Economy Wide Impacts of a Foreign Animal Disease in the United States

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Abstract

This report uses the CARD FAPRI model to evaluate the economy wide impacts of a disease outbreak that eliminates US pork and beef exports simultaneously and pork exports alone. In either case industry losses are enormous and spread well beyond the pork and beef sectors. Revenues fall significantly for poultry, corn and soybean producers and employment in rural areas is negatively impacted as the US pork and beef sectors are forced to downsize. Revenue losses in the combined US pork and beef industries fall by an average of $12.9 billion per year. The removal of this level of value added activity is equivalent to the loss of as many as 58,000 full time jobs. The report uses option prices to calculate the likelihood of a price impact of the magnitude reported here. This suggests a less than one percent possibility of an outbreak of this severity. Multiplying the probability of an outbreak times the reduction in pork industry net revenues over variable costs in the event of an outbreak, suggests that the annual benefit of eliminating the possibility of this outcome would be worth $137 million.

Keywords: Foot and Mouth Disease, Swine Fever, Economic Impact of Exports.

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Introduction

Infectious animal diseases such as Foot and Mouth Disease (Aphtae epizooticae***)*** and Swine Fever (hog cholera) can have a devastating impact on animal productivity often leading to the death of infected animals. Because these diseases spread so rapidly, eradication is difficult and control programs usually revolve around the isolation and slaughter of infected animals. Countries that are free of these diseases will typically prohibit the importation of chilled or frozen meat from countries where the disease is prevalent, even when the infected country uses vaccines to control the disease. Importation of meat from vaccinated animals has been prohibited because current tests cannot differentiate between animals that have been vaccinated and animals which have the disease. Countries that are infested with the disease but who are trying to get it under control typically prohibit meat imports from infected countries.

The US has been fortunate in avoiding FMD with the last outbreak registered as far back as 1929. The US eradicated swine fever in 1978 and it has never experienced an outbreak of African swine fever, the most damaging of the swine fevers. Other countries have not been so fortunate. The UK experienced outbreaks of FMD in 1967, 2001, and 2007 and Japan, Korea, Bulgaria and China were struggling with FMD as recently as 2011. Classical Swine fever is endemic in Asia, Central and South America, and Africa. African swine fever outbreaks occurred in Spain, Portugal, Cuba, and the Dominican

Republic in the late 1970,s and early 1980's and a devastating outbreak is ongoing and spreading in Russia, Georgia, Iran and Armenia.

An outbreak of one of these diseases in the US would have immediate consequences. Federal and local governments would step in to kill or vaccinate infected animals and all at risk animals in an area around the source. Wild animals in the infected zone would likely be slaughtered and almost all movement of animals from that state to other states and countries would be prohibited. Evidence from the UK and South Korea suggest that these costs could potentially be enormous. However the magnitude of these costs is impossible to determine prior to the event because the costs will depend on the severity of the outbreak.

It is possible to estimate one set of costs associated with the outbreak of one of these diseases. It is reasonably certain that such an outbreak of FMD would result in the loss of some US export markets for both beef and pork and that an outbreak of a swine fever would result in the loss of some export markets for pork. The sudden loss of these export markets would force this meat onto the US domestic market and potentially would force US prices down until the surplus product had cleared the market. The magnitude of the price associated losses will depend on the location of the outbreak and the willingness of importing countries to accept meat from states where no outbreak has occurred.

Costs associated with the loss of export markets are of immediate relevance because the US, unlike the UK or South Korea is a major exporter of both pork and also because the burden of these costs would likely fall on the producers rather than on taxpayers. The purpose of this paper is to examine the economy wide impacts of the elimination of export markets due to a foreign animal disease. We do this analysis for beef and pork and then separately for pork alone. In both cases we assume a worst case scenario and eliminate all US exports of that product for ten years. We use a ten year period because this is long enough to allow the industry to arrive at a new equilibrium where it downsizes and provides product only to US domestic market. By comparing the industry sales in the baseline scenario and the disease scenario we can get an estimate of the

impact of this downsizing on the US economy. The last part of the paper is an attempt at estimating the likelihood of such an outbreak. We do this by examining the distribution of lean hog futures prices that is used to determine the premium on options on this contract. The proportion of the distribution to the left to of the price reductions we project earlier in the paper provides some guidance on the likelihood of the disease over the course of one year. Multiplying the probability of the disease by the costs in the event of the disease provides a rough estimate of the annual burden this disease imposes on the US beef and pork industries. As we will show these private sector costs are large enough to justify preparation in the form of insurance against catastrophic price reductions as well as to motivate risk mitigation projects and regulations.

Likely Impact of a Foreign Animal Disease on the US economy

According to the USDA the US will export more than $10 billion of pork and beef in 2011[i]. This represents approximately 10 percent of the beef and 22 percent of the pork produced in the US. The loss of these exports markets would create an oversupply of meat on the domestic market with significant price reductions throughout the marketing system. Live animal prices would fall to encourage the US consumer to eat more beef and pork as well as to reduce or eliminate US meat imports.

The availability of inexpensive pork and beef in the US domestic market would lead to price reductions in competing proteins such as chicken, eggs and cheese. Consumers in the rest of the world who are suddenly cut off from imported meats will necessarily reduce consumption and turn towards domestic proteins or to meat imports from other exporting countries. Taiwan has never managed to regain the export markets it lost due to the FMD outbreak that occurred in 1997. Therefore it seems possible that the US would lose its status as a major exporter of pork and beef for a significant amount of time after the first outbreak. As the US beef, pork and poultry sectors adjust to lower domestic demand, feed-grain use will fall and employment in the US livestock sector and its affiliated industries will suffer. Second round impacts will include a reduction in the US trade balance and in rural employment.

Because we are focused on the economy wide impacts, we present results showing how both profits and total revenue adjust over a ten year period. We use this revenue impact to calculate the impact on employment. The profits based measure will underestimate the full economy wide impact because it excludes the impact of industry downsizing on input suppliers.

Previous Work

The most recent work in this area is from Schoenbaum and Disney (2003). The primary focus of their paper involves the costs of controlling the outbreak under several assumptions as how this might be attempted. This paper does provide an estimate of the cost of the outbreak in terms of lost producer and consumer surplus. This is estimated at $2.16 million per day. This estimate is based on a comparative static multi-commodity, price-endogenous spatial-equilibrium programming model of the US agriculture sector (USMP) that was calibrated to reflect projected economic conditions in 2005. This work is valuable but it does not allow us to go beyond the agricultural sector. To see why this is true consider the way producer surplus is measured. This is the difference between the marginal cost of production and the actual market price at each output level; it is closely related to producer profit if fixed costs are ignored. This measure therefore captures the losses to producers but not to society. For example suppose it costs $100 of variable costs to raise a hog and the market price is $105 then the producer surplus is $5. But if this hog is not ever produced because market conditions are poor then the true measure of the cost of the disease is the $105 of economic activity that is eliminated.

Another good source is Paarlberg et al (2002). This article focuses on revenue impacts and is based on the 2001 outbreak in the UK. It uses a model of the US agricultural sector calibrated to reflect 1999 to 2000 data and includes a measure of the lost export markets in the economic analysis. Change in gross revenue for each industry is as follows; live swine, –34%; pork, –24%; live cattle –17%; beef, –20%; milk, –16%; live lambs and sheep, –14%; lamb and sheep meat, –10%; forage, –15%; and soybean meal, –7%. The

base year for this study is now approximately ten years old and reflects a period when meat exports, particularity pork exports were much lower than they are today.

McCauley, (1979) examines the period immediately after the outbreak without the aid of an economic model. The focus of this paper is on the epidemiology of the disease under various control strategies. One interesting take away from this discussion is that society as a whole bears the cost of destroying the animals while the animal producer pays the costs associated with reductions in market prices. This sets up a tradeoff between the interests of the producer and the rest of society. The more animals that are destroyed, and by extension, the more meat taken off the market, the lower will be the negative price impact on producers. On the other hand if control is achieved by means of a vaccination program then fewer animals will be destroyed and the primary economic impact will be on market prices. This tradeoff between the interest of producers and the rest of society sets up an incentive problem which has not been explored. In the event of an outbreak producers will be the ones with primary responsibility for obeying restrictions on animal movement, but the more effectively they implement these rules, the greater the proportion of the adjustment burden that will be placed on them.

Methodology

The results presented below are from the FAPRI model that is maintained at the University of Missouri and at Iowa State University. The model is designed for use by the US House and Senate to allow policy makers to understand the full economic impacts of various policy changes. The model is best used when an existing published baseline is used against which to examine the impact of a policy or economic shock.

In our case the baseline is the existing FAPRI ISU 2011 baseline and the shock consists of the loss of all export markets for pork, beef, live hogs and live cattle in the FMD scenario and for pork and live hogs in the Swine Fever scenario. To implement this shock we simply restrict these export parameters to zero and then allow the model to arrive at a new equilibrium.

This full FAPRI model is documented at Meyers *et. al.* 2010. Below we reproduce and summarize some key model details from that publication. The FAPRI model is an attempt to describe the behavior of world markets for temperate food and feed products. It consists of a set of dynamic, multi-market (multi-commodity and multi-country), econometric, non-spatial, partial-equilibrium models. The key drivers in the model are supply and demand equations for all of the important temperate commodities in all of the important producing and consuming countries. The international model covers most of the commodities listed in table 1, but not all commodities are covered in all countries. A total of 61 countries and regional aggregates are covered in the full model.

