

THE RENEWABLE FUEL STANDARD AND CONSUMER FOOD PRICES

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Executive Summary

The impact of biofuel production mandated by the Renewable Fuel Standard (RFS) on U.S. consumer food prices has once again emerged as an issue in public debate. The impact of biofuels on food prices remains a policy issue for several reasons. First, some concern persists about the impact of demand for feedstocks to produce biofuels on prices of major agricultural commodities. Critics continue to blame biofuels for the spike in agricultural prices between 2005 and 2008 and between 2010 and 2011. However, while the increase in prices between 2005 and 2008 is coincident with rising biofuel production, it is now generally recognized as having been primarily affected by the petroleum-led commodity price bubble and a combination of other factors. The second major reason is the impact of weather on agricultural markets. This was highlighted most recently by the 2012 drought which was the most severe in several decades. The purpose of this study is to examine the relationship between the RFS and recent changes in consumer food prices. Specifically this includes an examination of the relationship between corn prices and consumer food prices, the factors that affect corn prices, the role of the major industry participants in determining consumer food costs, and the relative importance of components such as agricultural commodities and energy on consumer food prices. Also addressed is the impact of the RFS on the major co-products of dry mill corn ethanol production, Distillers grains and carbon dioxide, and their contribution to the livestock and poultry sector and food processing industry.

Key findings

- Ethanol production and the demand for corn to produce ethanol have increased as a result of the RFS mandates. Corn prices also have increased over this period of time but increased demand to produce renewable fuels consistent with the RFS is only one factor behind the increase in corn prices. These factors included a sharp increase in petroleum prices, rapidly expanding global

demand for food and agricultural commodities, commodity market speculation, and an expansive U.S. monetary policy.

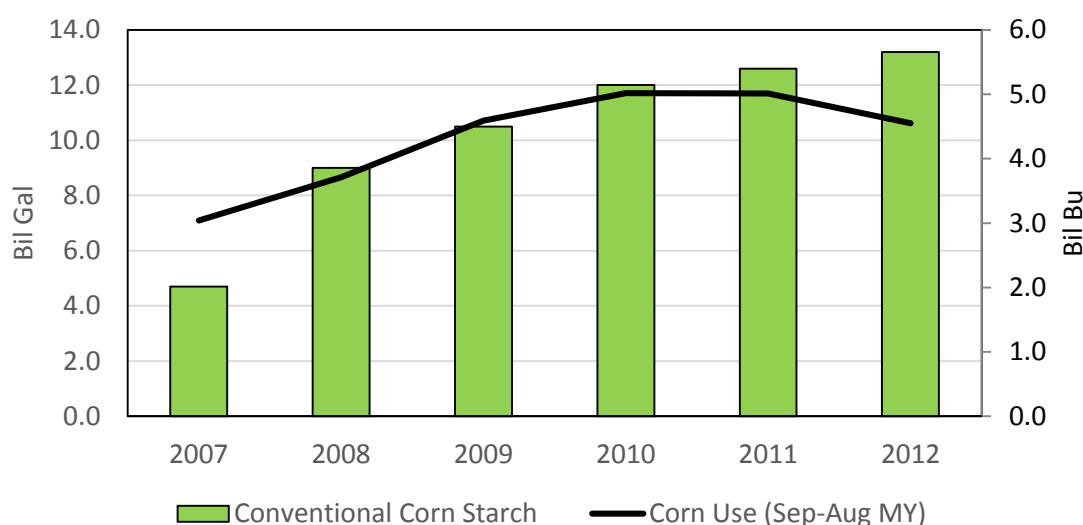
- A careful examination of food price inflation measured by the Consumer Price Index indicates that retail level food prices have increased at a slower rate since the RFS took effect than during the comparable five years before the RFS.
- The food processing industry accounts for a larger share of consumer food costs than does production agriculture. Moreover, energy prices play a more significant role in costs for food processors than do the prices for any individual agricultural commodity.
- The RFS has contributed to the production of important co-products of the dry mill corn ethanol industry. Specifically, Distillers dried grains have positively contributed to reducing net feed costs for livestock, dairy, and poultry producers. Higher ethanol output resulting from the RFS has led to increased production of DDGS. Because DDGS has a positive substitution rate for corn and soybean meal, these higher production levels have increased the total availability of feed for livestock and poultry producers by 21 percent compared to feed use of corn alone.
- The ethanol industry is a major source of captured carbon dioxide which is used in food processing, refrigeration and packaging to enhance the quality of processed foods and improve profit margins for processors.
- The RFS has not had an adverse impact on consumers' ability to afford a safe and healthy food supply. Although food prices have increased modestly faster than overall inflation in the past several years consumers are not spending a greater share of income on food than was the case before the RFS was implemented.
- The severe recession of 2008-2009 and sluggish recovery in real incomes has played a more significant role than commodity price increases in the decline in red meat and poultry consumption that has taken place since before the RFS was implemented.

The RFS and Food Prices

The RFS provision in the Energy Independence and Security Act of 2007 ("EISA") requires that 36 billion gallons of renewable fuels be used in the nation's motor fuel supply by 2022. As shown in Figure 1, the RFS targets for conventional renewable fuel (primarily corn ethanol) have increased from 4.7 billion gallons in 2007 to 13.2 billion gallons in 2012. Consistent with these targets the amount of corn used to produce ethanol for fuel increased from 2.1 billion bushels in the 2006-07 marketing year to 5.0 billion in the 2011-12 marketing year. USDA currently projects corn use for ethanol to decline to 4.6 billion

bushels in the current 2012-13 marketing year.¹ EIA reports that the U.S. ethanol industry produced 13.3 billion gallons in 2012, virtually all from corn. EISA caps the use of conventional ethanol produced from cornstarch at 15 billion gallons in 2015 and requires the remaining 21 billion gallons by 2022 to be produced from advanced biofuels including at least 16 billion gallons from cellulosic feedstocks.

Figure 1
RFS II Targets and Corn Use for Ethanol



Critics of the RFS contend that demand for corn to produce ethanol to meet RFS mandates has been the primary reason for high and increasing corn prices. Moreover critics contend that high corn prices have increased costs of producing meat (beef, pork and poultry), eggs, and dairy products, which in turn, have reduced profitability and resulted in lower production and, ultimately, higher consumer food prices.

