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

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The environment facing the ethanol industry in 2013 was modestly more favorable than in 2012. After two consecutive years of decline, motor gasoline consumption increased in 2013 and was accompanied by an increase in ethanol consumption. Perhaps most significant was a substantial improvement in industry profitability resulting from declining feedstock prices. Early-season expectations for a large corn crop were exceeded by the largest corn crop on record and were accompanied by sharply lower corn prices. By year's end, cash market corn prices were more than 40 percent below 2012 levels. When combined with higher ethanol and strong co-product prices, net returns over variable costs for a typical Iowa dry mill ethanol plant increased nearly threefold in 2013.[1]

In addition, 2013 marked the first commercial scale production of cellulosic ethanol and increased investment in new capacity for ethanol from cellulose and other advanced biofuel feedstock. Reflecting this environment, total ethanol production on a national level increased by an estimated 0.4 percent from 2012 levels to 13.3 billion gallons.

However, 2013 was not without challenges. Opposition to the Renewable Fuels Standard (RFS) from oil, livestock and poultry, and food industries continued throughout the year and regulatory pressures continued to challenge the renewable fuels industry. Perhaps most significant was the USEPA's proposal to reduce the 2014 renewable volume obligation (RVO) for the RFS. The ethanol industry hit the 10% ethanol "blend wall" and slow improvements in infrastructure restrained growth in the availability and consumption of higher blends of ethanol, notably E-15 and E-85. Finally, failure of the U.S. Congress to

[1] Iowa State University "AgDecision Maker D1-10 Ethanol Profitability" available at http://www.extension.iastate.edu/agdm/energy/xls/d1-10ethanolprofitability.xlsx accessed January 3, 2014.

pass a Farm Bill and authorize extensions of tax credits for cellulosic and advanced biofuels increased the level of uncertainty for investors.

According to the Renewable Fuels Association (RFA), at year's end the ethanol industry comprised approximately 210 plants in 28 states with nameplate capacity of 14.9 billion gallons and operating at an annualized rate of 13.8 billion gallons.[2] At year's end 167 million gallons of new capacity were under construction. This study estimates the contribution of the ethanol industry to the American economy in 2013 in terms of the employment, income, and Gross Domestic Product (GDP) directly and indirectly supported by the industry.

Expenditures by the Ethanol Industry in 2013

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.

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.[3] Ethanol industry expenditures can be broken into three major categories: construction of new production facilities, ongoing production operations, and research and development.

1. Construction

   2013 was highlighted by construction of both new conventional corn ethanol and cellulosic ethanol capacity. As reported by the RFA, 167 million gallons of new capacity was under construction at the end of 2013, of which 82 million gallons were for cellulosic and advanced

[2] The 13.8 billion gallons represents RFA's estimate of annualized production at the end of 2013. EPA reported full year production of 13.3 billion gallons.

[3] Expenditures for feedstock and energy were estimated using 2013 calendar year average prices. Revenues were estimated using 2013 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.

biofuels feedstock. Reflecting this we included construction expenditures of $480 million for 2013.[4]

2. Ongoing production operations

The industry spent nearly $40 billion on raw materials, other inputs, and goods and services to produce 13.3 billion gallons of ethanol during 2013. 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 2013.

Table 1
Estimated Ethanol Production Expenditures 2013

	Mil $	$/gal
Feedstock (corn)	$29,450	$2.21
Enzymes, yeast and chemicals	$964	$0.07
Denaturant	$1,137	$0.09
Natural Gas	$2,051	$0.15
Electricity	$639	$0.05
Water	$216	$0.02
Direct labor	$791	$0.06
Maintenance & Repairs	$346	$0.03
Transportation	$100	$0.01
GS&A	$412	$0.03
Total Operating Costs	$36,106	$2.72

The largest share of spending was for corn and other feedstock used as raw material to make ethanol. The ethanol industry used 4.8 billion bushels of corn on a gross basis in 2013, valued at more than $29.4 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

[4] We assumed capital expenditures of $2 per gallon for conventional corn ethanol capacity and $4 per gallon for cellulosic capacity.

[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

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 by private sector firms undertaking research in a wide range of biofuels activities. Based on a review of publically available data, we estimate that R&D expenditures for biofuels in the U.S. amounted to $1.7 billion in 2013.[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 (DDG) and industrial corn oil.[7] The ethanol industry produced an estimated

[6] 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, and Mary Solecki, Anna Scodel and Bob Epstein. "Advanced Biofuel Market Report 2013". E2 Environmental Entrepreneurs.

[7] Industry estimates suggest that 85 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.

35.2 million tons of DDG and 2.9 billion pounds of industrial corn in 2013 with an aggregate market value of $8.8 billion. It is notable that these co-products are produced with little additional expenditures.

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.

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. .

