National Impacts of a Domestic Outbreak of Foot and Mouth Disease and African Swine Fever in the United States

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Introduction

In March of 2023, Turkey detected a strain of Food and Mouth Disease (FMD) in the nation's cattle.[1] In May of 2022, an FMD outbreak was reported in Indonesian cattle; and, China is currently experiencing a surge in African Swine Fever (ASF), especially in the northern part of the country. This recent surge is estimated to have affected 10% of China's hog population.[2] ASF and FMD are two viral animal diseases that are highly contagious and deadly, and can have devastating effects on nations' meat markets. Outbreaks of ASF and FMD are common in many parts of the world and they are extremely difficult to eradicate, which results in mass slaughter of infected animals. As a result, countries with infected livestock face prohibition of meat exports to importing countries even for meat from vaccinated animals (in the case of FMD). The United States has been successful in eradicating FMD, and ASF has not been found in the U.S. hog population. Classical swine fever (CSF) was eradicated in the U.S. hog herd in 1978. However, the mere threat of a disease outbreak can move markets. Case in point is the recent rumor of a potential outbreak of ASF in the United States that resulted in a significant drop in Chicago Mercantile Exchange lean hog futures.

[1] Food Navigator, https://www.feednavigator.com/Article/2023/03/30/Foot-and-mouth-disease-strain-detected-in-cows-in-Turkey.

[2] Farm Policy News, https://farmpolicynews.illinois.edu/2023/03/african-swine-fever-surges-in-china-potentially-driving-pork-prices-higher/.

Figure 1 shows the countries where ASF is currently present (2021 to present). ASF has been reported in 40 countries, affecting about 0.9 million pigs and more than 22,000 wild boars. Losses have totaled almost one million animals. This is likely an underestimate because counties in Africa, Asia and the Americas (Dominican Republic and Haiti) reported no cases during the reporting period.[3] Figure 2 is a map of the 2021 status for seven endemic pools of FMD as reported by the World Reference Laboratory for FMD. FMD is estimated to be present in 77% of the global livestock population.

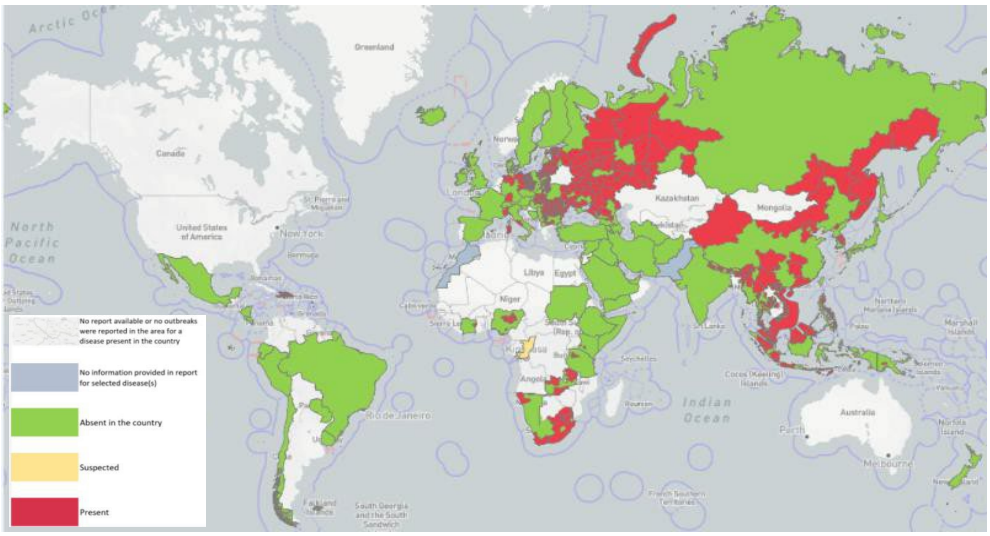

Figure 1. Map of the world displaying the presence of ASF (2021 – 01/05/2023). Source: https://www.woah.org/app/uploads/2023/01/asf-report25.pdf.

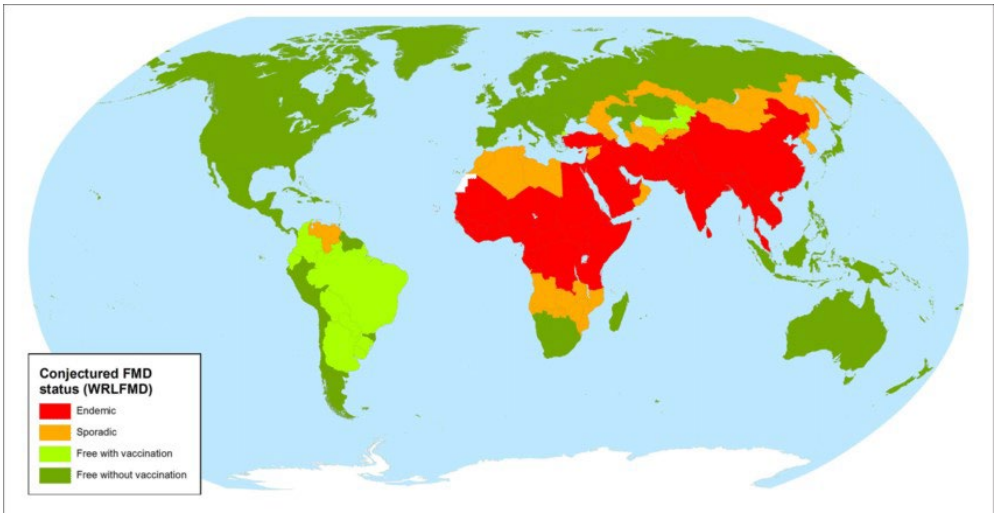

Figure 2. Map of FMD status (World Reference Laboratory for FMD). Source: https://www.wrlfmd.org/ref-lab-reports#panel-4902.

[3] https://www.woah.org/app/uploads/2023/01/asf-report25.pdf

As experienced in other countries, an outbreak of one or both of these diseases in the United States would have a devastating direct impact on the livestock sector. In addition to the loss of animals due to the diseases themselves, infected animals would have to be depopulated and disposed of, leading to further losses. Currently, there is no cure for FMD or ASF. Established vaccines are available for FMD and but not yet for ASF. Furthermore, there is the added challenge and cost of containing wild animals in infected zones. Thus, depending on the severity of the outbreak, the economic effects would not only be exorbitant for livestock producers specifically but also far reaching in the economy as a whole.

It is possible to estimate the costs associated with the outbreak of one or both of these diseases. It is reasonably certain that an outbreak of FMD would result in the loss of some U.S. export markets for both beef and pork and that an outbreak of ASF would result in the loss of export markets for pork. The sudden loss of these export markets would force this meat onto the U.S. domestic market and potentially would force U.S. 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 United States, unlike the UK or South Korea, is a major exporter of both pork and beef and also because the burden of these costs would likely fall on the producers rather than on taxpayers. The purpose of this study is to examine the national impacts of the elimination of export markets due to hypothetical outbreaks of two foreign animal diseases. The study first establishes a baseline or status quo scenario (no diseases exist) and then analyzes the impact of an animal disease on pork (ASF) and on beef and pork (FMD). In both cases, we assume a worst-case scenario by eliminating all U.S. exports of the affected meat product for 10 years using an agricultural modeling system that generates 10-year projections. This 10-year timeframe allows the industry to arrive at a new equilibrium where it downsizes and provides pork and beef products only to the U.S.

domestic market.[4] By comparing the baseline scenario and the disease scenarios, we can get an estimate of the impact of this downsizing on the U.S. agricultural market.