Table 1. Commodity Coverage in FAPRI's Deterministic Model of U.S. Markets

Crops	Crop-based products	Livestock and poultry	Animal-based products
Corn	Ethanol	Beef cattle	Beef
Wheat	Biodiesel	Dairy cattle	Pork
Soybeans	Sugar	Hogs	Chicken
Upland cotton	High-fructose corn syrup	Chickens	Turkey
Long-grain rice	Distillers grains	Turkeys	Fluid milk
Short/medium grain rice	Corn gluten feed		American cheese
Sorghum	Corn gluten meal		Other cheese
Barley	Corn oil		Nonfat dry milk
Oats	Corn stover		Butter
Sunflowerseed	Soybean meal and oil		Evaporated milk
Peanuts	Sunflower meal and oil		Ice cream
Canola	Canola meal and oil		Eggs
Hay	Peanut meal and oil		

Sugar beets	Cottonseed
Sugarcane	Cottonseed meal and oil
Switchgrass	

The FAPRI model for the United States covers 16 crops, 20 crop products, 5 types of livestock and poultry, and 12 animal-based products. Modeled commodities accounted for approximately two-thirds of U.S. crop receipts and 96 percent of livestock and poultry sector receipts.

For almost all commodities, the model estimates production, consumption and prices. For example for corn, the model includes corn planted area, harvested area, and yields per acre on a regional basis. Domestic corn consumption is divided into feed and residual, ethanol, high-fructose corn syrup, seed, and other food and industrial uses. The model estimates corn prices by the equilibrium condition that total supply (production plus imports and beginning stocks) must equal total demand (domestic consumption plus exports and ending stocks). U.S. exports must be consistent with net trade by all the other countries in the world model.

Model parameters are derived from a combination of econometric estimation from time series data, prior information based on economic theory, technical relationships, the literature, and analyst judgment. For example, corn feed and residual use is a function of feed and livestock prices, an index of grain-consuming animals, and the quantities of competing feeds consumed. The equation is constructed to ensure that corn feed and residual use changes proportionally with livestock and poultry production. Given this assumed structure and parameters, econometric estimation is used to estimate the responsiveness of corn feed use with respect to corn and soybean meal prices and a weighted index of livestock prices.

The modeling system captures the biological, technical, and economic relations among key variables within a particular commodity and across commodities. The model is based on historical data analysis, current academic research, and a reliance on accepted economic, agronomic, and biological relationships in agricultural production and markets. Specifically, the model attempts to explicitly capture the extensive linkages that

exist in agricultural markets such as the derived demand for feed in livestock and dairy sectors, competition for land in production, and consumer substitution possibilities for sets of close substitutes.

The model includes detailed policy variable coverage. In particular, agricultural and trade policies for each commodity in a country are included in the sub-models to the extent that they affect the supply and demand decisions of the economic agents. These include taxes on exports and imports, tariffs, tariff rate quotas, export subsidies, intervention prices, other domestic support instruments, and set-aside rates.

For the baseline analysis, existing agricultural and trade policy variables are extended at current levels through the outlook period. For the scenarios of interest in this paper we do not need to know how each country outside the US responds but we need to know how they respond in aggregate. Therefore the results presented below are based on a version of the model that includes only this aggregate response.

Data for commodity supply and utilization are obtained from the Production, Supply and Distribution (PSD) online database of the U.S. Department of Agriculture (USDA), the F.O. Lichts online database, the Food and Agriculture Organization (FAO) of the United Nations (FAOSTAT Online), the European Commission Directorate General for Energy and Transport, and Brazilian Sugarcane Industry Association **(**UNICA), among others. Macroeconomic data such as gross domestic product (GDP), GDP deflator, population, and exchange rate are exogenous variables that drive the projections of the model. They are from the International Monetary Fund and IHS Global Insight.

FMD Scenario Results

The FMD scenario was implemented by eliminating all pork and beef exports as well as lives exports of swine and cattle for 10 years. The impact of this change was to force the domestic pork and beef markets to come to find a price at which US consumers would purchase the meat that would otherwise have been exported. We did not restrict US meat imports but lower US meat prices did cause these imports to fall significantly.

With shocks of this magnitude considered here the model needs several years to find a new level of production that allows pork and beef producers to break even. There is no historical evidence on how long this process might take and therefore we implemented a rule to bring prices back to breakeven in 2016.

The impact of the FMD scenario is greatest on pork and beef producers. These impacts are shown in Figures 1 and 2 below.

Beef prices fall by almost 25% in the first year and stay low for three years. The beef industry responds to these low prices by reducing imports by approximately 50% and cutting back on production. This reduction in production allows prices to rebound for much of the rest of the simulation period. Prices overshoot slightly and long-run equilibrium is achieved in 2021.

US net pork exports as a percent of production are far greater than net beef exports. Therefore the impact of the export restriction is greater on the pork market and the price reduction in the first year is just in excess of 50%. It takes less than a year to alter US pork production, and as a result prices begin to improve in the second year and are almost back to baseline levels in 2016.

