Supply reductions, export restrictions, and expectations for hog returns in a potential classical swine fever outbreak in the United States

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Summary

An economic model of pork, swine, and related markets examines effects of hypothetical classical swine fever (CSF) outbreaks in the United States. Equations determine deviations in endogenous variables from observed supply and demand values. The analysis assumes 11 million US hogs are destroyed. Live swine and pork exports are stopped during the outbreak, with full recovery. Pork demand by US consumers is assumed to fall by 1% during the outbreaks, with a gradual recovery. Hog growers adjust expectations of future prices on the basis of current market conditions. One potential CSF outbreak reflects losses in the hog population skewed towards grower and finisher swine, while another outbreak has stronger effects on breeding inventory and the pig crop. The largest effects occur in pork and swine. Effects on other sectors are small. Over 20 quarters, the pork industry returns lose $4 billion. Losses for hogs, including the value of animals destroyed, range from $2.6 billion to $4.1 billion. An assumption of unchanged hog-grower expectations for returns is compared to that when expectations adjust. Unchanged expectations alter the pattern of slaughter and prices because breeding inventory falls less, thus more hogs are available for sale after Quarter 7.

Keywords: swine, classical swine fever, economic impacts, pork, trade

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Resumen - Reducción de abastecimiento, restricciones de exportación, y expectativas de rendimiento de cerdos en un potencial brote de fiebre porcina clásica en los Estados Unidos

Un modelo económico de los mercados de carne de cerdo, de cerdo en pie, y otros mercados relacionados examina los efectos de brotes hipotéticos de fiebre porcina clásica (CSF por sus siglas en inglés) en los Estados Unidos. Las ecuaciones determinan las desviaciones de variables endógenas de valores de demanda y abastecimiento observados. El análisis supone que 11 millones de cerdos de los USA son destruidos. Las exportaciones de carne de cerdo y cerdo en pie se detienen durante el brote, con un futuro restablecimiento total. Se supone que la demanda de carne de cerdo por parte de los consumidores de USA baja en un 1% durante los brotes, con un restablecimiento gradual. Los productores de cerdos ajustan sus expectativas de precios futuros en base a las condiciones actuales del mercado. Un brote potencial de CSF refleja pérdidas en la población de cerdos con una desviación hacia los cerdos de crecimiento y finalización, mientras que otro brote tiene efectos más fuertes en el inventario de pie de cría y la cosecha de lechones. Los efectos más grandes ocurren en la carne de cerdo y los cerdos en pie. Los efectos en otros sectores son menores. En 20 trimestres, el rendimiento de la industria porcina pierde $4 mil millones. Las pérdidas de cerdos incluyen el valor de los animales destruidos, variando entre $2.6 mil millones y $4.1 mil millones. El supuesto de que las expectativas de rendimiento de los productores no cambien se compara con aquella donde las expectativas se ajustan. Las expectativas que no cambian alteran el patrón de sacrificio y precios porque el inventario de pie de cría baja menos, de manera que hay más cerdos disponibles para la venta después del trimestre 7.

Résumé - Réductions des approvisionnements, restrictions des exportations, et attentes sur les revenus suite à un épisode potentiel de peste porcine classique aux États-Unis

Un modèle économique des marchés de la viande de porc et du cochon ainsi que des marchés reliés a évalué les effets d'épisodes hypothétiques de peste porcine classique (CSF) aux États-Unis. Les équations ont déterminé les écarts des variables endogènes par rapport aux valeurs observées de l'offre et de la demande. Les analyses ont pris pour acquis que 11 millions de porcs américains étaient détruits. La diminution de la demande en porc par les consommateurs américains durant cet épisode est évaluée à 1% avec un retour graduel à la normale. Les producteurs de porcs ajustent leurs attentes des prix futurs sur la base des conditions actuelles de marché. Un épisode potentiel de CSF démontre des pertes dans la population porcine biaisées vers les porcs en croissance et en finition, alors qu'un autre épisode avait des effets plus marqués sur l'inventaire des animaux reproducteurs et la récolte des porcelets. L'effet le plus marqué s'est produit sur la viande de porc et les cochons. Les effets sur les autres

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secteurs sont limités. Sur une période de 20 trimestres, les retours à l'industrie porcine auraient été réduits de $4 milliards de dollars. Les pertes pour les cochons, incluant la valeur des animaux détruits, variaient de 2.6 milliards à 4.1 milliards de dollars. Une supposition d'aucun changement dans les attentes des producteurs sur les retours est comparée à celle d'un ajustement des attentes. Les attentes inchangées affectent le patron des abattages et des prix parce que l'inventaire des reproducteurs diminue moins, rendant ainsi plus de porcs disponibles pour la vente après le 7e trimestre.