Likely Impact of a Foreign Animal Disease on the U.S. Economy

The United States is the second-largest exporter of pork (after the European Union) and among the top three exporters of beef (with Brazil and Australia). The United States exported about $20 billion of pork and beef in 2022.[5] According to the U.S. Department of Agriculture (USDA), the United States will export more than six billion pounds of pork and three billion pounds of beef in 2023. This represents approximately 28% of the pork and 11% of the beef produced in the United States. The loss of these exports markets would create an oversupply of meat in the domestic market with significant price reductions throughout the marketing system. Live animal prices would fall to encourage U.S. consumers to eat more pork and beef as well as to reduce or eliminate U.S. meat imports.

The availability of inexpensive pork and beef in the U.S. 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. There is a possibility that the United States would lose its status as a major exporter of pork and beef for a significant amount of time after the first outbreak. As the U.S. beef, pork, and poultry sectors adjust to lower domestic demand, feed-grain use will fall and employment in the U.S. livestock sector and its affiliated industries will suffer. Second-round impacts will include a reduction in the U.S. trade balance and in rural employment.

[4] We also consider scenarios where the export market recovers after two years of zero exports for beef and pork. Please see the Appendix for these results.
[5] See https://apps.fas.usda.gov/gats/ExpressQuery1.aspx for an estimate of 2022 pork and beef exports.

Because we are focused on the national impacts, we present results showing how both prices and total revenue adjust over a 10-year period. We use the revenue impact to calculate the impact on employment. It is important to note that this measure will underestimate the full economywide impacts because it excludes the impact of the industry's downsizing on input suppliers.

Methodology

The results presented below are from the CARD Long-Run Land Use (LRLU) modeling system that is maintained at Iowa State University. This agricultural modeling system is designed for use in understanding the full economic impacts of various market and policy changes. First, a baseline (status quo) scenario is established against which we examine the impact of a policy or economic shock. In our case, the baseline represents no ASF or FMD outbreak and is based on historical supply, utilization, and price data up to 2020/21 as well as macroeconomic data up to January 2022.[6] We run three scenarios in which there is an outbreak of ASF or an outbreak of ASF and FMD. The scenarios consist of the loss of all export markets for pork and beef in the FMD scenario and for pork in the ASF scenario (see the Scenario Results section for details). To implement these shocks, we simply restrict these export parameters to zero and then allow the model to arrive at a new equilibrium. Unless specified, results are expressed in percent changes from the baseline for each scenario.

Model Description

CARD LRLU is a deterministic agricultural modeling system used to quantify the impact of changes in market conditions and policies on global land allocation including forestry and pasture. The system uses a partial-equilibrium framework to solve for a set of commodity prices (in real terms) that equate global supply and demand for agricultural

[6] For the macroeconomic data, see https://www.ers.usda.gov/data-products/international-macroeconomic-data-set.aspx.

products. The model is non-spatial in the sense that trade flows are aggregated, that is, they are not assessed between individual countries.

The modeling system is a modified version of the initial CARD agricultural modeling system, which has been validated through numerous academic publications. The LRLU model was developed to better capture the long-term nature of climate change. These changes include: (*a*) a comprehensive restructuring of the land allocation mechanism to explicitly include forestry and pasture land; (*b*) an extension of the time horizon projected to 40 years to better reflect the longer time horizon of forestry enterprises; (*c*) the incorporation of nutritional restrictions (such as appropriate limits on caloric intake) on the demand side, which become increasingly more important in the longer time horizon planned; (*d*) the incorporation of a specification to allow carbon prices to impact land-use allocations; and, (*e*) endogenizing the price of fertilizer, which was initially considered exogenous to the model.

The inclusion of returns to pasture affecting the cropland in a selected group of countries is incorporated. The projection period is extended to 40 years as opposed to the original 10–15 years used in previous versions. For this study, we run the model to produce projections for 10 years. The model is currently calibrated on the most recent marketing-year data for crops (2020/21) and the most recent calendar year data for livestock and biofuels (2020), and 10-year projections are generated. The model is recursively solved for 10 successive annual equilibria.

Instead of the separate, commodity-specific models found in the previous version of the CARD model, the current version of the modeling system is comprised of countries/regions with all agricultural sectors (commodities) contained within each country or region. There are 22 regional models included in the enhanced system selected according to their significance in the agricultural commodity marketplace.[7] Within each

[7] The countries/regions modeled are Argentina, Australia, Brazil, Canada, Chile, China, Egypt, the European Union, India, Indonesia, Japan, Malaysia, Mexico, New Zealand, Nigeria, Peru, Russia, South Africa, Ukraine, the United States, Vietnam, and the aggregate rest of the world region required to close the model.

153 country or region, the land use associated with each sector is placed within the
154 hierarchical land-use structure (Figure 3).
155
156 Historical land-use data are derived from the United Nations Food and Agriculture
157 Organization (FAO) crop and land resource databases as well as from the reports
158 published by the Forest Resource Assessment (FRA) program of the FAO. Within this
159 structure, we estimate the total land devoted to agriculture, as well as the areas for
160 forest actively in production, pasture areas, and the areas for all major crops for which
161 USDA data is available, including barley, maize, cotton, oats, palm kernel complex,
162 peanut complex, rapeseed complex, rice, rye, sorghum, soybean complex, sugar beet,
163 sugarcane, sunflower seed complex, and wheat.
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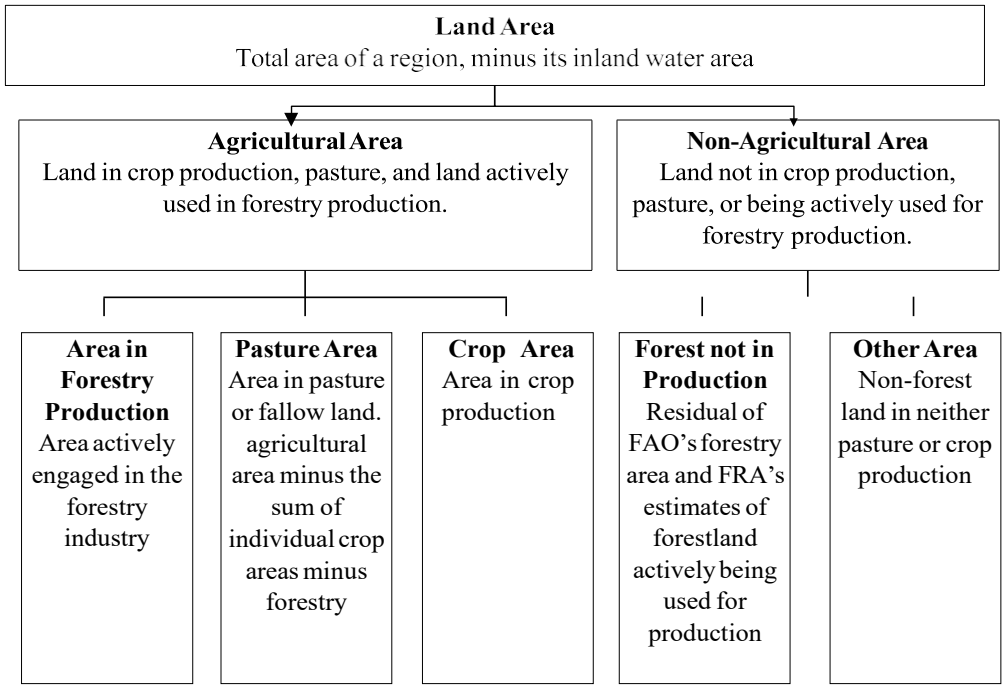

165
166
167 **Figure 3.** Components and structure of the land-use categories in the
168 CARD LRLU Model.
169

170 Land allocation projections are determined by competition and driven by net returns
171 within three tiers. In figure 3, the first tier determines the total land allocated to
172 agriculture and is driven by the net returns to agriculture. Thus, as agriculture
173 becomes more profitable, land is taken away from the non-agricultural areas. In the

second tier, productive forestry, pasture, and total crop area compete for shares of the total agricultural area. Thus, if crop production overall becomes more profitable, it is assumed that land will be taken out of pasture (or forestry) before new land is brought into agriculture. The third and final tier is competition between crops. If one crop becomes more profitable relative to other crops, it is assumed that land will be first taken away from the existing land devoted to crops before land is taken out of pasture or forestry. The proportion of the total crop area devoted to crops not modeled is held fixed. The modeling system also includes biofuels (ethanol and biodiesel) as well as livestock and dairy by country or region.