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 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 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 more than $44 billion to the nation's GDP in 2013. 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: 2013

	GDP (Mil 2013$)	Employment (Jobs)	Income (Mil 2013$)
Ethanol Production	$11,212	104,555	$7,010
Direct	$2,185	13,108	$1,857
Indirect	$4,839	40,769	$2,611
Induced	$4,188	50,678	$2,542
Construction	$600	8,020	$439
Direct	$247	4,077	$232
Indirect	$115	1,135	$73
Induced	$238	2,808	$134
Agriculture	$29,340	242,348	$21,174
Direct	$1,445	59,822	$1,123
Indirect	$14,804	38,192	$12,734
Induced	$13,091	144,334	$7,317
R&D	$2,885	31,858	$2,086
Direct	$991	9,496	$990.15
Indirect	$609	7,069	$377.20
Induced	$1,285	15,293	$718.53
Total	$44,037	386,781	$30,709
Direct	$4,867	86,503	$4,203
Indirect	$20,367	87,164	$15,795
Induced	$18,803	213,113	$10,712

Employment

Jobs are created from the economic activity supported by ethanol production. While ethanol production is not a labor-intensive industry (accounting for about 12,000 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 386,000 jobs in 2013. The distribution by economic sector of jobs supported by the ethanol industry is summarized in Table 3.

Table 3
Employment Impacts by Industry 2013
(Full Time Equivalent Jobs)

Industry	Direct	Indirect	Induced	Total
Agriculture	57,611	13,642	3,807	75,061
Mining	0	2,798	1,151	3,949
Construction	4,206	6,969	4,945	16,121
Manufacturing	13,691	4,880	9,905	28,476
Transportation/Public Utilities	0	10,766	8,340	19,106
Wholesale/Retail Trade	0	15,039	45,488	60,527
Services	10,995	32,002	136,728	179,725
Government	0	1,068	2,749	3,817
Total	86,503	87,164	213,113	386,782

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 $31 billion into the pockets of Americans in 2013. 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 construction. 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 acreage and increased prices.

Table 4
Income Impacts by Industry
(Million 2013 $)

Industry	Direct	Indirect	Induced	Total
Agriculture	$1,124	$10,544	$116	$11,784
Mining	$0	$384	$133	$518
Construction	$247	$372	$219	$838
Manufacturing	$1,487	$584	$846	$2,916
Transportation/Public Utilities	$0	$1,050	$604	$1,654
Wholesale/Retail Trade	$0	$885	$1,968	$2,853
Services	$1,345	$1,885	$6,592	$9,822
Government	$0	$90	$234	$325
Total	$4,203	$15,794	$10,712	$30,710

Tax revenue

The combination of GDP and household income supported by the ethanol industry contributed more than $4.5 billion to the Federal Treasury in 2013. State and local governments also benefit from the economic activity supported by the ethanol industry earning $3.8 billion in 2013.

Crude oil displacement

Ethanol reduces our dependence on imported oil and reduces the U.S. trade deficit. The production and use of ethanol displaces crude oil needed to manufacture gasoline. According to the Energy Information Administration (EIA), U.S. dependence on imported oil has dramatically declined since peaking in 2005. EIA credits increased use of domestic biofuels (ethanol and biodiesel) as one of the factors contributing to the steady decline in oil import dependence. EIA reports that in 2012 imports accounted for 40 percent of our crude oil and refined petroleum supplies and oil imports, compared to 60 percent in 2005.[9] The production of 13.3 billion gallons of ethanol means that the U.S. needed to import 476 million fewer barrels of oil in 2013 to refine gasoline. This is roughly the equivalent of 13 percent of total expected U.S. crude oil and petroleum product imports in 2013.[10] The value of the crude oil displaced by ethanol amounted to $48.2 billion in 2013.[11] This is money that stays in the American economy.

Challenges for 2014

The renewable fuels industry faces significant challenges in 2014. Perhaps the most critical will be dealing with regulatory actions proposed by USEPA and continuing to defend the RFS against attacks by oil and food industries. In addition, the renewable fuels industry will need to attract investment in infrastructure needed to increase the supply and availability of higher ethanol blends. This is a particularly critical issue for the ethanol industry since the E10 "blend wall" has been met, and the primary way to increase consumption is through the sale of higher blends. E15 blends have been approved for most automobiles on the road; however, E15 sales have been slow. Much broader consumption of E15 is necessary not only to meet the requirements of the RFS, but also to meaningfully increase ethanol demand and support profitability in the industry. The oil industry will continue to support

[9] EIA. *Energy in Brief*. "How dependent are we on foreign oil?" http://www.eia.gov/energy_in_brief/article/foreign_oil_dependence.cfm Updated May 10, 2013.

[10] According to the EIA, the U.S. imported 3.28 billion barrels of crude oil and petroleum products during the first 11 months of 2013, implying an annual total of 3.58 billion barrels.

[11] 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 2013. 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, 13.3 billion gallons of ethanol are the equivalent of 9.0 billion gallons of gasoline. Since one barrel of crude produces 18.9 gallons of gasoline, it takes 476 million barrels of crude to produce 9.0 billion gallons of gasoline, the amount displaced by ethanol. This oil was valued at the 2013 average composite acquisition cost of crude oil by refiners of $101.08/bbl.

and encourage attacks on the RFS, and create hurdles to increased penetration of higher ethanol blends.

Finally, fiscal issues that impact tax policy and appropriations for blender pump investment may constrain the industry. The U.S. Congress allowed important tax incentives including the Cellulosic Biofuel Producer Credit to expire. Failure to extend these important incentives will continue to increase uncertainty for the investment community and may constrain access to essential private capital.

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. 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 feedstock will enhance the industry's position as the original creator of green jobs, and will enable America to make further strides toward independence from imported fossil fuels.