Although the United States is free of classical swine fever (CSF), the ability of livestock diseases to travel the world motivates concern about how an outbreak would affect the United States. During 1997 and 1998, the Netherlands experienced an outbreak of CSF. This analysis uses the length and magnitude of that outbreak to calculate swine depopulation for a hypothetical US outbreak. The resulting animal destruction, export losses, and assumed consumer-response scenarios are introduced into an economic simulation model of US agriculture.

There has been some analysis of the economic impacts of swine disease. Meuwissen et al[1] indicate how costly the Dutch outbreak was, with estimated costs at $2.3 billion ($US). Rendleman and Spinelli[2] analyzed the economic impacts of the United States experiencing an outbreak of African swine fever using a national simulation model. Petry et al[3] estimated the impacts of porcine reproductive and respiratory syndrome (PRRS) on US swine trade with Mexico. This analysis differs from the earlier studies by examining CSF using a US agricultural sector model that recognizes market interactions among meats and livestock and linkages to feeds. A static annual model capturing those linkages was used to estimate the revenue impacts in the United States of a hypothetical foot-and-mouth (FMD) outbreak.[4] This analysis uses the dynamic quarterly model used previously to examine FMD control options[5] and regionalization of US exports in the event of an outbreak of highly pathogenic avian influenza.[6]

The objectives in developing this production tool are to examine how differences in hog grower-price expectations and composition of depopulated swine affect the economic impacts of an outbreak of CSF. Specifically considered is the consequence of growers adjusting expectations of future prices. Further, the economic implications of whether breeding animals or market animals are more depopulated are investigated.

Materials and methods

The analysis comprises two key components. One component consists of the economic model that generates the numerical outcomes, and the second consists of the shocks to the economy generated by the hypothetical CSF outbreak that are introduced into the economic model. Shocks considered include extent of swine depopulation, impacts on US pork and live-swine exports, consumer response, and reaction of hog growers to changes in price.

Economic model

The economic model is a quarterly, multicommodity, partial equilibrium model of US agriculture designed to capture vertical and horizontal linkages in agricultural markets. This model is documented in Paarlberg et al.[5] The model relies on complementarity conditions in differential equation form to describe the effects of shocks introduced as percent changes.[7] The percent changes are applied to a no-disease quarterly baseline from the first quarter of 2008 to the fourth quarter of 2012.

Demands for final commodities are consistent with economic theory, where consumers maximize utility subject to a budget constraint. Demands are expressed as logarithmic differential equations consisting of own and cross-price elasticities, which give the percent change in quantity resulting from a 1% change in price, obtained from statistical estimates in the literature. For this analysis, meat-demand elasticities are the most critical. Meat-demand elasticities for beef, pork, and poultry meat[8] and lamb meat[9] are derived from recent econometric work. The remaining elasticities are from older studies, but reflect commonly accepted values: milk,[10] wheat and rice,[11] soybean oil,[12] coarse grains for food and industrial use,[13] and eggs.[14] Prices for factors of production (inputs) are specified in logarithmic differential form and are consistent with zero economic profit conditions. The assumption of zero economic profits means that profit-maximizing firms and farms operate under perfect competition, where unit revenue equals unit cost and unit cost includes returns on capital and management. Changes in prices of factors of production depend on the change in output prices and unit-revenue shares. Revenue shares for corn, wheat, soybeans, rice, hogs, cattle, and milk are obtained from the USDA/ERS data website.[15] The remaining revenue shares come from a variety of sources: forage and pasture revenue shares,[16] poultry meat,[17] lambs and sheep,[18] beef,[19] pork,[20,21] and live poultry.[22]

The large share devoted to animal costs means meat industries show low returns on capital and management. The exceptions are poultry meat and eggs, where the value of the bird is implicit. Revenue shares for the individual feed ingredients are calculated from the livestock-feed balances for the individual feeds.

Logarithmic changes in production and derived demands are determined by logarithmic changes in production technologies and factor supplies. Changes in technologies are linked to changes in factor prices through elasticities of substitution. Substitution elasticities for the meats are econometrically estimated by MacDonald and Ollinger.[20,21] As model solutions using the estimated values resulted in meat-yield changes considered excessive by industry experts, the substitution elasticities are reduced. The substitution elasticities used in feeding animals are generated using a technique based on least-cost feed rations by species.[23] No estimates for the remaining substitution elasticities were found, so values are used for which the differential supply equations are consistent with common supply elasticities.