On the demand side, given the 40-year horizon, per capita demand for food increases with income but at a decreasing rate. That is, as consumers' per capita income increases and their food demands become increasingly satisfied, they devote smaller shares of the additional income to food products. Therefore, while there is no cap on caloric or nutritional intakes, these do not rise indefinitely as time passes and incomes increase.

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.

Data for commodity supply and utilization are obtained from the USDA's Production, Supply and Distribution (PSD) online database, FAO (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 are from USDA's International Macroeconomic Data Set.

Scenario Results

The results are presented for three scenarios:

1. ASF Scenario: Elimination of all U.S. pork net exports (no exports or imports) due to the outbreak of ASF. Pork imports are restricted because U.S. pork prices would be so low that countries that export to the United States would find markets elsewhere.
2. ASF-FMD Scenario: Elimination of all U.S. pork net exports (no exports or imports) due to the outbreak of ASF as well as the elimination of beef exports due to an FMD outbreak (no exports while imports are exogenously held at baseline levels).
3. ASF-FMD50 Scenario: Elimination of all U.S. pork net exports (no exports or imports) due to the outbreak of ASF as well as elimination of beef exports due to FMD with imports exogenously kept at 50% of baseline levels to reflect lower domestic prices making imports unattractive. The rationale for this scenario is that the United States would likely still continue to import certain types of beef.

The impact of the elimination of exports in the model would force the domestic pork and beef markets to arrive at a price at which U.S. consumers would purchase the meat that would otherwise have been exported. With shocks of the magnitudes considered here, the model needs several years to find a new level of production that allows pork and beef producers to break even (return to normal profits). 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 the fifth year after the shock (2025/26).

The impact of the FMD scenarios is significant to pork and beef producers given that both pork and beef exports are eliminated. In the FMD scenario, pork prices fall not only because pork exports are eliminated but also because the U.S. domestic market is swamped with inexpensive beef. In order to tease out these two impacts, we also report results where only pork exports are restricted. This might happen if the United States experiences an outbreak of one of the swine fevers.

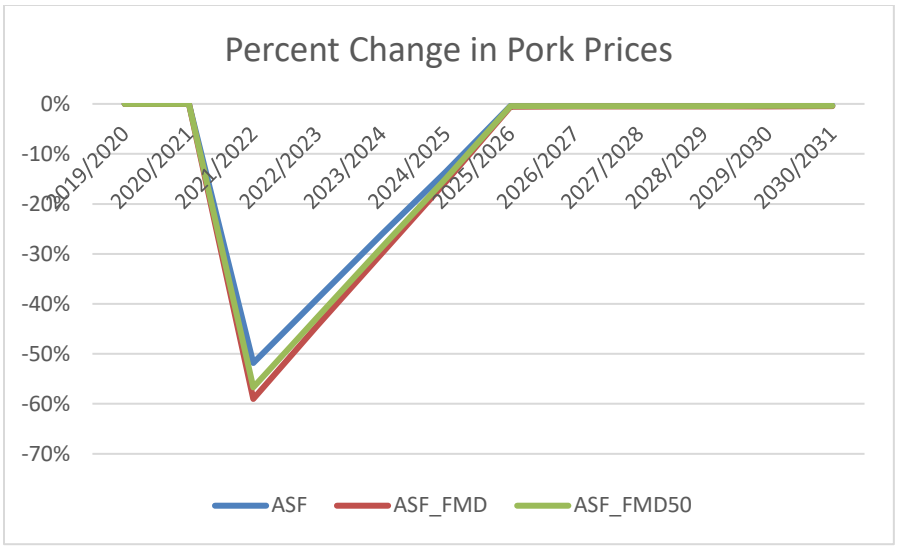

Figure 1. Impact on pork prices (national base 51-52% equiv. barrows and gilts).

Pork prices fall by between 50% and 60% depending on the scenario (figure 1). The impact is largest (57%) for an outbreak of both ASF and FMD and lowest in the ASF only scenario. Prices stay low for three years before they start to recover. The pork industry responds to the lower prices by reducing production, which initially falls by between 13% to 14% and continues to fall by an average of over 20% over the projection period. Pork production does not recover and remains below baseline levels in all three scenarios.

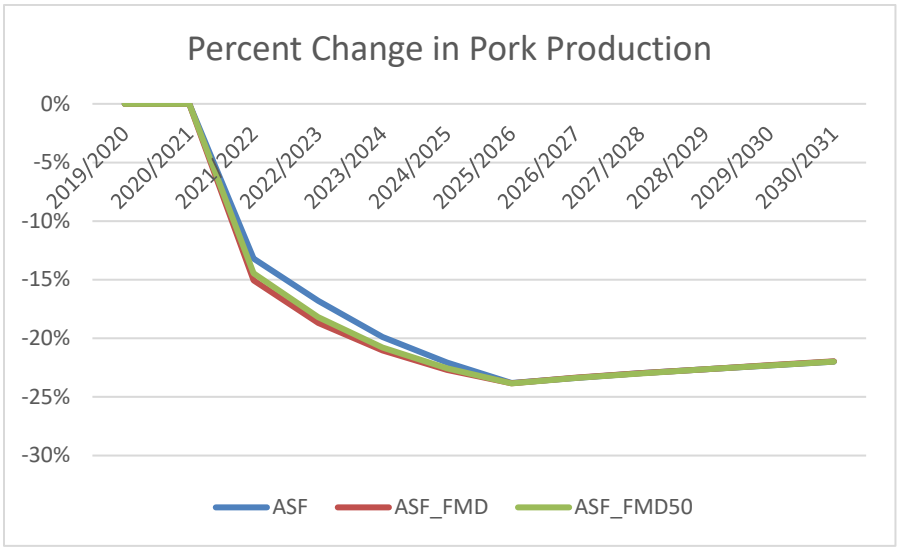

Figure 2. Impact on pork production.

U.S. net pork exports as a percent of production are far greater than are net beef exports. Therefore, the impact of the export restriction is greater on the pork market. It takes less than a year to alter U.S. pork production, and, as a result, prices begin to improve in the second year and are almost back to baseline levels in 2025/26.

The beef industry is not affected by an outbreak of ASF, and, therefore, the impact is very small in terms of beef prices and production (the largest changes being -5% and -0.5% in the first year, respectively). Beef prices fall by over 50% in the first projection year in the ASF-FMD scenario and stay below baseline levels for three years. The impact is significant but less pronounced (40% reduction) in the ASF-FMD scenario with a 50% reduction in imports. The beef industry responds to these low prices by cutting back on production by 12% on average over the projection period. This reduction in production allows prices to rebound and return to baseline levels in the fifth year since the shock.