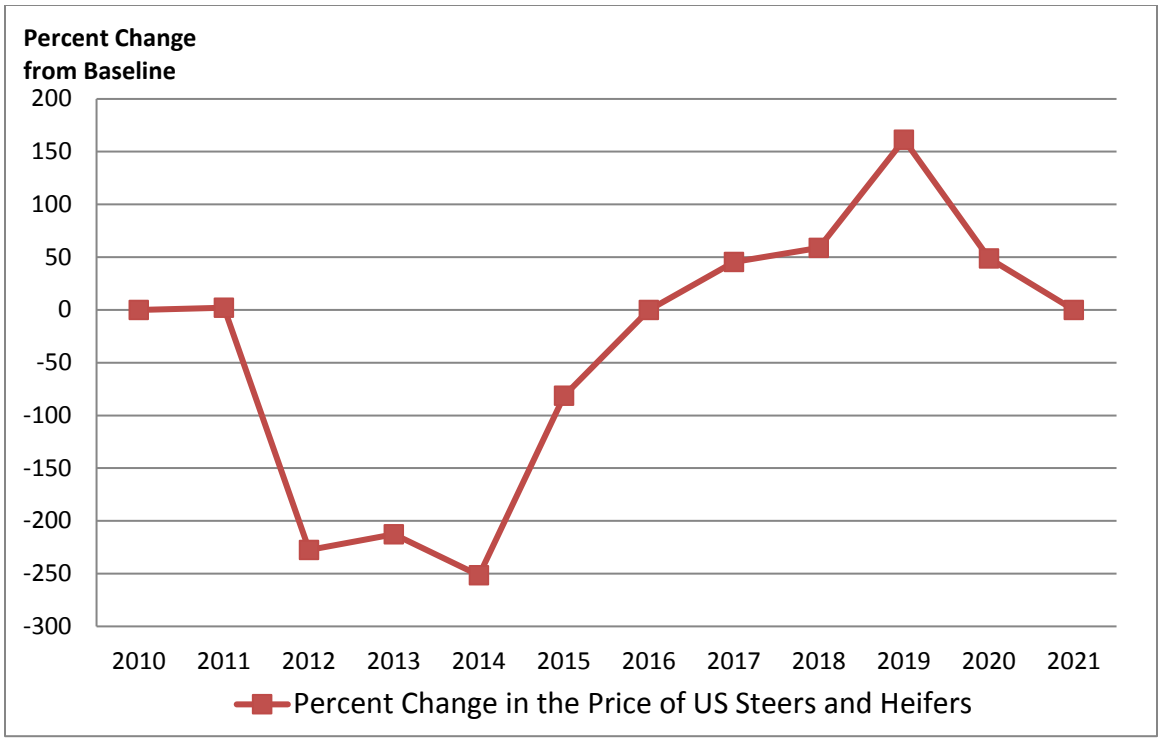

Figure 1. Impact of FMD on Beef Prices

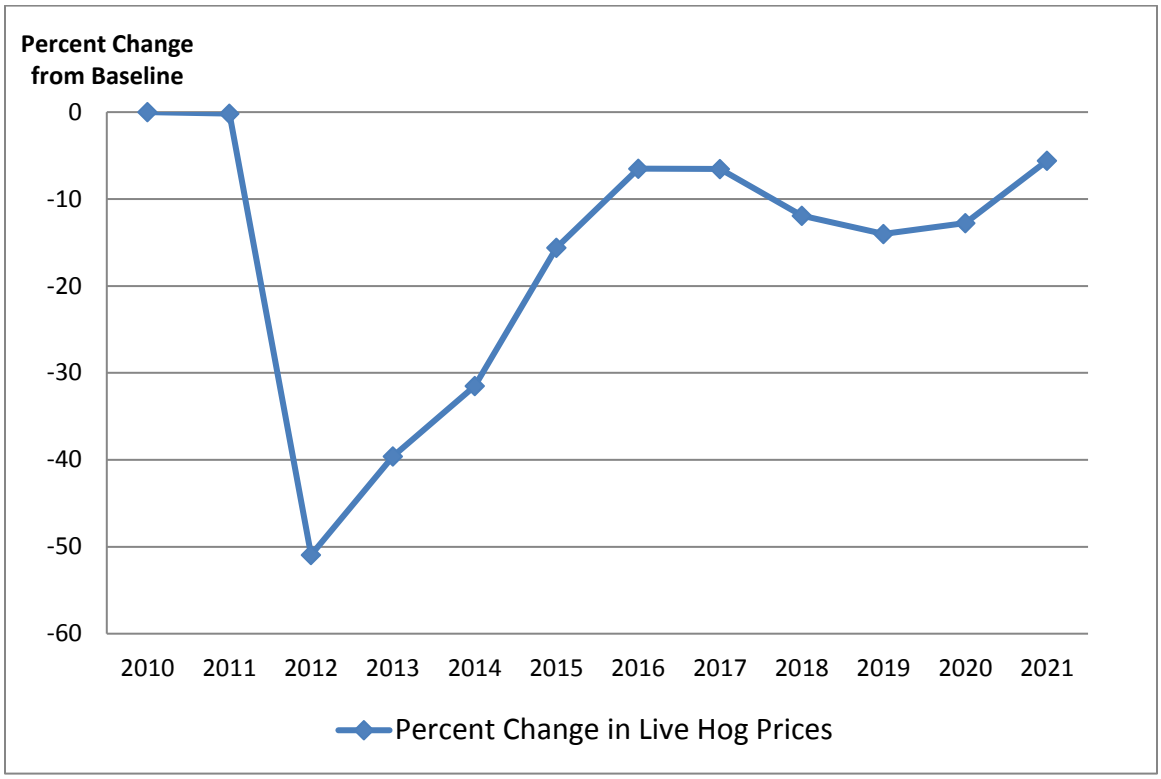

Figure 2. Impact of FMD on Hog Prices

The price recovery shown in Figures 1 and 2 disguises the overall impact of the disease on the economy. This is true because the price impact comes about because the industry downsizes. The impact of smaller beef and pork industries will last much longer than the period it takes prices to recover. For example a 20% reduction in the size of the US pork industry will cause some packing plant to close down, reduce domestic demand for corn and soybean meal and reduce the level of input purchases such as transport, construction, labor and veterinary services. These industries essentially contribute the revenue of the two sectors and one way to measure the overall impact is to examine the total revenue impact. In order to ensure than the packing sector impacts are included in estimate revenue loss is evaluated by estimating the wholesale meat price for each industry multiplied by wholesale meat production. These impacts are shown below.

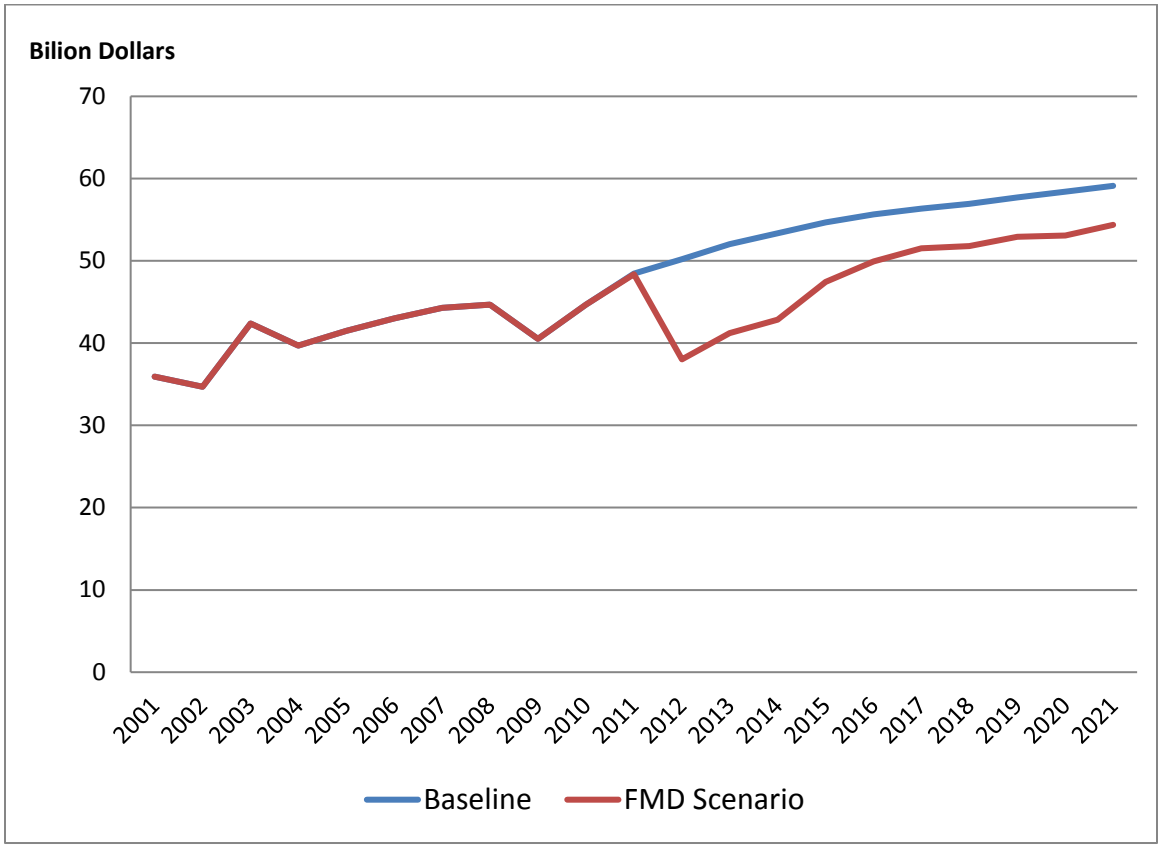

Figure 3. Impact of FMD on Beef Industry Revenue
(Beef Production times Boxed Beef Cutout Value)
Cumulative Lost Value = $71.23 Billion

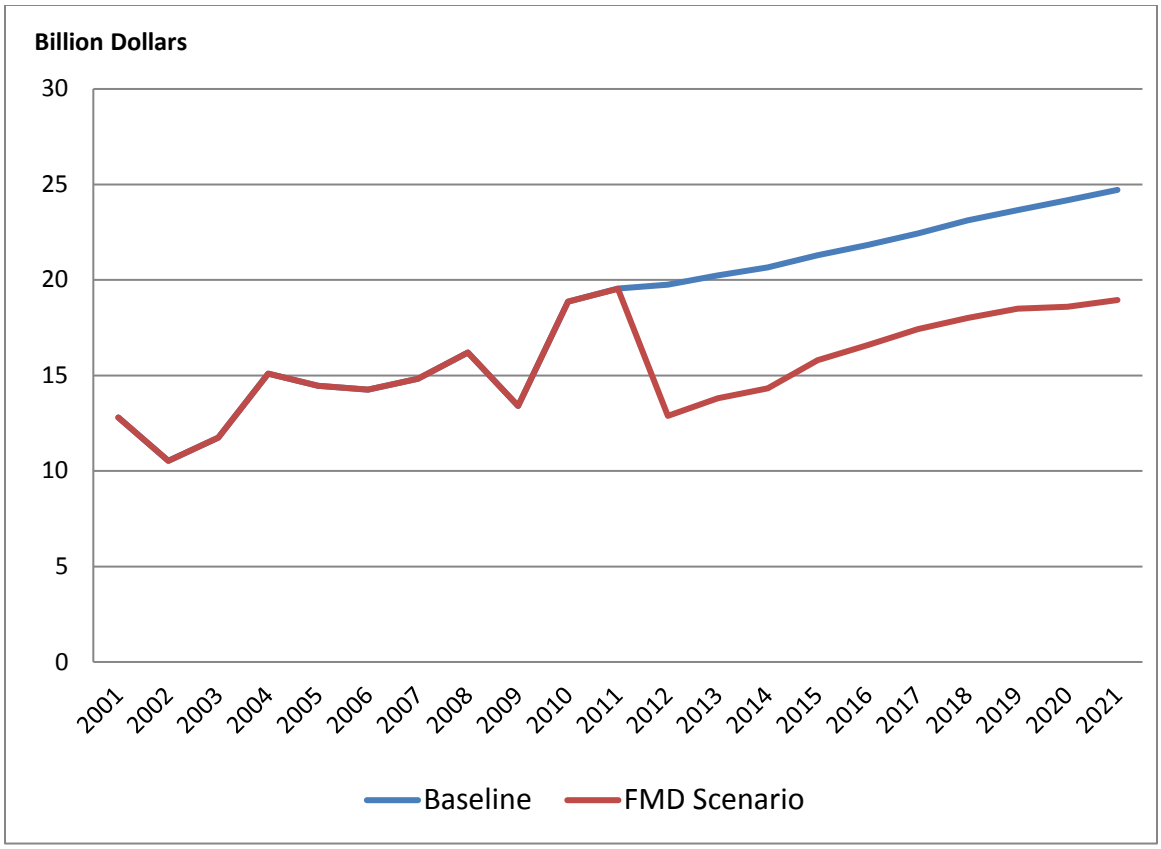

Figure 4. Impact of FMD on Pork Industry Revenue
(US Pork Production times Carcass Cutout Value)
Cumulative Loss = $57 Billion

The cumulative impact on both sectors over the ten year period is $128.23 billion and average $12.8 billion per year. The USDA has estimated that each billion dollars of export value supports 4,528 jobs directly and 12,000 jobs throughout the economy (Edmonson, 2008). Using this as a measure of the labor intensity of these industries the annual jobs impact of a $12.8 billion reduction in industry revenue is 58,066 in direct employment direct 153,876 in total. Compare this job loss with total US based GM employment (salaried and hourly) of 79,000[ii].