Changes in international trade behavior are captured by logarithmic differential excess-supply and excess-demand equations. The elasticities of excess demands for beef, pork, and poultry meat are derived from estimates for Japanese purchases of US meats.[24] The estimates for beef are similar to the values reported by Zhao et al.[25] Elasticities for coarse grains, wheat, soybeans, and soybean products are derived from policy simulators.[13]

Scenarios

Two hypothetical CSF outbreak scenarios examine depopulation of hogs to control the disease in the United States, a loss of exports of hogs and pork, and an adverse reaction by US pork consumers. The results from those scenarios are compared to the no-disease baseline scenario for 20 quarters. The baseline is the February 2008 US Department of Agriculture baseline from the first quarter of 2008 through the fourth quarter of 2012. Scenario policy options include

disease-related destruction of both diseased and healthy animals, trade restrictions, consumer reactions, and assumed expectations of returns to hog growers. Scenario One considers a pattern of swine depopulation skewed towards breeding swine and pigs. Scenario Two skews the depopulation pattern towards market hogs. Both scenarios initially assume that growers expect the future return on a breeding sow to change and match the current return. The outbreak in Scenario One, where the breeding inventory dominates, is then rerun with differing expectations, where growers believe the future return on a sow will be unchanged by the outbreak. The Scenario One population is used for this comparison because the supply reductions in that scenario are skewed toward breeding inventory, which is more sensitive to the expectations assumption.

To develop a plausible hypothetical CSF outbreak, the 1997-1998 Dutch outbreak is used to set an assumed magnitude of animal depopulation and outbreak duration. Because the Dutch swine herd at that time was smaller than the herd in the United States, the observed number of animals destroyed is increased proportionally. Attaché reports indicate that 1,681,688 Dutch hogs were destroyed either because they resided on contaminated farms or represented the potential to spread CSF.[26] The 1.7 million animals killed to control CSF constituted 8.43% of the Dutch inventory of sows and slaughter hogs. Using US data for breeding inventory and hog slaughter gives an estimate that an equivalent outbreak in the United States would lead to the destruction of 11.0 million head.

The Dutch outbreak lasted for five quarters, including all of 1997 and part of the first quarter of 1998, and consisted of 429 cases.[27] When the cases are separated by quarter, 12% of cases appear in Quarter 1, 69% in Quarter 2, 12% in Quarter 3, 6% in Quarter 4, and 1% in Quarter 5. For this analysis, it is assumed that the 11.0 million US swine are destroyed in these same quarterly proportions.

The number of hogs destroyed in each quarter expressed as percent changes in total US hog numbers for each quarter are inserted into the economic model as supply reductions. The effects of two patterns of animal destruction are compared. One pattern, Scenario One, has relatively larger losses in the breeding inventory and pig crop. The other pattern, Scenario Two, has relatively larger animal losses for market animals. These two sets of supply reductions are intended to examine the implications of outbreaks that recognize the differences in regional production patterns in the United States. Calculation of the differences in depopulation patterns is based on the data from two states with different production characteristics. One region, North Carolina, focuses more on producing weaned and feeder pigs. On the other hand, Iowa focuses more on market hogs. The compositions of swine populations for the two states are used to allocate the depopulation patterns for the total US swine population. The intent is not to confine the hypothetical outbreaks to those states, but rather to introduce differences in depopulation using the patterns of swine population in those states.

To model the CSF outbreak, the North Carolina and Iowa hog populations are separated into breeding swine, the pig crop, market hogs early-on-feed, and market hogs late-on-feed. This requires combining data from *Agricultural Statistics*[28] and the 2002 *Census of Agriculture*[29] plus making some assumptions. Since the *Census of Agriculture*[29] data are for 2002, that year is used to calculate the percentage changes. Sales data by operation type are reported, but because the categories may include the same animals, those data are insufficient and other information must be used. The *Census of Agriculture*[29] gives a 2002 breeding inventory of 964,000 head for North Carolina and 1.1 million head for Iowa. Pig crops are reported in *Agricultural Statistics,*[28] with 19.6 million head born in North Carolina and 14.9 million head born in Iowa. Thus, two of the swine types are determined.

The remaining two types of swine are market hogs in their last quarter on feed (late-on-feed hogs) and market hogs in their first quarter on feed (early-on-feed hogs). The number of finisher animals sold is calculated by assuming finish-only hogs are not counted in any other category and that farrow-to-finish hogs are sold for slaughter. Adding these numbers gives market hogs sold for slaughter of 11.6 million head in North Carolina and 29.6 million head in Iowa. The animals from both production types are treated as the late-on-feed category.

Determining the number of market hogs in their first quarter on feed requires that interstate trade be determined, because hogs might be shipped at different weights. Comparing the number of hogs for slaughter to the reported pig crop suggests that North Carolina exports 8.0 million head while Iowa imports 14.7 million head. How these traded hogs are distributed by age requires making assumptions. Inventory by weight is given in *Agricultural Statistics*.[28] Because there are no flow data by weight, inventory data are used to infer flows. A plausible estimate is that 90% of the swine moving out of North Carolina are weaned pigs and pigs in the early-on-feed stage. The Iowa inventory data imply that hogs moving into Iowa are weaned and feeder pigs in the early-on-feed stage.

The compositions of hog populations for these two states set the pattern of quarterly depopulation. What emerges is that depopulation in Scenario One is based on the North Carolina data, which shows larger losses in the pig crop and breeding inventory, while the pattern for Scenario Two is based on the Iowa data, with larger losses in market swine. The animals destroyed by quarter are converted into percent shocks, introduced into the model by dividing by the baseline national number of animals at each production stage in each quarter (Table 1). The largest destruction occurs in Quarter 2.

