in the United States has become an alternative to gasoline.

The introduction of ethanol has significant but subtle impacts, some of which were not initially expected. It substantially improved the U.S. energy trade-balance and contributed to the United States becoming a net exporter of petroleum products in 2012. However, although there is much potential for future advancements, current contribution of conventional biofuels to the reduction of the U.S. greenhouse-gas (GHG) emissions is limited.

The introduction of ethanol to the fuel mix in the new millennium and its resurrection did not begin as a response to energy scarcity. Congress passed the 1990 Clean Air Act Amendments, which required fuel oxygenates, such as methyl tertiary butyl ether (MTBE) and ethanol, to be added to Reformulated Gasoline (RFG) so as to reduce automotive emissions and improve air quality.

Petroleum refineries preferred the use of MTBE for various reasons, but new information toward the end of the 1990s suggested that MTBE may be a serious health hazard and contaminate public water systems and private water wells. This led many states in the late 1990s and early 2000s to phase out the use of MTBE, and limit or ban the use of MTBE in gasoline. But the increases in the price of oil around 2005 led to larger scale introduction of ethanol as a biofuel and a substitute for gasoline.

While much of the debate about biofuel was related to its impact on food prices, it has significant effects which will be addressed here. We will illustrate the effect of the introduction of ethanol on the U.S. balance of trade and its effect on GHG emissions—showing that ethanol substantially contributed to the improvement of the U.S. balance of trade.

The Conceptual Framework

Our analysis considers three major stages in the life of gasoline: extraction and production of crude oil, petroleum refining, and blending and consumption. The production of oil is dominated by a cartel-of-nations (OPEC) whose production is supplemented by other countries, which individually have a much smaller impact on prices. The crude oil produced is distributed to petroleum refineries, which utilize a multi-product process that is very capital intensive and costly to modify to produce petroleum products.

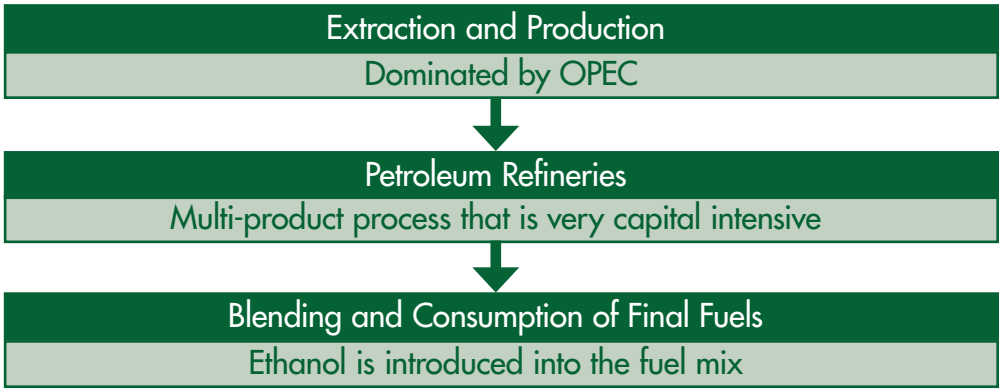

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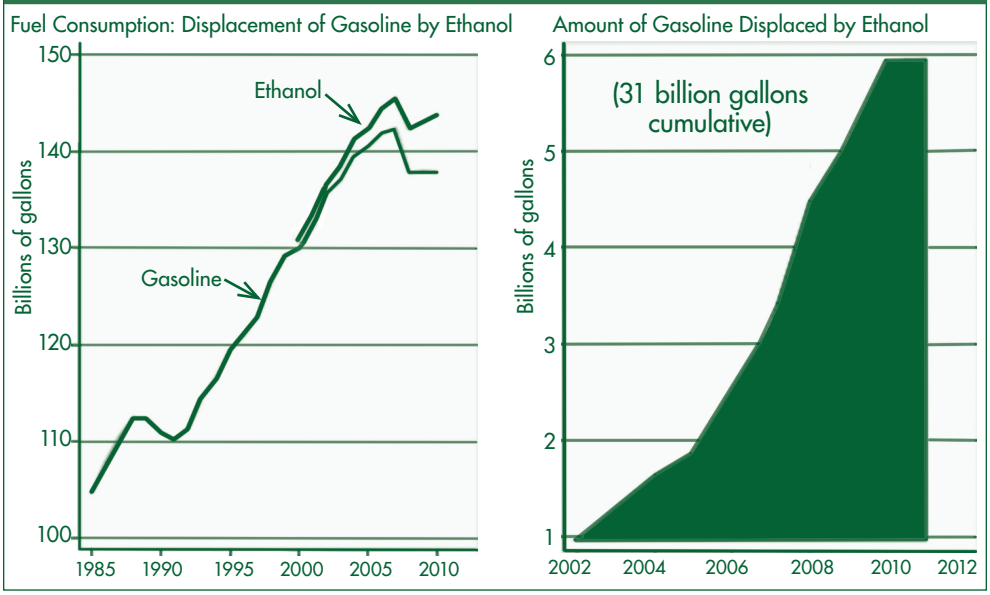
Figure 1. The Decline of Finished Motor Gasoline Consumption