This employment measure likely overstates the global impact of this outbreak because other industry segments will adjust to the elimination of US meat exports and to lower input prices for corn and soybean meal. In particular livestock production in other countries will grow as the world economy adjusts. Also US consumers will benefit from lower meat prices and should have more money to spend on other items. These second round adjustments occur with every major economic shock and it is impossible to provide

an employment estimate that includes these adjustments because they involve every sector of the international economy.

Impact on Profitability

The FAPRI model calculates the net returns over variable expenses for each sector of agriculture and therefore we can estimate the impact of FMD on net returns. This is shown for the US Pork industry in Figure 5. Returns fall dramatically in the years after the outbreak and never fully recover to baseline levels. Baseline projections for US pork returns are high because pork exports are strong throughout the period. Expected net returns over the ten year baseline are approximately $8.54 Billion, net returns in the scenario are $-10.19 billion. The difference between these two amounts is $18.65 Billion over a ten year period or $1.8 billion per year.

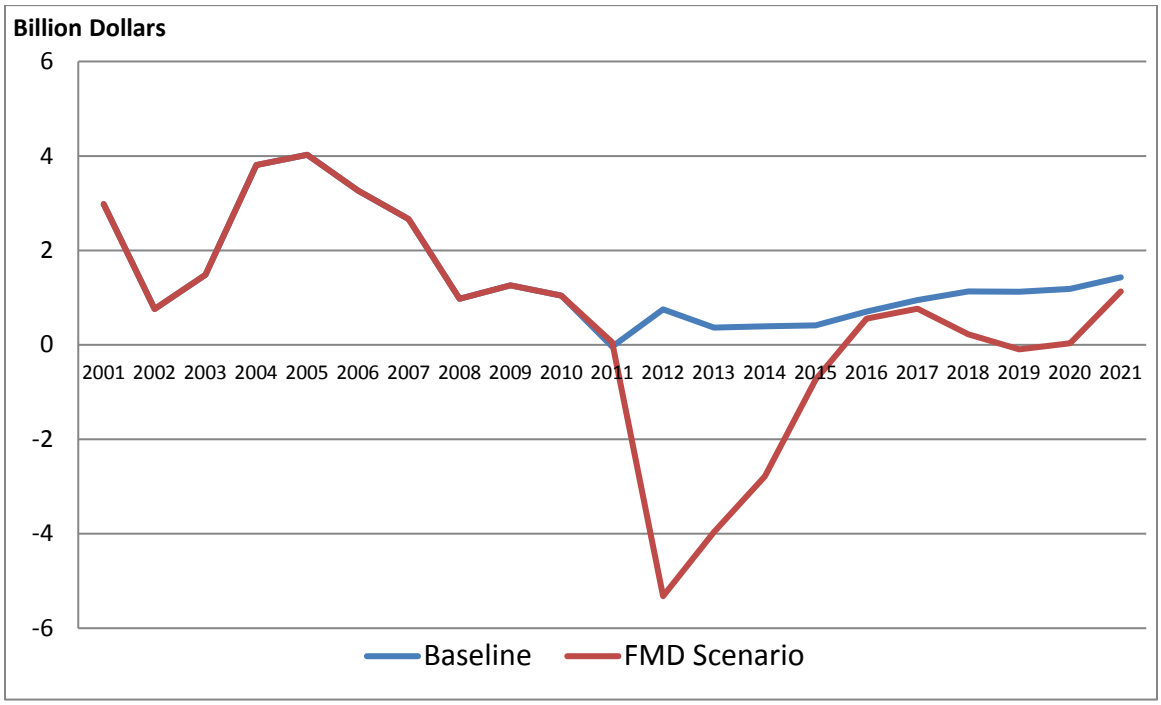

Figure 5. Impact of FMD on Total Net Returns in the US Pork Industry
Cumulative Difference $18.65 Billion, Net Returns in the FMD Scenario $-10.19 Billion

Impact on Poultry and Grains

US poultry producers will experience two offsetting impacts. First the availability of inexpensive pork and beef will drive US poultry prices down. But consumers in meat

importing countries will import poultry rather than pork or beef and this will support poultry. The results shown in Figure 6 suggest that the first effect will dominate and that revenues in the US poultry sector will fall slightly.

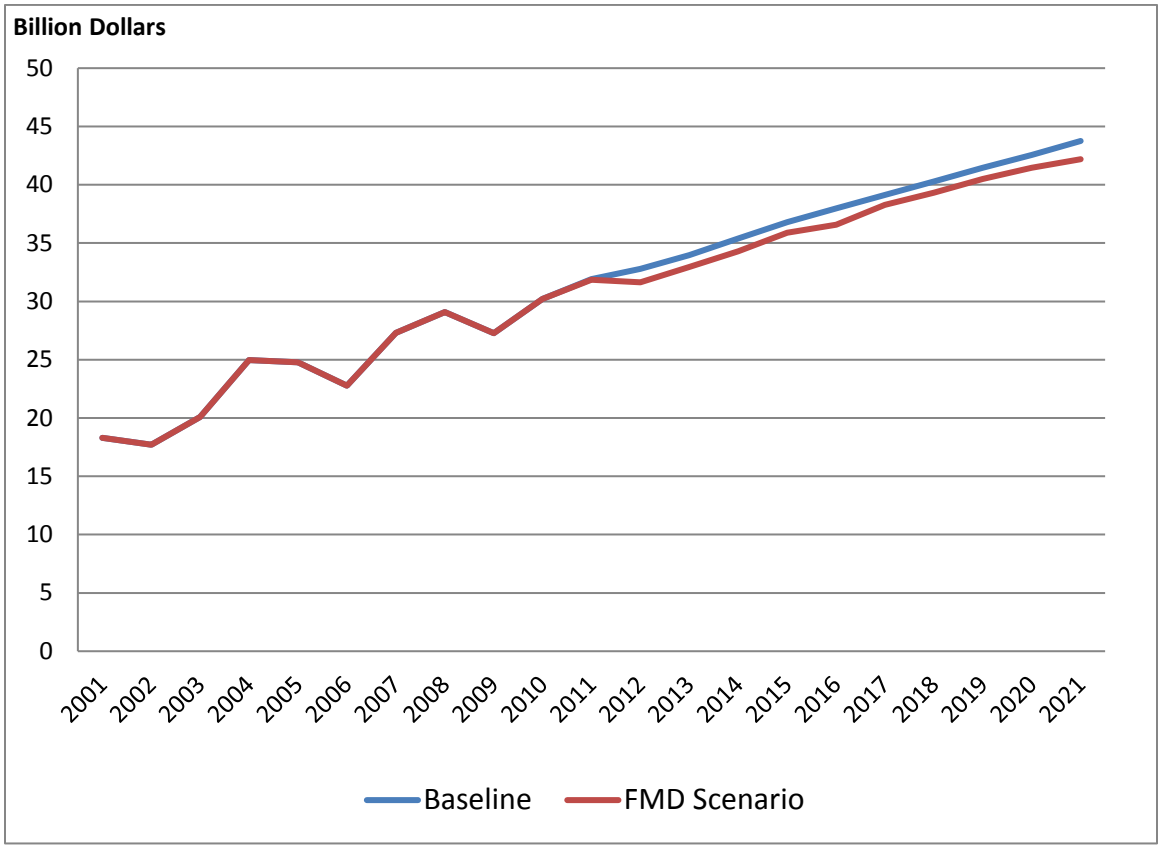

Figure 6. Revenues from Poultry Production
Cumulative Impact of FMD: $0.98 Billion

The baseline results projects relatively strong corn and soybean prices for the entire period. This is true because growth in incomes in developing countries and in biofuel production pushes world land resources to capacity. In the FMD scenario we relax one of the drivers of these high prices because we reduce the size of two major feed grain using industries. With lower US beef, pork and poultry production and lower world meat consumption some of the economic tensions that generated high prices in the baseline are removed and therefore corn and soybean prices fall substantially as shown in Figures 7 and 8. Corn prices fall by about $0.20 per bushel and soybeans by $0.60 per bushel and these price impacts last for the entire period. Cumulative revenues for corn growers fall

by $44 billion and $24.9 for soybeans Figures 9 and 10. The impact on US wheat producers is much lower as shown in Figure 11.