The trade response assumed is based on guidelines from the World Organization of Animal Health (OIE) and experience with export recovery for other outbreaks. If a country is CSF-free prior to the outbreak, OIE rules allow resumption of exports 30 days after the outbreak is concluded. European Union (EU) authorities banned piglet and live-swine exports during the Dutch outbreak, but pork continued to be exported within the EU.[27] Non-EU nations ended hog, piglet, and pork purchases from the Netherlands. Dutch exports declined and did not recover for 1.5 years,[30] although there was also a buy-out program[26] underway at the time that appears to have reflected environmental concerns. A similar pattern occurred for the FMD outbreak in Taiwan, where pork exports did not recover quickly[31] because the government appeared to use the outbreak as a means of shrinking the industry through exit of small growers.[32]

Thus, both scenarios assume pork and live-hog exports are banned during the 5-quarter outbreak. Recovery begins after 30 days, with full recovery in Quarter 14. Exports in Quarters 6 to 9 recover an average of 50%, with exports in Quarters 10 to 13 averaging 89% of base exports. Because the hypothetical outbreaks occur in major production regions and are widespread, it is assumed that regionalization of exports is precluded.

Table 1: Logarithmic reductions in US swine population due to hypothetical classical swine fever outbreaks compared to a baseline scenario of no outbreak

Quarter	Swine type	Scenario One*	Scenario Two†
1	Breeding	-0.01756	-0.01259
	Pig crop	-0.02227	-0.01016
	Young market	-0.01551	-0.02236
	Finish	-0.01475	-0.02273
2	Breeding	-0.09906	-0.07106
	Pig crop	-0.13074	-0.05962
	Young market	-0.07740	-0.11159
	Finish	-0.08131	-0.12530
3	Breeding	-0.01680	-0.01205
	Pig crop	-0.02068	-0.00943
	Young market	-0.01430	-0.02061
	Finish	-0.01219	-0.01878
4	Breeding	-0.00809	-0.00580
	Pig crop	-0.00989	-0.00451
	Young market	-0.00684	-0.00986
	Finish	-0.00642	-0.00990
5	Breeding	-0.00166	-0.00119
	Pig crop	-0.00205	-0.00094
	Young market	-0.00137	-0.00198
	Finish	-0.00133	-0.00204

* Scenario One, based on data for North Carolina, assumes that the largest percent of swine depopulation occurs for breeding swine and the pig crop.

† Scenario Two, based on data for Iowa, assumes that the largest percent of swine depopulation occurs in market hogs.

The response of US consumers to the CSF outbreak is unknown. Studies indicate that US consumer response to the discovery of bovine spongiform encephalopathy (BSE), which unlike CSF represents a human health risk, was insignificant. Survey results suggested that 77% of consumers did not change consumption patterns after BSE was detected.[33] Vickner et al[34] analyzed weekly grocery purchases for beef in Utah and found that Utah consumers were not responsive to BSE announcements. Kuchler and Tegene[35] found similar results on a national scale. The scenarios assume a small adverse US consumer response. Demand for pork by US consumers falls 1% during the 5-quarter outbreaks and recovers fully by Quarter 10.

Other scenarios consider economic effects from changes in hog-producer expectations for future returns on raising hogs as a result of the outbreak. Pig production depends partly on the relationship between the market price last quarter and the expectation of the hog price two quarters ahead. Sow inventories also influence pig production and are affected by the price expected 4 quarters in the future relative to the current price. Assumptions are introduced about hog growers' expectations for future returns on capital and management. Two types of expectation assumptions commonly used in economic analysis are compared. One type of expectation assumes that producers adjust to the outbreak by expecting future returns to equal the returns observed in the current quarter. Thus, expectations adjust throughout the simulation period. In another type of expectation, hog growers anticipate no change in future returns as a result of the outbreak, and therefore expectations do not adjust throughout the simulation period.

Results

Two hypothetical CSF outbreak scenarios examine depopulation of hogs to control the disease in the United States, a loss of exports of hogs and pork, and an adverse reaction by US pork consumers. Scenario One skews the swine depopulation towards breeding swine and pigs, while Scenario Two skews the depopulation towards market hogs. The initial scenarios assume producers expect the future return on a breeding sow to change and match the current return. These are labeled "Scenario One adjusted" and "Scenario Two adjusted" in the graphed results (Figures 1 through 5). The outbreak in Scenario One is then rerun with differing expectations, where producers believe the future return on a sow will be unchanged by the outbreak. This is labeled "Scenario One unadjusted" in the results graphed in Figures 1 through 5.

