ESTIMATING THE POTENTIAL ECONOMIC IMPACT OF LATE WILT OF CORN (HARPOPHORA MAYDIS) INCURSIONS INTO THE UNITED STATES

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Abstract

This analysis estimates the economic impacts of late wilt of corn; a seed- and soil-borne pathogen affecting corn. The assumed infestation originates in central Illinois in crop year 2012/13 and spreads through the 2017/18 crop year. The infestation triggers a loss in U.S. coarse grains exports. With no trade regionalization the export loss dominates the output loss so prices for corn and other crops fall. From 2012/13 to 2017/18 losses in returns to U.S. agricultural producers total $41.3 billion. Coarse grains producers lose $21.8 billion. That loss consists of a $20.1 billion loss to uninfested producers combined with a loss to infested growers of $1.7 billion. Losses to infested growers are concentrated on a few producers in central Illinois while the larger loss to uninfested grower is spread among growers throughout the United States. Land owners are a separate group and lose $9.9 billion. Competing crops experience reduced returns. Lower commodity prices mean gains in consumer surplus. If the export market is regionalized, the output reduction and the export loss offset. Infested corn growers continue to experience losses but higher corn prices generate gains to uninfected growers to balance the loss to infested growers.

Keywords: Late Wilt of Corn, Economic Impacts, Trade

JEL Classification: Q02, Q13, Q17

Introduction

This analysis uses a partial equilibrium agricultural sector model to estimate the impacts of hypothetical incursions of *Harpophora maydis*, Late Wilt of Corn. The report describes scenarios analyzed and the results. The scenarios begin with detection of the pest in central Illinois and simulate a 6-year situation of hypothetical reductions in crop output and disruptions in U.S. exports compared to the USDA baseline projections of February 2013. Results are reported as deviations from the no detection baseline. The model reports the percent changes in prices, quantities produced, consumed, and traded for the livestock and feed commodities included in the model that result from potential pest related shocks. These percent changes are used to calculate changes in economic welfare. A detailed model description is in Paarlberg, Hillberg Seitzinger, Lee, and Mathews, Jr. (2008).

The estimated potential economic impact of Late Wilt of Corn is overwhelmingly determined by trade effects. If importers apply trade restrictions to all of the United States, that is, do not regionalize U.S. coarse grains exports, the marked increase in domestic supply remaining in the United States lowers coarse grains prices and leads to benefits to consumers of $35.3 billion over the 6-year simulation period. However, U.S. agricultural producers lose $41.3 billion over that same time period. The greatest losses are incurred by the U.S. coarse grain and forage producers, and land owners.

If importers limit their embargoes of U.S. coarse grains to Illinois, that is, "regionalize" U.S. trade, the economic welfare gain to consumers estimated without export regionalization disappears and becomes a small economic welfare loss, $1.4 billion, or a decline of 0.09%. The increases in returns to capital and management for livestock growers estimated in the situation without export regionalization also disappear. Coarse grains producers with crops that can be sold gain a total of $169 million over 6 years under regionalization as losses in the first few years are offset by gains in later years.. The loss to infested growers remains at $1.7 billion, so a small group of corn growers continues to bear the bulk of the economic effects.

Modeling Approach

The results can be understood as the outcome of the conflict between the assumed output reduction and the export reduction due to the plant pathogen. By itself an output reduction is a cut in crop supply in the United States. As a consequence, prices rise to ration the reduced production and existing stocks based on the price responsiveness of demand. In contrast, reduced exports by themselves are a cut in the demand for U.S. crops. As a result, prices fall to encourage expanded use inside the United States. The equilibrium price reached when these events occur simultaneously is determined by which of these two effects dominates. If the output reduction is stronger than the export reduction, the equilibrium price will be higher. If the export demand reduction dominates, the equilibrium price will be lower.

The impacts of a plant pest infestation using a conceptual model helps clarify the results (Figure 1). In the figure there are two panels. The panel on the left represents the United States domestic market for a crop. The panel on the right shows the world market for the crop. The U.S. domestic demand is denoted by D. The initial supply in the United States before any infestation is shown as S_0. As drawn the United States is an exporter of the crop. That is, S_0 lies to the right of D for most prices. The difference between the initial supply and the demand is shown as ES_0 in the world market which gives the quantity the United States is willing to export at each price. The initial excess demand in the right panel is labeled as ED_0 and gives the quantity the rest of the world wants to import at each price.

Prior to any infestation the equilibrium is determined where the quantity the United States is willing to export equals the quantity the rest of the world wants to buy. This equilibrium yields a price of P_0 and U.S. exports of X_0. Inside the United States the quantity consumed is C_0 and the quantity produced is Q_0.

An infestation reduces output. This is shown as a leftward shift in the U.S. supply to S_1. The supply reduction means less of the crop is available for export at each price so the excess supply shifts left as well to ES_1. Price rises to P_1 and exports fall to X_1. In the United States the quantity of output falls to Q_1 and the quantity of the crop consumed falls to C_1.