A careful examination of food price inflation measured by the Consumer Price Index indicates that retail level food prices have increased at a slower rate since the RFS took effect than during the comparable five years before the RFS. The comparable percentage increases for the five years prior to implementation of the RFS and through the end of 2012 are illustrated in Table 1.

¹ The RFS targets are expressed on a calendar year basis while corn use is expressed on a September to August marketing year. For example the 2012 marketing year begin with harvest in September 2012 and ends in August 2013.

Table 1
Comparative Changes in the CPI, All Urban Workers

	Jan 2003-Dec 2007	Jan 2008-Dec 2012
All Items	15.8%	8.9%
All Less Food & Energy	10.8%	8.3%
All Food	16.8%	13.3%
Cereal & Bakery Prods	13.9%	17.4%
Meat, Fish & Poultry	21.2%	17.7%
Eggs	58.2%	-4.4%
Dairy Products	36.2%	1.3%
Energy	69.2%	7.0%

It is important to note that the results of any comparison of growth rates is highly dependent on selection of the time periods. A recent analysis prepared by the consulting firm FarmEcon² selectively compared the changes in components of the CPI for the five year period after implementation of the RFS (January 2008 to December 2012) to the change experienced over the previous three years (January 2005 to December 2007) and arrived at significantly different conclusions. A comparison of equivalent time periods such as that presented above is a more appropriate approach.

It is undeniable that corn used for ethanol production and corn prices both have increased since imposition of the RFS. However the increase in corn prices reflects factors other than demand for ethanol. These include the sharp increase in petroleum prices to record levels in 2008; a rapidly expanding global demand for food and agricultural commodities, and an expansionary U.S. monetary policy. The expansionary monetary policy pursued (to this day) by the Federal Reserve supports demand by reducing the cost of holding inventories and depreciates the value of the U.S. dollar which makes commodities denominated in dollars more affordable to foreign buyers works to bid up their prices.³ Specifically this period has been difficult for the corn sector.

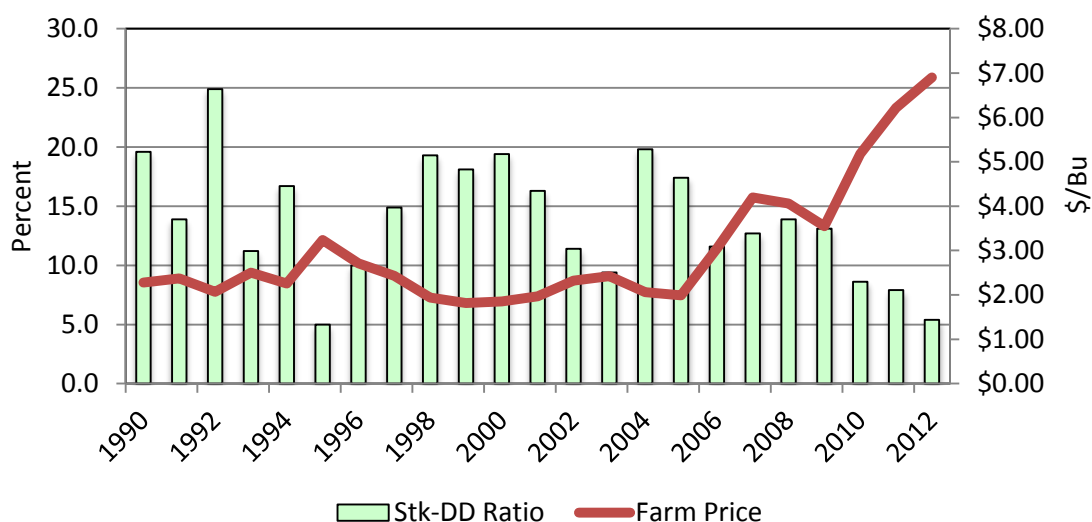
² Thomas E. Elam. *The RFS, Fuel and Food Prices, and the Need for Reform*. FarmEcon LLC. April 18, 2013

³ Brett Fawley and Luciana Juvenal. "Commodity Price Gains: Speculation vs. Fundamentals" *The Regional Economist*. Federal Reserve Bank of St. Louis. July 2011. Ujjayant Chakravorty, Marie-Helene Hubert, Michel Moreaux and Linda Nostbakken. "The Long Run Impact of Biofuels on Food Prices". CESifo Working Paper No. 3876. July 2012. CESifo Group. www.cesifo.org/wp

- Corn prices more than doubled between July 2007 and June 2008, reaching a peak of \$7.11 per bushel due in large part to the petroleum-led commodity price bubble. After the bubble burst corn prices fell to below \$3.00 per bushel by December 2008.
- Average corn yields which reached a record 164.7 bu/ac in 2009, declined for three consecutive years bottoming out at 123.2 bu/ac in 2012 as the Midwest suffered the most severe drought in decades.
- An unusually cold and wet spring this year has restrained corn planting in major states leading to some concerns about the potential size of the 2013 corn crop. Farmers have shown that they can plant quickly when conditions permit and there is little empirical evidence in the academic literature linking delayed planting to below-average yields. Nonetheless 2013 is demonstrating the effect weather can have on the markets.

Considering these factors, corn supplies are tight. Current USDA projections suggest the ratio of corn stocks to demand for the 2012 marketing year to be the second lowest on record. The relationship between corn stocks and demand and farm-level prices is illustrated in Figure 2.

