ABF Economics
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CONTRIBUTION OF THE ETHANOL INDUSTRY TO THE ECONOMY OF THE UNITED STATES IN 2015

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February 5, 2016

The U.S. ethanol industry experienced another record-breaking year in 2015 despite a challenging economic and regulatory environment. Industry output through October 2015 was 3.7 percent above 2014 levels and was poised to set a new record of 14.7 billion gallons for the year. The year started off with strong year-over-year gains in ethanol production as producers responded to lower feedstock prices. The third-largest ever 2015 corn crop pushed feedstock prices lower until the third quarter of the year. The collapse in global oil prices accompanied by record levels of ethanol production helped drive ethanol prices lower and strained profitability. Average cash market corn prices during 2015 were 8.4 percent lower than a year earlier while ethanol prices were 32 percent lower for the full year.[1]

On the demand side, consumers responded to sharply lower retail gasoline prices by increasing consumption of finished motor gasoline. Reflecting this, domestic ethanol use increased 4 percent during 2015 to record levels. While still small relative to domestic use, ethanol exports posted a 3.4 percent increase for the first 10 months of 2015.

The ethanol industry faced both economic and regulatory challenges in 2015. The economic challenges included the sharpest decline in world oil and refined product prices since the bursting of the 2008 "Commodity Price Bubble." West Texas Intermediate crude oil prices that peaked at $105.79 per barrel in June 2014 fell steadily through 2015, averaging $37 per barrel in December 2015, 65 percent below peak levels. During this same period ethanol prices, FOB Iowa Plant and Omaha Rack, were down nearly 40 percent. As pointed out, feedstock (corn) prices also declined during 2015 but so did co-product prices with DDGS prices (10 percent moisture, Iowa) down 9.5 percent and corn distiller's oil prices down 19.5 percent during 2015. As a result of these factors, ethanol profitability suffered.

[1] No. 2 Yellow Corn, Central Illinois; ethanol FOB Iowa Plant and Ethanol Omaha Rack. Source USDA

According to Iowa State University, net returns over variable costs for a typical Iowa dry mill ethanol plant averaged $0.21 per gallon during 2015, down sharply from the $0.71 per gallon return experienced in 2014.[2]

The regulatory environment also provided challenges for the industry. In November the EPA released the final volume requirements for 2014, 2015 and 2016 under the Renewable Fuel Standard (RFS) program. EPA's final rule requires volumes for most biofuels that are well above the Agency's proposal released earlier in the year. However, the required volumes remained well below the statutory requirements set forth by the 2007 law establishing the RFS. Overall, the EPA final rule calls for total biofuels — conventional biofuel (e.g., corn ethanol), advanced biofuels, cellulosic ethanol, and biomass biodiesel to be blended at 18.11 billion gallons, well under the 22.25 billion gallon statutory level set by the 2007 law. In particular, the 2016 RFS level of 14.5 billion gallons for conventional biofuel (e.g., corn ethanol) is 500 million under the 15-billion gallon statutory level. Similarly, the RFS targets for Cellulosic and Other Advanced biofuels, while higher than EPA's initial 2015 proposal, are substantially below statutory levels.

According to the Renewable Fuels Association (RFA), at year's end the ethanol industry comprised approximately 214 plants in 29 states with nameplate capacity of 15.5 billion gallons and operating at an annualized rate of 14.7 billion gallons.[3] At year's end more than 160 million gallons of capacity was under expansion or construction.

This study estimates the contribution of the ethanol industry to the American economy in 2015 in terms of the employment, income, and Gross Domestic Product (GDP) directly and indirectly supported by the industry.

Expenditures by the Ethanol Industry in 2015

Ethanol producers are part of a manufacturing sector that adds substantial value to agricultural commodities produced in the United States and make a significant contribution to the American economy.

[2] Iowa State University AgDecision Maker Ethanol Profitability and Biodiesel Profitability available at http://www.extension.iastate.edu/agdm/energy/xls/d1-10ethanolprofitability.xlsx and http://www.agmrc.org/renewable_energy/biodiesel/biodiesel-profitability accessed January 24, 2016

[3] The 14.7 billion gallons represents RFA's estimate of annualized production at the end of 2015.

Expenditures by the ethanol industry for raw materials, other goods, and services represent the purchase of output of other industries. The spending for these purchases circulates through the local and national economy, generating additional value-added output, household income, and employment in all sectors of the economy.[4] Ethanol industry expenditures can be broken into three major categories: construction of new production facilities, ongoing production operations, and research and development.

