Meeting a Growing Demand for Food and Fuel in a Sustainable Manner

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Production of biofuel from grains has reached a limit, resulting from concerns about food and fuel trade-offs. Several nonfood biofuel feedstocks show promise. The introduction of new feedstocks and the adoption of new biofuels by consumers will be gradual.

The recent discovery of the genome and DNA, combined with concerns about reliance on nonrenewable energy sources and climate change, have led to efforts to introduce alternative industrial processes that rely on biological processes and renewable resources. These emerging industries are sometimes referred to as the "bioeconomy" and include biofuels, biotechnology, and green-chemistry industries. The bioeconomy is expanding the range of activities that are pursued by agriculture to include the production of feedstock for energy and chemical production, in addition to the production of foods, feeds, and fiber. This paper provides an overview of recent research findings on the economics of biofuel and its relationship to the food sector and the environment.

The biofuel industry is probably the most obvious sector of the bioeconomy. It is producing ethanol from sugarcane in Brazil, from corn in the United States, and from cassava and sugar beets in Thailand and Europe. It is producing biodiesel from vegetable oil, from palm oil in Malaysia, and from rapeseed in Europe. Current biofuel production in Brazil cannot meet domestic demand as 50% of the vehicle fleet is flex-fuel cars, i.e., cars that can run on both gasoline and ethanol. Brazil has a significant amount of land reserves that will be able to increase ethanol production capacity in the future. But currently, it is importing ethanol from the United States.

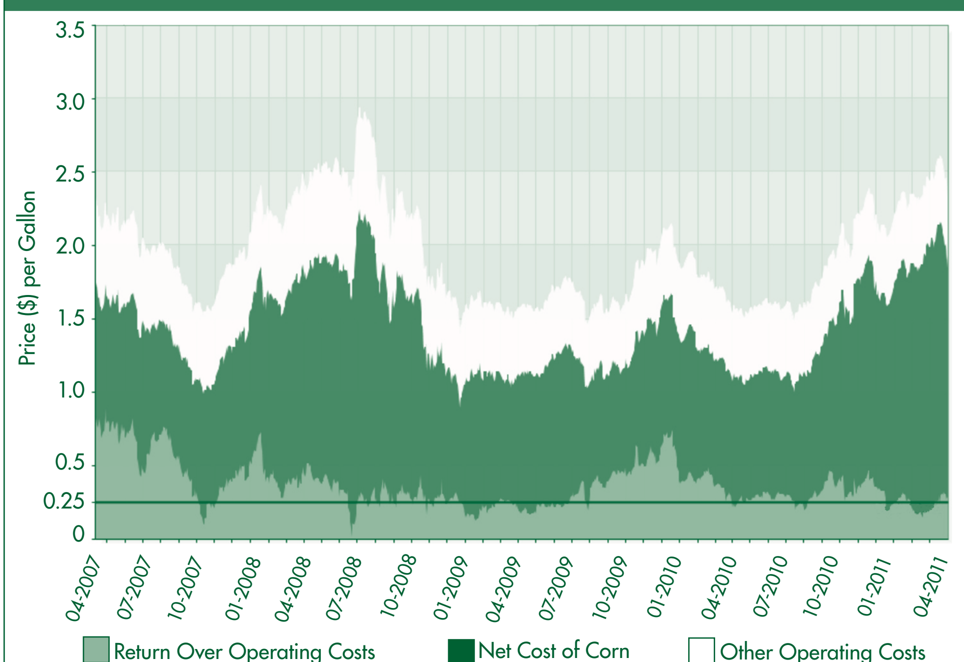
Currently, in the United States, corn ethanol is a breakeven business to biofuel refineries where revenues (including a 45 cents per gallon subsidy) cover both variable and fixed costs. The economics of the industry is strongly affected by the subsidy and mandate that reaches 14 million gallons annually. The profitability of the industry fluctuates depending on the relative price of corn versus fuel.

Figure 1 depicts the profitability of the industry between 2007 and 2011. The upper boundary of the white region is the price per gallon of ethanol. The cost includes the cost of corn and other operations costs, and what's left is the return to investment. A benchmark to assess profitability is that 25 cents per gallon required to repay the investment in five years. The 25-cents line is thus the breakeven line.

