Risk, Infrastructure and Industry Evolution

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Biofuel, the Rural Economy, and Farm Structure

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Introduction

Early expansion of the biofuel industry was driven by policies that provided federal and state ethanol tax credits, subsidies to reduce investment costs of smaller scale plants, EPA requirements for oxygenate additives in gasoline under the Clean Air Act Amendments and, in the case of Minnesota, that mandated a 10 percent ethanol blend initially and a 20 percent blend by 2012. Today, the ethanol industry is heavily driven by crude oil and gasoline prices, with biofuels becoming a competitive substitute for petroleum-based fuels at higher crude oil prices. In Figure 1, we can get a sense of the expansion magnitude, which went from 1.6 billion gallons in 2000 to roughly 7 billion gallons in 2007.

These plants, and particularly capacity, tend to be concentrated in the Midwestern States (Figure 2). Thus, the rural community impacts of biofuel expansion are going to be concentrated in this region. As the ethanol industry expands, a number of important changes in biofuel production have been occurring. New plants are larger scale (i.e., 50-100 million gallons per year (MGY), with some going as large as 275MGY relative to pre-2004 plants that were generally 5-40MGY), require fewer workers (i.e., 0.4 laborers/MGY as opposed 2.0/MGY in early dry mill plants), and have a norm of much higher capital costs/MGY in this era of higher crude oil prices. The structure of the industry is evolving with these changes, as well. The local ownership share is decreasing and the marginal rural economy impacts of corn ethanol production are positive but decreasing with industry expansion. These changes have important economic implications for rural communities, altering the economic impacts of further biofuels expansion.

This study examines the rural community and structural impacts of biofuel expansion, and assesses potential future impacts of further expansion of the corn ethanol industry. Ethanol industry expansion has been important to rural communities and rural America in terms of improved farm income and land rental rates, expanded job opportunities and incomes, and adding value to crops. At the same time, ethanol expansion may have impacts that raise concerns for some members of the community. Livestock producers are concerned over higher feed costs, humanitarians are concerned over potential increases in global food prices, malnutrition and starvation, and environmentalists are concerned with increased erosion and water quality problems, as well as increased greenhouse gas emissions as cropland acreage expands to meet growing demands. This analysis will focus only on economic impacts to the communities in terms of economic development, including direct and multiplier impacts on employment, value added and income in the community, and potentially offsetting economic impacts on the livestock industry.

Economic Impact of U.S. Corn Ethanol Expansion on Rural America

This assessment compares 2007 values with two future scenarios of ethanol expansion impacts. We use the IMPLAN national impact assessment model to project the economic impacts of ethanol production expansion on rural America. To assess the future economic impacts on rural communities, including the livestock industry, we use the Food and Agricultural Policy Research Initiative (FAPRI) simulations from Tokgoz *et al*., 2007. These simulations compare 2007 estimates with the 2016 baseline with $60/bbl (billion barrels) of oil and the 2016 long run equilibrium (LRE) with $70/bbl oil scenarios (Tokgoz *et al*., 2007). The 2016 baseline with $60/bbl oil and 2016 LRE with $70/bbl oil estimates are derived from current FAPRI projections for corn, ethanol and livestock production and global consumption. The simulation results also underlie the Searchinger *et al*., 2008 estimates. All of the estimates assume only corn ethanol production, using both dry-mill and wet-mill plants. Table 1 displays the primary inputs used in this exercise and the relevant technical assumptions. A survey of the current and planned ethanol firms was used to establish these industry coefficients.

[1] Miranowski is a Professor; Swenson is an Associate Scientist; Eathington is an Assistant Scientist; and Rosburg is a Graduate Student, all respectively, in the Department of Economics at Iowa State University, Ames, Iowa.