1. Construction

   Industry capacity increased an estimated 400 million gallons during 2015 with much of this accounted for by second generation (cellulose and advanced biofuels) production facilities. The most significant new cellulosic ethanol plant brought on-line during 2015 was the DuPont cellulosic facility in Nevada, IA. Capital expenditures for cellulosic ethanol plants are significantly higher than for conventional fermentation corn plants. For purposes of this study we have assumed an average cost per gallon for new capacity of $7.50 and have included construction expenditures of $2,625 million in 2015. It is important to note that the recent EPA Final Rule for the RVO is likely to provide a disincentive for new capital expenditures in 2016.

2. Ongoing production operations

   The industry spent an estimated $25.5 billion on raw materials, other inputs, and goods and services to produce ethanol during 2015, 8.4 percent less than in 2014. Even though industry output increased during 2015, lower prices for corn feedstock and natural gas largely accounted for the decline in total production expenditures. Production costs were based on a model of dry mill ethanol production maintained by the author of this report. These estimates are consistent with generic dry mill ethanol costs, such as those published by Iowa State University.[5] Table 1 details the expenditures by the ethanol industry in 2015.

[4] Expenditures for feedstock and energy were estimated using 2014 calendar year average prices. Revenues were estimated using 2014 calendar year average prices for ethanol, Omaha Rack; Distiller's grains, corn gluten feed and meal, and corn oil. Prices were sourced from USDA/ERS and AMS, and EIA.

[5] See the Ethanol profitability spreadsheet maintained by Don Hofstrand "AgDecision Maker D1-10 Ethanol Profitability" available at http://www.extension.iastate.edu/agdm/energy/xls/d1-10ethanolprofitability.xlsx

Table 1
Estimated Ethanol Production Expenditures 2015

	2015 Mil $	2015 $/gal	Change From 2014
Feedstock (corn)	$19,005	$1.29	-7.0%
Enzymes, yeast and chemicals	$998	$0.07	1.8%
Denaturant	$864	$0.06	-28.0%
Natural Gas	$1,773	$0.12	-27.5%
Electricity	$710	$0.05	-0.6%
Water	$247	$0.02	4.8%
Direct labor	$905	$0.06	4.6%
Maintenance & Repairs	$396	$0.03	4.7%
Transportation	$114	$0.01	4.7%
GS&A	$472	$0.03	4.6%
Total Operating Costs	$25,485	$1.73	-8.4%

The largest share of spending was for corn and other feedstocks used as raw material to make ethanol. The ethanol industry used 5.25 billion bushels of corn on a gross basis in 2015, valued at $19 billion. Consequently, the ethanol industry is a major source of support for agricultural output and farm income.

This analysis estimates both the total production effect and the crop price (farm income) effects of ethanol production on agriculture based on a structural model of U.S. agriculture maintained by the author. The impact of demand for corn to produce ethanol on farm income was adjusted so as to not overstate the impact of ethanol demand on revenue for the corn sector. This was accomplished by applying estimates of the effect of ethanol on corn prices taken from the literature to the share of corn demand accounted for by ethanol and actual change in corn prices.

The remainder of spending by the ethanol industry for ongoing operations is for a range of inputs such as enzymes, yeast and chemicals; electricity, natural gas, and water; labor; transportation; and services such as maintenance, insurance, and general overhead.

3. Research and Development

The renewable fuels industry is a significant engine for research and development (R&D) both in the public and private sectors. Much of the R&D activity in the biofuels industry is aimed at discovering and developing advanced biofuels feedstock and the technology needed to meet RFS2 targets for cellulose and advanced biofuels. The primary public sector agencies underwriting R&D in biofuels are the U.S. Departments of Energy (USDOE), Agriculture (USDA), and Defense (DOD). In addition to the federal government, many states are funding R&D in feedstock as well as infrastructure. These public funds are being leveraged significantly by private sector firms undertaking research in a wide range of biofuels activities. Based on a review of publically available data and recent published research on Federal government spending on R&D, we have reduced our estimate of R&D expenditures for biomass biofuels in the U.S. to $850 million in 2015, about half that assumed for 2014.[6]

4. Co-product value

Most ethanol is produced by dry mills that also produce valuable co-products in the form of distillers dried grains (DDGS) and (industrial) corn distillers' oil.[7] The ethanol industry produced an estimated 44.6 million short tons of DDG and 3.1 billion pounds of industrial corn distiller's oil in 2015 with an aggregate market value of $8 billion. It is notable that these co-products are produced with little additional expenditure.

Spending associated with current ethanol production, new construction, and R&D circulates and re-circulates throughout the entire economy several-fold, stimulating aggregate demand, and supporting jobs and household income. In addition, expanded economic activity generates tax revenue for government at all levels.