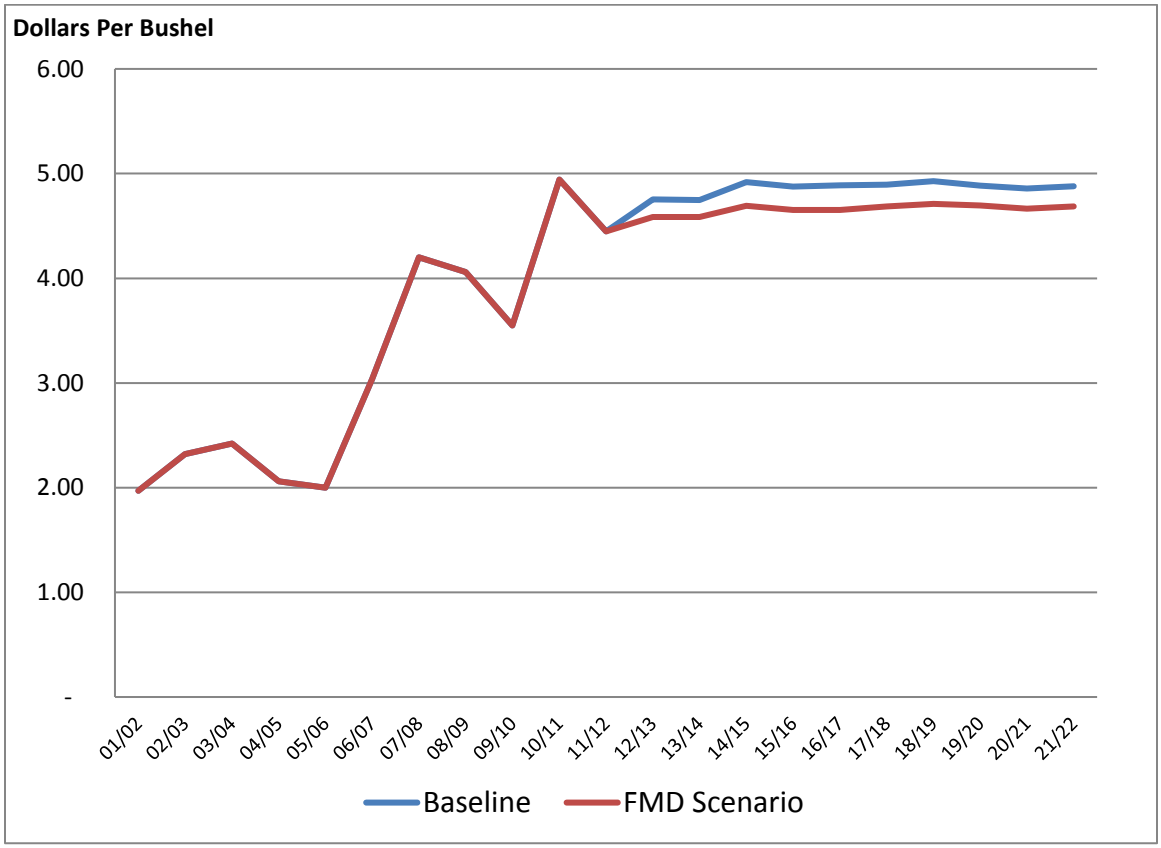

Figure 7. Impact of FMD on Corn Prices

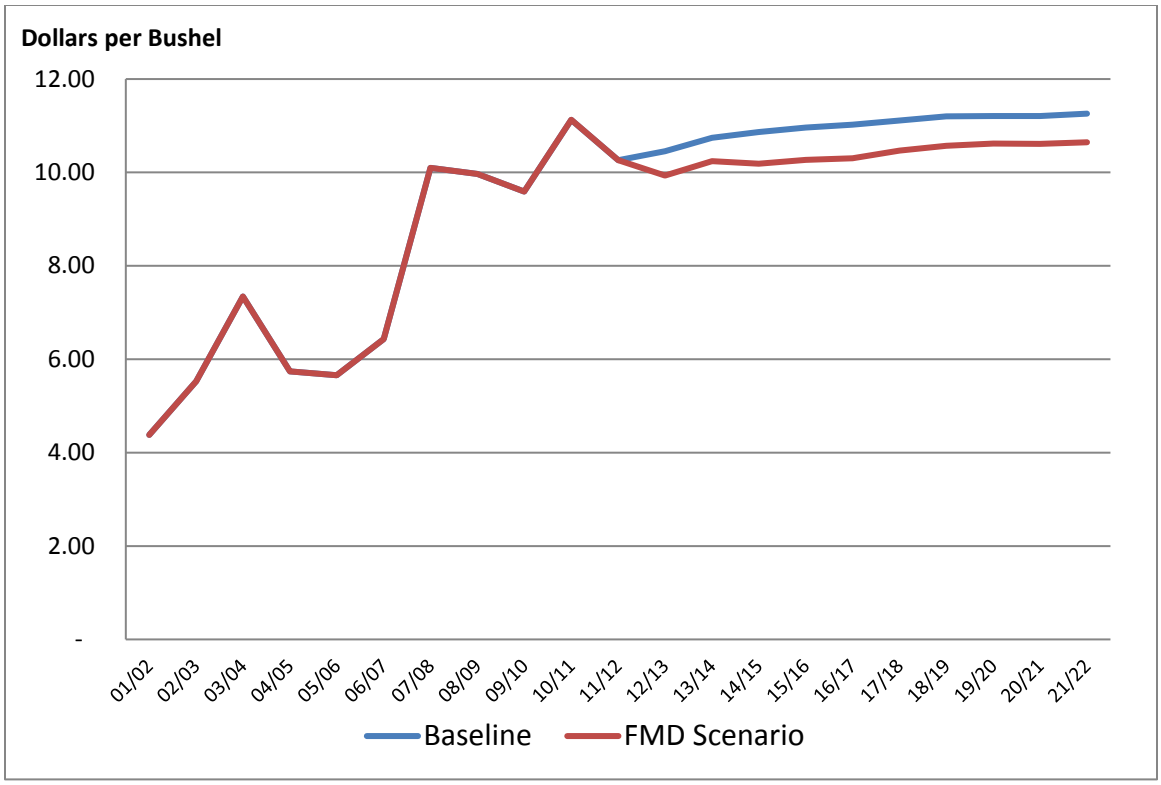

Figure 8. Impact of FMD on Soybean Prices

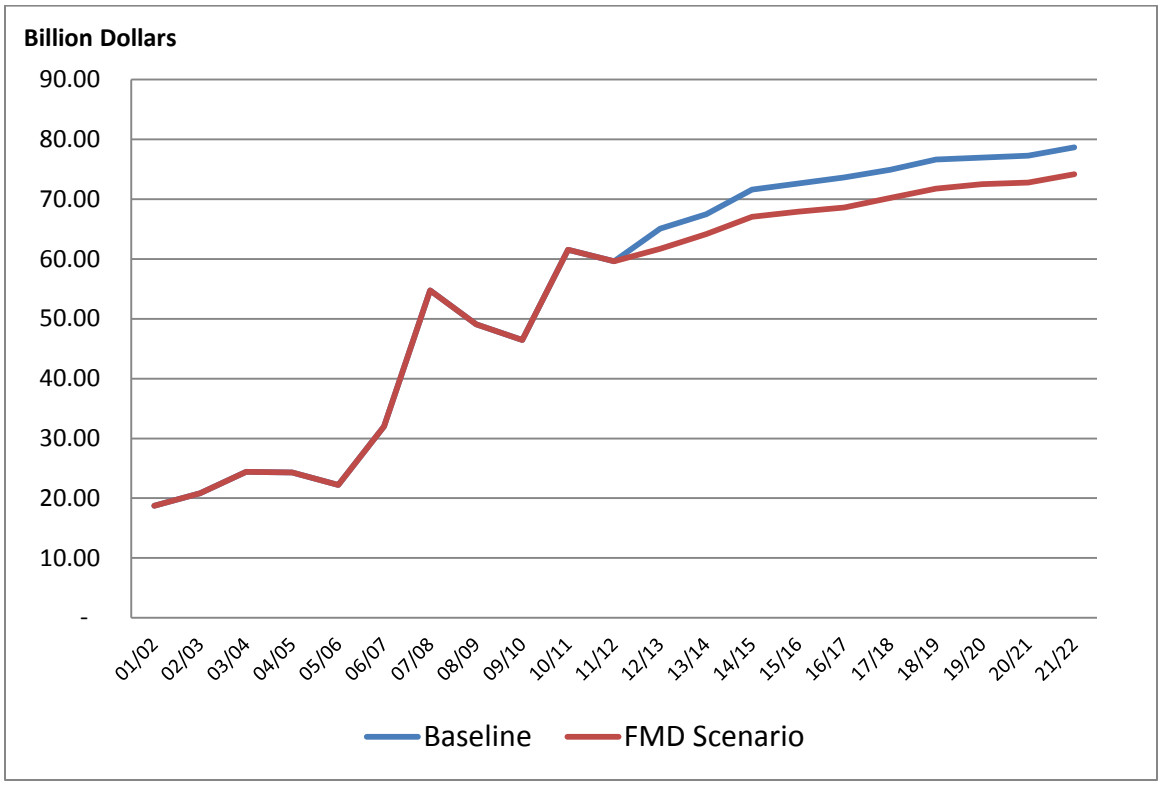

Figure 9. Revenue from Corn Production
Total Revenue Loss $44 Billion

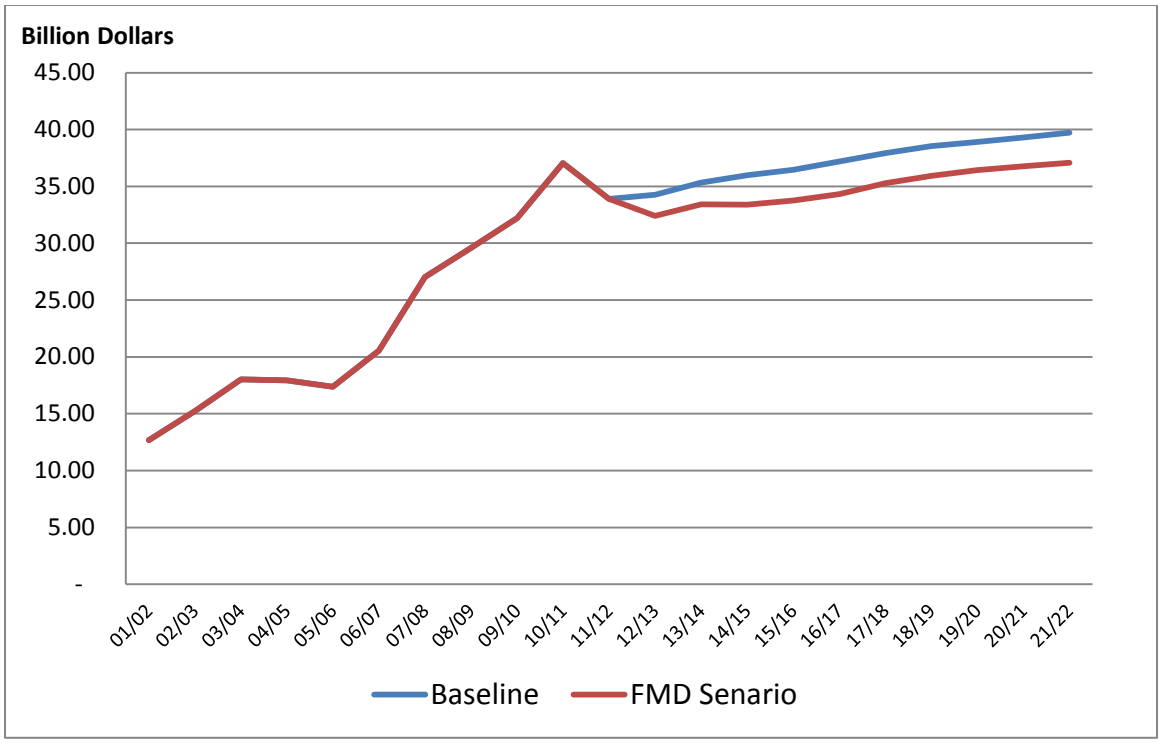

Figure 10. Soybean Revenues
Total Revenue Loss $24.9 Billion

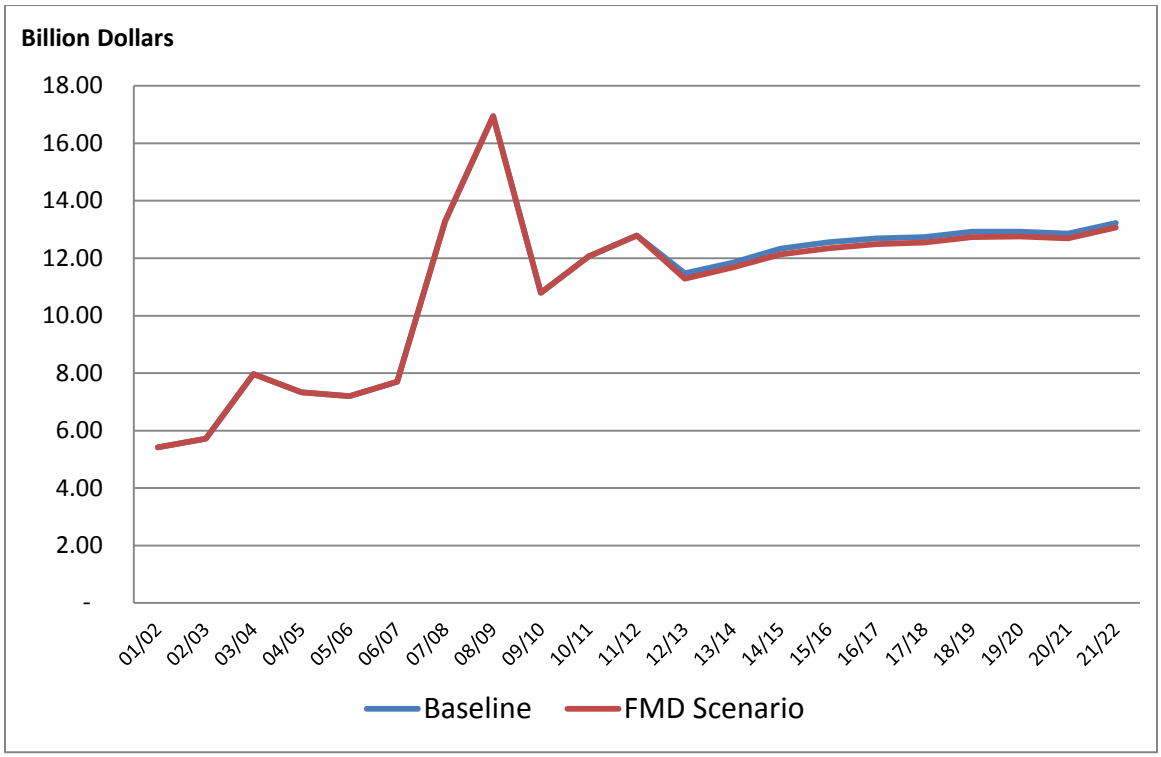

Figure 11. Impact of FMD on Wheat Revenues
Total Revenue Loss $1.84 Billion

Swine Fever Scenario

One reason for the dramatic impact of FMD on the US meat sector is that both beef and pork exports are restricted at the same time. In The FMD scenario pork prices fall not only because pork exports are eliminated but also because the US domestic market is swamped with inexpensive beef. In order to tease out these two impacts were now report results where only pork exports are restricted. This might happen if the US experiences and outbreak of one of the swine fevers. Therefore we call this the Classical Swine fever Scenario (CSF) scenario.

As shown in Figures 12 to 17 below, pork prices fall by approximately 45% in the CSF scenario and beef prices fall by approximately 7%. Corn prices fall by approximately $0.10 cents per bushel and soybean prices fall by approximately $0.50 per bushel. The proportionally greater losses for soybeans are due to the intensity of soybean use in the hog industry. These corn and soybean price and revenue impacts also go to show how much these industries benefited in the past as exports caused expansion in pork and beef production.

