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Explorations in Biofuels Economics, Policy, and History

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## Explorations in Biofuels Economics, Policy, and History: Introduction to the Special Issue

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# Explorations in Biofuels Economics, Policy, and History: Introduction to the Special Issue

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## Abstract

Biofuels are prominent in current discussion both as a solution to problems and as a creator of problems. They have promise as a substitute for fossil fuels, particularly for petroleum as the raw material for transportation fuel. But biofuels also have pitfalls, especially when produced at a scale sufficient to replace a significant proportion of the world's use of petroleum. The articles in this special issue analyze key aspects of both the promise and pitfalls of biofuels. They address issues in the technology of producing raw materials for biofuels and converting these raw materials into fuel, resource constraints facing expansion of biofuel production, and the demand for fuels. Particular attention is paid to the relationship between expanded biofuel production and the cost of food. The economics of biofuels is inherently linked to policy issues as well as market analysis because biofuels in every country have received subsidies from governments. Consequently several articles address the welfare economics of governmental efforts to promote biofuels, with a focus on U.S. ethanol subsidies. These subsidies generate net social losses (deadweight costs) on a global scale, although not necessarily from the U.S. national viewpoint. Governmental promotion of biofuels can be justified on the grounds of externalities created by the use of fossil fuels, most notably in recent debates on global warming caused by the release of sequestered carbon in the form of carbon dioxide. This justification is weakened and perhaps even nullified by externalities in the production and use of biofuels. The articles in this issue consider a range of topics concerning these matters, and the welfare losses caused by biofuel subsidies absent net environmental gains from biofuels.

**KEYWORDS:** biofuels, ethanol, biomass, subsidy, policy, economic history

This issue of the Journal of Agricultural & Food Industrial Organization contains ten articles devoted to a single topic, biofuels. The main focus is on the economics of biofuels and related policies, but the articles also address the history and prospective technology of biofuel production. In keeping with the agricultural and food subject matter of JAFIO, several of the articles analyze the resource and cost constraints involved with the use agricultural products as biofuel feedstocks, and the competition between fuel and food in the uses of agricultural resources.

Biofuels are energy sources derived from recently living organic material, as opposed to fossil fuels. Biofuels have a long history, with intensified attention in recent years as fossil fuels have become more costly and the benefits of leaving their carbon sequestered underground become more salient. In the United States, biofuels policy has had its greatest effects through ethanol from corn. In Brazil, ethanol from sugar cane dominates. Other feedstocks, and biofuels other than ethanol, are also on the political agenda in these countries and elsewhere. Recent attention has moved in the direction of biofuels from cellulosic feedstocks.

Topics that must be analyzed to provide a full picture of the situation and outlook for biofuels, and to provide estimates of the benefits and costs of policy options, include the following:

- Demand for biofuels, as related to fossil fuel markets, particularly for crude oil
- Industrial organization, economies of scale, and technological change in the biofuels industry
- Derived demand for feedstocks, particularly agricultural commodities.
- Supply of feedstock alternatives, including resource constraints on feedstock production, in land, water, and capital investment
- Environmental benefits and costs in the production and use of biofuels and associated feedstocks
- Interrelationships between biofuel and food markets, in competition for land and water, and in the use of feed by-products in biofuel production
- International trade in biofuels
- Impacts of biofuels policies on global poverty and hunger
- Evaluation of policy options for biofuels including subsidies and mandated use of biofuels

The articles in this issue of JAFIO pay most attention to the policy choices centered upon the subsidization of ethanol from corn. Ethanol subsidies are important politically because they link biofuels in energy policy with agricultural policy. Ethanol subsidies raise questions related to each of the topics listed above. In the context of U.S. ethanol policy, the issues include:

- To what extent is the U.S. demand for fuel ethanol created by ethanol policy, as compared to the price of crude oil or other economic forces?

- To what extent does the U.S. ethanol program reduce demand for oil imports and potentially provide welfare benefits through reduced oil prices?
- What is the distribution of gains and losses from ethanol subsidies among corn producers, the ethanol production industry, owners of agricultural land, and buyers of ethanol-related products?
- What is the extent of spillover effects between the market for corn and other agricultural products, both crops and livestock, and consumer food prices?
- What are the resource/environmental effects of additional corn produced for use in ethanol, and of substituting ethanol for crude oil as a fuel source?
- How do U.S. ethanol subsidies and import restrictions affect international trade, in corn and crude oil as well as ethanol itself?
- What are the overall benefits and costs of the U.S. ethanol subsidy?

Most of the preceding topics are addressed in the articles of this issue, some in more depth than others. Following are highlights:

“Policy Alternatives for the Future Biofuels Industry,” which leads off, reviews the history of U.S. biofuels policy, with its focus on ethanol. It then goes on to consider the possibilities for a broader-based policy focused on cellulosic sources of biofuels, and for alternative approaches to ethanol policy, notably a variable subsidy that would decrease as crude oil prices increase. This article introduces the two main sources of social gains that have been put forth as justifying biofuels subsidies, environmental benefits of substituting biofuels for fossil fuels, most notably reduction in emissions of greenhouse gases, and energy security benefits of replacing imported crude oil with alternative energy sources.