[6] Estimates of the amount of R&D spending on biomass and biofuels vary substantially. For a discussion of R&D spending on biofuels see "Agricultural Preparedness and the Agriculture Research Enterprise". President's Council of Advisors on Science and Technology. Washington DC, December 2012. A 2013 study prepared by Mary Solecki, Anna Scodel and Bob Epstein at E2 Environmental Entrepreneurs. "Advanced Biofuel Market Report 2013" suggests that R&D spending on biofuels approaches $1.7 billion. A (relatively) new report on federal spending on R&D in energy published by EIA ("Direct Federal Financial Interventions and Subsidies in Energy in Fiscal year 2013", March 2015) estimates Federal R&D expenditures for biomass of $300 million in FY 2013. This study does not include estimates for corporate (private sector) R&D.

[7] Industry estimates suggest that nearly 90 percent of dry mill corn ethanol plants recover corn oil that is used as a biodiesel feedstock and as a feed ingredient by the livestock industry.

Methodology

We estimate the impact of the ethanol industry on the American economy by applying expenditures by the relevant supplying industry to the appropriate final demand multipliers for value added output, earnings, and employment.

To understand how the economy is affected by an industry such as ethanol production, it is necessary to understand how different sectors or industries in the economy are linked. For example, in the renewable fuels production sector, the ethanol industry buys corn from the agriculture sector; which in turn, buys inputs from other suppliers such as fertilizer and pesticide producers that also purchase products from a range of other industries. These are referred to as backward linkages. Use by other sectors of natural gas as an input, such as manufacturing operations, is a forward linkage. Natural gas production and transmission industries are linked through both forward and backward linkages to other economic sectors in each state's economy.

The household sector is linked to all sectors as it provides the labor and management resources. In turn, changes that affect incomes of the household sector typically have significant impacts compared to a change in the sales of other sectors. This is because households typically spend most of their income on both retail and service goods and this is a critical component of the national economy

This study uses an economic model known as IMPLAN (Impact Analysis for Planning) to develop a model of the national economy, including sectors that support the ethanol industry, the links between them, and the level of national economic activity. IMPLAN is a commonly used economic input-output (I-O) model. I-O models are constructed based on the concept that all industries in an economy are linked together; and the output (i.e., sales) of one industry becomes the input of another industry until all final goods and services are produced. I-O models can be used both to analyze the structure of the economy and to estimate the total economic impact of projects or policies. For this analysis, a model for the U.S. economy was constructed using current IMPLAN software and the most recent data available.

In this year's analysis we have continued to treat the share of industry earnings accounted for by locally owned firms as an addition to the household sector since the income is paid to local owners. The result of this is that their impact is estimated using multipliers for the household sector rather than those for conventional corporate income.

IMPLAN models provide three economic measures that describe the economy: value added, income, and employment.

- Value added is the total value of the goods and services produced by businesses in the country and is generally referred to as gross domestic product (GDP). It is equivalent to the sum of labor income, taxes paid by the industry, and other property income or profit.

- Labor income is the sum of employee compensation (including all payroll and benefits) and proprietor income (income for self-employed work). In the case of this analysis, demand for corn and other feedstock to produce ethanol supports farm income through higher crop receipts than would be the case without ethanol production.

- Employment represents the annual average number of employees, whether full or part-time, of businesses producing output. Value added including labor Income and employment represent the net economic benefits that accrue to the nation as a result of increased economic output.

There are three types of effects measured with a multiplier: direct, indirect, and induced effects. Direct effects are the known or predicted changes in the economy. Indirect effects are the business-to-business transactions required to produce direct effects (i.e., increased output from businesses providing intermediate inputs). Finally, induced effects are derived from spending on goods and services by people working to satisfy direct and indirect effects (i.e., increased household spending resulting from higher personal income).

One change from previous years is the direct reflection of the additional value of output of co-products (DDG and industrial corn distillers' oil). Since these are co-products, and the backward linkages for their production is accounted for in the expenditures for ethanol production, the value for DDG and corn distillers oil was treated as income and value added only, and we applied income multipliers to the employee compensation portion to avoid double counting.

Results

The impact of the ethanol industry on the U.S. economy is summarized in Table 2. The full impact of the spending for annual operations of ethanol production, co-product output, and R&D is estimated to have contributed nearly $44 billion to the nation's GDP in 2015. A significant component of this is from agriculture, reflecting the importance of ethanol demand to total corn utilization, the aggregate value of crop production, and crop receipts and farm income.