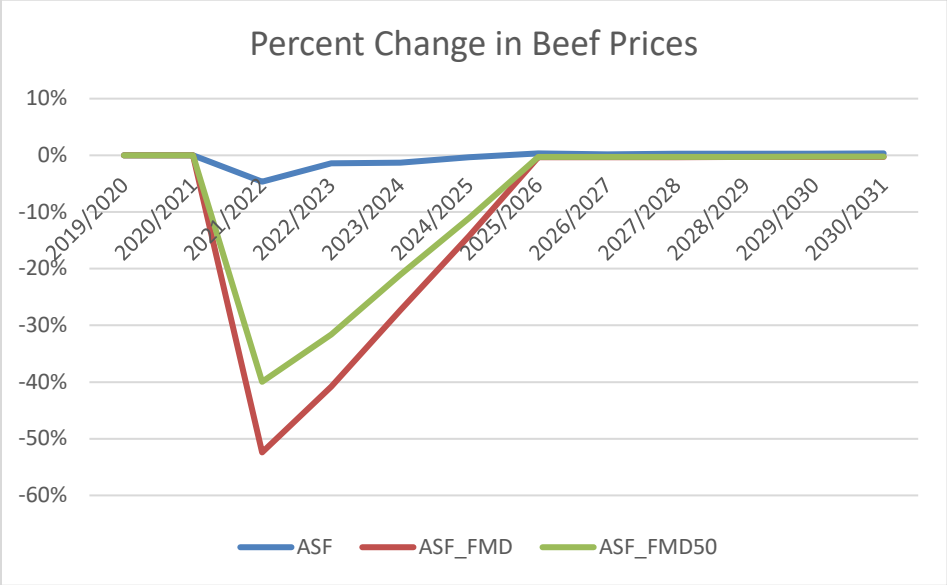

Figure 3. Impact on beef prices (5-area direct steer).

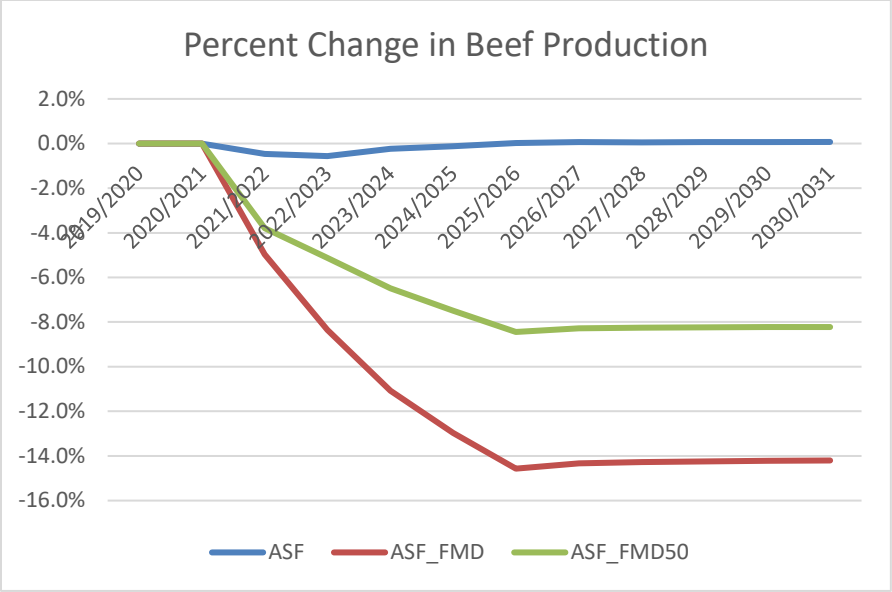

Figure 4. Impact on beef production.

The price recovery shown in figures 1 and 3 disguises the overall impact of the diseases on the economy. This is true as the price impact comes about because the industry downsizes. The impact of smaller pork and beef industries will last much longer than the period that it takes prices to recover. For example, a 20% reduction in the size of the U.S. pork industry will cause some packing plants 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. We estimate the total revenue impact by estimating the revenue loss using the wholesale meat price for the pork and beef industries multiplied by total pork and meat production, respectively. This ensures that the packing sector impacts are included in the estimates of revenue loss. These impacts are shown below.

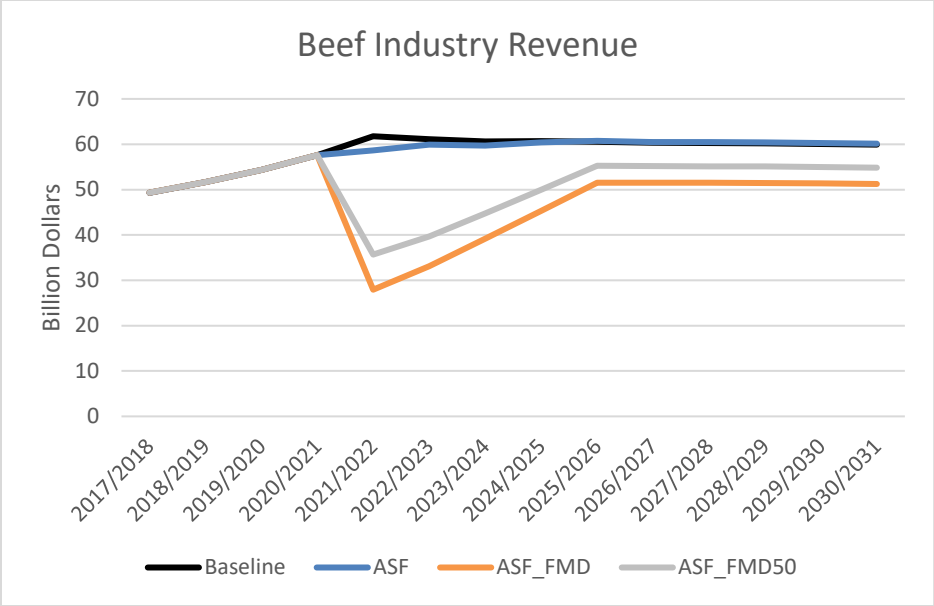

Figure 5. Impact on beef industry revenue.
(Beef Production times Boxed Beef Cutout Value)[8]
Cumulative Lost Value = $4.2 Billion for ASF, $151.3 billion in ASF-FMD, $105 billion for ASF-FMD50

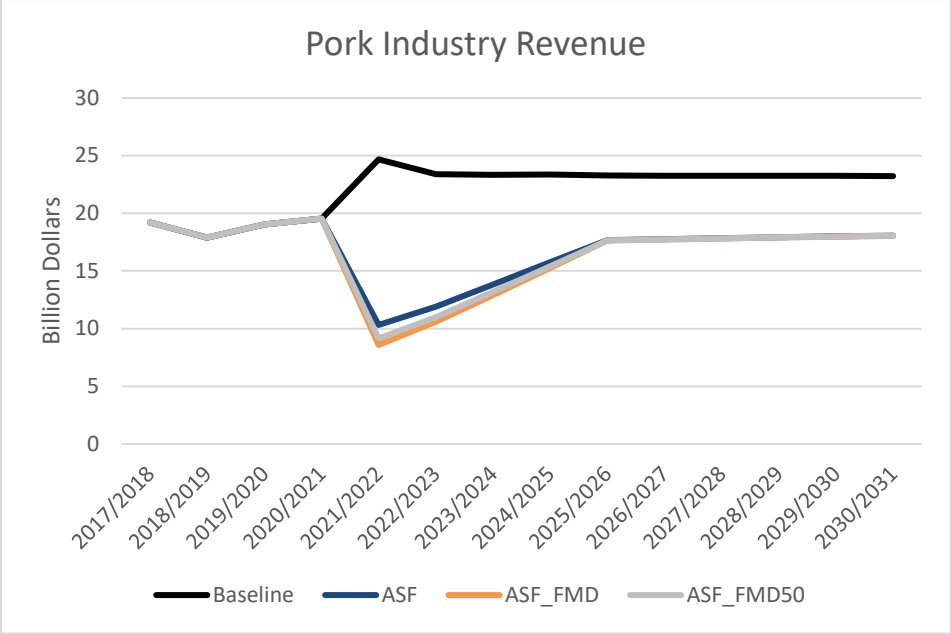

Figure 6. Impact of FMD on pork industry revenue.
(US Pork Production times Carcass Cutout Value)[9]
Cumulative Lost Value = $75.2 Billion for ASF, $79.8 billion in ASF-FMD, $78.4 billion for ASF-FMD50