“Ethanol: No Free Lunch” considers, in a series of supply-demand models, the consequences of expanded ethanol demand in the corn market, the costs of corn price support programs, the crude oil and gasoline markets, and widens the economic perspective further to include industries that compete with ethanol for use of corn, particularly beef and high-fructose corn syrup. This paper also provides an explicit analysis of the two foreign interests that are most affected by a U.S. ethanol subsidy, namely foreign buyers of U.S. corn, and foreign suppliers of crude oil to the U.S. energy market. The latter interest is typically ignored in discussion of U.S. ethanol policy, presumably because of the fact that even a large expansion of ethanol use in motor fuel, would replace only a tenth or so of the gasoline market. But even if this resulted in only a small reduction in crude oil imports and thus small crude oil price declines, the transfers from foreign suppliers to U.S. buyers could be significant because the crude oil market is so large. Indeed, the estimates of this paper show the possibility of net gains to the United States from expanded ethanol demand, even with subsidies at their current level. The big factors in this possibility are the transfer from foreign crude oil sellers to U.S. buyers and the reduction in Countercyclical Payments in the U.S. corn program as the corn price is boosted by ethanol demand.

“Fuel Ethanol Subsidies and Farm Program Support” considers more narrowly the distribution of gains and losses from the U.S. ethanol subsidy. A motivating question is why corn growers appear to value the ethanol subsidy as much as direct payments to corn in their political agenda. The article estimates the gains of farmers, consumers, and the ethanol industry from both the ethanol subsidy and a deficiency payment approach. It is indeed possible, although not likely, that corn growers could gain more from a dollar spent on ethanol subsidies than from a dollar spent on corn support. The consumer gains and losses are complex in that ethanol and other fuel buyers gain from the subsidy, while buyers of corn for non-ethanol uses, notably feed, bear losses. The possibility of net gains to the United States arises from higher corn prices transferring income from foreign buyers of corn to U.S. corn producers. This paper assumes corn prices would be above current Countercyclical Payment support levels even without the ethanol subsidy, so there is no offsetting reduction of corn program outlays attributable to ethanol subsidies. The result is a net deadweight loss to the United States (and a larger net worldwide loss) from the ethanol subsidy.

“Estimating the Welfare Effects of U.S. Distortions in the Ethanol Market” brings in an explicitly international approach. This article focuses on Brazil’s ethanol industry, finding Brazil has a comparative advantage in ethanol production relative to the United States and estimating Brazilian ethanol export supply and U.S. import demand. The article then estimates the distortive effects of the U.S. ethanol tariff, along with the U.S. domestic ethanol subsidy. The bottom line is an estimate of net losses to both the United States and Brazil, although the deadweight losses in total are not large compared to some of those in the preceding two papers.

The welfare economic analyses of U.S. ethanol policy in all three of the preceding articles are similar in using partial economic analysis and estimating gains and losses through standard approaches using consumers’ surplus and producers’ rents. Given that, the details they focus on and estimates of gains and losses they come up with are surprisingly different. There is uncertainty even over the question of whether the net U.S. welfare consequences of U.S. ethanol policy are positive or negative. The main uncertainties involve the possibility of second-best gains and terms of trade gains. The second-best gains result from the ethanol subsidy reducing the deadweight losses from U.S. commodity support programs. The terms of trade gains result from increases in prices paid by foreign buyers of U.S. corn, and decreases in prices received by foreign sellers of oil to the United States. Quantitative estimates of all three of these are highly uncertain. Under current farm programs at current world price levels, deadweight losses of U.S. commodity support may be quite small, so that second-best gains of the ethanol subsidy are small. Terms of trade gains depend on world price effects of U.S. ethanol policies, which are impossible to estimate with confidence.

The preceding pertains to welfare gains or losses from the U.S. viewpoint. From the global viewpoint, U.S. ethanol policy generates a net deadweight loss by the estimates of any of these articles, though the size of the loss is quite uncertain. However, all three of these articles omit quantification of environmental effects – gains from greenhouse gas reductions, other clean air gains, or losses of biodiversity, water resource problems, or other externalities associated with reallocating land use to biofuel feedstock production. There is also no consideration of energy security effects of ethanol subsidies or mandates. Moreover, many of the key elasticities that summarize the price responsiveness of buyers and producers to policy interventions are conjectural, and sensitive to length of run and to choices of what to hold constant while biofuels policies change. Thus, the estimates in these papers are far from the last word on the issues. Nonetheless, the papers in this issue provide the most comprehensive set of estimates now available of the effects of U.S. biofuels policy and some key global elements of policy.