Our quantitative analysis is simplified. It assumes that the demand for fuel and per unit costs of fuel are linear; there are two regions (the biofuel-producing nations and the rest of the world), and that ethanol is only consumed in the country where it is produced. When calibrating the model, all quantities were adjusted to gasoline-equivalent quantities. To assess how the equilibrium prices and consumption of fuels change with the introduction of ethanol, we use the calibrated functions to simulate the equilibrium outcome of a counterfactual scenario without ethanol.

We used data on gasoline prices and quantities, as well as ethanol quantity, taken from the U.S. Energy Information Administration. Further, when computing ethanol's contributions to GHG emissions, we recognize that every fuel feedstock has its own intensity, and that the introduction of ethanol results in a 9% reduction in emissions attributed to reduction in use of other petroleum products.

Impacts

The introduction of ethanol into the gasoline market in the United States caused fuel prices to decline by about 3% (2.50 US$) per barrel of gasoline. The introduction of ethanol creates pressure to reduce prices.

One of the most interesting outcomes is that OPEC countries alleviate the downward pressure on fuel prices (due to the introduction of ethanol) by redistributing benefits from ethanol to their domestic fuel consumers. That is, the introduction of ethanol reduces exports from OPEC countries but increases domestic consumption in those countries.

Introducing ethanol to the fuel markets did not reduce the consumption of gasoline by an equivalent amount. Actually, a barrel of ethanol displaced, in percentage terms, about 50% of a barrel of gasoline. This is because of the rebound effect—ethanol reduces the price of fuel, including gasoline, and thus increases consumption of gasoline. However, because of market power both at the upstream and the downstream oil markets, prices of fuel did not decline as much as they could, and overall fuel consumption declined more than under competition. Thus, the OPEC response to the introduction of ethanol plays a significant role in determining the rebound effect.

Further, lower demand (resulting from a move toward a more efficient light vehicle fleet) and introducing ethanol technologies that are more scalable, leading to a more price-sensitive ethanol supply, resulted in higher displacement of gasoline by ethanol and to a lower rebound effect. Thus, in 2005, the United States consumed 141 billion gallons of finished motor gasoline annually. However, in 2011 U.S. consumption of finished motor gasoline declined to 134 billion gallons annually. The amount of ethanol consumed in the United States in 2011 equaled 67.25% of the decline of finished motor gasoline consumption.

Figure 1 depicts the number of gallons of finished motor gasoline consumed, and contrasts these amounts with those of ethanol consumption for the period 2000–2011. The figure suggests that while the overall rate of growth of fuel (gasoline and biofuel) maintained the trend observed prior to 2000, growth rates of gasoline declined post 2000. These changes are observed while the amount of ethanol consumed increased significantly—from 2000 to 2011, the United States consumed more than 32 billion gallons of ethanol.

The reduction in imports of crude oil and petroleum products led to an improvement in the U.S. energy trade flows and the balance of trade. The introduction of ethanol resulted in savings in the United States of almost 100 billion US$ in currency outflows. This is based upon a reduction of 46 billion US$ paid for crude oil extracted in OPEC countries, combined with a similar amount saved by reduced currency paid for crude oil and gasoline imports from non-OPEC countries.

The introduction of ethanol in the United States not only impacted fuel and crude oil prices, but helped the U.S. become a net exporter of petroleum products. Figure 2 depicts U.S. refiners' and blenders' net production of gasoline—the gasoline available for consumption or net of the quantity used for its own production. When fitting a quadratic trend from 1945 to 2012 (dashed

line in Figure 2), throughout most of the 2000s U.S. net gasoline production was above its long-run trend. With 42 gallons per barrel, production of U.S. gasoline in 2005 was 3,036 million barrels, increasing to 3,306 million in 2011.