[8] Boxed Beef, Choice 1-3, 600-900 pounds. The boxed beef cutout represents the estimated gross value of a beef carcass based on prices paid for individual beef items derived from the carcass.
[9] Pork Cutout Composite (PCC) value is used to calculate industry revenues. PCC is the estimated value of a standardized pork carcass (currently 55-56% lean, 215 lbs.) based upon industry-average cut yields and average market prices of sub-primal pork cuts.

The cumulative impact on both sectors over the 10-year period ranges between $79.5 billion in the ASF scenario and $231 billion in the ASF-FMD scenario, which averages between $7.5 billion (ASF scenario) and $23.1 billion (ASF-FMD scenario) per year. USDA has estimated that, in 2020, each billion dollars of export value supported 7,550 jobs directly and 1.13 million jobs throughout the economy.[10] Figure 7 provides a breakdown of the jobs supported by agricultural exports for both on- and off-farm activities. Using USDA's estimated jobs per billion dollars of export value as a measure of the labor intensity of these industries, for the ASF scenario, the annual jobs impact of a $7.5 billion reduction in industry revenue is 60,000 direct-employment jobs. In the case of the ASF-FMD scenario, this number jumps to 174,405 jobs.

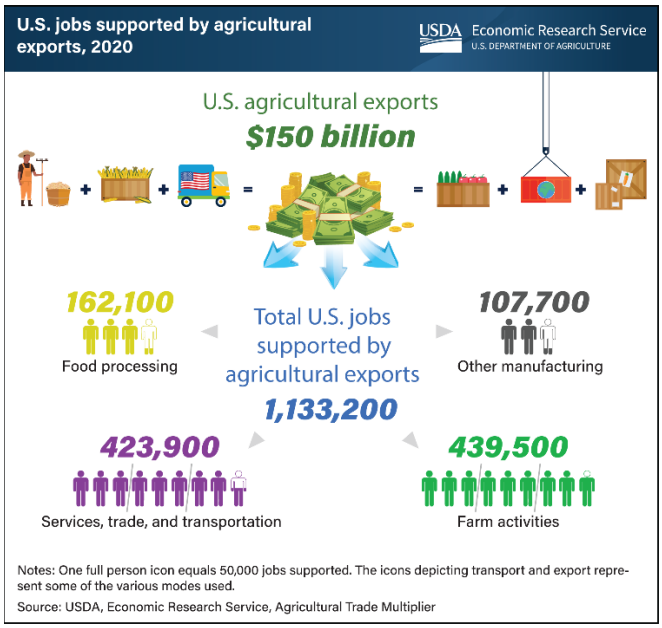

Figure 7. U.S. jobs supported by agricultural exports (2020).
Source: USDA, ERS https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=103827.

This employment measure likely overstates the global impact of this outbreak because other industry segments will adjust to the elimination of U.S. meat exports and to lower input prices for corn and soybean meal. Livestock production, particularly poultry in other countries, will grow as the world economy adjusts. Also, U.S. consumers will

[10] "U.S. agricultural exports supported more than 1 million jobs throughout the economy in 2020." https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=103827.

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 Poultry, Corn and Soybeans

U.S. poultry producers will experience two offsetting impacts. First, the availability of inexpensive pork and beef will drive U.S. poultry prices down. But consumers in meat importing countries will import poultry rather than pork or beef, which will support poultry. The results shown in figure 8 suggest that the first effect will dominate and the revenues in the U.S. poultry industry will fall between $0.9 billion and $1.7 billion depending on the scenario.

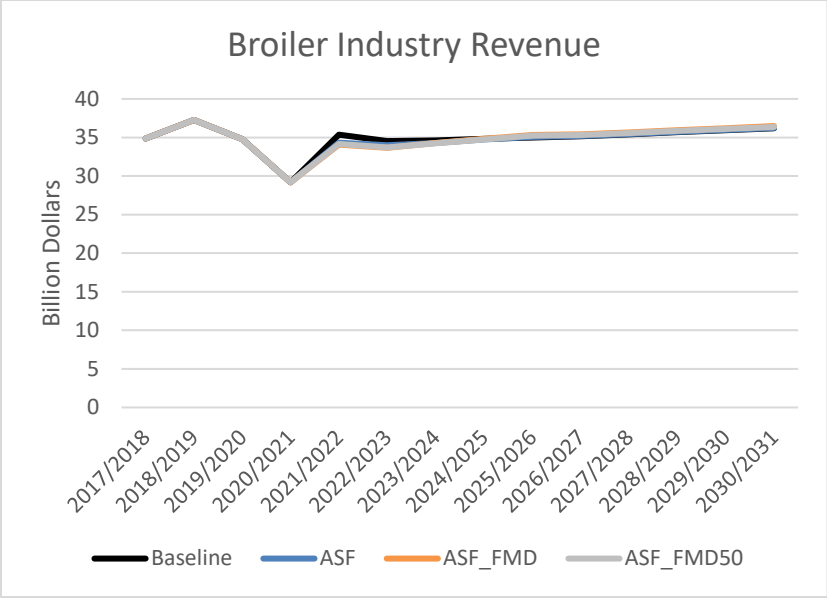

Figure 8. Impact of FMD on poultry industry revenue.
(US Broiler Production times National Wholesale Broiler Value)
Cumulative Lost Value = $1.65 Billion for ASF, $0.87 billion in ASF-FMD, $1.4 billion for ASF-FMD50.

With lower U.S. beef and pork production, corn, soybean, and soybean meal prices fall as shown in figures 9, 10 and 11. The decline in corn prices average -0.6% in the ASF scenario, about 1% in both the ASF-FMD scenario and the ASF-FMD scenario with beef imports at 50% of baseline levels. Although prices start to recover a bit after the fifth

year, they remain below the baseline for the rest of the projection period. The impact on soybean prices is smaller with prices declining by an average of between 0.4% and 0.5% over the 10-year projection period. As indicated in figures 11 and 12, revenue losses for corn and soybean reflect the smaller livestock industry and reduced demand for feed. Cumulative revenue losses for corn growers add up to $15 billion in the ASF-FMD with baseline-level beef imports scenario. Corn revenue losses total $7 billion in the ASF scenario and about $12 billion in the ASF-FMD scenario with 50% of the baseline imports. For soybeans, revenue losses are about $3 billion in all three scenarios.

