Estimating the Future Economic Impact of Corn Ethanol Production in the U.S.

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This brief exercise assesses the potential economic impact value of ethanol production comparing current, 2007, estimates with a future level of production for 2016 and a long run equilibrium level (LRE) for 2025. The values for this estimate are driven by current Food and Agricultural Policy Research Institute (FAPRI) forecasts of corn and ethanol production. All of the estimates assume corn ethanol production only. No other kind of ethanol production is measured nor should be implied. Table 1 displays the primary inputs used in this exercise and the relevant technical assumptions.

Table 1. Basic Production Characteristics and Assumptions Per Scenario

	September[5] 2007	Baseline 2016	Long run Equilibrium Solution
Average size MGY[1]	63	75	89
Corn (Mbu)	3,230	5,046	10,380
Ethanol (MGY)[2]	8,883	14,568	29,063
Plants[3]	142	194	325
Direct Jobs[4]	6,594	8,972	14,971

1. Average new plant size after 2007 is 100 MGY.
2. Plants in 2007 average 2.7 gallons per bushel, and 2.8 by 2016 and thereafter.
3. Plants produce at 110 percent of nameplate capacity.
4. Owing 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.
5. 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.

Given the listed assumptions, the U.S. needed the equivalent of 142 ethanol plants and 6,594 workers with the capacity to convert 3.23 billion bushels of corn into 8.9 billion gallons of ethanol by the end of 2007. The next scenario supposes a situation where, in 2016, the U.S. converts 5.05 billion bushels of corn into 14.468 billion gallons of ethanol. That will take an estimated 194 plants and just under 8,972 workers. When long run equilibrium is achieved, 325 plants with 14,971 jobs will convert 10.38 billion bushels of corn into 29.1 billion gallons of ethanol.

The next step involves estimating the overall economic impact of ethanol production in the U.S. for the baseline period and for the long-run equilibrium solution. There are a number of adjustments and simplifications that are employed to make this assessment. First, there are two prices used in this assessment: corn values in the baseline (2016) are set at $3.16; values for the LRE (2025) are 4.43. Please note that this is not an attempt to forecast the economy in 2016 and 2025; instead, the assessment simply measures the current (in 2007 amounts) relative values of the two future scenarios.

Because the industry has gone through a period of robust growth and high prices followed by a period of lower prices, there are wide fluctuations in the value of all output and the return to 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 the average values for 2007 (at 63 MGY average capacity) and for the future amounts (75 MGY average capacity in 2016 and 89 MGY average capacity in 2025). A demonstration of the different effects due to scale economies is attached as an appendix.

Last, a U.S. level IMPLAN model was configured with an organic chemical sector that reflected just the ethanol industry as opposed to the wide array of chemicals and products that 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, as in, for example, to petroleum refining, were reduced drastically to near zero so that, in the main, this industry in 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 arrays of fixed multipliers that would be applied to the total production inputs estimates for the baseline and the LRE scenarios.

Model Adjustments

Jobs, labor income, and value added multipliers were adjusted downward significantly for natural gas usage, water, electricity, and rail inputs. Confirming case-study research was conducted in Iowa to ascertain the utility level job impacts associated with ethanol plant construction. Across the board, the utility experts estimated job impacts that were a 10^{th} to as much as a 20^{th} as the amounts predicted by the average effects multipliers that input-output systems produce. That makes sense. A large user of natural gas, for example, is supplied that commodity much more efficiently than would be the case were that same amount of natural gas supplied to an area's average of all residential, commercial, and industrial users – the averages from which the model must depend. Consequently, for the input commodities listed above, 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 are applied to the corn inputs. Some analysts uncritically apply multipliers to the corn sector thereby implying that there is a concomitant increase in net agricultural production in the U.S. as a consequence of ethanol production. While corn stocks are projected to increase in the U.S. due to this industry, those increases will come at the expense primarily of other existing crops, the conversion of pasture land to row crops, by removing land in conservation programs, and of overall land quality and tilth. This analysis only measures the estimated impacts in non-ag inputs and leaves the estimate of the consequences to the agricultural sector to other researchers.

