BRIEFING

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The impact of the U.S. Renewable Fuel Standard on food and feed prices

Jane O'Malley, Stephanie Searle

Stakeholders have engaged in significant debate around the U.S. Renewable Fuel Standard (RFS) and its impact on food and feed prices since its implementation in 2005. Various stakeholders have expressed concerns that the RFS has adverse economic impacts on consumers, livestock farmers, food manufacturers, and restaurants. This briefing paper reviews evidence of the impacts of the RFS on food prices, with a focus on corn and soy, and presents new analysis on the impact of the RFS on U.S. livestock farmers. We summarize the history of debate surrounding the RFS from the perspective of farmers, industry, and policymakers; and analyze its economic impacts relative to a counterfactual, no-RFS scenario.

BACKGROUND ON THE RENEWABLE FUEL STANDARD AND NATIONAL DEBATE

Farmers in the United States consider the RFS to be a boon for their industry, particularly for the crops that are biofuel feedstocks, most notably corn and soybean. Today, nearly 40% of the U.S. national corn crop, or 6.2 billion bushels, is used for ethanol production while approximately 30% of soy oil produced in the United States is used in biodiesel.[1] The RFS is generally believed by stakeholders to increase corn prices.

1 David W. Olson and Thomas Capehart, "Dried Distillers Grains (DDGs) Have Emerged as a Key Ethanol Coproduct," United States Department of Agriculture Economic Research Service, October 1, 2019, https://www.ers.usda.gov/amber-waves/2019/october/dried-distillers-grains-ddgs-have-emerged-as-a-key-ethanol-coproduct/; U.S. Energy Information Administration, "Soybean Oil Comprises a Larger Share of Domestic Biodiesel Production," May 7, 2019, https://www.eia.gov/todayinenergy/detail.php?id=39372.

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According to the Renewable Fuels Association, dry-mill ethanol plants add nearly $2 of additional value to every bushel of corn processed.[2] The National Corn Growers Association claim that the recent increase in small refinery exemptions, under the RFS program which depresses ethanol demand, has resulted in "ripple effects negatively impacting agricultural commodity prices, farmers, and the food supply chain."[3]

In contrast, the U.S. livestock industry considers itself hard hit from increases in the price corn used for animal feed. The livestock industry has filed three notable RFS volume waiver petitions since the implementation of the program to request revision of annual biofuel mandates due to economic hardship. Texas Governor Rick Perry submitted a waiver petition in 2008 requesting a fifty percent reduction in mandated biofuel volumes, citing the program's "unintentional consequence of harming segments of [Texas'] agricultural industry and contributing to higher food prices."[4] In 2012, a coalition of livestock farmers petitioned the U.S. Environmental Protection Agency (EPA) to reduce mandated biofuel volumes stating that, in combination with widespread drought, the RFS "directly affected the supply and cost of feed in major agricultural sectors of this country, causing the type of economic harm that justifies issuance of an RFS waiver."[5] Likewise, in 2012, governors from ten U.S. states submitted RFS waivers stating that the program led to higher food costs and grain supply depletion.[6] In all three cases, EPA did not grant a waiver, concluding that the impacts of the program on livestock farmers did not meet their definition of severe economic harm.[7]

The restaurant industry is another stakeholder group affected by the RFS. A report commissioned by the National Council of Chain Restaurants found that the RFS led to an estimated $3.2 billion in lost profits for the chain restaurant industry in 2011.[8] The study is indicative of the economic uncertainty many have experienced as a result of the RFS. The RFS is also expected to impact profit margins from the food manufacturing industry, although no studies on this topic have been conducted to date.