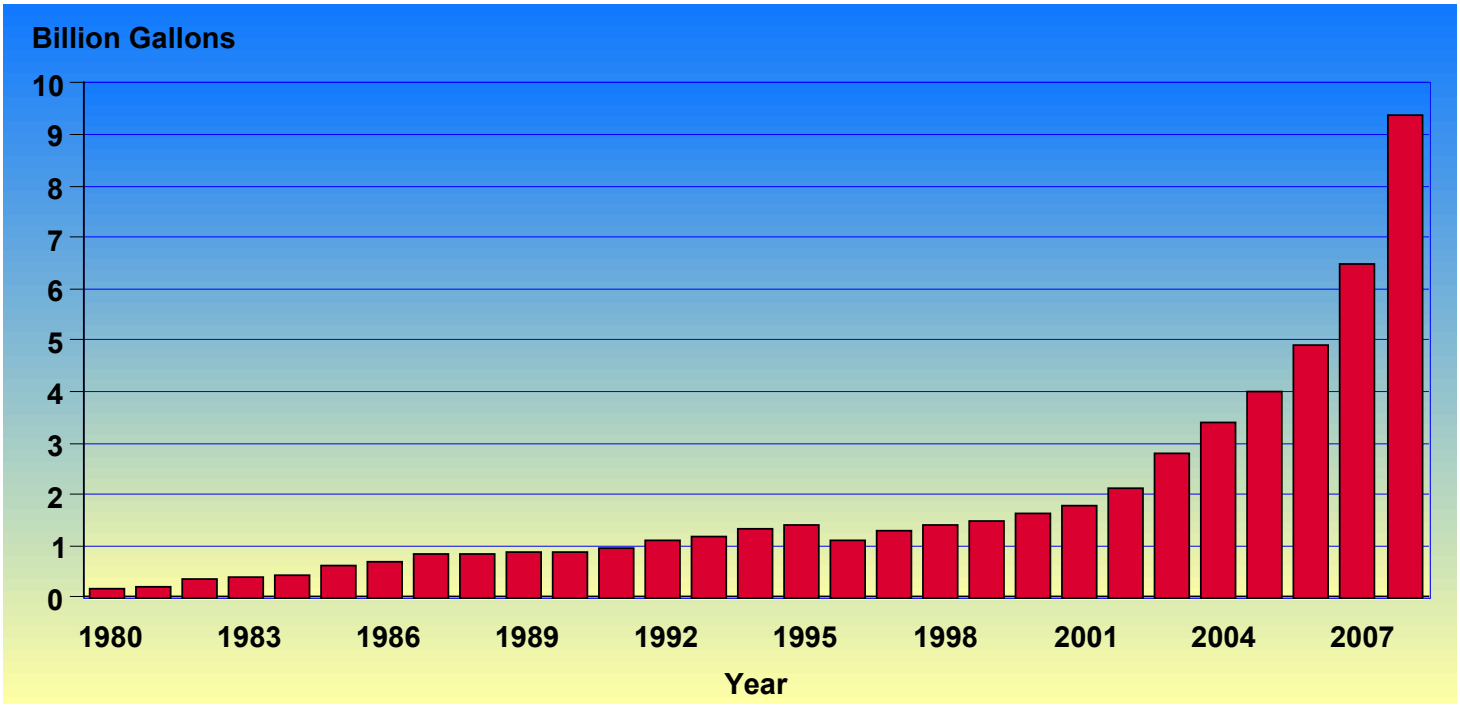

Figure 1. The Ethanol Explosion

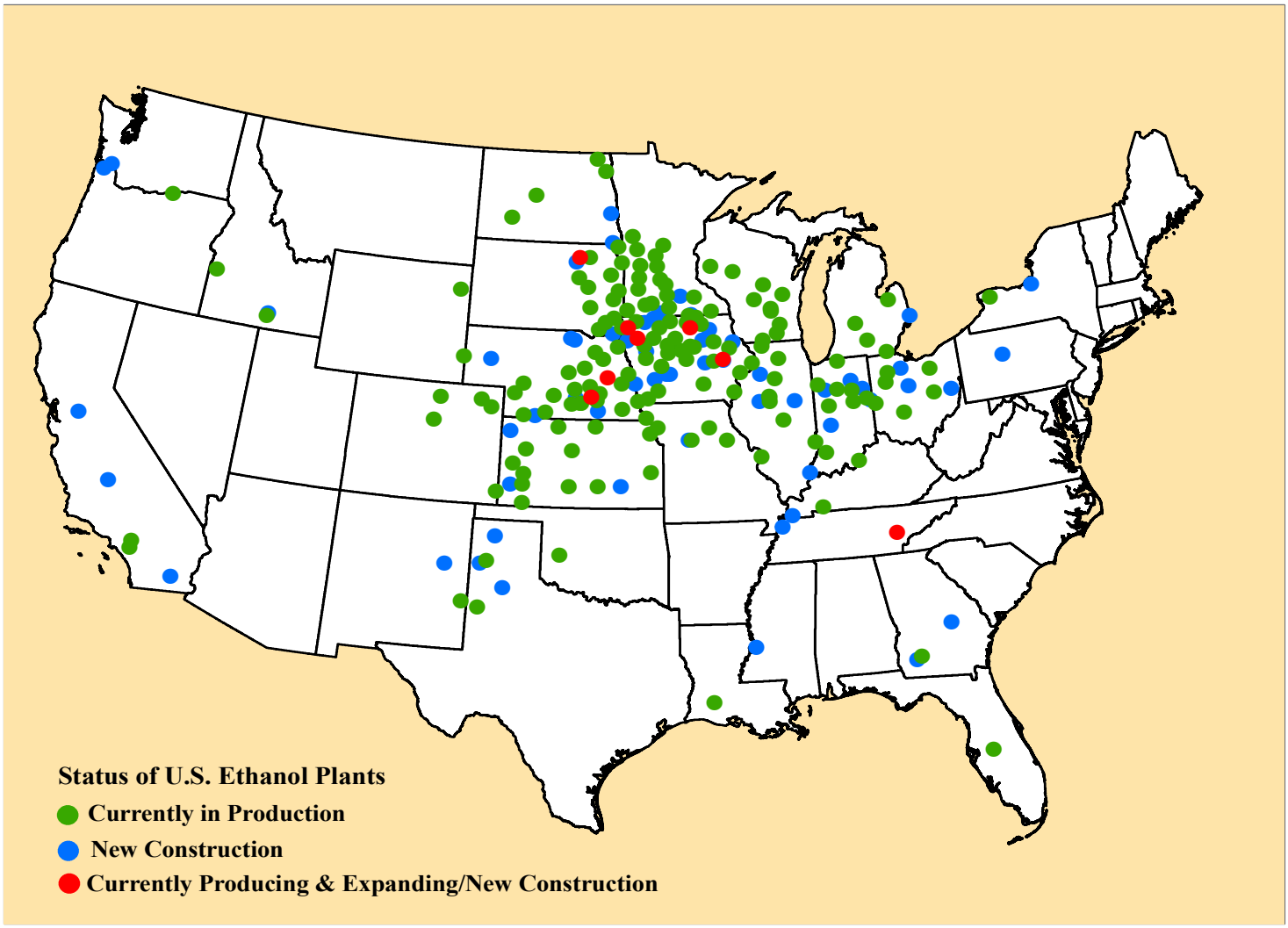

Figure 2. U.S. Ethanol Plants, 2008

Table 1. Underlying Production Characteristics and Assumptions Used in the Impact Analysis

Item	September 2007[a]	2016 Baseline with $60/bbl Oil	2016 LRE with $70/bbl Oil
Average Size (MGY)[b]	63	75	89
Corn (Mbu)	3,230	5,046	10,380
Ethanol (MGY)[c]	8,883	14,568	29,063
Plants[d]	142	194	325
Direct Jobs[e]	6,594	8,972	14,971

[a]September 2007 values were only used as a basis for building the model for projecting to future years. No impacts are reported for that period in this report.

[b]Average new plant size after 2007 is 100 MGY

[c]Plants in 2007 average 2.7 gallons per bushel and 2.8 by 2016 and thereafter

[d]Plants produce at 110 percent of nameplate capacity

eOwing to scale economies, all U.S. plants in 2005 averaged an estimated 50 jobs per plant. By 2016, the average declines to 46.4 jobs

Given the assumptions underlying Table 1, the United States needed 6,600 workers to convert 3.2 billion bushels of corn into 8.9 billion gallons of ethanol in 2007. The values for 2006 were 4,800 plant workers, 1.9 billion bushels of corn, producing 5.0 million gallons of ethanol. The 2016 baseline scenario projects a situation where the United States uses 9,000 workers to convert 5.0 billion bushels of corn into 14.5 billion gallons of ethanol. The 2016 LRE scenario would require 15,000 workers to convert 10.4 billion bushels of corn into 29.1 billion gallons of ethanol.

To derive an estimate of the national economic impact of U.S. ethanol production as projected in the FAPRI 2016 baseline and the 2016 LRE scenarios, a number of adjustments and simplifications are employed. First, two prices are used in this assessment: 1) corn value in the 2016 baseline is set at $3.16; and 2) corn value for the 2016 LRE is set at $4.43 (Tokgoz *et al*., 2007), assuming the baseline with $60/bbl oil and the LRE with $70/bbl oil price, or a $10/bbl oil price shock. It is important to note that we are estimating the national economic impacts as opposed to local economic impacts as was done by Low and Isserman (2007) and Swenson and Eathington (2006).