Figure 1 reports hog slaughter by quarter. Initial quarter slaughter falls slightly as few cases occur and few finished hogs are lost. The largest number of cases occurs in the second quarter and there are compounding effects from the loss of young hogs in Quarter 1. Second-quarter slaughter falls from the base level of 30.4 million head to 27.0 million head in the Scenario One outbreak. While most of the decline in slaughter reflects animal depopulation, imports of hogs from Canada also fall in response to the demand contraction for pork.

In the fourth quarter, the results of the two outbreak scenarios deviate. Slaughter in the Scenario Two outbreak, where the depopulation is skewed towards market hogs, begins to recover. The Scenario One outbreak shows the compounding effects of breeding inventory and pig-crop losses, so slaughter continues to weaken. Recovery for Scenario One starts in Quarter 5 and is complete by approximately Quarter 17. Different assumptions about expectations of sow returns also play a role. Because unadjusted expectations do not incorporate falling prices during the outbreak, and their effect on breeding-inventory decisions, slaughter recovers faster than it does when expectations adjust.

Figure 2 shows the price impacts for hogs. Quarter 1 prices fall from the baseline levels because few hogs are lost to CSF, but pork and swine exports are halted and consumer demand for pork falls. The price of hogs drops from $55.11 per cwt to $35 to $36 per cwt. In Quarter 2, the animal losses of the outbreak spread, but the export and US pork demand effects are the same as in Quarter 1. Market prices for hogs are closer to the baseline levels. The baseline price of hogs is $46.17 per cwt.

For the Scenario One adjusted outbreak, the hog price falls to $39.54 per cwt. The Scenario Two outbreak has a hog price of $46.00 per cwt, higher than the Scenario One outbreak prices because relatively more market hogs are lost. That situation reverses in Quarter 4 because of the lagged impact of CSF on breeding inventory and pig crops. Since those effects are larger in the Scenario One outbreak, those prices continue to increase. The hog price in the Scenario One adjusted outbreak rises to $44.48 per cwt versus a base price of $44.28 per cwt. The hog price in the Scenario Two outbreak of $37.34 per cwt is below the baseline price. After Quarter 4, hog prices for the Scenario One outbreaks are greater than those for the Scenario Two outbreak because of the continued stronger effects on breeding inventory and pig crop. By Quarter 10, the demand effects have dissipated, but the lagged effects of depopulation on hog numbers continue. Thus, prices move above the baseline before returning to the baseline in Quarter 17. The role of breeding inventory adjustment is especially strong when expectations of returns in the Scenario One outbreak are altered. With unadjusted expectations, producers do not adjust breeding inventory in response to lower returns in the early quarters, so more hogs are slaughtered, which lowers prices.

Figure 1: US commercial hog slaughter results from a quarterly US agricultural sector model under alternative hypothetical classical swine fever outbreaks. The baseline is the February 2008 US Department of Agriculture baseline from the first quarter of 2008 through the fourth quarter of 2012. Scenario One considers a pattern of swine depopulation skewed towards breeding swine and pigs. Scenario Two skews the depopulation pattern towards market hogs. "Scenario One adjusted" and "Scenario Two adjusted" assume that growers expect the future return on a breeding sow to change and match the current return. In "Scenario One unadjusted," producers believe the future return on a sow will be unchanged by the outbreak.

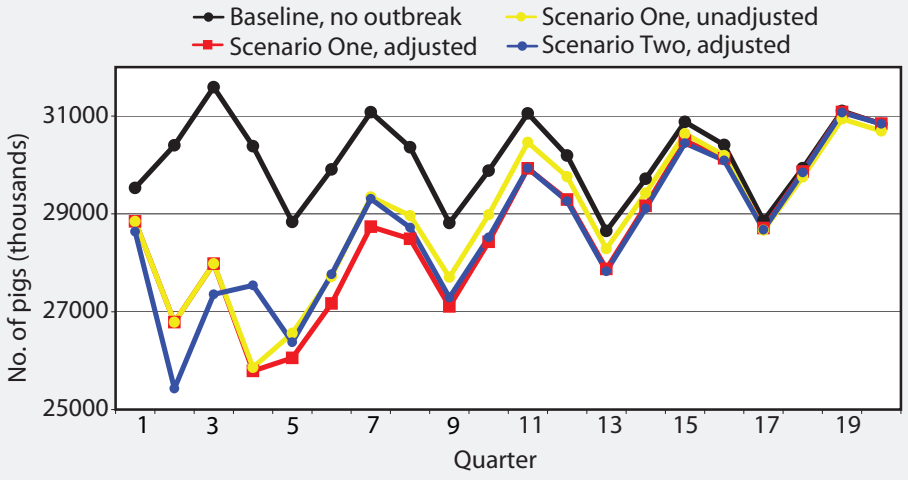


Figure 2: Price results ($US) for US market hogs from a quarterly US agricultural sector model under alternative hypothetical classical swine fever outbreaks as described in Figure 1.