IMPACTS ON CROP FARMERS

Crop farmers and ethanol producers benefit most from the RFS. The program has accelerated the growth of the ethanol industry, which supplies approximately 10% of the U.S. gasoline fuel market today.[9] Some analysts believe that this rapid increase in biofuels production has led to significant price increases in agricultural commodities used for biofuels, such as corn, and subsequent profit for crop farmers. For example, a study by the Center for Agricultural and Rural Development at Iowa State University estimated that, by 2015, the RFS had returned $14.1 billion in profits to the agricultural

2 Renewable Fuels Association, "Why Is Ethanol Important?," *Renewable Fuels Association* (blog), accessed November 5, 2020, https://ethanolrfa.org/consumers/why-is-ethanol-important/.

3 National Corn Growers Association, "U.S. Farm & Biofuel Leaders Demand Answers on Retroactive EPA Exemptions," National Corn Growers Association, June 12, 2020, https://ncga.com/stay-informed/media/in-the-news/article/2020/06/us-farm-and-biofuel-leaders-demand-answers-on-retroactive-epa-exemptions.

4 Office of Governor Rick Perry, "Texas RFS Waiver Request," April 25, 2008, https://www.epa.gov/sites/production/files/2015-08/documents/rfs-texas-letter.pdf.

5 "Livestock Coalition Urges Waiver of RFS," Meat + Poultry, July 30, 2012, https://www.meatpoultry.com/articles/7597-livestock-coalition-urges-waiver-of-rfs.

6 Coppess and Irwin, "The Other General Waiver."

7 U.S. Environmental Protection Agency, "EPA Decision to Deny Requests for Waiver of the Renewable Fuel Standard," November 2012, https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100FCJM.pdf.

8 pwc, "Federal Ethanol Policies and Chain Restaurant Food Costs," November 2012, https://cdn.nrf.com/sites/default/files/2018-10/Federal%20Ethanol%20Policies%20and%20Chain%20Restaurant%20Food%20Costs.pdf.

9 U.S. Energy Information Administration, "How Much Ethanol Is in Gasoline, and How Does It Affect Fuel Economy?," Frequently Asked Questions (FAQs), accessed November 11, 2020, https://www.eia.gov/tools/faqs/faq.php.

sector.[10] Based on this finding, DTN Progressive Farmer estimates that the RFS returns an average profit of $6,800 per farm.[11]

A number of studies examining the relationship between food prices and biofuels demand conclude that U.S. corn prices have increased relative to a no-RFS scenario, although there is a wide range in the estimated size of the corn price impact across these studies. Table 1 summarizes these results. Because the studies estimated the corn price change under varying amounts of corn ethanol demand increase, we also standardize the data, showing the change in the price of corn per billion gallon (BG) increase in ethanol demand in the third column. Several studies present a range in results depending on parameters such as projected fossil energy demand.

Table 1. Summary of studies on the impact of biofuels on U.S. corn prices.

Study Author(s)	Total price change	Price change per billion gallon increase in ethanol
Anderson & Cole	7%	7%
Bento et al.	24.5%	8.20%
Carter et al.	31%	5.6%
Chen and Khanna	24%–52%	4.7%
Cui et al.	18%	3.75%
Gehlhar et al.	3%–5%	0.4%–0.7%
Hayes et al.	19%–22%	2.2%
Hertel et al.	16%–18%	1.2%–1.3%
Huang et al.	15%	1.5%
Moschini et al.	40%	3.6%
Roberts & Schlenker	20%–30%	1.8%–2.7%
Roberts & Tran	14%–44%	1.3%–4%
Smith	31%	5.6%
Tyner et al.	71%	4.8%
U.S. EPA	3%–8%	1.3%–3.1%

Note: Citations can be found in the Note on sources section.

When attempting to understand what impact the RFS has had on ethanol prices, it is difficult to know how much additional ethanol the RFS has driven compared to an absence of the policy. Ethanol has uses outside of the biofuels sector as an octane enhancer and has been blended into gasoline since the 1980s. Following state-level phase-outs of methyl-tert butyl ether (MTBE), an alternative high-octane additive that was found to contaminate groundwater, refiners became increasingly reliant upon ethanol to meet octane grades.[12] Thus, in the absence of the RFS, we would likely still see significant amounts of ethanol blended into gasoline. The question is, then,

10 GianCarlo Moschini, Harvey Lapan, and Hyunseok Kim, "The Renewable Fuel Standard in Competitive Equilibrium: Market and Welfare Effects," *American Journal of Agricultural Economics* 99, no. 5 (October 2017): 1117–42, https://doi.org/10.1093/ajae/aax041.