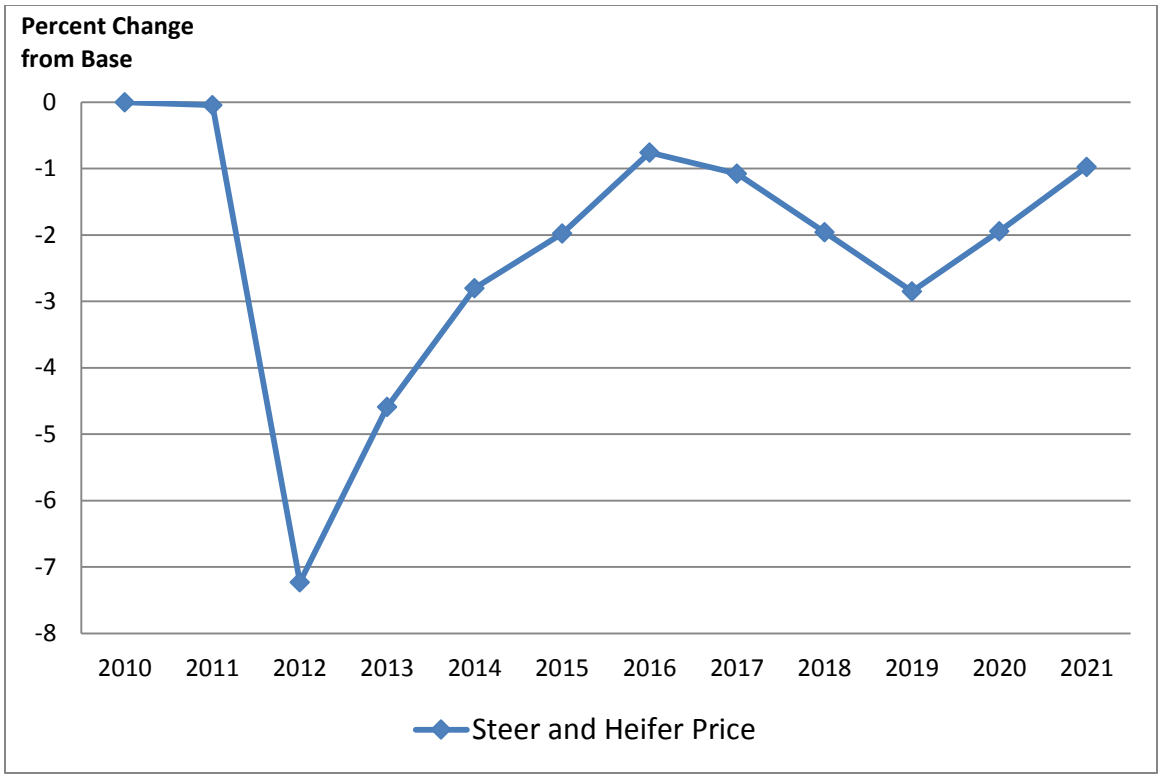

Figure 12. Impact of CSF on US Cattle Prices

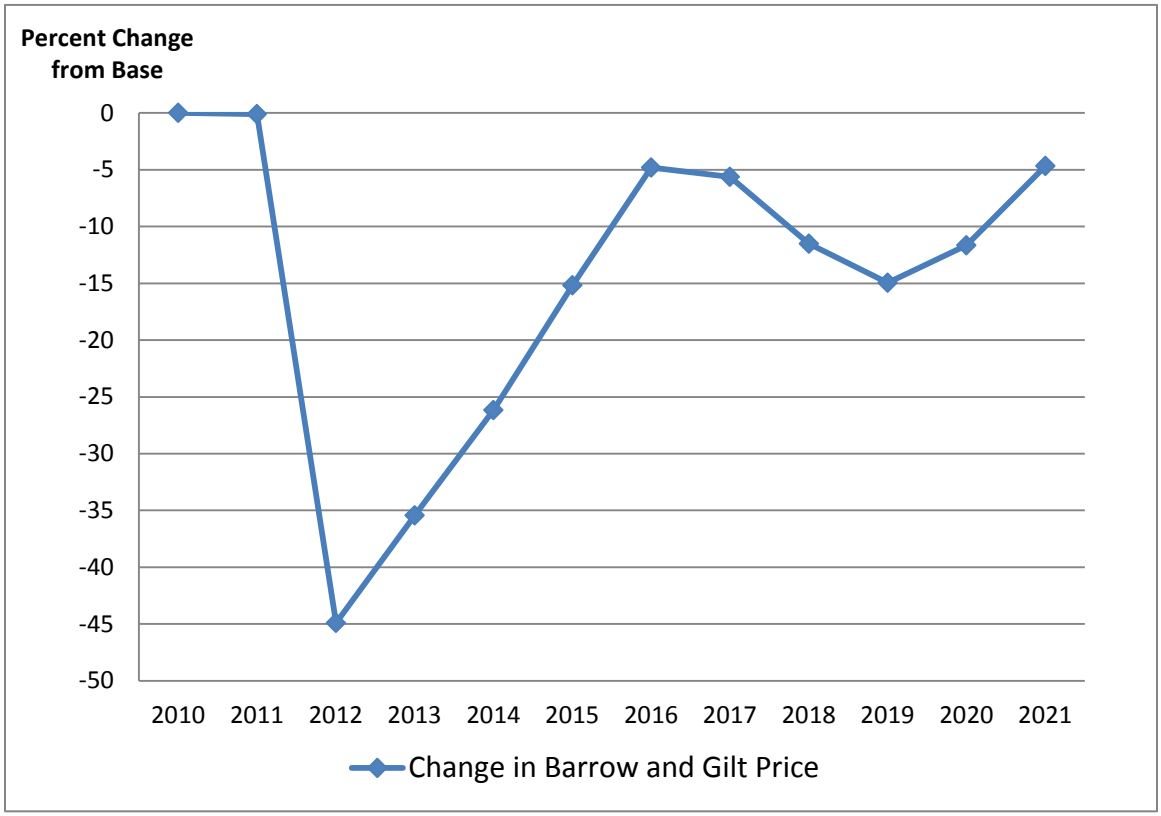

Figure 13. Impact of CSF On US Live Hog Prices

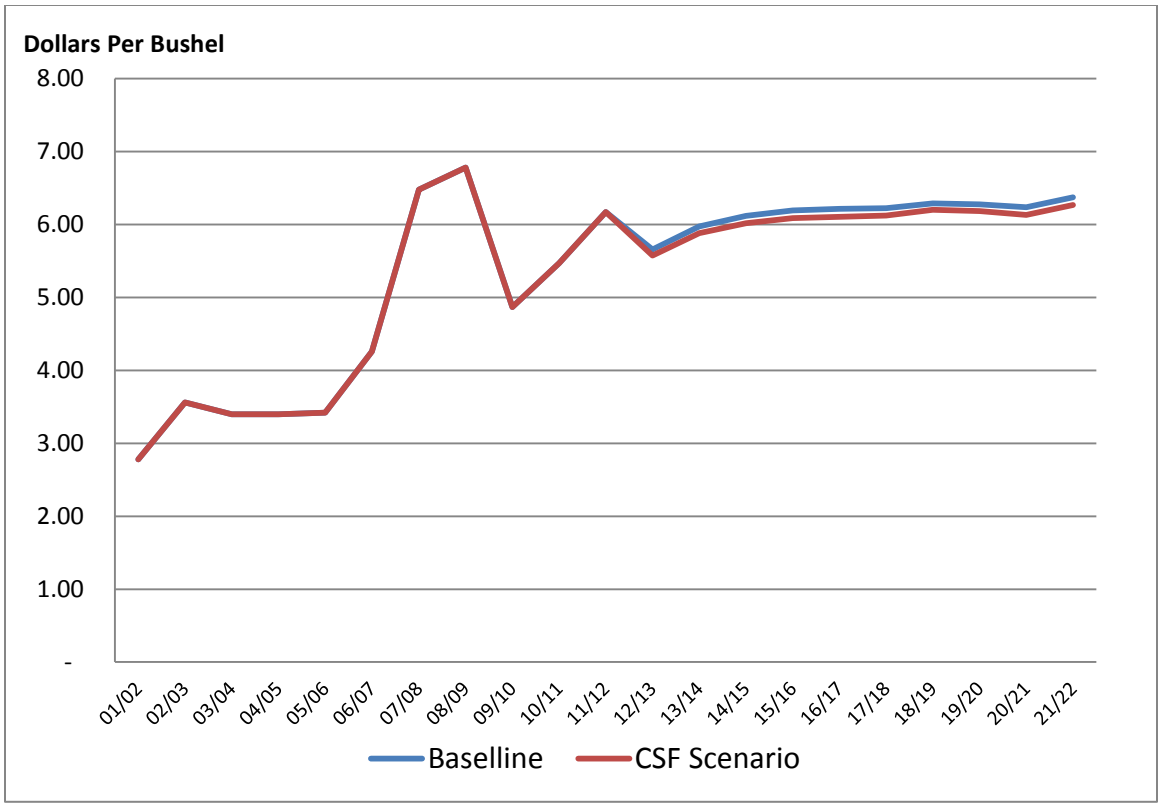

Figure 14. Impact of CSF on Farm Level Corn Prices

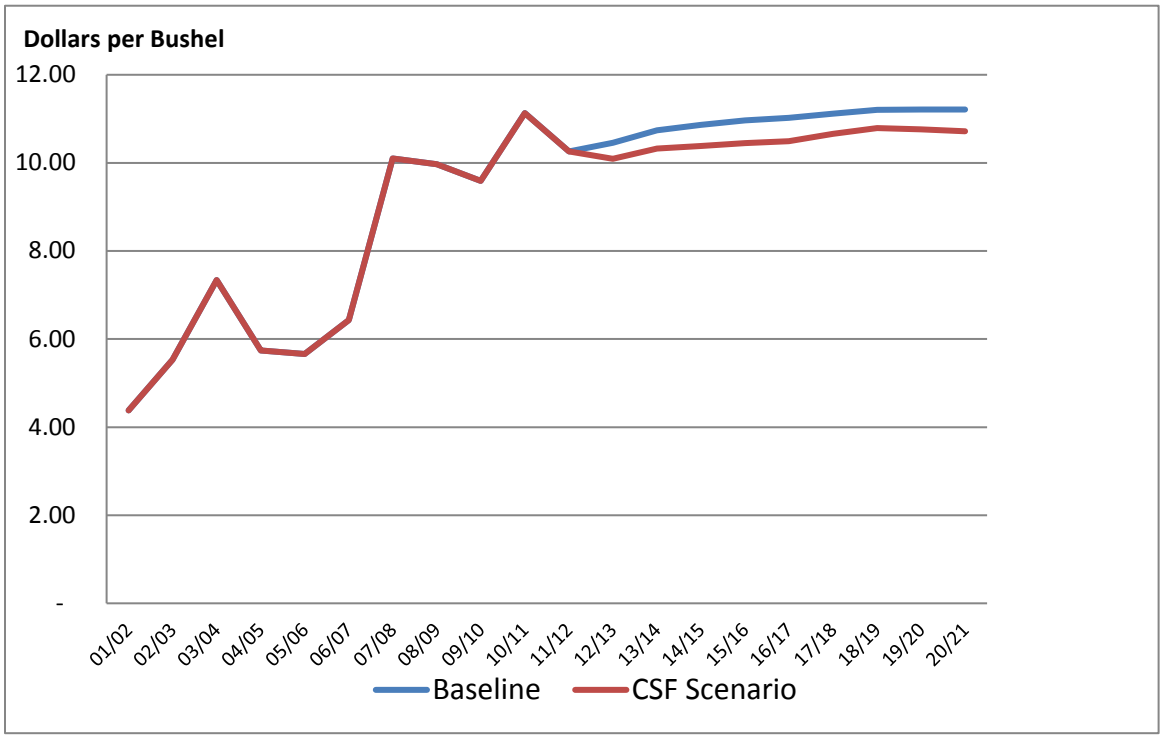

Figure 15. Impact of CSF on Farm Level Soybean Prices

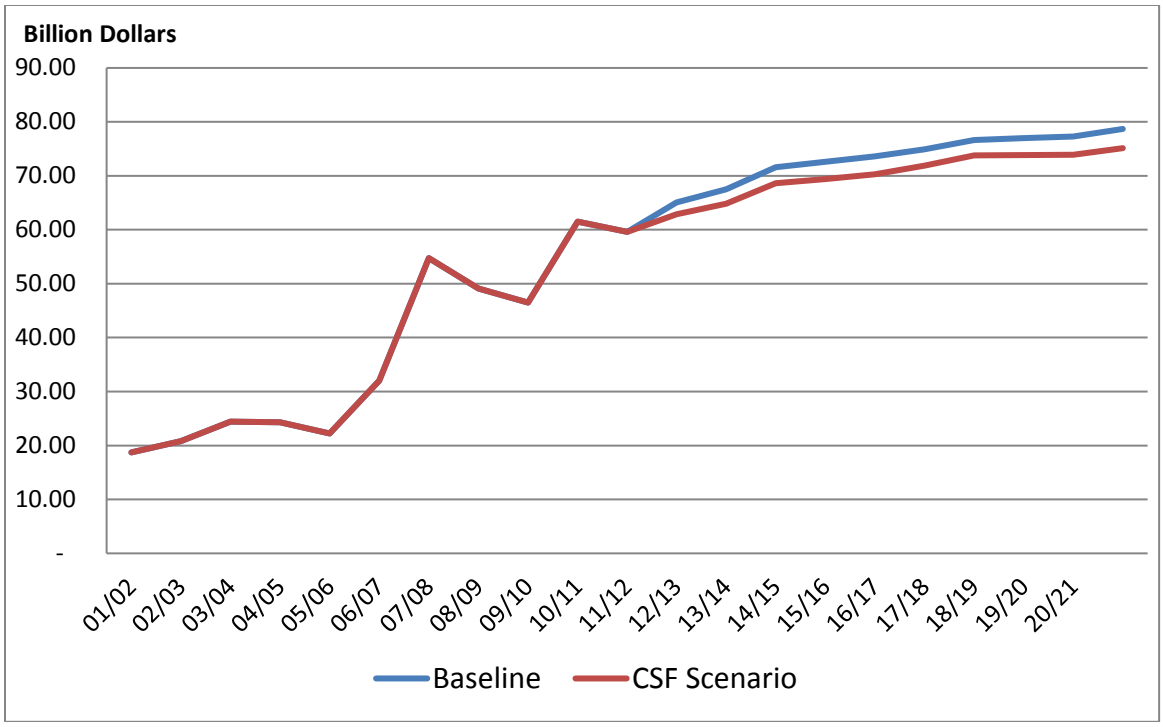

Figure 16. Impact of CSF on Corn Revenues:
Cumulative Impact $28.4 billion Over Ten Years

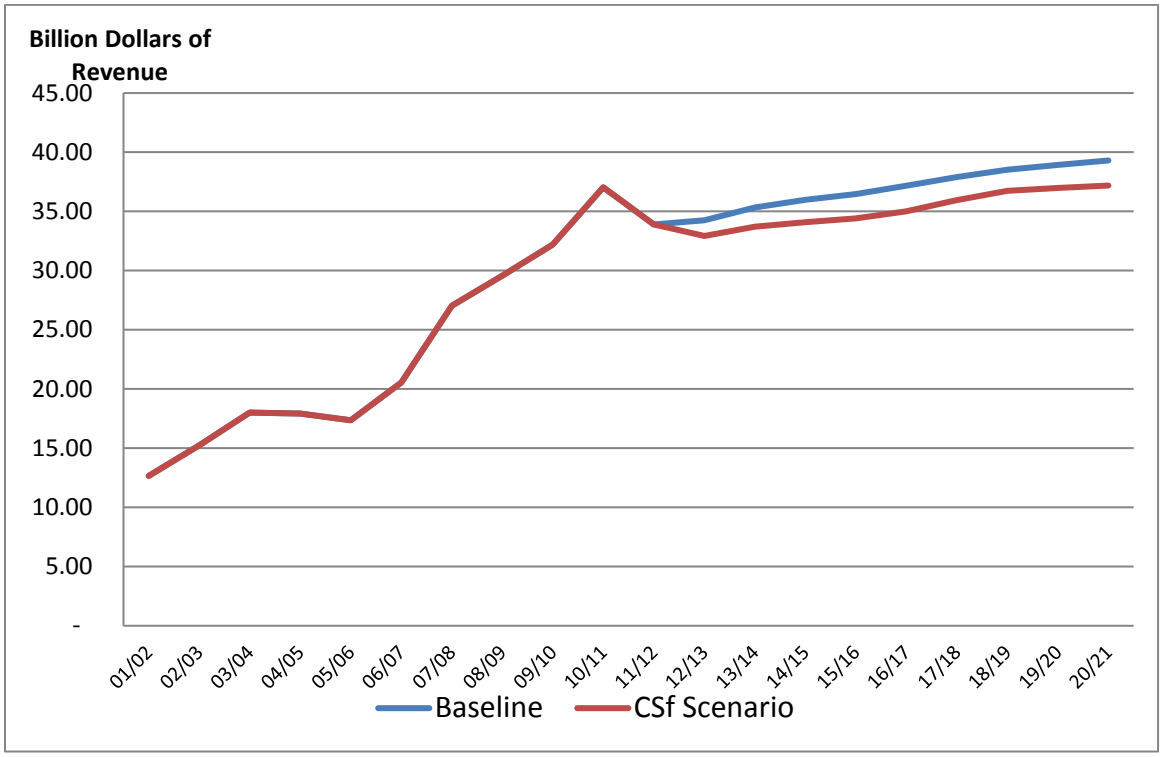

Figure 17. Impact of CSF on US Soybean Revenues
Cumulative Impact $16.8 Billion Over Ten Years

Calculating the Probability of a Disease Outbreak

We can get a sense for the likelihood of the kind of price reductions associated with an outbreak from the experts who trade options on the Chicago Mercantile Exchange. This is true because option premiums depend on the expected volatility of the underlying futures prices. The more the experts are willing to pay for options the greater the likelihood of major price movements. Figure 18 below shows the distribution of Dec 2012 lean hog futures as of November 17th 2011.

The data in Figure 18 suggest a 2.36 percent probability of a price reduction in excess of 40% in the December lean hog futures and a 0.76 percent chance of a price reduction of 50% or greater.