Last, this assessment makes no assumptions at the national level concerning construction effects. Construction effects are strongly distorting, are frequently mistakenly applied and reported, and must always be assessed carefully. The primary levels of fixed asset formation in the U.S. are residential construction, commercial development, industrial investment, and all public infrastructure and buildings. The existing construction industry of the U.S. is allocated over time to any of these sectors. The construction industry is therefore dependent on the overall rate of capital formation and the nature and pattern of private, public, and household investment. Minor shifts from one sector to another occur, and the construction industry responds accordingly. This industry, therefore, expands proportionate to the rate of change in fixed asset investment over the long run, not the particularities of localized industrial growth (or, for that matter, decline, a current condition in much of the Midwest). It remains to be demonstrated that the expansion of the ethanol industry in the U.S. creates net growth in all energy-producing U.S. industries considering all production offsets or construction shifts in all other energy producing U.S. industries. This is especially true insofar as the industry is significantly subsidized at the national, state, and local levels.

When new construction occurs in a region, however, there are discernible, albeit short-term construction impacts. The erection of a bio-refinery involves the purchase of land and its preparation for the capital development. Some fraction of that work may accrue to local firms, thus helping sustain their jobs. The few major firms that construct ethanol plants are highly specialized and very likely to be headquartered out of state. Those firms will bring along skilled workers that have experience in fitting pipe, hydraulics, and electronic devices – generally workers from traditional oil- and chemical-refinery states. Still, the plant will employ some of a region's skilled construction workers and tradespersons. In general, though, a very large amount of contracting activity, architecture, engineering, legal, financial, and the capital inputs will be purchased from non-local firms. Consequently, the community-level construction effects of biofuels expansion are quite muted.

Impact Tables

Following are the results of the input-output analysis. The findings are reported in the form of total industrial output, the sales value of annual production; value-added, the sum of all labor income to workers and to sole proprietors, plus returns to investors, and indirect tax payments; and jobs. The data are also summarized by direct, indirect, induced, and total economic effects for each of the above categories. Direct effects are attributable solely to the industry assessed. Indirect effects reflect the value of input purchases into the direct firm, as well as the inputs those suppliers require. Induced effects are also called household effects. They accumulate as workers in the direct industries and the indirect industries convert their labor incomes into household purchases. The total economic effects in each table reflect the sum of the direct, indirect, and induced activity. Last, the table lists a multiplier. A total multiplier here is simply the ratio of the total effect to the direct effect in each category. The multiplier may or may not imply net economic growth in the U.S. economy. More research needs to be done to determine the extent to which this expanding industry is contributing to net gains in Gross Domestic Product.

Table 2 contains the baseline values for 2016. In that year, in producing $27.6 billion in industrial output, 8,972 job holders would be paid $501.8 million in labor incomes. In so doing, the industry would stimulate $16.9 billion in inputs production, requiring 11,551 jobs paying $629.5 million in labor incomes. When workers converted their earnings into household level purchases, they would stimulate another $3.45 billion in output, and sustain 26,676 jobs making $1.02 billion. In all, in the baseline, the industry links to nearly $47.92 billion in total national industrial output, $3.955 billion in value added, $2.15 billion in labor income, and 47,199 jobs.

Multipliers are also listed. The industrial outputs multiplier of 1.74 means that there are $.74 in additional (non-corn) industrial sales in the remainder of the economy per dollar of output in the industry. The labor income multiplier of 4.29 means that there are $3.29 in additional labor incomes supported per dollar of labor income in the ethanol industry ($3.29 + $1.00 = $4.29). And last, the jobs multiplier of 5.26 means that there are 4.26 jobs in the rest of the economy per job in the ethanol industry.

