Bioenergy and Agriculture: Promises and Challenges

2020 VISION FOR FOOD, AGRICULTURE, AND THE ENVIRONMENT

Biofuels and the Global Food Balance

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Rising world fuel prices, the growing demand for energy, and concerns about global warming are the key factors driving the increasing interest in renewable energy sources, and in biofuels in particular. But some policymakers and analysts have voiced concern that aggressive growth in biofuel production could "crowd out" production of food crops in some developing countries, creating a tension between the need for energy and the need for food and feed.

This brief investigates the interaction between crop demand for biofuel feedstock and the demand and production of crops for both food and feed, in order to see how scenarios for projected growth in biofuel production could affect food availability, prices, and consumption at global and regional levels between now and 2020.

BIOFUEL SCENARIOS

The model used for this analysis is the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), which the International Food Policy Research Institute (IFPRI) has used to project global food supply, food demand, and food security to the year 2020 and beyond. The model contains three categories of commodity demand: food, feed, and other use demand. This study manipulates the "other use" demand category in order to reflect the use of commodities as biofuel feedstocks, depending on the projected level of biofuel production. The commodities in question are maize, sugarcane, sugar beet, wheat, and cassava for bioethanol, and soybean and oilseed crops for biodiesel. Given that cellulosic feedstock sources such as crop residues and switchgrass are not represented, their effect is modeled by reducing the demand on the food commodities that are represented within IMPACT. A limitation of this approach is that it does not allow for substitution among different feedstocks in the production of biofuels, which when combined with the absence of trade in biofuel products, can cause the feedstock costs of biofuel production to vary enormously by country in the model solutions. Although this assumption about trade may be realistic in the short term, it would have to be relaxed for longer-term projections to allow for possible expansion in future biofuel trade.

Drawing on projections for biofuel demand for the relevant countries and regions, IMPACT models three scenarios in addition to the normal baseline, which contains no extra "other demand" usage for biofuel feedstock beyond that used in the base year 1997. These scenarios are as follows:

1. **Aggressive biofuel growth scenario with no productivity change.** This scenario assumes very rapid growth in demand for bioethanol across all regions and for biodiesel in Europe, together with continued high oil prices, and rapid breakthroughs in biofuel technology to support expansion of supply to meet the demand growth, but holds projected productivity increases for yields at baseline projection levels. The "aggressive biofuel growth" scenario replaces 10 percent of gasoline production with biofuels by 2010, 15 percent by 2015, and 20 percent by 2020 throughout most of the world, except for adjustments in line with other projections for Brazil, the European Union, and the United States. The biodiesel projections focus solely on the European Union 15 (EU-15) countries because they account for almost 90 percent of global production volume. Projections for all regions other than the European Union focus solely on bioethanol. For bioethanol production, maize, sugarcane, sugar beet, cassava, and wheat are considered feedstock crops. Table 1 shows the shares of biofuels in the context of total road transport fuel use, and these figures reflect the fact that although the scenario assumes displacement of either gasoline or diesel fuel in each country or region, many countries and regions use both types of fuel.
2. **Cellulosic biofuel scenario.** In this scenario, second-generation cellulosic conversion technologies come on line for large-scale production by 2015. In this case, the volume of biofuel feedstock demand is held constant starting in 2015, in order to represent the relaxation in the demand for food-based feedstock crops created by the rise of the new technologies that convert nonfood crop residues, grasses, and forest products. Crop productivity changes are still held to baseline levels.
3. **Aggressive biofuel growth scenario with productivity change and cellulosic conversion.** This scenario now considers, in addition to second-generation technologies, the effect of investments in crop technology that would lead to increased productivity over time, in order to better support the expansion of feedstock supply in response to growth in biofuel demand. These productivity improvements are parallel to those used in other IMPACT-based studies to show the benefits of sound agricultural investment policies in developing agricultural economies, and they emphasize strong agricultural productivity growth in Sub-Saharan Africa.

Table 1—Biofuel Production as Energy-Equivalent Shares of Total Gasoline and Diesel Demand for Transportation in the Aggressive Biofuel Growth Scenario (percent)

Year	China	India	Brazil	United States	European Union	Rest of world
2005	2	1	37	2	1	0
2010	4	5	47	3	4	2
2015	6	8	49	3	7	2
2020	8	11	58	4	10	2

Source: Authors' calculations based on 2005 actual production and energy demands from the Worldwatch Institute and the International Energy Agency (IEA). Brazil and U.S. projections based on IEA bioenergy and U.S. Department of Agriculture (USDA) sources, respectively.

Note: Higher shares in Brazil have significant exports of ethanol production embedded in them. The projection for the European Union is based on a potential path dominated by biodiesel, while other regions only represented displacement by bioethanol.