11 "Study Finds RFS Beneficial Overall to US Ag Economy, But Questions Biodiesel Future," *DTN Progressive Farmer*, August 8, 2017, https://www.dtnpf.com/agriculture/web/ag/news/business-inputs/article/2017/08/18/study-finds-rfs-beneficial-overall.

12 Nicole Condon, Heather Klemick, and Ann Wolverton, "Impacts of Ethanol Policy on Corn Prices: A Review and Meta-Analysis of Recent Evidence," *Food Policy* 51 (February 2015): 63–73, https://doi.org/10.1016/j.foodpol.2014.12.007.

how much? Carter et al. approached this problem by comparing the United States Department of Agriculture's (USDA) projections for ethanol consumption in 2006, before the RFS was passed by Congress, and in 2007 after the RFS was passed.[13] These authors assumed that USDA's 2006 projection reflected the amount of ethanol the agency expected would be blended into gasoline purely because of its octane value. The difference between the 2006 and 2007 projections, extrapolated through 2019, would then reflect the increase in expected ethanol consumption specifically because of the RFS. We find this change to be equivalent to 4.8 billion gallons; for context, 14.5 billion gallons of ethanol were consumed in the United States in 2019.[14] Based on the estimated ethanol volume increase due to the RFS and the standardized median increase in the price of corn from Table 1, we estimate that the RFS has led to a 12% increase in the price of corn in the U.S. Accounting for this, we also estimate that corn farmers received an increase of $5.9 billion in revenue in 2019.

Some studies also consider the price impact of the RFS on soybeans because soy biodiesel is another major type of biofuel used in the United States.[15] Soybeans are a unique biofuel crop because soy oil, which is less than half of the crop, is used for biofuel, while the remaining soy meal is primarily used for livestock feed. In theory, increased demand for soy oil in biofuel would increase the price of soy oil and lead to increased soybean production. The resulting increase in soymeal production should reduce the soymeal price, which would be a boon for livestock farmers who mix soymeal into livestock feed to add protein. However, this is not exactly what most studies we identified on this topic assess—they estimate an increase in the price of whole soybeans due to the RFS. We have not found any literature modeling a price change for soymeal in response to soy biofuel demand. Moreover, there is reason to believe that an increase in the price of soy oil due to biofuel demand may not be efficiently transmitted to the price of soymeal. Soy oil accounts for roughly one-fifth of the mass and one-third of the economic value of a soybean, so the economic decision to plant more or less soy should rely more on the demand and price of meal rather than oil.[16] Soy oil is also highly substitutable with other cooking oils including palm and rapeseed.[17] We therefore may not expect to see any significant change in soybean production—and thus soymeal price—as a result of the RFS at all. Indeed, Santeramo found that changes in the soy oil price in the United States have a larger impact on changes in the quantity of palm oil imports than on changes in the quantity of soy oil produced from soybean cultivation.[18] Unlike corn, we therefore expect the increased demand for soy oil in biofuel production as a result of the RFS to significantly impact soy oil prices and palm oil imports but not soybeans or soymeal supply and prices.

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13 Colin A. Carter, Gordon C. Rausser, and Aaron Smith, "Commodity Storage and the Market Effects of Biofuel Policies," *American Journal of Agricultural Economics* 99, no. 4 (July 2017): 1027–55, https://doi.org/10.1093/ajae/aaw010.

14 U.S. Energy Information Authority (EIA), "Biofuels Explained: Use of Ethanol," June 24, 2020, https://www.eia.gov/energyexplained/biofuels/use-of-ethanol-in-depth.php.