The industry was very profitable in 2006–07 where profit margins (revenue–variable costs) in some months reached 80 cents per gallon—much above the 25 cents per gallon required to repay the investment in five years. Yet, during the period of high food prices in 2008, revenues hardly covered variable costs. Because of this volatility, investors who were able to establish biorefineries during the high-margin period of 2006–07 were able to recapture their investment in two years, while investors in biorefineries that were launched during the period of relatively low biofuel prices faced financial difficulties.

While the industry's profitability is strongly affected by the subsidy, it is very likely that it would have existed in a somewhat smaller capacity with a smaller (or no) subsidy because of the periods of high margin that make

Figure 1. Ethanol Operating Margins Based on Nearby Futures and Iowa Corn Prices



Source: Center for Agricultural and Rural Development (CARD); www.card.iastate.edu, Iowa State University, Ames, Iowa investment very lucrative and possible to recapture in a short period of time. However, the capacity of the industry has been strongly affected by the assurance provided by the biofuel mandates introduced by the U.S. Energy Independence and Security Act.

The ability of the industry to grow is constrained by the blending mandates that restrict the amount of biofuel to be 10% of the fuel in a traditional gasoline car. Altogether, the industry has the capacity to produce 15 billion gallons of corn ethanol, but it is not likely to expand much in the future because of the current mandates.

The industry could expand if the blending barrier were raised to 15%, which is not likely to cause major problems with current car fleets. But this is subject to political debate. The industry could also expand if the number of flex-fuel cars and, in particular, the gas stations that serve them, were increased.

The value of biofuel is apparent from a realistic perspective on the capacity to address climate change with other technologies. California aims to reduce emissions by 80% of the 1990 emissions level by 2050. While this target cannot be met with existing technologies, even reducing the emissions level by 60% cannot be met without biofuels that are used in power as well as transportation.

Biofuels, relative to other alternatives, are a cost-effective way to rely on biological procedures to harness solar energy. Biofuels may be needed to meet greenhouse gas (GHG) emission-reduction objectives globally. However, there is significant concern about the impact of biofuels on food prices, which is a major constraint on the growth of the first-generation biofuels originating from starches.

While the impact on food available to consumers in the United States is quite low (less than 1%), impacts on prices of corn and soybeans could be significant, depending on overall harvests as well as inventory levels. For example, in 2008, some estimates suggest that biofuel demand contributed to a 30% increase in the price of corn. But, overall, these estimates also suggest that the impact of biofuel demand on food-price inflation is secondary to the impact of economic growth in developing countries, such as China and India.

Biotechnology and the Food/Fuel Dilemma

The impact of biofuels on food prices could be mitigated if the use of genetically modified (GM) varieties were expanded. Thus far, GM varieties have been used mostly in the production of corn, soybeans, and rapeseed in the United States, Canada, Brazil, and Argentina. The reduction of corn and soybean prices due to the current use of GM varieties is of the same order of magnitude as the increase in food prices attributed to biofuels in 2008. The impact of GM varieties on food prices could have been much larger if GM varieties of corn and soybeans were adopted in Europe or Africa and/or if GM rice or wheat varieties were used anywhere in the world.

Expansion of the use of GM varieties could have a beneficial environmental effect as well as reduce food prices to counter the impact of biofuels. The recent report of the National Research Council suggests that, based on the U.S. experience, the use of GM varieties has significant beneficial effects on the environment by reducing the use of pesticides, runoff, and soil erosion through increased adoption of low-tillage. Sustaining these gains is at risk because of the emergence of resistance to herbicide-tolerant varieties, which suggests the need for better management of the use of GM varieties as well as the introduction of new GM traits.

Thus, expansion and better management of the use of GM varieties can mitigate the impact of biofuels on food prices and have significant beneficial environmental effects.