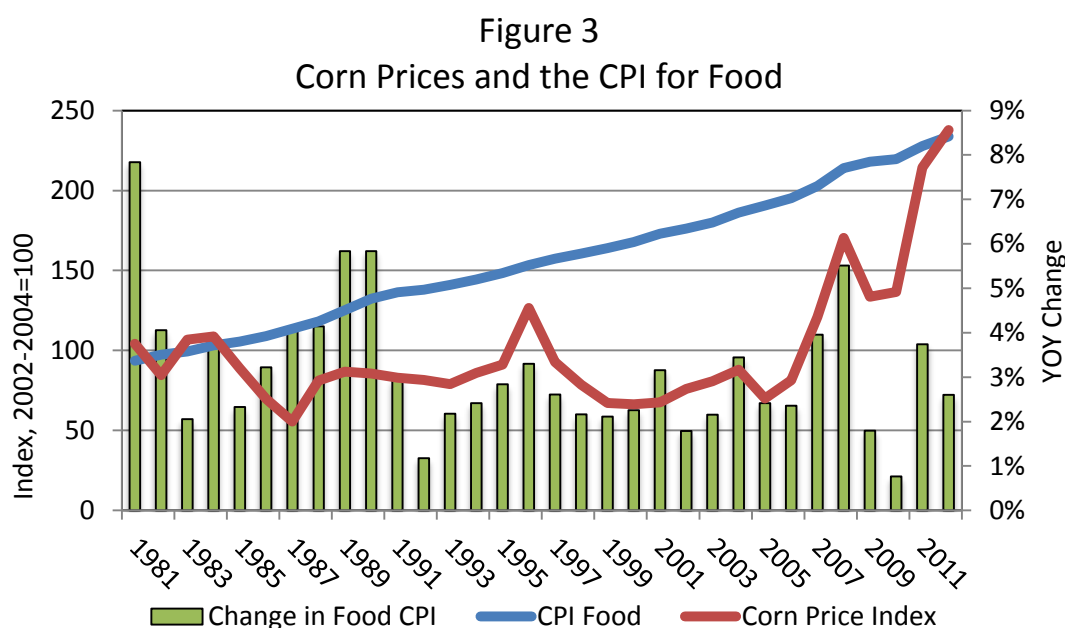
Figure 2
Corn Stock Demand Ratio and Prices



It is interesting to note that the response of prices to demand in the past three years has been considerably larger than has been the case in the past. Critics contend that but for the demand for corn

to produce ethanol to meet RFS mandates, corn stocks would have been larger and prices lower. This contention ignores the fact that lower demand, and presumably prices, would have reduced the incentive for farmers to plant as much corn and production would have been much lower, offsetting the decline in demand. Since the enactment of the RFS in 2007 farmers planted an average of 90.5 million acres to corn, 11.5 million acres more than was planted during the previous six years. Additional corn acres have come primarily through crop-switching, with fewer acres being planted to cotton, barley, oats and wheat. The additional corn acres planted post 2007 resulted in an annual average of nearly 2 billion more bushels of corn.

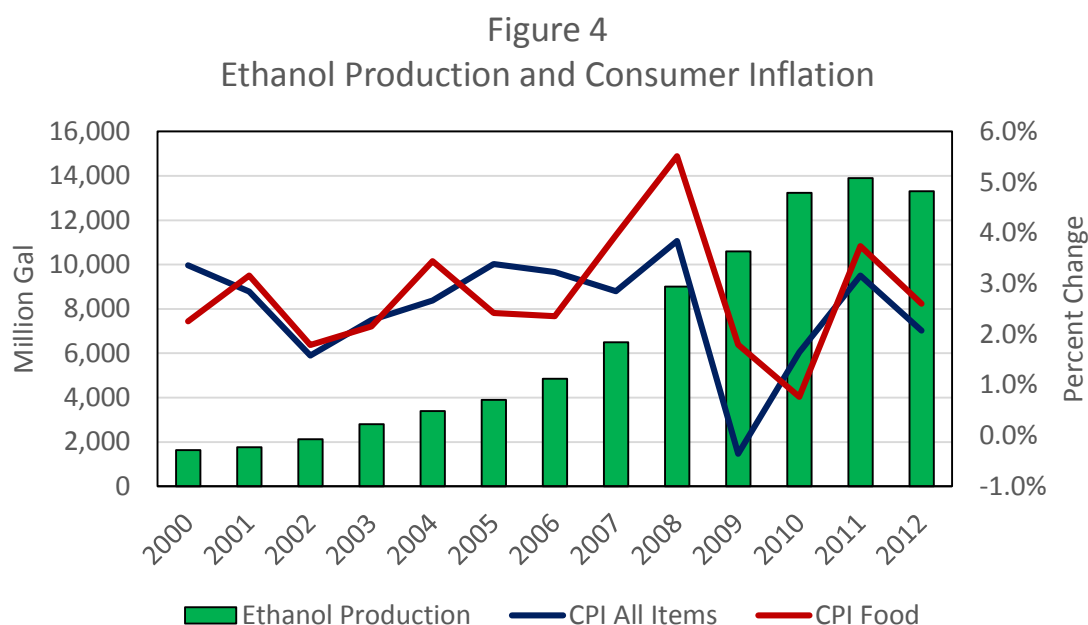
The recent increases in retail food prices are not unprecedented. Figure 3 compares the annual increases in the CPI for All Food to the level of the CPI for Food and calendar year corn prices. The CPI is expressed as an index with a base of 2002-2004. For ease of comparison the calendar year average market price of corn (No.2 Yellow, Central Illinois) was converted to an index with the same base period.



As can be seen in Figure 4, while the index of consumer food prices has steadily grown over time, corn prices have been far more volatile. Movements in the price index for corn are indications of year over year changes. An examination of Figure 3 illustrates the point that the recent increases in food prices are not unique. Recent food prices increased at a substantially slower rate than during the late 1980s,

and are comparable to price increases experienced during much of the 1990s. Second, the relationship between corn prices and food prices is tenuous. The annual average change in consumer food prices increased over much of the 1980s while corn prices generally trended downward. The CPI for food accelerated modestly 1996 coincident with high corn prices caused by the severe 1995 drought. Similarly, both corn and food prices spiked in 2008 in response to the global commodity price bubble and declined in 2009 as the bubble burst and the economy fell into recession. Corn prices fell in calendar year 2009 and 2010 in response to the record corn crop in 2009 but have increased sharply over the past two years. Consumer food prices in 2010 reflected a general absence of inflationary pressure caused in large part by sluggish economic growth. All of this has occurred while ethanol production continued to dramatically increase.