15 See Dermot Hayes et al., "Biofuels: Potential Production Capacity, Effects on Grain and Livestock Sectors, and Implications for Food Prices and Consumers," *Journal of Agricultural and Applied Economics* 41, no. 2 (August 2009): 465–91, https://doi.org/10.1017/S1074070800002935.

16 Fabio Gaetano Santeramo and Stephanie Searle, "Linking Soy Oil Demand from the US Renewable Fuel Standard to Palm Oil Expansion through an Analysis on Vegetable Oil Price Elasticities," *Energy Policy* 127 (November 26, 2018): 19–23, https://doi.org/10.1016/j.enpol.2018.11.054.

17 *Ibid.*

18 Fabio Santeramo, "Cross-Price Elasticities for Oils and Fats in the U.S. and the EU" (Washington, D.C.: International Council on Clean Transportation, March 6, 2017), https://theicct.org/publications/cross-price-elasticities-oils-and-fats-us-and-eu.

The supply of dried distillers grains and solubles (DDGS), which can be substituted for soymeal and other high-protein ingredients in livestock feed, has also expanded since implementation of the RFS. DDGS is primarily produced as a byproduct of ethanol production, although approximately one million metric tons per year is sourced from beverage facilities.[19] Following growth across the ethanol market, DDGS production increased fourfold between the 2005/06 and 2017/18 growing seasons. Because DDGS is generally less expensive than soymeal and other protein feeds, the higher supply of DDGS reduces the cost of supplying protein in livestock feed. However, while the RFS has increased DDGS availability, it has also likely increased DDGS prices. Two studies, Langemeier and Cui et al., found that DDGS price tracks the price of corn.[20] This likely occurs because corn is the main input to the corn ethanol production process and so higher corn prices due to the RFS translate to higher overall costs for the corn ethanol process.

IMPACTS ON LIVESTOCK FARMERS

Profit for crop farmers from higher commodity prices equates to lost revenue for livestock farmers who spend a significant portion of production costs on feed alone. Feed makes up an estimated 50% to 69% of production costs for livestock farmers and primarily consists of corn, soybean meal, and DDGS.[21] Other feed ingredients include wheat, alfalfa hay, bone meal, limestone, and bakery waste.[22] Higher feed prices raise the overall costs of livestock production which may have a downstream effect on the prices of meat, dairy, and eggs, and thus on consumer demand. Lost revenue due to increased production costs or reduced consumer demand is especially detrimental to livestock farmers at a time the industry is facing record debt, farm closures, and loan delinquencies.[23]

We perform a new analysis on the economic impact of the RFS on livestock farmers, first considering lost revenue due to higher corn prices. We consider 3 factors: 1) the increase in livestock feed prices due to the increase in corn prices under the RFS, 2) the effect of DDGS substitution for soymeal and other protein feeds in livestock feed, and 3) the reduced consumer demand for livestock products, and thus livestock farm revenue, due to the RFS.

First, we consider the impact of increased corn prices on livestock farmers. Using the median corn price change per BG increase in ethanol production from Table 1, we assess the change in ethanol production attributable to the RFS following the same approach as Carter et al. Drawing upon these two values, we estimate that the RFS increased the price of corn 12% relative to a counterfactual, no-RFS scenario.

Next, we consider the effect of changes in the DDGS market on livestock feed price. Drawing from Langemeier for the proportional relationship between corn and DDGS

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19 Olson and Capehart, "Dried Distillers Grains (DDGs) Have Emerged as a Key Ethanol Coproduct."

20 Michael Langemeier, "Explaining Fluctuations in DDG Prices," *Center for Commercial Agriculture* (blog), June 26, 2020, https://ag.purdue.edu/commercialag/home/resource/2020/06/explaining-fluctuations-in-ddg-prices/; Jingbo Cui et al., "Welfare Impacts of Alternative Biofuel and Energy Policies," *American Journal of Agricultural Economics* 93, no. 5 (October 2011): 1235–56, https://doi.org/10.1093/ajae/aar053.