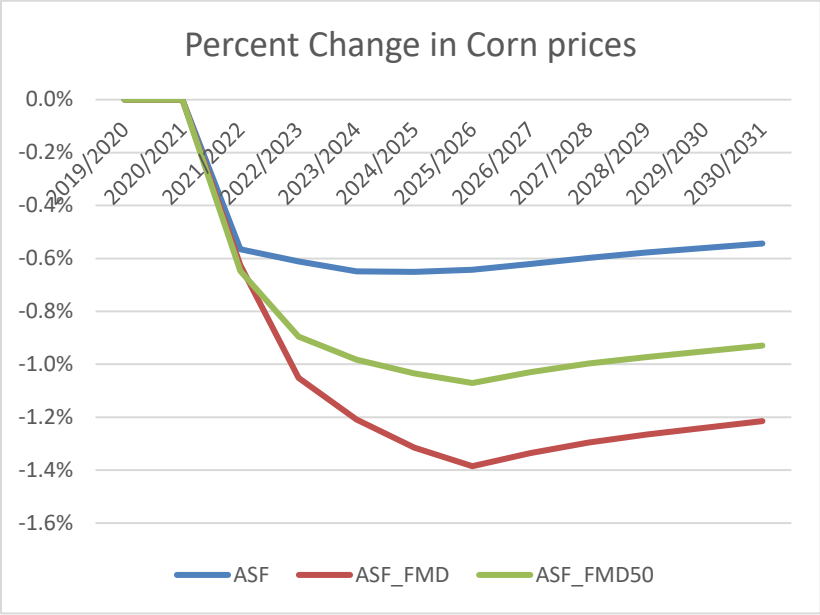

Figure 9. Impact on corn prices (farm average price).

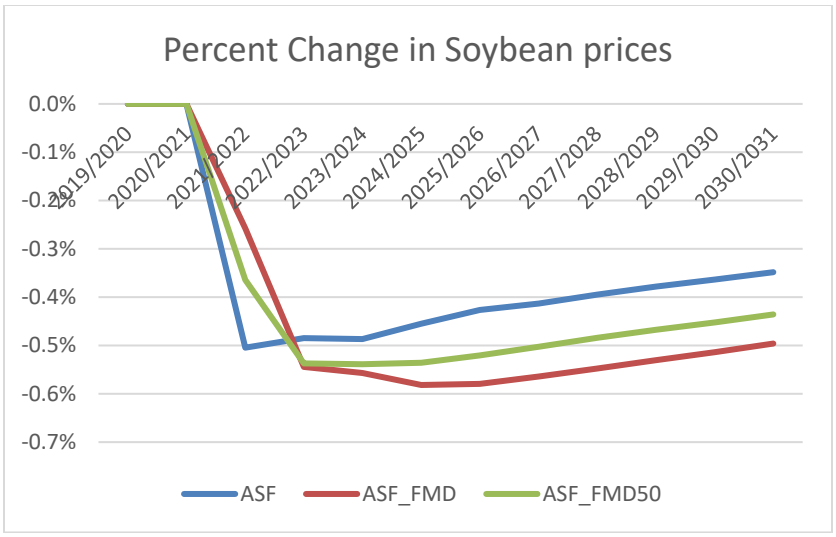

Figure 10. Impact on soybean prices (farm average price).

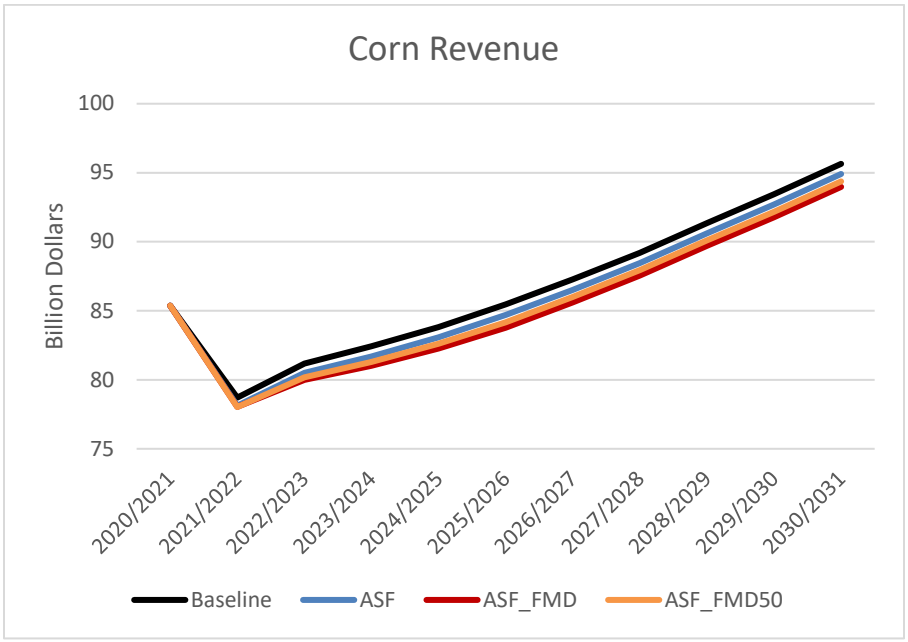

Figure 11. Impact on corn revenue.

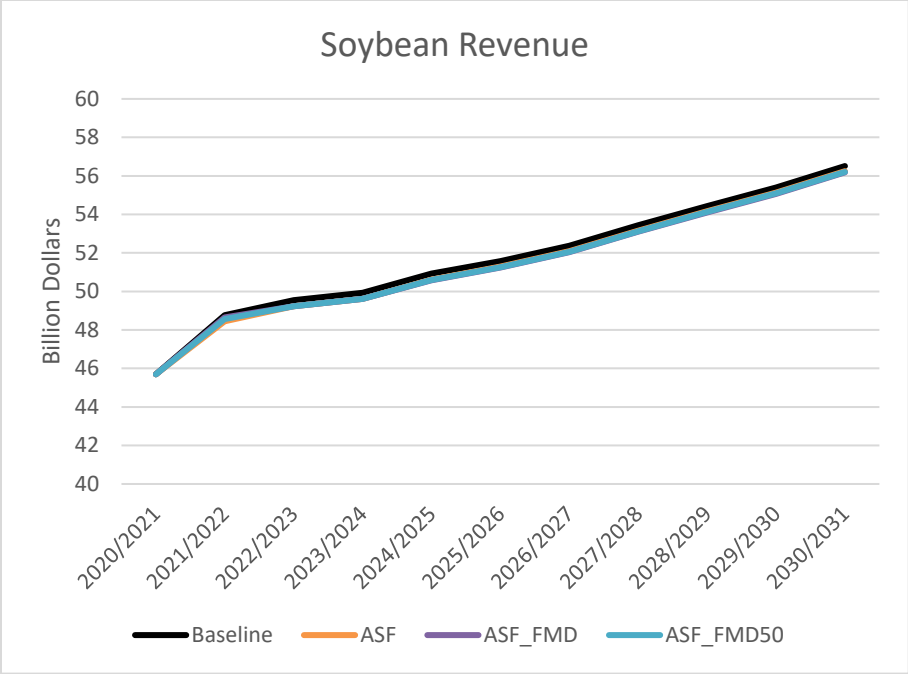

Figure 12. Impact on soybean revenue.

Similarly, the decline in beef and pork production result in a reduction in demand for soybean meal whose prices decline in all three scenarios. The impact on soybean meal prices is larger than on corn at a little over 1% in the first year for all three scenarios. The proportionally greater losses for soybean meal are due to the intensity of soybean use in the hog industry. As is the case for corn and soybean prices, because of the smaller pork and beef industries, soybean meal prices do not return to baseline levels.