The relationship between ethanol production and year-to-year changes in the CPI for All Items and Food is illustrated in Figure 4. Ethanol production increased through 2011 with the most significant growth occurring after implementation of the RFS in 2007. Ethanol production declined modestly in 2012 in response to high corn prices and blend wall issues. As shown in Figure 4, year-over-year changes in consumer prices post RFS have been relatively volatile. This volatility largely reflects the boom-bust cycle of prices caused by the 2008 global commodity price bubble and recession of 2009 that followed the financial collapse. Having said this, the average increase in the CPI for food since 2008 has been virtually identical to that of the previous five years.



Corn Prices, Energy, and Consumer Food Inflation

Corn is an important commodity, ranking first in terms of value of crop for American farmers. However corn is an intermediate input for consumer foods. That is, the corn for grain that is produced is not consumed directly by consumers but is a major raw material for meat, milk and eggs. Moreover, all feed and in particular corn, is only one component of the cost of producing meat and milk. For example, a review of farm-level costs and returns published by USDA indicates that all feed (of which corn is the major input) accounts for 57 percent of operating costs for hog producers, 25 percent of operating costs for cow-calf operations, and 58 percent of dairy operating costs.⁴ USDA does not publish costs and returns for cattle feeding but a review of enterprise budgets for Iowa cattle feeders published by the Iowa Cooperative Extension Service suggests that corn accounts for about a third of operating costs. The takeaway from this is that increases in the prices of other inputs such as energy and labor also impact costs and returns for livestock and dairy producers.

⁴ USDA Economic Research Service. Commodity Costs and Returns. <http://www.ers.usda.gov/data-products/commodity-costs-and-returns.aspx>. Accessed May 10, 2013.

The RFS, Distillers grains, and feed availability

The livestock and poultry industry have blamed deteriorating profitability on high corn prices they blame almost exclusively on the RFS. As pointed out earlier, corn prices were affected by several factors including the 2008 commodity price bubble, several years of declining yields, and the extreme 2012 drought. It is important to note that the drought not only affected grain yields but also severely impact the production and prices of forage crops, important for beef and dairy cattle, and increased death losses that affected slaughter and meat production.

The livestock and poultry industry benefitted from increased production of Distillers dried grains (DDGS)⁵ as a result of the RFS. DDGS are a major co-product cry mill corn ethanol production. When corn is used to make ethanol in a dry mill, enzymes are used to convert the starch to sugars which are fermented and distilled into alcohol (ethanol). The proteins, other nutrients, and fiber left over after fermentation are collected and processed into Distillers grains which are returned to the livestock sector as a feed ingredient. Since most of the starch in corn is converted to ethanol during the fermentation process, the fat and fiber concentrations in DDGS are increased by a factor of three compared with that in corn.

The use of DDGS has increased sharply in recent years as production and availability grew along with corn ethanol output. A bushel of corn used for dry-mill ethanol production generates about 17.5 pounds of DDGS, or about a third of the corn's original weight. Considering this, as a result of the RFS the availability of DDGS for the livestock and poultry sector has more than doubled between 2007 and 2012, increasing from 21.3 million tons to nearly 40 million tons in 2011. DDG production declined modestly in 2012 as ethanol output fell.

The production and of DDGS expands the amount of feed available to livestock and poultry producers. On a gross basis DDGS production increased the amount of corn equivalent available for feed by 21 percent over the five years since implementation of the RFS. This is illustrated in Table 2.

⁵ This paper uses the term "DDGS" to refer to all forms of distillers grains, including wet and modified distiller's grains.

Table 2
Impact of DDGS on Feed Availability 2007/08 – 2012/13

Mkt Year Beg Sep 1	DDGS Production (Mil Tons)	DDGS Exports (Mil Tons)	DDGS Net Avail (Mil Tons)	DDGS Corn Equiv (Mil bu)	Corn Feed Use (Mil bu)	Total Feed Avail (Mil bu)	Total Feed Gain due To DDGS
2007	21.343	1.962	19.381	692	5,858	6,550	11.8%
2008	29.208	4.297	24.912	890	5,182	6,072	17.2%
2009	36.154	5.470	30.685	1,096	5,125	6,221	21.4%
2010	39.540	9.128	30.412	1,086	4,793	5,879	22.7%
2011	39.462	9.136	30.326	1,083	4,548	5,631	23.8%
2012 (est)	36.225	8.317	27.908	997	4,550	5,547	21.9%

To calculate the amount of feed available (corn grain plus the corn equivalent of DDGS) I assumed that 90 percent of ethanol was produced in dry mills using corn as the feedstock and that 17.5 pounds of DDGS are produced for every bushel of corn use for ethanol production. Export data for DDGS was taken from the USITC Interactive Tariff and Trade Database.⁶ The corn equivalent of DDGS was estimated by dividing pounds of DDGS produced by 56 (pounds per bushel),

The analysis of the RFS prepared by FarmEcon also examined the production of DDGS and pointed out that the supply of corn plus DDGS declined between 2005/06 and 2012/13.⁷ While in an absolute sense this is correct, *FarmEcon misses the point. That is, because of the increase in DDGS production due to the RFS, the amount of corn equivalent (grain plus DDGS) was as much as 21 percent higher than would have been the case without ethanol production.* Year to year changes in feed demand for corn are determined by a number of factors including the prices of corn and competing feeds and, animal numbers, and feeding rates.

Animal feeders use DDGS as a protein and energy supplement for dairy cattle, beef cattle, swine, and poultry rations because it is an economical source of energy compared to feed grains like corn and an economical source of protein compared to soybean meal. Today, more DDGS is fed to livestock, dairy and poultry than soybean meal, indicating the importance of this product to the U.S. feed complex. Since DDGS has a superior energy value to corn when being feed to beef cattle, by using DDGS livestock

⁶ http://dataweb.usitc.gov/scripts/user_set.asp. Accessed May 20, 2013

⁷ Elam, FarmEcon Report, 2013 p 21.

feeders can effectively replace a portion of the corn used to produce ethanol. Moreover since DDGS produced from corn typically has a protein content of 25 to 30 percent it also replaces expensive high protein soybean meal. DDGS competes with a wide range of other protein and energy feeds including other cereal energy feeds, cereal protein feeds, oilseed meals, and animal protein feeds. The USDA DDGS analysis

Extension Service specialists recommend that up to 20 percent of a dairy cow feed ration may consist of DDGS, while most recommendations for beef cattle call for inclusion at the 30 percent level. It should be noted that higher levels of DDGS (e.g., 40-50 percent of the diet) have been fed to beef cattle when economical. Dairy cows consume more feed and the feed passes through the digestive tract more quickly than in beef cattle. Dairy cows require more bypass protein than beef cattle and also more digestible fiber to maintain milk fat levels. The combination of bypass protein, digestible fiber, and fat in DDGS makes it a highly desirable feed for dairy cows.⁸ DDGS also are used by swine and poultry feeders, however issues related to fiber content and lysine deficiencies typically limit feeding rates of a 20 percent maximum for swine, 15 percent for layers, and 6 percent for broiler chickens.