21 National Research Council, *Renewable Fuel Standard: Potential Economic and Environmental Effects of U.S. Biofuel Policy* (Washington, D.C.: National Academies Press, 2011), https://doi.org/10.17226/13105.

22 Kirk Klasing, "Displacement Ratios for US Corn DDGS" (Washington, D.C.: International Council on Clean Transportation, May 25, 2012), https://theicct.org/publications/displacement-ratios-us-corn-ddgs.

23 Alana Semuels, "'They're Trying to Wipe Us Off the Map.' Why Independent Farming in America Is Close to Extinction," *Time*, November 27, 2019, https://time.com/5736789/small-american-farmers-debt-crisis-extinction/.

prices, we can predict the DDGS price in the absence of the RFS based on our estimate of the impact of the RFS on corn prices. We find that the RFS increased DDGS prices 8% relative to the counterfactual scenario.

Although DDGS prices increase, we expect that higher DDGS availability mitigates the overall increase in the cost of livestock feed. This is because DDGS is cheaper than common substitutes, including corn and soybean meal. We now consider that savings along with the overall ingredient shifts in livestock diets as a result of increased DDGS availability. The USDA estimates that 28.12 million metric tons (mt) of DDGS are consumed in livestock feed today, an increase of 150% since 2006.[24] The growth of DDGS is closely proportional to growth in the ethanol market, so we reference the counterfactual ethanol production scenario to determine how much DDGS would have been produced in absence of the RFS. We find that DDGS consumption in livestock feed would be 57% lower than it is today under a counterfactual scenario, or 12 million mt.

We can then assess the impact of greater DDGS availability on the feed mix for specific types of livestock including beef and dairy cattle, hogs, poultry, and egg-laying hens. We draw upon population count data reported by the U.S. EPA[25] and daily feed consumption estimates.[26] to calculate the total weight of feed consumed by each livestock type annually. From this data and annual DDGS diversion ratios by livestock type reported by the Renewable Fuels Association,[27] we can determine the percent share of DDGS in livestock diets for the RFS and no-RFS scenarios. We use this information to adjust optimized feed diets by livestock categories reported by Klasing. Because livestock diets vary by region, we select regions where the highest number of farms are located (e.g. high plains, mid-west) for each livestock type for our analysis. To estimate the increase in feed costs for the two scenarios, we multiply the 2019 real cost data of each ingredient by its percent share in overall feed. Real cost data is drawn from the US Department of Agriculture (USDA) Feed Grains database[28] and university cooperative extension websites.[29] This calculation is performed for both RFS and no-RFS scenarios, assuming the relative change in corn and DDGS prices from our above calculations, to estimate the percent change in the cost of livestock feed due to the RFS. This cost is scaled up to the national level by multiplying it by the estimated ratio of feed cost to total production cost drawn from a National Research Council report[30] and national livestock farm revenue from USDA[31] The feed:production cost ratio is shown in Table 2, along with our total estimated percent increase in feed cost and farmer production cost due to the RFS for each livestock type.

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24 Olson and Capehart, "Dried Distillers Grains (DDGs) Have Emerged as a Key Ethanol Coproduct."

25 Environmental Protection Agency, "US GHG Inventory 2019 Annex 3 Additional Source or Sink Categories Part B," accessed September 21, 2020, https://www.epa.gov/sites/production/files/2019-04/documents/us-ghg-inventory-2019-annex-3-additional-source-or-sink-categories-part-b.pdf.