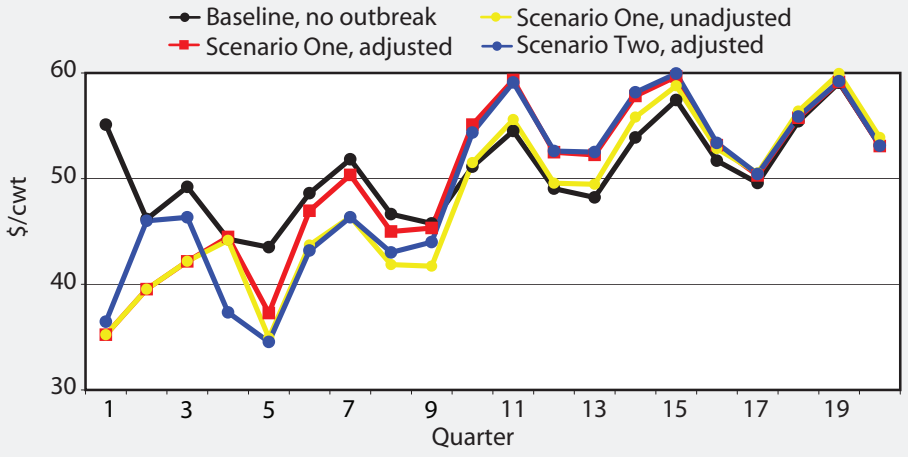


Figure 3 shows the outbreak lowering the retail price of pork through Quarter 10. The breeding inventory effect can be seen, as the price in Scenario Two recovers more in Quarters 2 and 3 but drops more in Quarter 4. Unadjusted price expectations result in lower pork prices, while adjusted price expectations cause a slightly faster recovery.

Returns on capital and management in the pork industry are shown in Figure 4. The percentage change in the hog price exceeds that for the pork price. A hog price increase shrinks the per-pound margin, while a hog price decrease increases the per-pound margin. The CSF outbreak reduces Quarter 1 total returns on capital and management in the pork industry by $94 to $109 million, since the loss of exports and reduced US demand cause a loss in sales volume. The largest declines occur in Quarters 4 and 5. With the end of the CSF animal deaths in Quarter 5, the recovery of US consumer demand in Quarter 10, and the recovery in exports in Quarter 14, returns begin to recover.

Aggregate returns on capital and management for market hogs are shown in Figure 5. The returns shown are the returns to growers whose animals are not depopulated, less the value of animals depopulated. Because the US government often compensates growers for depopulated animals, taxpayers may incur part of the losses shown in Quarters 1 to 5. Returns fall sharply in the first two quarters, but in the third quarter, as prices rise and the loss of animals diminishes, returns begin to recover. Returns for Scenario One rise more in Quarter 4 than those for Scenario Two, because the price recovery for hogs is greater for the Scenario One outbreak. The pattern shifts in Quarter 5, where the recovery in returns in Scenario One with unadjusted expectations lags. This pattern reflects the absence of adjustment in breeding inventories to lower prices in earlier quarters.

Because of the ambiguity of impacts on producers, hog growers need to be separated into two groups (Paarlberg et al[36]). One group of growers has hogs that are not destroyed and can be marketed. In Quarter 2, the return on capital and management by this group in the Scenario One outbreak is $209 million compared to a return to the sector of $601 million in the absence

of an outbreak. For Quarter 3, this group experiences returns of $238 million versus a baseline return of $644 million. The returns in the Scenario Two outbreak are $486 million in Quarter 2 and $424 million in Quarter 3.

The second group of hog producers has animals destroyed to control the disease. There is a loss equal to the foregone sales revenue because the cost of raising the animal is borne, but the animal no longer has market value. Who incurs this loss depends on the extent of government indemnities relative to foregone sale revenue. The foregone sales revenue in the Scenario One outbreak in Quarter 2 is $632 million, which is more than the return experienced by the growers with hogs that can be sold. For the Scenario Two outbreak, the second quarter foregone sales revenue is $793 million. That loss also exceeds the return to those who can sell hogs. It is important to recognize that the depopulation is concentrated among a much smaller share of producers.

The impact of the CSF outbreaks on returns on capital and management in US agriculture and related industries over the 20-quarter simulation period is reported in Table 2. Depending on scenario, the total 20-quarter loss in returns on capital and management ranges from $5.82 billion to $7.74 billion. The largest effects occur in the sectors of direct interest – pork and swine. The CSF outbreak acts like a supply control combined with a demand reduction. Returns on capital and management in pork fall from $24.71 billion to between $20.44 billion and $20.57 billion with adjusted price expectations. The declines in returns to the pork industry over the 20 quarters are of similar magnitude in all situations, just over $4 billion. The returns on capital and management to hog growers over the 20 quarters are sharply lower. Compared to base returns of $13.42 billion, gross returns in the Scenario One and Scenario Two outbreak scenarios with adjusted expectations are $11.82 billion and $11.31 billion. Adjusting for the value of swine destroyed further reduces returns by $943 million and $1.18 billion. The combined losses range from $2.6 billion to $3.3 billion. Under unadjusted price expectations, gross returns are lower by even more – $10.27 billion. Animal destruction adds losses of $955 million, so the combined loss increases to $4.1 billion. The spillover effects on other sectors are generally small. Other meat sectors and animal sectors benefit slightly. Crop producers experience small declines in returns as prices decline because of reduced feeding to swine.