A recent USDA study found that DDGS substitutes for corn and soybean meal in livestock and poultry diets and reduces the impact of ethanol on the feed market. The USDA analysis reviewed DDGS inclusion rates and concluded that "... recent estimates of the substitution rate of DDGS for corn and soybean meal reveal that 1 pound of DDGS replaces more than a pound of corn and soybean meal combined for beef and dairy cattle."⁹ However they further point out that one pound of DDGS replaces about a pound of corn and soybean meal combined for swine and poultry. Specifically, the USDA authors estimated that one pound of DDGS replaces 1.2 pounds of corn for beef cattle, 0.73 pounds of corn for dairy cattle, and 0.7 and 0.61 pounds of corn, respectively for swine and poultry. The USDA analysis estimated the average market share of DDGS consumption over the five year period 2006 through 2010 at 49.0 percent for beef cattle, 26.3 percent for dairy cattle, 13.4 percent for swine, and 11.3 percent for poultry.

The increased production and availability of DDGS has had an important impact on the beef cattle industry by stimulating a migration of feedlot cattle from the southwest to Corn Belt ethanol producing

⁸ Glen Aines, Terry Klopfenstein, and Rick Stock. *Distillers Grains*. Institute of Agriculture and Natural Resources. University of Nebraska-Lincoln. 1986.

⁹ Linwood A. Hoffman and Allen Baker. *Estimating the Substitution of Distillers' Grains for Corn and Soybean Meal in the U.S. Feed Complex*. USDA Economic Research Service FDS-11-I-01. October 2011.

states. For example, the number of cattle in feedlots of 1,000 or more cattle in Iowa increased from 375,000 head in 2000 to 610,000 on January 1, 2013 while the number of cattle on feed in South Dakota increased from 194,000 to 230,000 over the same period. Together, these two major ethanol producing states currently account for 7.5 percent of cattle on feed, up from 5 percent in 2000. By comparison, the share of cattle on feed in Texas fell from 25 percent in 2000 to 24 percent on January 1, 2013. Clearly proximity to large supplies of wet distiller's grains has attracted feedlots to locate near ethanol plants.

The RFS and meat consumption

In the FarmEcon study Dr. Elam states that "The post-2007 decline in U.S. meat and poultry consumption is unprecedented" and goes on to blame the RFS for the "... the reduct(ion) in this industry's access to its basic feedstock, corn".¹⁰ In fact, USDA statistics indicate that per capita consumption of beef, pork and broiler chicken fell 5.3 percent between 2008 (the first year after implementation of the RFS) and 2012. By comparison, per capita consumption of these three meat products fell 7.6 percent between 1971 and 1975.¹¹ Dr. Elam also fails to point out that per capita consumption of beef, pork, and broilers peaked at 200.9 pounds in 2004, well before the RFS was implemented and, with the exception of a small increase in 2006, has declined every year since. As pointed out, Dr. Elam lays blame for the decline in consumption at the feet of the RFS. However demand for food products such as meat have a relatively high income elasticity (that is, their demand is more responsive to changes in income than other foods). Dr. Elam fails to mention that the five years since implementation of the RFS were victim to the most severe recession since the end of World War II. The accompanying decline in real per capita disposable income and unusually sluggish recovery adversely affected consumers. By comparison, the more significant decline in consumption between 1971 and 1975 coincided with the recession and inflation that followed the first Arab oil embargo in 1973.

Further, USDA projects 2013 red meat and poultry production to be the second-highest on record, trailing only 2008.¹² Red meat and poultry output has seen successive increases every year since 2009. How would this be possible if there was truly less total feed available? While it is true that less whole corn is being fed today than 5-7 years ago, use of lower-cost corn processing co-products, corn stalks, and

¹⁰ Elam, FarmEcon Report, 2013. P 22

¹¹ Source for 2012 and 2011: World Supply and Demand Estimates. USDA World Agricultural Outlook Board. May10, 2013 and December 11, 2012. Data for prior years from [http://www.ers.usda.gov/data-products/food-availability-\(per-capita\)-data-system.aspx](http://www.ers.usda.gov/data-products/food-availability-(per-capita)-data-system.aspx)

¹² World Supply and Demand Estimates. USDA World Agricultural Outlook Board. May10, 2013.

other alternative feeds has increased dramatically. In fact, total feed intake by the livestock industry continues to trend upward when all feed sources are considered. Additionally, feed conversion efficiency has improved significantly in recent years, meaning it takes less feed to produce a pound of meat today than in the past.

Corn and food prices

The relationship between consumer food inflation and corn prices or ethanol production is tenuous at best. Clearly increases in corn prices have a larger impact on meat, poultry and dairy products than other food products. The pass through of these changes from the farm to the consumer is muted by the share of these products in the overall consumer food basket. For example, all food accounts for only 13.7 percent of the full CPI and the foods most affected by corn prices represent less than half of the CPI for food (meat, poultry, fish and eggs 22.4 percent; cereals and bakery products 14.2 percent, and dairy products 10.5 percent).¹³ Consequently, an increase in only one commodity -- even one as important as corn -- can be expected to have a relatively small impact on overall consumer prices.