Table 2
Economic Impact of the Ethanol Industry: 2015

	GDP (Mil 2015$)	Employment FTEs	Income (Mil 2015$)
Ethanol Production	**$15,804**	**71,362**	**$6,851**
Direct	$7,382	10,383	$2,536
Indirect	$4,960	23,793	$2,342
Induced	$3,461	37,186	$1,974
Construction	**$3,568**	**35,950**	**$2,418**
Direct	$1,232	13,303	$1,044
Indirect	$1,061	9,028	$650
Induced	$1,275	13,619	$724
Agriculture	**$23,291**	**238,432**	**$13,163**
Direct	$1,208	58,758	$900
Indirect	$15,128	105,301	$8,307
Induced	$6,956	74,373	$3,955
R&D Expenditures	**$1,266**	**11,663**	**$1,103**
Direct	$446	3,522	$542
Indirect	$383	3,473	$231
Induced	$437	4,668	$331
Total Ethanol	**$43,929**	**357,407**	**$23,535**
Direct	$10,269	85,967	$5,021
Indirect	$21,531	141,595	$11,530
Induced	$12,129	129,845	$6,984

Employment

Jobs are created from the economic activity supported by ethanol production. While ethanol production is not a labor-intensive industry (accounting for about 10,400 full time equivalent direct jobs nation-wide)[8], the economic activity of supporting industries generates a substantial number of jobs in the nation. When the direct, indirect and induced jobs supported by ethanol production, construction activity, agriculture, and R&D are included, the ethanol industry supported more than 357,400 jobs in 2015. The distribution by economic sector of jobs supported by the ethanol industry is summarized in Table 3.

Table 3
Employment Impacts by Industry 2015
(Full Time Equivalent Jobs)

Industry	Direct	Indirect	Induced	Total
Agriculture	57,254	22,161	2,320	81,734
Mining	0	4,545	702	5,247
Construction	4,180	11,321	3,013	18,514
Manufacturing	13,606	7,927	6,035	27,569
Transportation/Public Utilities	0	17,489	5,081	22,570
Wholesale/Retail Trade	0	24,430	27,715	52,145
Services	10,926	51,986	83,305	146,218
Government	0	1,735	1,675	3,410
Total	85,967	141,595	129,845	357,407

Since ethanol production is more capital intensive rather than labor intensive, the number of direct jobs supported by the ethanol industry is relatively small and is concentrated primarily in manufacturing and agriculture. Most agriculture jobs supported by the ethanol industry are jobs in support activities related to crop production, ranging from farm managers and bookkeepers to farm equipment operators. In addition, jobs supported by income generated and spent by employees supports a significant number of jobs in seemingly unrelated sectors such as retailers and service sectors. In general, as the impact of the direct spending by the ethanol industry expands throughout

[8] The Census Bureau does not report employment in ethanol production.

the economy, the employment impact expands significantly and is spread over a large number of sectors.

Income

Economic activity and associated jobs produce income for American households. The economic activities of the ethanol industry put nearly $24 billion into the pockets of Americans in 2015. The distribution of income gains by industry are summarized in Table 4.

As is the case with employment, the direct impact on income by the ethanol industry is limited to manufacturing and services. However, the most significant impact of the ethanol industry is to increase income to farmers who benefit from the demand for feedstock, which leads to both increased production and increased prices as well as earnings from locally-owned ethanol plants.

Table 4
Income Impacts by Industry
(Million 2015 $)

Industry	Direct	Indirect	Induced	Total
Agriculture	$1,343	$7,697	$76	$9,116
Mining	$0	$281	$86	$367
Construction	$295	$271	$143	$709
Manufacturing	$1,777	$426	$552	$2,754
Transportation/Public Utilities	$0	$767	$394	$1,161
Wholesale/Retail Trade	$0	$646	$1,283	$1,929
Services	$1,607	$1,376	$4,298	$7,281
Government	$0	$66	$152	$218
Total	$5,021	$11,530	$6,984	$23,535

Tax revenue

The combination of GDP and household income supported by the ethanol industry contributed an estimated $4.8 billion in tax revenue to the Federal Treasury in 2015. State and local governments also benefit from the economic activity supported by the ethanol industry, earning $3.9 billion in 2015.

Crude oil displacement and GHG Reduction

Ethanol plays a positive role in reducing our dependence on imported oil, expands the supply of motor gasoline, reduces the U.S. trade deficit, and reduces Greenhouse Gas Emissions relative to conventional gasoline.