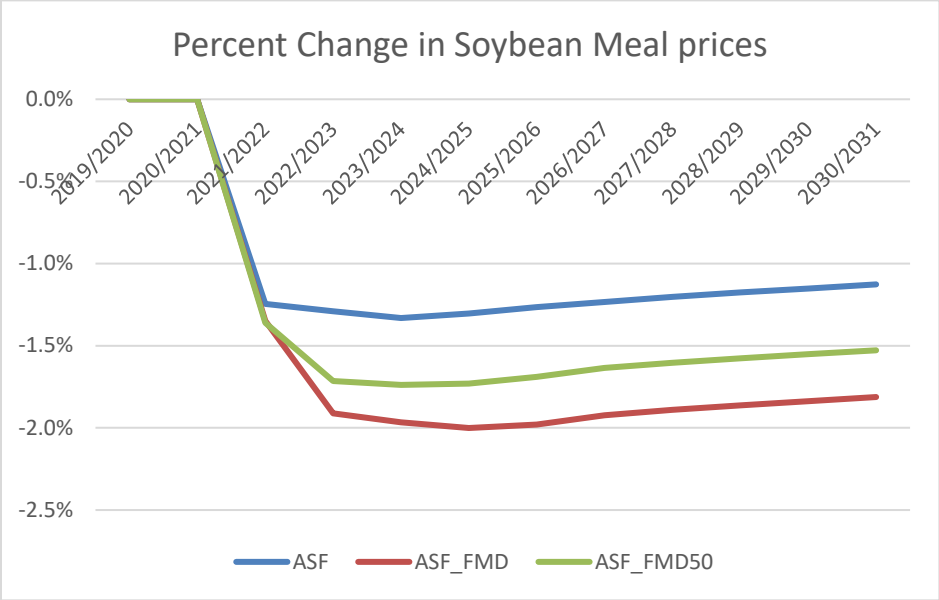

Figure 13. Impact on soymeal price (domestic farm price).

APPENDIX

RESULTS FOR THE TWO-YEAR ASF-FMD SCENARIOS

This Appendix includes the results for the elimination of U.S. pork and beef exports based on a recovery that occurs only two years after the outbreak. All results are expressed in percent change relative to the baseline.

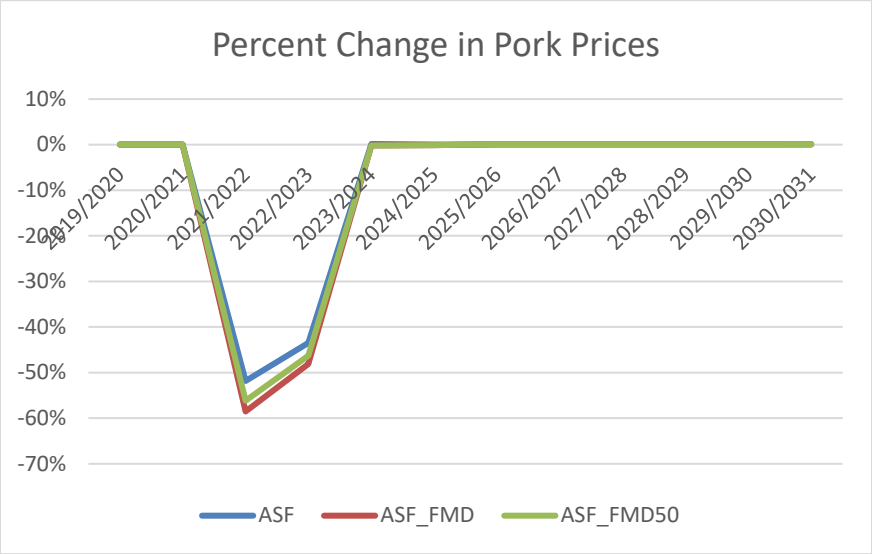

Figure A1. Impact on pork prices.

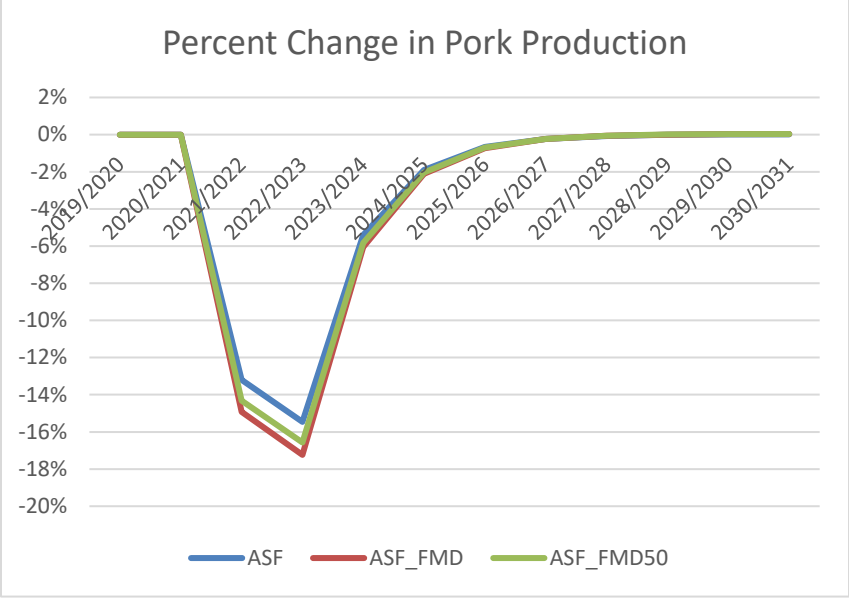

Figure A2. Impact on pork production.

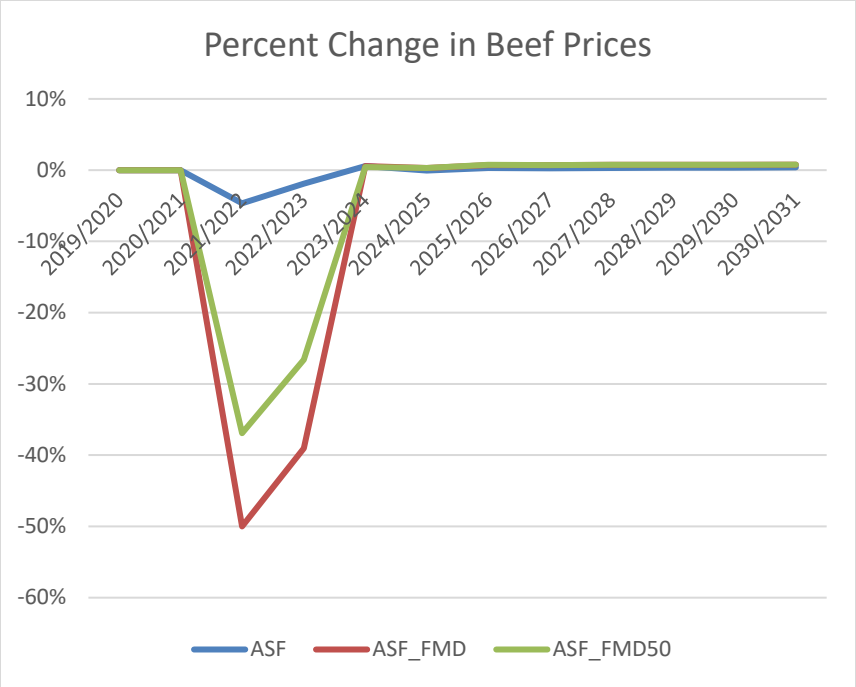

Figure A3. Impact on beef prices.