The relative small impact on consumers of an increase in corn prices is further illustrated by considering that the share of the consumer food dollar received by the farmer (e.g. the share that is represented by the sum of all raw or unprocessed food commodities – including corn and the products that incorporate corn as a raw material) has declined over time while other components have increased. The most current data published by USDA reports that the farmer received 15.5 cents of the consumer food dollar in 2011, down 15.8 percent over the past twenty years and virtually unchanged since the RFS was implemented.¹⁴ By comparison the share of the consumer food dollar accounted for by the marketing bill (the activities of the food supply chain industries involved in all post-farm activities) amounted to 84.5 cents in 2011.

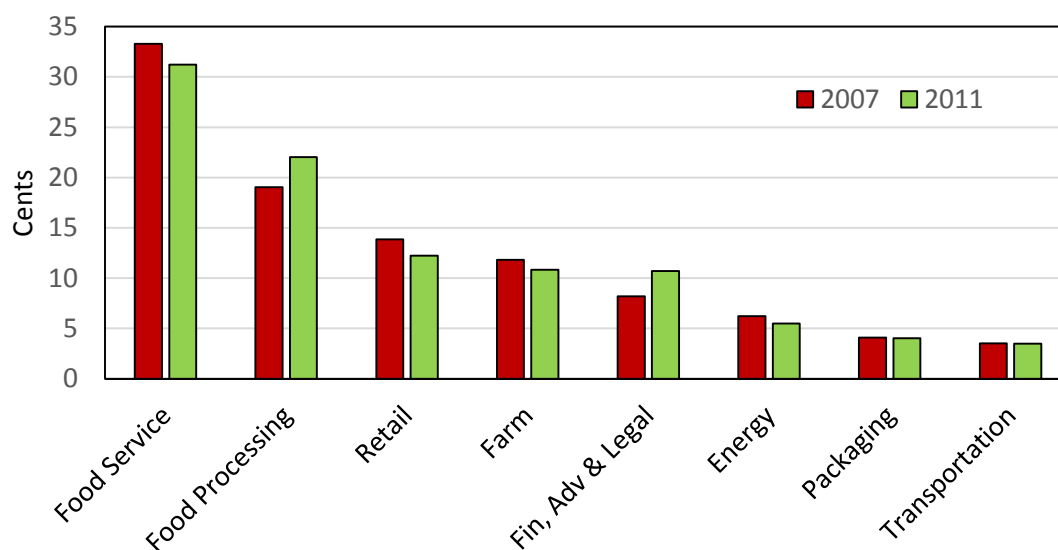
Another way of looking at the allocation of the consumer food dollar is to examine value added, or contribution of cost, by the industries involved in bringing food to the consumer. The cost of food equals the sum of the value added by all members of the supply chain that links the farmer to the consumer. According to the USDA Economic Research Service the share of the cost of food provided by the farm

¹³ Source: Bureau of Labor Statistics. "Relative importance of components in the Consumer Price Indices: U.S. city average, December 2012". <http://www.bls.gov/cpi/cpiri2012.pdf>

¹⁴ Patrick Canning. "A Revised and Expanded Food Dollar Series: A Better Understanding of Our Food Costs". USDA/ERS. Economic Research Report Number 114. February 2011.

and agribusiness sector in 2011 amounted to 10.8 cents of the consumer food dollar, 8.4 percent less than 2007 when the RFS was implemented.¹⁵ By comparison the share of food cost accounted by the food processing industry in 2011 amounted to 22 cents, up 15.7 percent over the same period. The allocation of the value added, or cost, of the consumer food dollar by industry in 2011 and 2007 is detailed in Figure 5.

Figure 5
Consumer Food Dollar by Value Added Industry



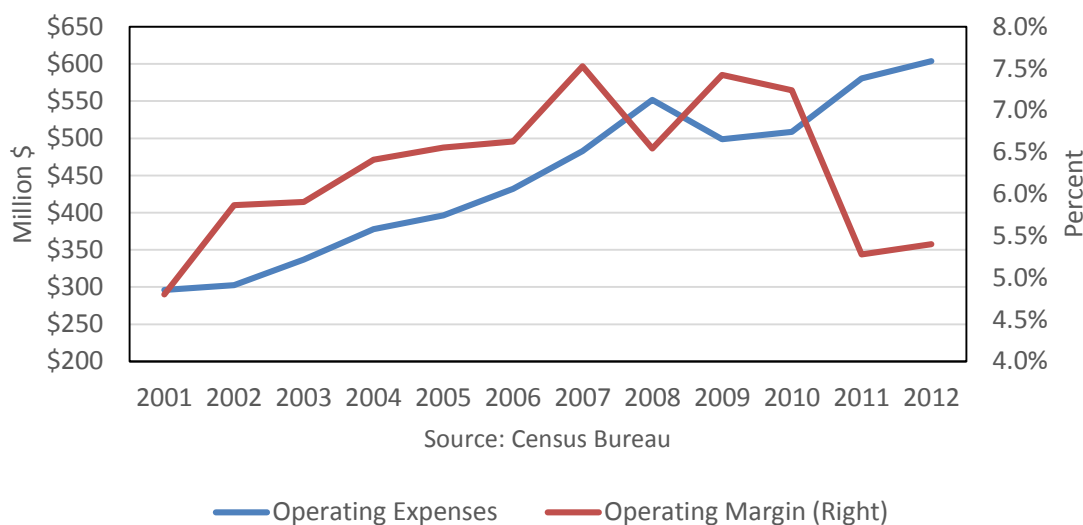
Source: USDA

Energy, food processing, and food prices

As pointed out above the food processing industry accounted for an estimated 22 percent of the cost of consumer food in 2011, more than twice that accounted for by production agriculture (the farm and agribusiness industry). Moreover, the food processing industry share of food costs increased while the production agriculture share fell despite higher commodity prices. The increase in operating costs faced by the food processing industry is illustrated in Figure 6.

¹⁵ Source: <http://ers.usda.gov/data-products/food-dollar-series/food-dollar-application.aspx?reportPath=/FoodDollar/Nominal>. Accessed May 10, 2013.