Figure 3: US retail pork price results ($US) from a quarterly US agricultural sector model under alternative hypothetical classical swine fever outbreaks as described in Figure 1.

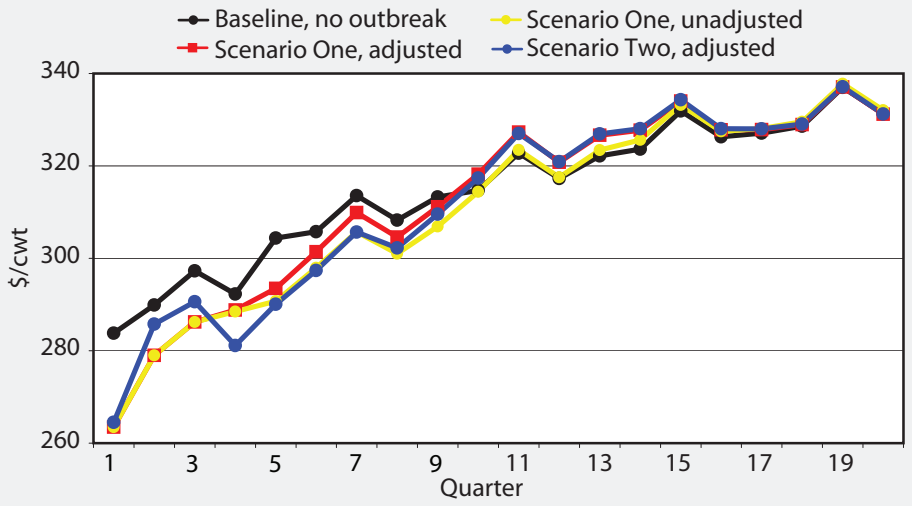
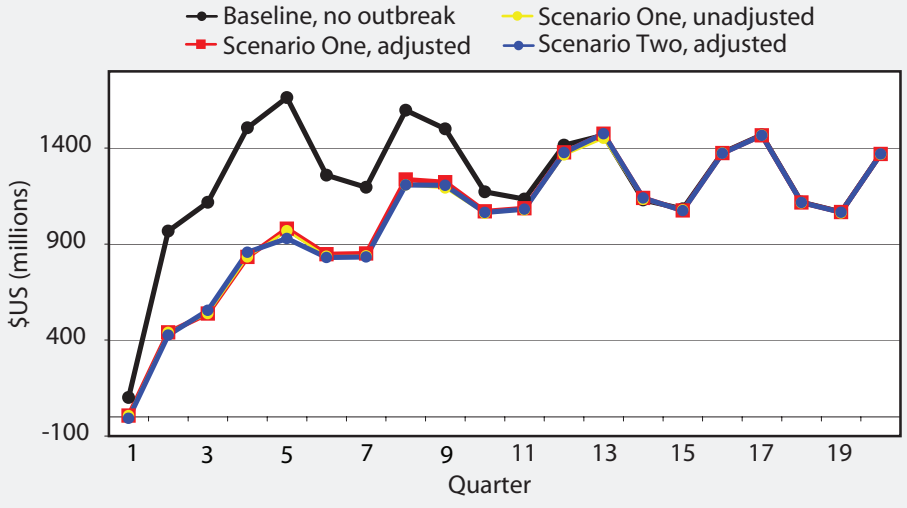


Figure 4: Estimated returns to capital and management in the US pork industry from a quarterly US agricultural model under alternative hypothetical classical swine fever outbreaks as described in Figure 1.