Biofuels, Sugarcane, and Deforestation

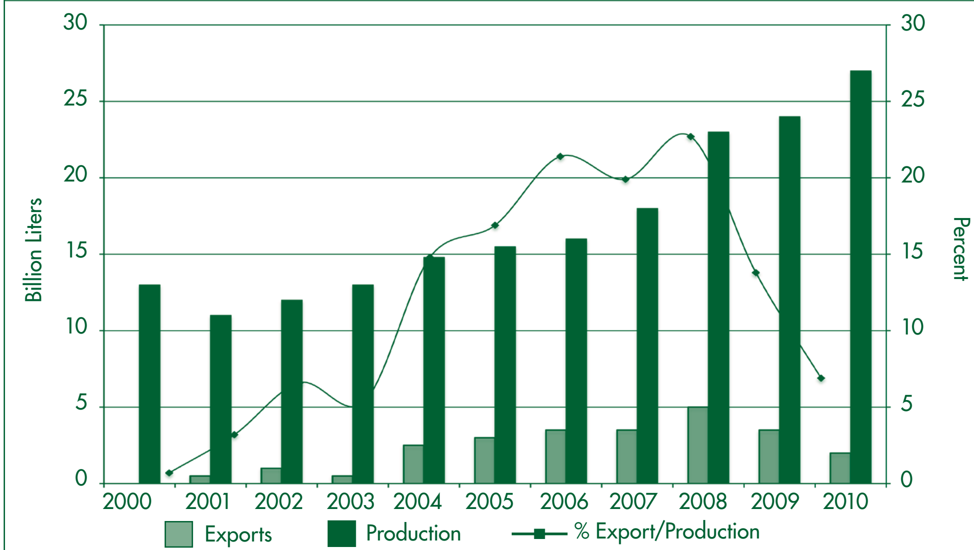
While the potential of biofuel production from staple food crops, such as corn and soybeans, is limited even with the adoption of GM varieties, there is significant potential to increase the production of biofuels from sugarcane and new sources. There are concerns that expansion of sugarcane biofuels in the tropics will lead to deforestation and significant emission of GHG. But there is significant potential to increase fivefold the acreage of sugarcane for biofuel in the savannas of Brazil and in Africa, without much loss of biodiversity or, in particular, large emissions of GHGs in the transition.

It is also suggested that expansion of biofuel production will expand deforestation indirectly, especially in Brazil. Conversion of range or savannas from grazing to farming will accelerate the conversion of forests to grazing. Transition from forests to grazing have occurred in the past, but the deforestation process in the Amazon was part of a historical land-settlement process. It was supported by government policies and by expansion of infrastructure, such as railroads and highways, that enabled the shipment of products from the interlands to the coastal areas. The process of land-based expansion in Brazil in the last 100 years is similar to the process of settlement in the United States in the 19th Century and in Europe and China earlier.

The American experience suggests that, once an agricultural land base has been stabilized, there is continuous growth in productivity through further intensification. While increased profitability of soybeans or sugarcane because of biofuels may contribute to the deforestation process, deforestation will continue nevertheless as long as cheap land is available and new cattle ranching operations are profitable.

Deforestation can be controlled only by establishing and enforcing strong environment-protection policies in the Amazon. The Brazilian government is establishing such policies, but the enforcement could be improved. However, intensification of range-management practices can significantly increase cattle production on existing land and reduce GHGs. Such intensification efforts are supported by the research agenda of the Brazilian Agricultural Research Corporation (a government national plan for climate and mitigation action), by producer responsibility movements, and by efforts to establish certification of sustainable production of cattle. The Brazilian policies have resulted in the deforestation rate slowing markedly since 2005.

Figure 2. Ethanol Exports in Brazil



Azevedo, Paulo. 2011. "Brazil: Building International Markets for Biofuel." www.berkeleybioeconomy.com/presentations-2/de_azevedo

Alternative Feedstocks for Biofuels

In addition to the expansion of sugarcane ethanol production, the growth of the production of biofuels without significant food-price effects would be made possible by the introduction of second-generation biofuels that can be grown on lands that are not used for food crops, but have the rainfall and other attributes to support biofuel production.

The challenge is to reduce the cost of this new type of biofuel significantly so that it can be competitive. Government mandates can provide a base for the industry, but breakthroughs in research and development (R&D) are crucial for its expansion. The feed crops for this industry could include grasses, such as miscanthus and switchgrass, for ethanol, as well as plants, such as Jatropha, for biodiesel. Some industrial forests could be converted for the production of biofuels.

Municipal waste is another important source of biofuel for both transportation and power. The economics of this feedstock stems from the cost of landfills and waste disposal that will be saved by the conversion of waste to energy, in addition to the revenue from the energy generation as well as other byproducts that can be captured in the process.