26 University of Illinois Extension, "Illinois Livestock Trail - Dairy Cattle," November 7, 2002, http://livestocktrail.illinois.edu/dairynet/questionDisplay.cfm?ContentID=1327.; Glenn Selk, "How Much Hay Will a Cow Consume?," *Drovers*, November 13, 2018, https://www.drovers.com/article/how-much-hay-will-cow-consume-0.; "How Much Does a Chicken Eat," Nutrena, accessed November 10, 2020, https://www.nutrenaworld.com/blog/how-much-does-a-chicken-eat.

27 Renewable Fuels Association, "2020 Industry Ethanol Outlook," 2020.

28 "USDA ERS - Feed Grains Database," accessed October 13, 2020, https://www.ers.usda.gov/data-products/feed-grains-database/.

29 Missouri University, "Agricultural Electronic Bulletin Board," October 8, 2020, http://agebb.missouri.edu/dairy/byprod/energygain.php.; Kansas State University, "Forage Options for Drought-Stressed Wheat," K-State Extension Agronomy, May 11, 2018, https://webapp.agron.ksu.edu/agr_social/eu_article.throck?article_id=1826.; Jonathan LaPorte, "Pricing Standing Corn Silage," Michigan State University Farm Management, August 19, 2019, https://www.canr.msu.edu/news/pricing-standing-corn-silage.

30 National Research Council, *Renewable Fuel Standard*, December 29, 2011

31 USDA Economic Research Service, "Farm Income and Wealth Statistics," September 2, 2020.

Table 2. Impacts of RFS across the supply chain.

Product	Increase in feed cost	Feed: production cost ratio	Increase in production cost (farmer)	Marketing margin*	Increase in product cost (consumer)	Reduction in consumer demand
Beef	3.7%	0.65	2.4%	0.54	1.1%	0.8%
Dairy	1.4%	0.50	0.7%	0.75	0.2%	0.1%
Pork	6.1%	0.65	4.0%	0.69	1.2%	0.9%
Poultry/Eggs	6.3%	0.69	4.4%	0.58	1.8%	0.9%

Notes: Feed:production cost ratio factors drawn from National Research Council, Renewable Fuel Standard. Price elasticity data drawn from Andreyeva et al., "The Impact of Food Prices on Consumption: A Systematic Review of Research on the Price Elasticity of Demand for Food."

Next, we consider how changes in feed prices could affect the cost of consumer products such as meat, eggs, and dairy. Farmers have a choice between absorbing the cost of higher livestock feed and suffer reduced profit, or passing on the cost to consumers in the form of higher meat, egg, and dairy prices. We do not know which strategy livestock farmers are more likely to follow. In the absence of such information, we present 3 scenarios:

» Scenario 1: The farmer absorbs 100% of the increased cost of livestock feed and does not pass on any of that cost to consumers in the form of higher prices.

» Scenario 2: The farmer absorbs 50% of the increased cost of livestock feed and passes 50% on to consumers in the form of higher prices. Consumers buy less livestock products due to the higher prices.

» Scenario 3: The farmer passes on 100% of the increased cost of livestock feed to consumers in the form of higher prices. Consumers buy less livestock products due to the higher prices.

For Scenario 1, lost revenue is equivalent to the increase in production costs (Column 4 in Table 2) for farmers. Farmers have the highest revenue losses under this scenario since they absorb 100% of costs, but they do not suffer from reduced consumer demand because they do not increase livestock product prices. Next, we consider Scenarios 2 and 3 where farmers pass on 50% or 100% of the increased cost of livestock feed to consumers in the form of higher prices. We use formulas provided by the National Research Council to calculate the total increase in livestock product cost as a function of marketing margin and feed-to-production ratio. The effect of higher feed prices on livestock products is diluted by the marketing margins shown in Table 2, which account for all costs along the supply chain from farm to retailer. Column 6 in Table 2 shows the increase in product cost if livestock farmers pass on 100% of the cost increase from the RFS to consumers.