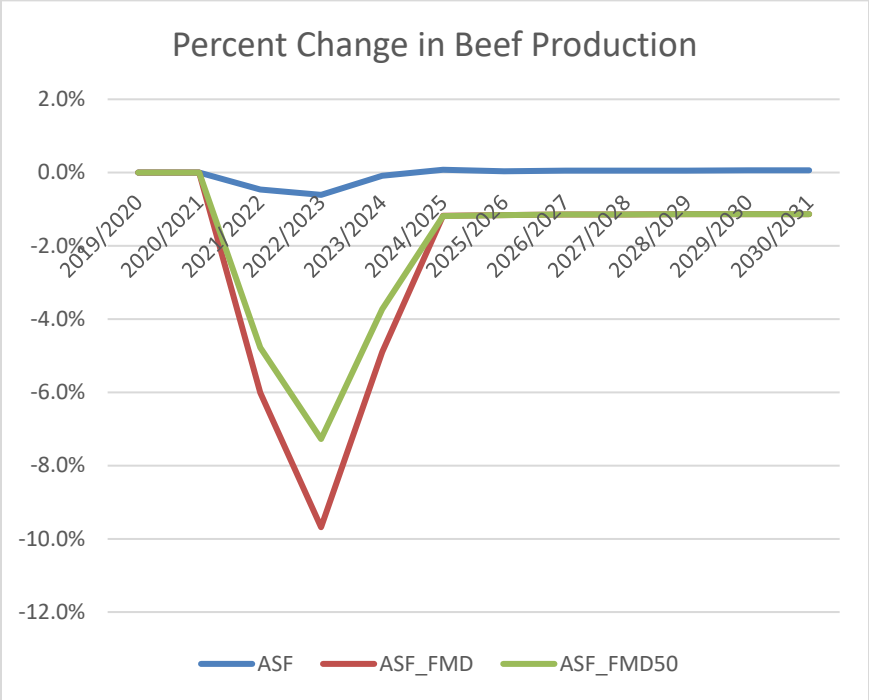

Figure A4. Impact on beef production.

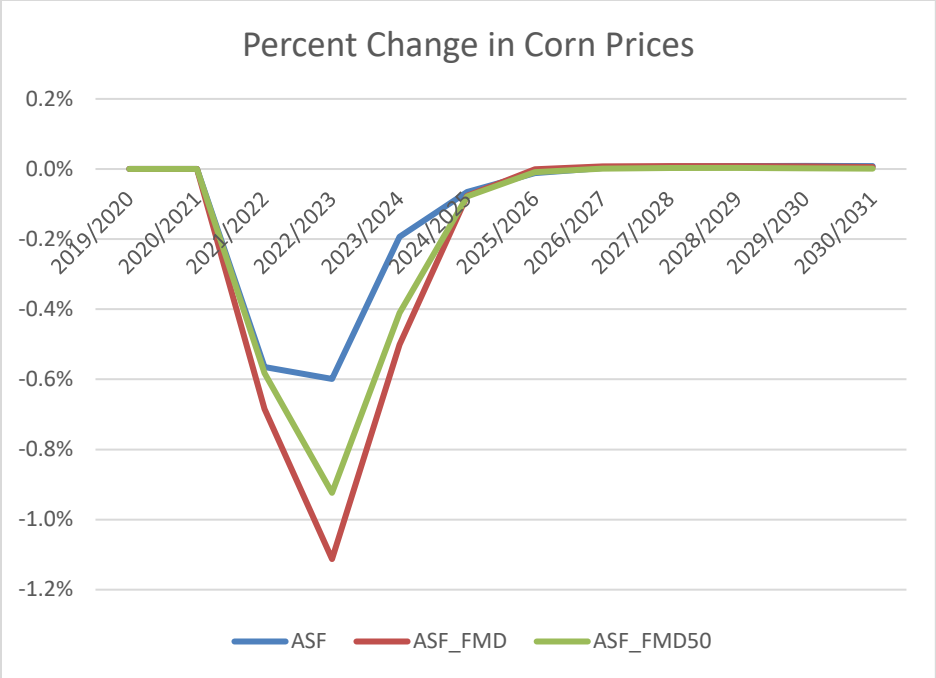

Figure A5. Impact on corn prices.

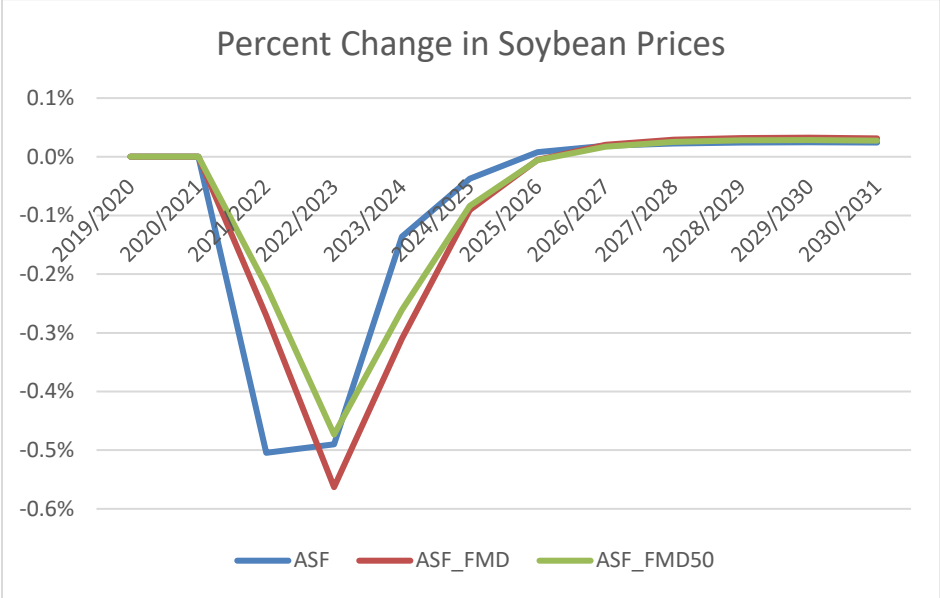

Figure A6. Impact on soybean prices.

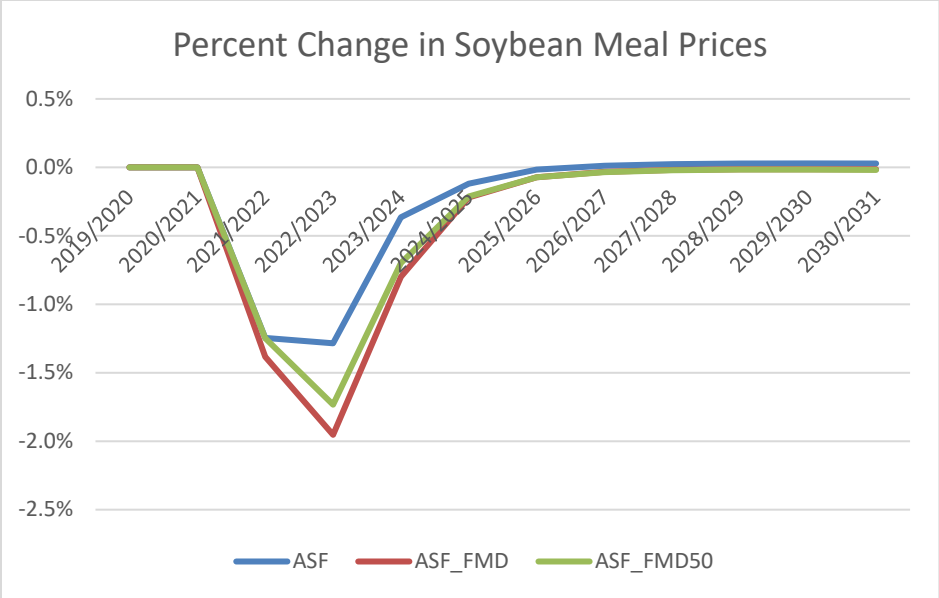

Figure A7. Impact on soybean meal prices.