As the corn based biofuel industry goes through a rapid expansion phase with high ethanol and corn prices, followed by a period of lower prices, one can expect wide fluctuations in the value of output and the returns to ethanol investors. Average 2007 prices were entered into a detailed inputs and outputs direct values model. That model is sensitive to the price of all inputs, the amount of capital investment, labor requirements and costs, the overall productivity and efficiency of the operating plant, and the plant size, among other variables. That model was calibrated to average values for 2007 of 63 MGY average plant capacity. Average plant capacity for the 2016 baseline was assumed to be 75 MGY and for the 2016 LRE scenario was assumed to be 89 MGY, based on our compiled databases.

A U.S. level IMPLAN model was configured with an organic chemical sector that reflects just the ethanol industry, as opposed to the wide array of chemicals and products that the sector normally produces. Output, jobs, and value added assumptions for the baseline were inserted into the model. Next, the social accounts were modified to reflect the top 10 primary inputs into ethanol production, allowing all other standard industrial input coefficients to then rebalance the remaining costs of production. All inappropriate linkages were reduced so that the model reflected the average U.S. dry mill ethanol plant, not the average U.S. organic chemical manufacturing firm. That model was then recompiled and used to produce fixed multipliers that would be applied to the total production input estimates for the 2016 baseline and the 2016 LRE scenarios.

Model Adjustments

Jobs, labor income, and value added multipliers were adjusted downward for natural gas usage, water, electricity, and rail inputs. Only 20 percent of the predicted job and labor income increments were allowed. Expectations for value added in those sectors were also revised downward to reflect marginal, not average, gains in sales. Next, no multipliers were applied to the corn inputs as a consequence of ethanol production. While corn stocks are projected to increase in the United States due to this industry, those increases will come at the expense of other crops, and through the conversion of pasture land to row crops, the removal of land in conservation programs, and overall land quality changes. This assessment makes no attempt to estimate construction effects at the national level. The national construction industry is dependent on the overall rate of capital formation and the nature and pattern of private, public, and household investment. If we

assume full employment, increases in construction activity in one subsector are typically offset by decreases elsewhere in the national construction industry.

Impact Tables

The findings of the input-output analysis are summarized in Table 2 as direct, indirect, induced, and total economic effects for each of the above categories for the 2007 crop, the 2016 baseline with $60/bbl oil, and the 2016 LRE with $70/bbl oil (i.e., the oil price shock scenario). Direct effects are attributable solely to the ethanol industry. Indirect effects reflect the value of input purchases into the direct firm, as well as the inputs their suppliers require. Induced effects, sometimes referred to as household effects, accumulate as workers in the direct and indirect industries convert their labor incomes into household purchases. The total economic effects represent the sum of the direct, indirect and induced activity.

Table 2 contains only the impacts of shocking the input-output model with the expansion of the corn ethanol industry. The impacts on the livestock industry will be considered later. The 2016 baseline with $60/bbl oil simulation indicates that in producing $27.6 billion in industrial output, almost 9,000 job holders would be paid $502 million in labor incomes. The industry would stimulate $16.9 billion in inputs production, requiring almost 11,600 jobs paying $630 million in labor incomes. When workers converted their earnings into household level purchases, they would stimulate over $3.4 billion in output and sustain nearly 26,700 jobs earning $1 billion. In the 2016 baseline, the industry links to nearly $47.9 billion in total national industrial output, almost $4 billion in value added, $2.2 billion in labor income, and 47,200 jobs. The 2016 LRE with $70/bbl oil simulation indicates that producing $69.0 billion in industrial output, almost 15,000 job holders would be paid $973 million in labor incomes. The industry would stimulate $34.6 billion in inputs production, requiring an additional 23,600 jobs paying $1.3 billion in labor incomes. When workers convert their earnings into household level purchases, they will stimulate $6.0 billion in output and sustain over 45,800 jobs earning over $3.9 billion. The total estimated impacts, including all linkages of U.S. ethanol production in the 2016 LRE scenario, would include over 84,400 jobs, $3.9 billion in labor income effects, and $6.6 billion in value added. Due to ethanol plant scale economies, labor and income needs in future plants do not grow proportionately. Above normal returns to investors are reduced to zero in the 2016 LRE model.