Algae are another feedstock for the production of biodiesel. The economics of algae as a source of biofuel is dependent on combining revenue from energy generation with revenue generated by the coproduction of high-value byproducts (fine chemicals, such as beta carotene). However, the market for many of these byproducts is very limited, which restricts the capacity to produce biofuels from algae economically. The future of algae as a source of biofuel will depend on its capacity to reduce the cost of biofuels.

Agave that is used to produce tequila has a large potential to be a feedstock to produce liquid fuel. Currently, the production of liquid fuel from agave is very expensive but, with technological innovation, production of byproducts, and the direct combustion of leaves to produce energy, agave may become a more viable source of alternative energy.

At present, biofuel mandates have been the dominant driver of the expansion of biofuels throughout the world, and several studies suggest that they contribute to at least a 10% reduction in the price of fuel. A continued rise in the price of oil combined with technological progress will lead to expansion in biofuel production beyond what is dictated by mandates. The growth of biofuels will also be dependent on the impact on food prices and support in financial incentives for GHG reduction.

While it is assumed that consumers will pay for biofuels in proportion to its energy content, there is growing evidence that the demand and the price paid for biofuel are affected by factors other than energy content. There is evidence of large differences in consumers' willingness to pay for ethanol in Brazil. Some factors are associated with willingness to pay a higher premium (more than 10%) for ethanol, including young age (<25), college education, living in regions that produce ethanol, and environmental preferences. Other characteristics are associated with willingness to pay more for gasoline, including older age, living in states that import ethanol, driving frequently, or driving expensive cars. Because of these differences, even in Brazil, the adoption of ethanol will be gradual and prices will vary among regions.

Indeed, the adoption of ethanol in Brazil is an ongoing process. Figure 2 depicts the production, export, and

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the export/production ratio of biofuels in Brazil during the last 10 years. While ethanol production in Brazil has increased by 18% annually on average over the last eight years, the share of exports in production, which reached 23% in 2008, has declined and is less than 10% in 2011. The growth of the domestic consumption of ethanol in Brazil has been associated with the gradual adoption of flex-fuel engines and investment in infrastructure to market ethanol-intensive fuels, which led to consumption beyond the mandates in some regions.

International buyers of Brazilian ethanol differ in their preferences. Some buyers from Japan and the European Union require more comprehensive information related to sustainability attributes of biofuels, while the demand for Brazilian ethanol in the United States/Caribbean is derived from short-term relative-price opportunities. One of the challenges is to develop credible certification programs for sustainable biofuels that would open doors to the adoption of biofuels in certain countries in Europe as well as in Japan, and increase the premiums, as some consumers will be willing to pay for sustainable ethanol in those countries.

There is evidence that U.S. consumers tend to pay a premium for ethanol compared to gasoline. Farmers and other individuals who are concerned with food security or the environment are more likely to pay a premium for biofuel. The existence of a large segment of the population with a preference for biofuel over gasoline reduces the overall economic cost of moderate biofuel mandates. The targeting of the sales of biofuels to regions with a high willingness to pay for these products will increase their profitability and enhance the growth of the industry.

Conclusion

Biofuels can play an important role in reducing GHG emissions and increasing fuel security. Yet, production of biofuel from grains has reached a limit, resulting from concerns about food and fuel trade-offs. The adoption of agricultural biotechnology will allow sustaining and even expanding production of agricultural biofuel production from food crops. However, substantial growth will require increased production of sugarcane-based biofuels and the introduction of second-generation products, which rely on feedstock that would not infringe much on food production. Some of these new products (e.g., biofuels from waste products) are more economically viable than others, but all require further R&D.

The expansion of the use of biofuels may require modification of the car fleet to increase the share of flex-fuel cars, and it also will require modification of the fuel supply chain to provide more access to biofuel products. Ideally, further R&D will result in new biofuel products that can be mixed with gasoline to reduce the cost of adjustment to biofuels. Both the introduction of new feedstocks and the adoption of new biofuels by consumers will be gradual. The understanding of regional differences in the cost of production of, and willingness to pay for, biofuels should guide efforts to market biofuels and enhance their economic viability.

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For additional information, the authors recommend:

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