Figure 6
Food Industry Operating Expenses and Margins



Some of the higher costs are passed on to consumers in the form of increased prices for processed foods and are reflected in the CPI and some are borne by shareholders and are reflected in operating or profit margins. Operating expenses for the food industry increased 25 percent between 2007 (the year the RFS was implemented) and 2012, significantly slower than the 43 percent increase posted during the five years prior to the RFS. Industry profit margins average 6.6 percent since implementation of the RFS compared to 6.4 percent during the previous five years.¹⁶

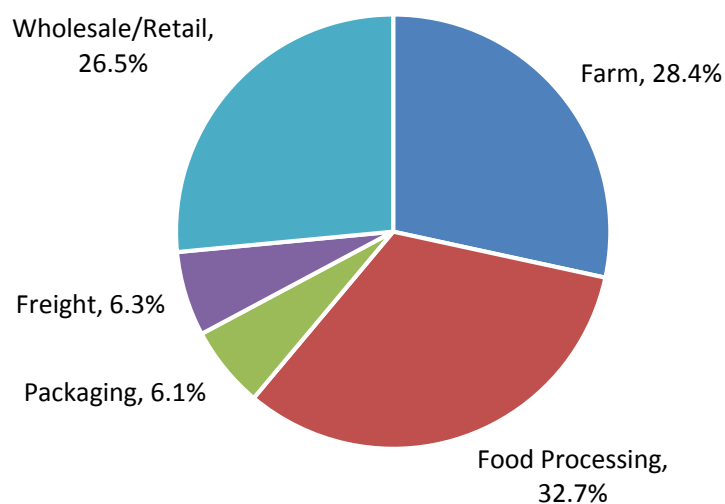
While higher agricultural commodity prices have contributed to the increase in industry expenses and recent decline in margins, energy prices also have played a major and increasing role. An analysis of energy flows in the U.S. food system published by USDA indicates that the food processing industry accounts for the largest share of energy used in food system.¹⁷ According to USDA, "...energy has become an increasingly prominent component of food industry costs as households and foodservice establishments increasingly outsourced manual food preparation and cleanup activities to the

¹⁶ U.S. Census Bureau "Quarterly Financial Report (QFR) Manufacturing, Mining, Trade, and Selected Service Industries". <http://www.census.gov/econ/qfr/>

¹⁷ Patrick Canning, Ainsley Charles, Sonya Huang, Karen R. Polenske and Arnold Waters. "Energy Use in the U.S. Food System": USDA/ERS Economic Research Report Number 94. March 2010.

manufacturing sector, which relied on energy using technologies to carry out these processes”¹⁸ Figure 7 compares the per capita energy flows by industry sector within the food system.

Figure 7
Distribution of Food System Per Capita Energy Flows, 2002

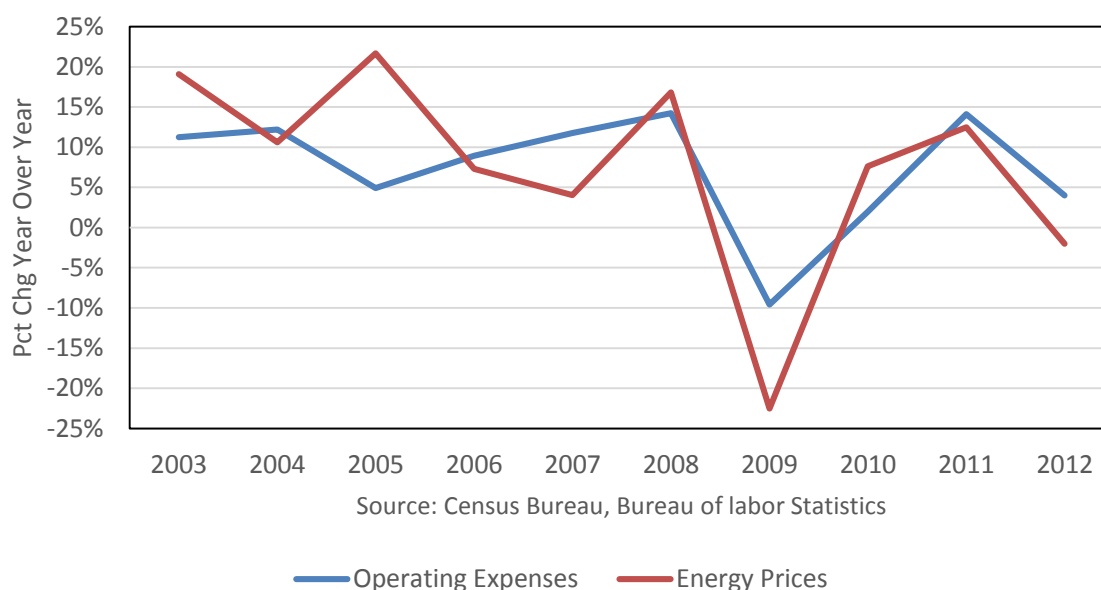


Source: USDA/ERS

The relationship between the annual change in operating expenses and energy prices faced by the food processing industry is illustrated in Figure 8. Energy prices are measured by the average of Producer Price Indices for industrial electricity, industrial natural gas, and refined petroleum products.

¹⁸ Canning et. al, 2010, iv

Figure 8
Food Processing Industry Operating Expenses and Energy Prices



Considering the relative importance of energy to the food industry and the role of food processing in consumer food costs, it is safe to point out that energy prices have a greater impact on consumer food prices than any one individual agricultural commodity such as corn.

The interaction of the RFS, carbon dioxide, and food prices

The two major co-products of the dry mill corn ethanol industry are Distillers grains (discussed above) and carbon dioxide (CO₂). Carbon dioxide is becoming an increasingly important additional revenue stream for ethanol plants in proximity to markets. CO₂ captured from ethanol production is particularly attractive to industrial markets because of its very high purity level. Additionally the capture (and marketing) of CO₂ is becoming increasingly important greenhouse gas reduction strategy for the ethanol industry. As is the case with DDGS, the RFS has resulted in a substantial increase in industrial CO₂ production. According to industry experts, the ethanol industry provides as much as 40 percent of the CO₂ used in North America.¹⁹ CO₂ is provided both as a liquid form and as dry ice. The primary markets for CO₂ include food processing (soft drinks, beer and frozen foods), refrigeration and freezing, and

¹⁹ Sam Rushing. "CO₂ Increasingly Important to Ethanol" *Biofuels Digest*, August 27, 2010.

multiple industrial uses such as grain fumigation, pH reduction of municipal water and effluent, welding, metallurgy, rubber manufacturing and chemical production.