Impacts on the Livestock Industry of Expanded Corn Ethanol Production

The impact of expanding ethanol production on livestock production may be significant. Ethanol and livestock compete for corn as a feedstock and a feed source. Every bushel of corn used in ethanol production is two-thirds less of a bushel of corn for livestock feed (assuming that corn byproducts (dry distillers grain (DDGs)) substitute for one-third of a bushel of corn, especially in ruminant animal rations). As the demand for corn in ethanol production increases, livestock producers face higher feed costs and adjust livestock production accordingly in the long run. So we estimate the direct job change in livestock production relative to 2007, using both the 2016 baseline and 2016 LRE FAPRI projections for livestock production (Table 3). To put livestock worker displacement into a slightly different perspective, we compare the 2006 baseline livestock production with the 2016 baseline livestock

Table 2. Estimated Economic Impacts of U.S. Corn Ethanol Industry

Variables	Solutions	Direct	Indirect	Induced	Total
Output ($ billions)	2007 Crop	22.9	13.6	3.1	39.6
	2016 Baseline[a]	27.6	16.9	0.43	47.9
	2016 LRE[b]	69.0	34.5	6.0	109.5
Value Added ($ millions)	2007 Crop	669	958	1,495	3,122
	2016 Baseline[a]	970	1,185	1,800	3,955
	2016 LRE[b]	973	2,414	3,164	6,551
Labor Income ($ millions)	2007 Crop	369	503	712	1,584
	2016 Baseline[a]	502	623	1,020	2,145
	2016 LRE[b]	837	1,284	1,791	3,912
Jobs (thousands)	2007 Crop	6.6	8.5	18.6	33.7
	2016 Baseline[a]	9.0	11.6	26.7	47.3
	2016 LRE[b]	15.0	23.6	45.8	84.4

[a]with $60/bbl

[b]with $70/bbl

Source: IMPLAN 2006 Data; Iowa State University-Biofuel Impacts Study Database, 2007

Table 3. Change in Livestock Workers Required

Livestock	2007-2016	2016-LRE
	thousand	
Beef	29.7	(13.8)
Milk	34.6	(2.3)
Pork	3.4	(2.4)
Broilers	5.6	(2.2)
Turkeys	0.5	(0.2)
Eggs	2.5	(0.4)
Total Workers	76.3	(21.3)

production, and estimate the livestock worker impact in Table 3. It is important to note that the FAPRI baseline scenario reflects crop acreage reallocation in response to corn and "other crop" relative prices, trend yield growth, growing global demand for livestock and other agricultural products, and changing global production and trade flows. Thus, the 2016 baseline indicates substantial growth in U.S. livestock production and, in turn, an implied growth of 120-140 thousand in number of livestock workers required. Based on the FAPRI projections for the 2016 baseline, growing global demand for livestock products actually increases the number of livestock workers by 76 thousand. Going from the 2016 baseline to the 2016 LRE with the oil price shock does result in a livestock reduction of 21 thousand, but with over 50 thousand more livestock workers than in 2007.

Then these livestock worker changes were used to derive an estimate of the direct employment impact (assumed linear) on the livestock processing industry. These estimates of the adjustment in direct livestock employment were used to shock the IMPLAN input-output model reported in Table 4 to estimate the direct economic impacts of livestock processing changes as well as the upstream and downstream impacts associated with livestock worker adjustment associated with the expanding corn ethanol industry.

What are the livestock industry impacts of expanded corn ethanol production? Modest expansion to 15 billion gallons of corn ethanol (i.e., the level established under the Renewable Fuels Standard) should continue to have largely positive aggregate economic impacts in rural regions. Expansion beyond this level will likely have some negative economic impacts in terms of livestock industry economic impact, and partially offset the positive economic impacts of going beyond 15 billion gallons of ethanol production.

Conclusions

- Ethanol industry structure will continue to evolve, as will Midwest farm structure. Moving to biomass fuels will likely speed structural change in the future.
- Ethanol expansion is having a positive impact on the U.S. rural economy, but with decreasing marginal impacts with continued expansion.

Expansion of corn ethanol to 29 billion gallons will offset a portion of the economic gains to the rural economy created by expanding corn ethanol production to 15 billion gallons. However, expansion from a cellulosic based ethanol industry will alter these offsets.

Table 4. Estimated Economic Impact of Combined Corn Ethanol and Meat Industry Adjustments

Variables	Solution	Direct	Indirect	Induced	Total
Output ($ billions)	2007-2016	11.1	22.1	10.4	43.6
	2016-LRE	(3.1)	(6.1)	(2.9)	(12.1)
Value Added ($ millions)	2007-2016	1.6	8.0	5.6	15.2
	2016-LRE	(0.4)	(2.2)	(1.6)	(4.2)
Labor Income ($ millions)	2007-2016	1.3	4.6	3.2	9.1
	2016-LRE	(0.4)	(1.3)	(0.9)	(2.6)
Jobs	2007-2016	34.3	151.8	82.3	268.4
	2016-LRE	(9.5)	(42.2)	(22.8)	(74.5)

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