Our FMD scenario analysis predicts a reduction of slightly more than 50%. This suggests that the CME traders believe that there is a less than 1% chance that this will occur in 2012.

As mentioned earlier if there is an outbreak of FMD, pork sector net returns over variable costs will fall by an average of $1.8 billion per year. If we multiply the probability of an outbreak (0.76%) by the expected reduction in net revenues in the event of an outbreak ($1.8) billion then the burden of this disease can be estimated at $137 million per year. In other words the mere possibility of this disease adds an expected cost to the US Pork industry of $137 million per year. It would be worth at least this much to US pork producers to eliminate the possibility of a disease outbreak or to buy insurance that protect margins in the event that the disease occurs.

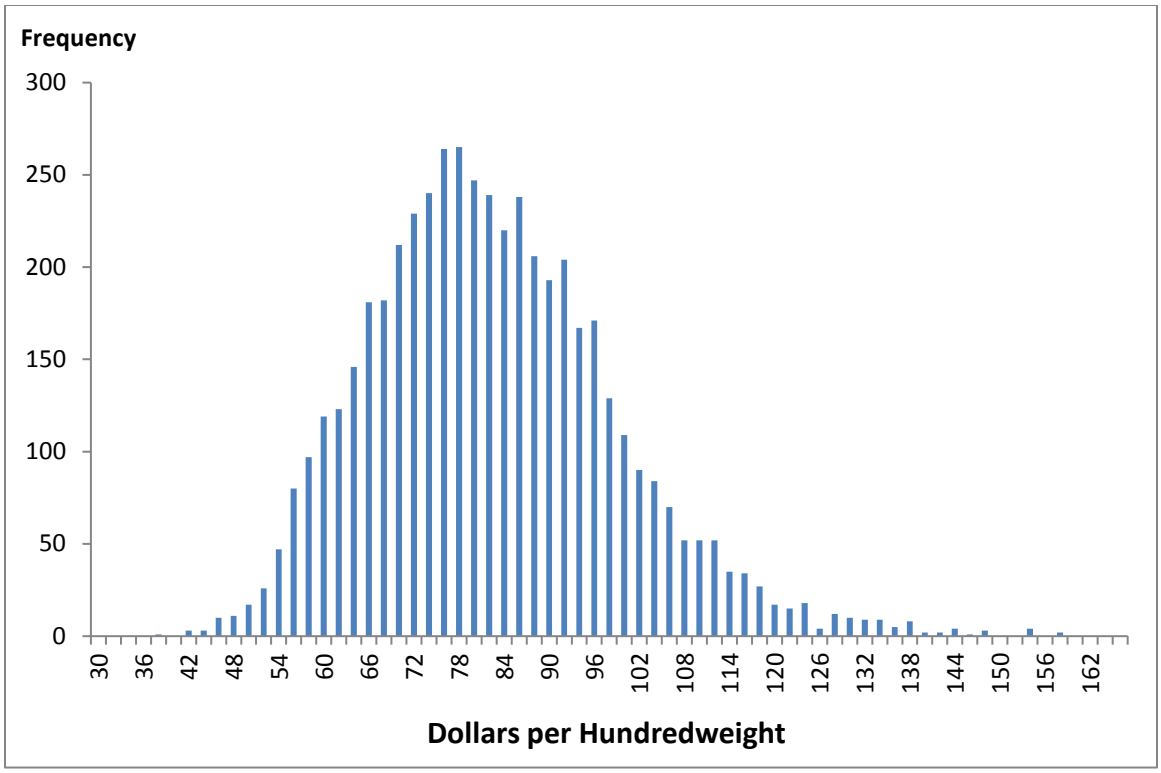

Figure 18. Distribution of Dec 2012, Lean Hog Futures Prices as Implied by Futures and Option Prices on the CME, November 17th, 2011. (Futures Price $81.5 Options Implied Volatility 19.5%)

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[i] See http://www.fas.usda.gov/psdonline/psdquery.aspx for an estimate of 2011 pork and beef exports
[ii] See http://media.gm.com/product/public/us/en/gmfacts/facts.html