Table 2—Percentage Changes in World Prices of Feedstock Crops under Three Scenarios, Compared with Baseline

Feedstock crop	Scenario 1: Aggressive biofuel growth without technology improvements		Scenario 2: Cellulosic biofuel	Scenario 3: Aggressive biofuel growth with productivity change and cellulosic conversion
	2010	2020	2020	2020
Cassava	33	135	89	54
Maize	20	41	29	23
Oilseeds	26	76	45	43
Sugar beet	7	25	14	10
Sugarcane	26	66	49	43
Wheat	11	30	21	16

Source: IFPRI IMPACT projections.

RESULTS

The "aggressive biofuel growth" scenario shows dramatic increases in world prices for feedstock crops (Table 2). If cassava were to be used aggressively as a feedstock for bioethanol, cassava prices would rise tremendously, causing sizable welfare losses to the major consumers of this crop, who reside mostly in Sub-Saharan Africa. There would also be high economic costs. If cassava is not profitable as a biofuel feedstock at today's oil prices, it certainly would not be at more than double the cassava price. Thus, this scenario would entail subsidies for the biofuel sector, which already exist for many countries (such as within the European Union), and could take the form of tax concessions at the pump or producer credits. The high price increases for oils and cassava suggest that the relatively low-yielding oil and root crops will have to make up fairly high shares of total production in order to meet the oil-displacement trends embedded in the "aggressive biofuel growth" scenario.

In contrast, the second scenario, which includes the impact of cellulosic technologies, shows a considerable softening of these effects, especially for cassava and oil crops, and underlines the potential importance of such technical innovations at the industry level. Improvements in conversion efficiency for non-cellulosic processes are not introduced into the model, since these technologies have been in use for some time and show little room for improvement, based on studies cited in the literature.

The third scenario illustrates the importance of crop technology innovation at the farm production level and shows a further softening of price impacts, with cassava undergoing the largest decrease. This third scenario in particular shows how investments in the biofuel industry and the agricultural sector can be combined to produce a more favorable outcome, which can mitigate the consumer-level impacts. Moreover, this scenario seems the most plausible of the three, as neither national governments nor fuel producers would want to engage in a large-scale expansion of production without the necessary investments being in place to ensure a reliable supply of feedstock material at a reasonable cost, both for producers and for consumers of food and feed commodities.

Although the mechanisms by which feedstocks might be substituted in and out of biofuel production according to their competitiveness with long-term fossil-fuel prices and each other have not been modeled, an illustrative set of results (for a "fixed" menu of inputs) argues strongly for preparatory investments in both the agricultural sector and the fuel industry itself.

SUMMARY AND CONCLUSIONS

The results show a "food-versus-fuel" trade-off in cases where innovations and technology investments are largely absent and where trade and subsidy policies are failing. In view of past agricultural policy, such a scenario cannot be ruled out, unfortunately, but it could certainly be avoided. This bleak picture changes considerably when biofuel and crop production technology advancements are taken into account. Although there is some uncertainty about the timing of eventual large-scale use of cellulosic conversion technologies for biofuel production, the potential benefits are well recognized in the literature, making a strong case for further research in that area. The strong price increases for root crops like cassava in the first aggressive scenario suggest that without the necessary productivity improvements, aggressive growth in biofuels could have adverse effects on well-being in regions like Sub-Saharan Africa, where a large proportion of cassava consumption is for food. The third scenario, which gives an added boost to agricultural productivity growth in Africa, demonstrates this clearly.

The results suggest that the cost of biofuels could be considerably higher than the projected price of oil, so there would need to be compelling nonprice factors for its uptake at the aggressive levels assumed in first scenario in particular. Indeed, there may be factors favoring the decision to adopt biofuel production that cannot be captured within a strict quantitative comparison of biofuel versus fossil-fuel costs, such as national energy security or positive externalities to the environment. Nonetheless, if developing economies are to participate beneficially in the growth of renewable bioenergy production and still maintain adequate levels of food security, then a complementary set of investments would need to be made along the lines suggested. By making such investments, these countries are likely to produce benefits for consumers of both food and energy, while also contributing to the broader growth of their economies and the betterment of human well-being. ■

For further reading see L. Fulton, T. Howes, and J. Hardy, *Biofuels for Transport: An International Perspective* (Paris: International Energy Agency [IEA], 2004); International Energy Agency (IEA), *Bioenergy*, http://www.ieabioenergy.com; IEA, *World Energy Outlook*, http://www.worldenergyoutlook.org/; and Worldwatch Biofuels Project, http://www.worldwatch.org/taxonomy/term/62#1.

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