We reference price elasticities of consumer products from a study by Andreyeva et al.[32] to estimate lost farm revenue due to reduced demand for scenarios 2 and 3. For example, Andreyeva et al. estimate that a 1% increase in the price of pork will result in a 0.72% reduction in pork demand. We find above that the cost of pork increases 1.2%, and so we multiply these two values together to determine a 0.9% decrease in consumer demand for pork products. Column 7 in Table 2 presents the reduction in demand if farmers pass on 100% of feed cost increases to consumers. In this case,

32 Tatiana Andreyeva, Michael W. Long, and Kelly D. Brownell, "The Impact of Food Prices on Consumption: A Systematic Review of Research on the Price Elasticity of Demand for Food," *American Journal of Public Health* 100, no. 2 (February 2010): 216–22, https://doi.org/10.2105/AJPH.2008.151415.

the farmer would not directly suffer from the increased feed costs shown in Column 2. For Scenario 2, in which farmers pass on 50% of the cost increases, we assume half the impact of both increased feed cost (Column 2) and reduced consumer demand (Column 7). For Scenario 2, we estimate a total economic impact on livestock farmers of -$2.8 billion (-1.7% of total revenue) due to the RFS.

Figure 1 shows this impact as well as the revenue loss from the three scenarios. Negative values in the graph indicate lower revenue due to the RFS compared to a no-RFS scenario while markers on the secondary axis indicate the percent share of revenue lost as a result of the RFS in 2019. On average, we find that beef and poultry farmers have the greatest absolute reduction in annual revenue while swine and poultry farmers lose the largest share of annual revenue on a percentage basis. This is largely due to the relative sizes of these industries. Dairy farmers have a high marketing margin, so their revenue lost due to reduced consumer demand is minimized.

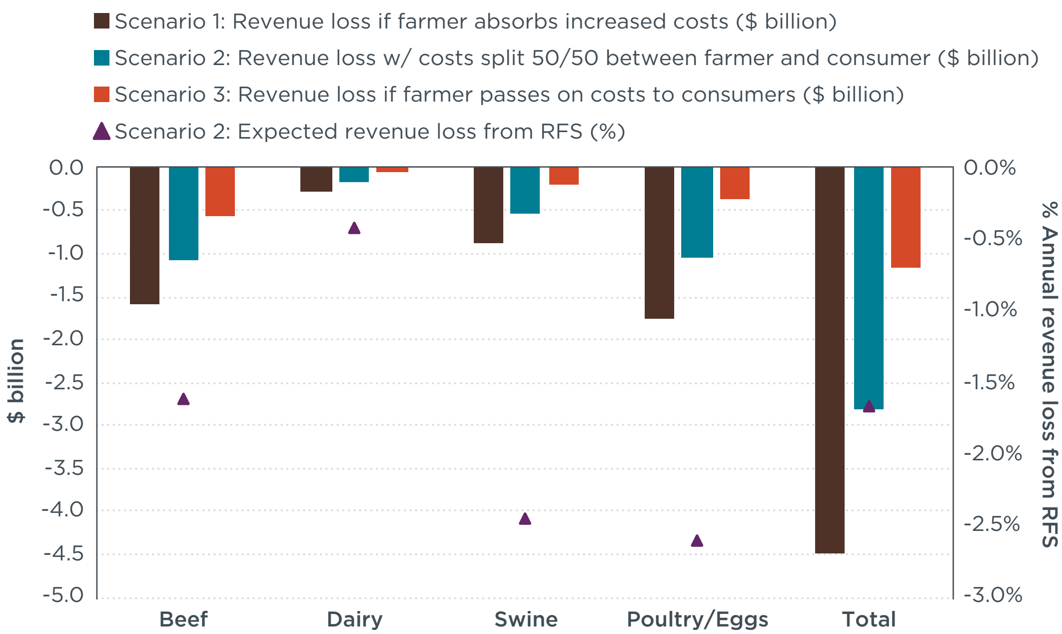

Figure 1. Economic impact of RFS on livestock farmers ($ billion lost) (left axis) and expected percent annual revenue lost (%) (right axis) in 2019.