“Ethanol Expansion in the Food versus Fuel Debate: How Will Developing Countries Fare?” investigates global food price impacts of expanding U.S. ethanol production. This article considers expansion triggered by higher crude oil prices, but the analysis applies as well to policy-induced ethanol expansion. A collection of individual-country supply-demand estimates is integrated to obtain a multi-commodity and multi-country modeling system. Given the food consumption baskets for each region, the authors estimate the impacts of U.S. ethanol expansion on the cost of that food basket. Not surprisingly, regions with a higher proportion of corn in the diet, such as Latin America, experience higher food basket cost increases, as much as 10 percent. Regions more dependent on rice, such as Southeast Asia, see much lower food cost increases. These costs are not included in any analyses of the preceding three articles. Since these cost estimates fix the food basket and do not allow substitution, they need to be considered as upper limits. In addition to the consumer impacts, there will also be impacts on developing country producers. There will be some countries and regions who could gain substantially from higher commodity prices due to biofuels. With 70% of the world’s poor in rural areas in developing countries and gaining their primary livelihood from agriculture, it stands to reason that some will be better off. Consumers will be worse off, but the net effects on poverty are not clear because so much of the poverty is in agriculture. Related to this, all of our quantitative models do a miserable job of predicting supply response. So we simply do not have a good idea what will be the supply responses globally to the current high commodity prices.

The article on “European Union Policy on Bioenergy and the Role of Sustainability Criteria and Certification Systems” shifts the spotlight to European policies. The authors describe what is happening in the E.U. with respect to ensuring that biofuels policies are implemented in a sustainable manner. It is clear that approaches to the certification of sustainability are necessarily complex and difficult to implement and to match with the appropriate policy objectives. The article provides a comprehensive set of references on E.U. biofuels issues, analysis, and policy directives.

“Biofuels Policies in Asian Countries” widens the policy perspective further to include the policies of China, Malaysia, India, Japan, Thailand, and Indonesia. The policies are given especially detailed treatment for China. In all the Asian economies, biofuel policies are in flux and are relatively recent. The question is how competitive these countries will be in biofuels from alternative feedstocks, especially tropical products that may give South Asian countries future comparative advantages. For currently predominant biofuel feedstocks, notably corn, the Asian countries, as food importers, face particularly difficult choices in allocating agricultural output to energy production rather than food.

“Potential Land Use Implications of a Global Biofuels Industry” uses a general equilibrium approach to examine the implications for land use, food prices, and other dimensions of development of a viable second generation cellulosic biofuels industry. Since land use changes are the major focus, the paper uses two different approaches for estimating potential land conversion to biofuels – one using land supply elasticities and another that uses cost of land conversion. The model allows cellulosic materials to be used either for liquid fuels or for electricity generation, but the results have virtually all the cellulose being allocated to liquid fuels. There is both a reference scenario and a policy with greenhouse gas reduction included. Under the GHG reduction policy, substantially more biofuels are produced by 2100, as much as 32 percent of primary energy. Surprisingly, this increase is achieved with modest food price increases ranging between 5 and 10 percent by 2100. This result probably comes about due to greater supply response globally than seen in other models.

“Techno-economic Feasibility of Distributed Bio-processing Using Regional Biomass Pre-processing Facilities” also deals with cellulosic feedstock, but from a micro firm or industry perspective in the U.S. Essentially, it evaluates whether it would be more attractive to pre-process the cellulosic material in distributed processing centers and then send the concentrated raw material on to a central facility for further processing into biofuels. Specifically, the authors evaluate the ammonia fiber expansion (AFEX) pre-treatment process, and, under certain assumptions, conclude that the pre-processing approach can be viable.

“Fueling the Automobile: An Economic Exploration of Early Adoption of Gasoline over Ethanol,” as the title implies, is really an economic history paper

covering two periods during which gasoline and ethanol competed for the liquid fuels market. The first period was early in the 20<sup>th</sup> century as automobile production was ramping up. At that point, engine designers could have gone either way, but the decision was made to go with gasoline, and the paper posits explanations for that decision. The second period was shortly after the Second World War, as companies were searching for an additive to boost octane and eliminate knock in gasoline engines. In that case, the industry went with lead as the additive despite its known health issues. As is well known, that decision was later reversed because of the health concerns. Interestingly, history repeated itself in as sense, as MTBE, a known toxic substance, replaced lead at the major additive. Only by 2006 had ethanol largely supplanted MTBE in fuel blends.

In summary, this special issue covers a wide range of issues related to the biofuels industry. While the focus is on economic and policy issues, related topics, encompassing land use change, technologies, regulatory issues, and fuel choice history are covered. At the same time, some important topics are given only cursory treatment. From the bulleted list of issues at the beginning of this introduction, perhaps the most surprising omission given JAFIO's usual coverage is the lack of detailed attention to the industrial organization of the biofuels industry. Beyond this, the main omission from these articles is quantitative discussion of the environmental benefits and costs of biofuels as compared to fossil fuels. It is not as obvious as it might seem at first glance that the net environmental benefits of biofuels are even positive, much less what their magnitude is. It seems likely however that on a global scale the net economic benefits of ethanol subsidies are negative, and possibly substantial. So the justification of subsidies requires significant environmental or energy security gains. Notwithstanding its incompleteness in these respects, readers should find lots of interesting material in this special issue.