Other major sources of CO₂ supply include natural CO₂ wells, natural gas sweetening or synthesis gas purification byproducts, anhydrous ammonia production, and flue gases. The viability of anhydrous ammonia supply is tied to natural gas prices. Natural well sources have the potential for contamination with radon gas, sulfur compounds and other organics. Flue gases have long been an important source of CO₂, however flue gas CO₂ recovery process cannot economically compete with by-product CO₂ where it is available in sufficient quantity.²⁰

It is difficult to quantify the contribution of CO₂ to food industry costs, however the importance of refrigeration for food products and carbonation for beverages underline the importance of this input. An example of this is the development of cryogenic food freezing processes that use CO₂ that provide rapid freezing, a reduction of moisture loss, and improved yield and appearance of food products. Many meat products have an improved 'bloom', or color, when using cryogenic freezing methods rather than mechanical means. The use of cryogenic freezing results in less damage to the cellular walls, less water and fluid loss, increased weight sold to the consumer, and higher profit margins for the processor.²¹

.Any disruption of CO₂ production, such as would occur in the absence of the RFS, would force the food and beverage industry to quickly identify and secure an alternative source. Considering the large share of CO₂ production provided by the ethanol industry, and disruption in supply can be reasonably expected to result in a significant increase in price that would in large part be passed along to consumers in the form of higher food prices.

Food affordability and consumer spending

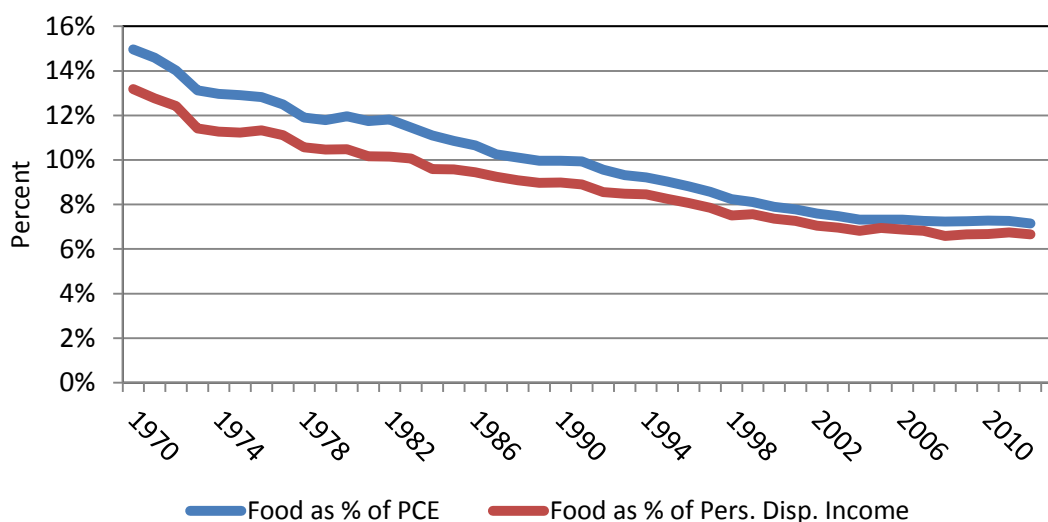
The RFS has not had an impact on the share of disposable income devoted to food or the share of personal consumption expenditures devoted to food. Figure 9 compares the ratio of personal real consumer spending for food purchased for off premise consumption (i.e. food at home) to total consumer spending and spending on food for off premise consumption to real personal disposable income from

²⁰ Dan G. Chapel, Carl L. Mintz and John Ernest. "Recovery of CO₂ from Flue Gases: Commercial Trends". Fluor Daniel Inc. October 1999.

²¹ Sam A. Rushing. "Carbon dioxide and the food processing sector". *Gasworld*. Sep 10, 2010.

1970 to 2012.²² Personal consumption expenditures (PCE) for food purchased for off premise consumption was used for this comparison because it is a more accurate representation of spending by consumers for food purchased at the retail level (i.e. grocery stores and markets) and prepared at home. The NIPA accounts also report spending for purchased meals and beverages and food furnished to employees as part of the expenditures for food and accommodations. This is analogous to spending for food at restaurants and eating places. Including these data with food for off premise consumption overstates food spending because actual food products account for only a part of spending at restaurants and eating places.

Figure 9
Food Purchased for Off Premise Consumption



As can be seen in Figure 9, consumer spending for food at home both as a share of total consumer spending and real disposable income has declined significantly over the past four decades. The share of spending on food for home consumption relative to all spending in 2012 is half that consumers spent in 1970. Further, the share of real disposable income devoted by American consumers for food purchased at grocery stores and food markets also has been cut in half over the past 43 years. Of most significant importance however that is the ratio of real spending on food to total spending and real disposable income has been essentially flat for the past 10 years. This includes the post RFS period and is an

²² Source: Bureau of Economic Analysis National Income Accounts
<http://www.bea.gov/iTable/iTable.cfm?ReqID=9&step=1#reqid=9&step=1&isuri=1> Accessed May 3, 2013

indication that consumers have not been disadvantaged by increases in corn or retail food prices as a result of the RFS.

Conclusion

Ethanol production and the demand for corn to produce ethanol have increased as a result of the RFS mandates. Corn prices also have increased over this period of time but increased demand is only one factor behind the increase in corn prices. A careful examination of food price inflation measured by the Consumer Price Index indicates that retail level food prices have increased at a slower rate since the RFS took effect than during the comparable five years before the RFS.

The food processing industry accounts for a larger share of consumer food costs than does production agriculture. Moreover, energy prices play a more significant role in costs for food processors than do the prices for any individual agricultural commodity.

Higher ethanol output resulting from the RFS has led to increased production of DDGS, a feed ingredient co-product of dry mill corn ethanol production. Because DDGS has a positive substitution rate for corn, these higher production levels have increased the total availability of feed for livestock and poultry producers compared to corn grain.

Finally, while it is true that food prices have increased modestly faster than overall inflation in the past several years consumers are not spending a greater share of income on food than was the case before the RFS was implemented.