Although total quantity of fuel consumed increased with the introduction of ethanol, less gasoline is consumed in equilibrium. Since ethanol did not fully replace gasoline (i.e., the rebound effect), our numerical analysis suggests only a modest effect of the introduction of ethanol on carbon emissions. The introduction of corn ethanol resulted in a decrease of about 40 million tons of CO_2 that the United States emitted from 2000 to 2011. If a ton of carbon costs society 30 US$, the cost saving from reduced CO_2 emissions is equivalent to 437 million US$ This cost is relatively small compared to the volume of economic activities in the energy sector, which is in the billions of dollars.

Although the introduction of corn ethanol led to a modest reduction of the stock of carbon, and under certain assumptions may even result in an increase in carbon emitted to the air, the potential from a carbon-neutral feedstock is large. The introduction of advanced biofuels that sequester almost as much carbon as they emit will result in a reduction of the stock that may be up to 10-fold larger than the CO_2 reduction from the use of ethanol.

Finally, the multi-product refinery process suggests that the introduction of ethanol impacted diesel production and affected yield. The data suggest that from January 2000 to March 2012, diesel share increased from 21.9% to 28.5%, while gasoline share decreased from 47.8% to 44.6%. Much of the output of diesel was exported to Europe, contributing to the gain in the U.S. balance of trade.

Conclusion

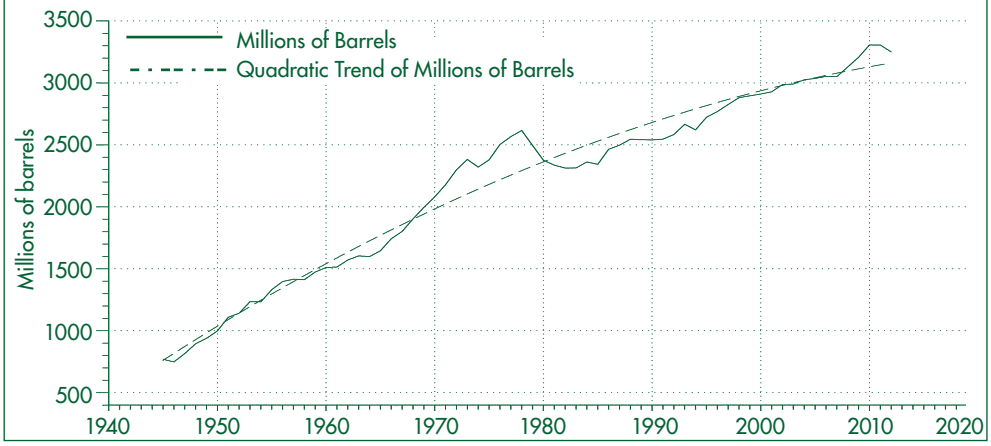
The analysis provided in this paper adds insight into the economic impacts of the introduction of ethanol. This work complements studies that alluded to the cost of U.S. biofuel, as well as its effect on food prices, and argues that the introduction of ethanol into the U.S. fuel markets has significantly impacted the U.S. balance of trade and helped it become a net exporter of petroleum products.

While there is much discussion on the impact of biofuels on the price of food and cost to consumer, there are other effects, including the effect on the U.S. balance of trade. These effects not only reduced imports but also increased exports of petroleum products. Because of the increase in exports of petroleum products, the change in GHG emissions might have been smaller than otherwise thought. However, the GHG effect on U.S. fuel consumption was much more substantial.

The numerical analysis suggests that as oil demand increases, the gains from ethanol are likely to increase. It also suggests that as the ethanol sector grows, further reduction in foreign oil supply may follow, and that the corn ethanol contribution to the U.S. balance of trade may become much larger.

Our analysis is a partial equilibrium analysis, and more research is needed to assess the global implications of U.S. ethanol production. Such analysis will also add insight to our understanding of the implications of the introduction of second generation biofuels and natural gas, where production of fossil fuels may not decline as much as previously thought because of exports. U.S. biofuel mandates were motivated by energy security and climate-change considerations. Our analysis suggests that they made a modest contribution to reduce greenhouse-gas emissions but significantly reduced dependence on foreign fuel. Perhaps their most significant contribution has been to an unstated objective—improved balance of trade.

Figure 2. Blenders and Refineries Net Gasoline Production



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Gal Hochman is an associate professor at Rutgers University who can be reached at hochman@aesop.rutgers.edu. Geoff Barrows is a Ph.D. student and David Zilberman is a professor, both in the ARE department at UC Berkeley. They can be reached by e-mail at gmb103@berkeley.edu and zilber11@berkeley.edu, respectively.

For additional information, the authors recommend:

Hochman, G., D. Rajagopal, and D. Zilberman. "The Effect of Biofuels on the International Oil Market," *Applied Economic Perspectives and Policy*, 33(3) (2011): 402-427.

U.S. Energy Information Administration. www.eia.gov.