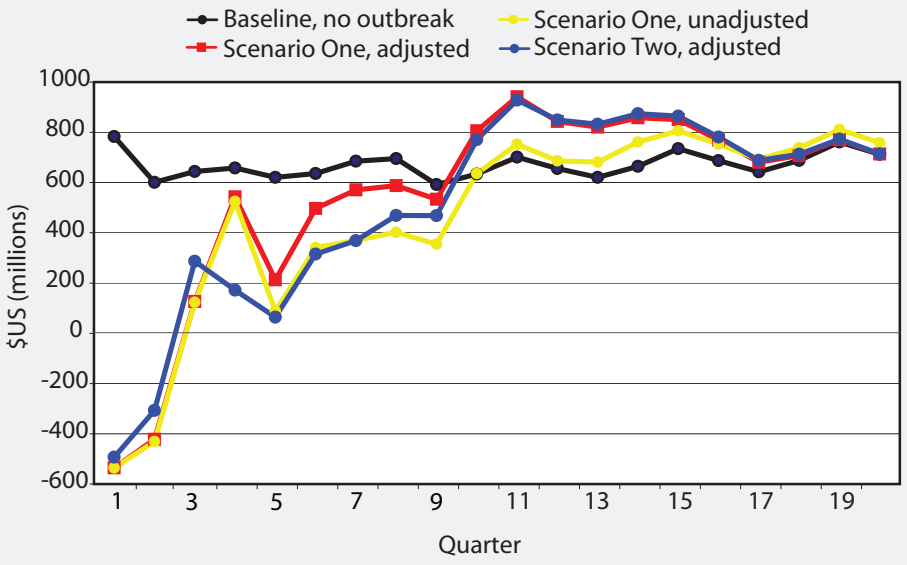
Discussion

The model results highlight some key issues surrounding a livestock disease outbreak like CSF. One issue is the length of the outbreak and how it spreads. The initial quarter effects are dominated by the loss of exports and US consumer-demand effects, so prices fall. Subsequent quarters see larger supply effects. In this example, the supply effects increase in Quarters 2 and 3, so prices fall less and return closer to baseline levels. After Quarter 8, prices are above the baseline, since the export loss and US demand contraction effects dissipate while the depopulation effects persist.

Another issue centers on differences in the price changes and trajectory during the initial quarters due to type of animals affected. The outbreak in a region with its hog population skewed toward market animals shows a stronger price recovery in Quarters 2 and 3. Since the breeding inventory and pig crop are not as strongly reduced by the outbreak, the hog price falls more in Quarter 4. By Quarter 9, the differences in trajectories arising from differences in population are largely gone.

Differences in producer expectations of returns on animals also affect the magnitudes and trajectories of effects. When

Figure 5: Estimated returns on capital and management for US hogs from a quarterly US agricultural sector model under alternative hypothetical classical swine fever outbreaks as described in Figure 1.



expectations of future returns are adjusted by growers on the basis of current market conditions, breeding inventory changes, which means differences in future pig crops and market hogs. The initial quarter results are not sensitive to the expectations assumptions. During Quarters 7 to 8, the adjustment in expectations dampens price reductions and causes price increases above the baseline in Quarters 9 to 20. Under unadjusted expectations, prices decrease more and increase less. Differences in expectations of returns on breeding sows alter returns on capital management. Adjustment in expectations dampens the losses in the pork industry for most of the simulation period. Losses to hog growers are lessened when expectations adjust to current market prices because growers alter inventories.

Implications

- The impact of a livestock disease outbreak depends on magnitude of animal loss, location of the animals, type of animals affected, demand and

Table 2: Estimated 20-quarter returns ($US) to capital and management in US agriculture for hypothetical classical swine fever outbreaks* compared to a no-outbreak baseline from a US agricultural sector model

Commodity	Base (no outbreak) (millions of dollars)	Adjusted price expectations (millions of dollars)		Unadjusted price expectations (millions of dollars)
		Scenario One	Scenario Two	Scenario One
Beef	5759	5767	5765	5753
Beef cattle	25,961	26,348	26,272	26,256
Eggs	-541	-514	-518	-519
Swine				
Uninfected†	13,419	11,819	11,308	10,271
Destroyed‡	0	943	1175	935
Net return§	13,419	10,825	10,133	9316
Pork	24,714	20,574	20,441	20,415
Lambs	307	303	303	303
Lamb meat	164	176	176	176
Milk and dairy	13,896	14,302	14,254	14,231
Poultry	6806	6,920	6,883	6,845
Crops	271,785	271,380	271,431	271,449
Soy crush	-4302	-3839	-3987	-3999
Total	**357,968**	**352,150**	**351,153**	**350,226**

* Scenario One, swine depopulation skewed towards breeding swine and pigs; Scenario Two, swine depopulation skewed towards market hogs.

† Returns on capital and management for hog growers with marketable animals.

‡ Value of swine destroyed; animal value varies by age so cost differs by scenario. May be paid by taxpayers depending on US government indemnities.

§ Returns on uninfected animals less value of animals destroyed.

trade impacts and their duration, and producer expectations of future returns.
- Price patterns in an outbreak initially decline due to the export ban and fall in consumer demand, then stronger prices follow as the disease spreads.
- As the outbreak ebbs, prices remain below the baseline until exports and US domestic demand recover.
- The pork industry experiences reduced returns on capital and management of over $4 billion with recovery at approximately Quarter 17.
- Hog growers have lower returns on capital and management in the initial quarters, but earn higher returns after Quarter 9.
- Total losses for hogs, including the value of animals destroyed, range from $2.6 billion to $4.1 billion.
- Returns on capital and management for all commodities included in the model fall by $5.8 billion to $7.7 billion.
- Differences in hog-grower expectations of future returns alter the magnitudes and pattern of results because breeding inventory is affected. After Quarter 5, an assumption of unadjusted expectations results in larger hog slaughter and lower prices.

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