Table 2. 2016 Baseline

Baseline 2016	Direct	Indirect	Induced	Total	Total Multipliers
Output	27,599.0	16,870.9	3,446.8	47,916.7	1.74
Value Added	969.5	1,184.9	1,800.4	3,954.8	4.08
Labor income	501.8	629.5	1,019.5	2,150.7	4.29
Jobs	8,972	11,551	26,676	47,199	5.26

Table 3. Long-Run Equilibrium Solution

LRE	Direct	Indirect	Induced	Total	Total Multipliers
Output	69,048.9	34,561.6	6,058.0	109,668.5	1.59
Value Added	972.8	2,413.8	3,164.3	6,550.9	6.73
Labor income	837.4	1,284.2	1,791.8	3,913.3	4.67
Jobs	14,971	23,556	45,831	84,358	5.63

Table 3 lists the long-run equilibrium solution output. The estimated total job value of ethanol production in the U.S. considering all linkages grows 84,358 in 2025 and labor income effects grow to $3.86 billion. Last, multipliers increase for value added, labor income, and jobs; due to scale economy gains, as plants get larger, labor and income needs in future plants do not grow proportionately. In addition, returns to investors are reduced to zero in the LRE model for 2025 thereby increasing the multiplier ratio for value added significantly due mostly to a harsh reduction in value added in the direct sector.

An important note on the multipliers. This is a U.S. model; thus, versus a local or regional assessment, a very large fraction of all economic activity will get captured in the induced round of economic activity as, at the national level, leakages are small. Owing to the mathematics of input-output analysis, the more robust level of spending reported in the induced round stimulates significant iterations of concomitant industrial supply to household-selling sectors and, in turn, additional rounds of induced activity. It is therefore quite inappropriate to apply these national level multipliers to state or regional ethanol production because those levels of economic assessment will be subject to significant leakages outside of the study economies resulting in significantly lower labor income and job multipliers.

Appendix: A Comparison of the Regional Economic Impacts of a 50 MGY and a 100 MGY Ethanol Refinery

This summary highlights the overall economic impact differences between a 50 MGY and a 100 MGY ethanol refinery. This analysis is based on previous work at Iowa State University that investigated the basic regional impact expectations from ethanol plant development, to include increments to local impacts due to different levels of local ownership. This comparison considers two separate scenarios within a three-county region in Iowa. In the first comparison, an input-output model of the regional economy was configured to accept the 50 MGY plant. In the second, it was configured to accept a 100 MGY plant. In both cases, the prices used for all inputs and outputs were annual averages for 2005. Readers should be mindful that that was a year in which very high profits were made in the ethanol industry. More recent results would produce somewhat more muted economic impact results. Last, this analysis does not presuppose changes in agricultural production in the area studied. As we are measuring the net increment to regional productivity, the value of purchasing corn inputs is not considered as that productivity already existed in the area.

The following table compares the two scenarios. The 50 MGY plant requires 35 workers. Importantly, it has strong linkages to the remaining (non-corn producing) economy, which requires 75 jobs. When the direct and the indirect jobs convert their earnings into household incomes, they induce in the region $1.55 million in additional induced spending, necessitating 23 jobs for a total job impact of 133. By doubling the size of the plant, however, significant scale economies emerge. The refinery processes exactly twice as much corn, produces twice as much output, uses nearly twice as many inputs, but only needs 46 workers at the facility. Overall, in this simulation, the total regional job impact grows to 170, just 28 percent more. Consequently, as the average size of plants in the U.S. increases, there is a diminished regional job impact per million gallons of ethanol production.

Economic Impact Estimates for a 50 MGY and a 100 MGY Ethanol Refinery: 2005

50 MGY	Direct	Indirect	Induced	Total	Multiplier
Output	118,648,636	13,301,156	1,546,605	133,496,397	1.13
Value Added	18,405,433	6,011,897	942,326	25,359,656	1.38
Jobs	35	75	23	133	3.79

100 MGY	Direct	Indirect	Induced	Total	Multiplier
Output	226,980,005	25,272,196	1,982,466	254,234,667	1.12
Value Added	35,523,902	11,003,203	1,207,890	47,734,994	1.37
Jobs	46	95	29	170	3.70