The production and use of ethanol displaces crude oil needed to manufacture gasoline and expands the volume of motor gasoline available to consumers. According to the Energy Information Administration (EIA), U.S. dependence on imported oil and refined products has dramatically declined since peaking in 2005. The use of domestic biofuels (ethanol and biodiesel) is a contributor to the steady decline in oil import dependence. EIA reports that in 2014 about 46 percent of the crude oil processed in U.S. refineries was imported, and in total 27 percent of all petroleum products consumed in the U.S. were imported from foreign sources.[9] The production of 14.7 billion gallons of ethanol means that the U.S. needed to import 527 million fewer barrels of crude oil to produce gasoline in 2015. As a result of the recent decline in global oil prices, the value of the crude oil displaced by ethanol declined to nearly $26 billion in 2015.[10] This is money that stays in the American economy.

The importance of the U.S. ethanol industry to America's energy independence is expected to increase through 2016 as domestic oil producers close wells and cut output due to economic losses as oil prices remain significantly below breakeven levels.

Ethanol also provides significant environmental benefits relative to gasoline. According to EIA burning a gallon of gasoline that does not contain ethanol produces about 19.64 pounds of CO2 while a gallon of pure ethanol produces about 12.73 pounds of CO2.[11] Since virtually all of the retail gasoline now sold in the United States contains about 10 percent ethanol by volume (E10), the use of E10 reduces CO2

[9] EIA. *Frequently Asked Questions. "How much oil consumed by the United States comes from foreign sources??"* http://www.eia.gov/tools/faqs/faq.cfm?id=32&t=6. Accessed Jan 24, 2016.

[10] Ethanol directly competes with and displaces gasoline as a motor fuel. According to the EIA, one 42 gallon barrel of crude oil produced 18.9 gallons of gasoline in 2015. Ethanol has a lower energy content (76,700 btu per gallon LHV) than gasoline (114,000 btu per gallon LHV), and thus it takes 1.48 gallons of ethanol to provide the same energy as one gallon of gasoline. Therefore, 14.7 billion gallons of ethanol are the equivalent of 9.95 billion gallons of gasoline. Since one barrel of crude produces 18.9 gallons of gasoline, it takes 526.8 million barrels of crude to produce 9.95 billion gallons of gasoline, the amount displaced by ethanol. This oil was valued at the 2015 average composite acquisition cost of crude oil by refiners of $49.60/bbl.

[11] EIA. *Frequently Asked Questions. "How much carbon dioxide is produced by burning gasoline and diesel fuel?"* *http://www.eia.gov/tools/faqs/faq.cfm?id=307&t=11*. Accessed January 25, 2016.

emissions 3.5 percent relative to gasoline with no ethanol (18.95 pounds of CO2 for E10 versus 19.64 for gasoline). EIA estimates that nearly 123 billion gallons of gasoline were delivered for sale in 2015 and that virtually all of this was blended with 10 percent ethanol. Applying emission data provided by EIA suggests that the use of ethanol in the nation's motor fuel supply removed 38.4 million metric tonnes of CO2.

Challenges for 2016

The most significant challenges facing the renewable fuels industry in 2016 are likely to result from competitive pressures from falling world oil and refined product prices and an uncertain political and regulatory environment.

The competitive environment for renewable fuels has deteriorated as refined product prices continue to fall along with world oil prices. As of this writing crude oil prices have fallen 70 percent from their mid-2014 highs. Crude oil prices are now approaching the breakeven price for most new wells in North America. According to a recent CNBC report, "It's still cost-effective down to prices of $10 per barrel to maintain many existing wells across the United States, which is why drillers have not shut in production. But producers face a significantly higher bar when it comes to authorizing new production, because the cost of drilling and finishing a well accounts for the lion's share of lifetime costs." [12] Moreover, the North Dakota Department of Mineral Resources reported that the break-even cost of drilling in the Bakken formation has fallen to the mid-$20 range. As the oil industry adjusts production in response to falling prices and supply and demand for petroleum comes into balance, the market for renewable fuels is expected to continue to expand.

The other challenge for the ethanol industry is the uncertainty surrounding the 2016 Presidential election and the impact a change in administration may have on EPA leadership and rulemaking and the continued implementation of the RFS. The recent EPA final rule on the RVO for 2015 and 2016 sent a less than positive message to the investment community, particularly for sorely needed new cellulosic and advanced biofuels capacity. Whether and how this changes remains an open question.

[12] Tom DiChristopher. "US crude oil's break-even cost: How low can it go? CNBC 20 August 2015. http://www.cnbc.com/2015/08/20/

Conclusion

The ethanol industry continues to make a significant contribution to the economy in terms of job creation, generation of tax revenue, and displacement of imported crude oil and petroleum products. The importance of the ethanol industry to agriculture and rural economies is particularly notable. Continued growth and expansion of the ethanol industry through new technologies and feedstocks will enhance the industry's position as the original creator of green jobs, and will enable America to make further strides toward energy independence.