Finally, we consider the economic impact of higher cost livestock products on consumers who purchase these items at the grocery store. The 2018 Bureau of Labor Statistics (BLS) Consumer Expenditure Survey finds that American households spend roughly 6.6% of their gross annual income on groceries. Of that total, approximately 28% each year is spent on meat, eggs, and dairy products. We draw from BLS consumer expenditure data to determine the percent change in consumer spending relative to the counterfactual no-RFS scenario.[33] We multiply the percent increase in the price of livestock products by the average annual amount spent on these products, factoring in the reduction in product demand in Scenario 2 (farmers pass on half the costs to consumers). We then divide this value by the average total amount spent on at-home food products and sum across all livestock products. We find that at-home food spending across all livestock products including dairy, eggs, and meat does

33 Bureau of Labor and Statistics, "2018 Consumer Expenditure Survey," 2018, https://www.bls.gov/cex/2018/combined/income.pdf.

not increase significantly since the share of livestock production price paid by the consumer is relatively small. In total, we estimate that the RFS increased at-home food spending 0.1% in 2019 compared to a no-RFS scenario. We thus conclude that the RFS has had a small but negative impact on most U.S. consumers. This impact is more pronounced for consumers in lower-income groups that spend a larger share of annual income on food purchases than the average U.S. household.

GLOBAL IMPACTS

For livestock farmers, lost revenue from reduced consumer demand may be mitigated through trade markets. The United States exports a significant amount of livestock products to countries such as China, Mexico, and Canada. In 2017, exports accounted for 26.6 % of U.S. pork production and 12.9% of beef production.[34] For poultry, exports account for a much smaller share at an estimated 4.5%. However, like domestic consumers, foreign consumers of U.S. livestock products would likely be price sensitive as well. Consumers in China and Mexico may be more price sensitive than U.S. consumers because food purchases make up a larger share of household spending in those countries.[35] This could lead to a larger reduction in demand and thus farmer revenue than we project here.

Previous studies have concluded that biofuels policy increases food insecurity in developing nations that are heavily reliant on food imports. Many households in these nations spend a disproportionately high share of income on staple foods. For example, in Nigeria, households spend as much as 56% of their annual income on food.[36] Comparatively, the average U.S. resident spends 6.6% of household income on food. In the short-term, biofuels policy can lead to price volatility in commodity crop markets, which generates significant uncertainty for consumers with constrained budgets. While the adverse effects of commodity crop price fluctuations are endured by developing nations, factors such as tariffs, poor infrastructure, and established local trade networks can isolate local markets from global price changes.[37] Still, it seems likely that the food price increases with the RFS impact consumers in low-income countries more negatively than those in the United States.

CONCLUSION

Biofuel demand driven by the RFS has increased the price of corn in both domestic and global markets. Crop farmers have benefited the most from increased commodity crop prices while we estimate that livestock farmers lost an estimated $3 billion in revenue in 2019 relative to a counterfactual, no-RFS scenario. This economic impact has strained a livestock industry already in decline. Moreover, half of the benefits to the farming industry on a whole are negated by economic losses incurred by livestock farmers. We also find that, although small, the RFS has a negative economic impact on household consumers. This impact is more significant for domestic and international consumers that are food insecure.

34 "USDA ERS - Livestock and Meat International Trade Data," accessed October 1, 2020, https://www.ers.usda.gov/data-products/livestock-and-meat-international-trade-data/.

35 USDA Economic Research Service, "Percent of Consumer Expenditures Spent on Food, Alcoholic Beverages, and Tobacco That Were Consumed at Home, by Selected Countries," n.d., https://www.ers.usda.gov/media/10271/2013-2018-food-spending_update-april-2019.xls.

36 *Ibid.*

37 Chris Malins, "Thought for Food - A Review of the Interaction between Biofuel Consumption and Food Markets" (Cerulogy, 2017).

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The following sources are used for Table 1:

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