An infestation can also trigger a response from importers which reduces the quantity they buy from the United States, shown as an inward shift of excess demand in the right panel to position 1. Consequently U.S. exports fall to X_2 and the market price falls to P_2 in order to force the U.S. market to absorb the lower export volume. As a result the quantity consumed inside the United States moves to C_2 which exceeds the initial quantity. The output quantity falls further to Q_2 depending on the price responsiveness of supply. As drawn in Figure 1 then, the export reduction dominates the supply reduction and the new equilibrium price is lower due to the infestation.

In order to examine this interaction of shocks to the supply and demand schedules, a partial equilibrium agricultural livestock and feed sector model is employed to quantitatively estimate the potential economic impacts of an incursion of *Harpophora maydis*, Late Wilt of Corn into the United States. A more detailed model description appears in Appendix A. The model reports the percent changes in prices, quantities produced, consumed, and traded for the commodities included in the model that result from potential pest related shocks. These percent changes are used to calculate changes in economic welfare.

The change in the economic welfare of producers consists of changes in three variables. One variable is the change in returns to capital and management from sales. For crop growers, returns to capital and management are market sales less purchased inputs and a land rent. This measures the residual monies available to cover payments to owned capital such as buildings and equipment, to pay taxes and other fixed costs, and for operator labor. The model separates land owners from operators so calculates a return to land separately. For livestock growers, returns to capital and management are market sales less feed costs. For meat processors, returns are calculated by subtracting purchased input costs from market sales. In a sense, the returns to capital and management for crop and livestock growers and meat processors are a measure of value added along the supply chain. The second component of change in producer economic welfare is any change in U.S. Government commodity program payments. Although subject to various rules, these payments tend to increase as price falls and decline as price rises. The third component of the change in producer welfare is the value of the crop lost. The previous components of the change in producer economic welfare use sales quantity. In the case of a disease outbreak growers planted a crop and incurred the expenses but experience a loss of output. As argued by Paarlberg, Lee, and Seitzinger an adjustment of the full value of the lost sales must be made since production expenses are already incurred to estimate this third component.

The economic welfare of consumers is measured by the difference between what consumers are willing to pay and what they must pay for each unit consumed. This difference is called consumer surplus.

The impacts of a disease infestation on economic welfare can be observed in Figure 1. When the price falls from P_0 to P_2 because of the lost exports, consumers gain surplus. The same price reduction means uninfested producers lose economic welfare – returns to quasi-fixed inputs. Infested growers suffer from the lost output. If the price increases from P_0 to P_1 consumers lose economic welfare. Uninfested grows gain economic welfare while infested growers suffer an economic welfare loss.

Although the net national change in economic welfare is conditioned by the magnitudes of the output reduction and export shock as shown in Figure 1, there are other critical aspects to consider. One factor is that except for lamb meat, the United States is a “large” country which can affect its terms-of-trade. Free trade is not an optimal policy for a “large” country, rather welfare optimizing import tariffs and export taxes are the optimal policy instruments to correct for the externality of country size. A related aspect is that the United States engaged in land retirement for many years. The idea behind land retirement was that the United States could raise market prices and farm income by taking land out of production. This behavior is also related to the terms-of-trade effects discussed above since land retirement act like an implicit tax on consumption and exports. An infestation is a form of land retirement because output is reduced. Part of the output reduction and ensuing price increase is conditioned on the output response in the Rest-of-the-World. Land retirement or disease infestation works to boost returns in the short-run when other nations’ production response is limited. The model used in this analysis is quarterly and precludes a long-run response by other nations. The economic welfare changes in Figure 1 are for a single crop which is treated as a final good and evaluated at a common market level. The simulation modeled includes multiple crops so there are spillover effects, crops are used at multiple market level along the supply chain, and the producer and consumer economic welfare changes are evaluated at different market levels. Reduced prices of corn or wheat cause sympathetic price movements for forage and soybean meal prices which generate welfare gains for users of those crops. Lower feed costs generate gains for livestock growers and translate into reduced animal prices. Lower cost animals yield benefits for livestock processors and lower livestock product prices which mean gains for consumers of beef, pork, poultry meat, eggs, and dairy products. The total changes in economic welfare reflect the aggregate of gains for all of these agents.

Scenario Supply Shocks

Potential output reductions are determined by following a general process. First is determination of the crop or crops affected. Next, the means of introduction is identified. Third, the location of detection is specified. Output reductions with detection depend on the degree of infestation, the yield effects, and control strategies. Based on the nature of the pest, movement and spread are projected to indicate output reductions in subsequent years. An important feature of the output reductions are that they are introduced in the assumed quarter of harvest. Another important behavior is that crop producers react to the previous season's return relative to alternative crops but do not anticipate continued infestations. That means a price increase last season from one crop relative to another crop's price induces an increase in planned output even though the price increase last season resulted from a pest infestation.

Late wilt of corn is a seed- and soil-borne vascular pathogen (USDA/APHIS, Recovery Plan for Late Wilt of Corn). Risk mapping indicates the highest risk in three regions: (a) Northeast Louisiana; (b) the boot heel area of Missouri and adjacent counties across the Mississippi River in Tennessee and Kentucky; and (c) southwest of Springfield, Illinois (Figure 2). Of these areas, the last represents the largest share of U.S. corn production and is assumed to be the initial point of detection. That is, the scenario analyzed assumes that the infestation occurs in a high risk region that is also a major growing region.

To motivate the hypothetical scenario assume that a corn plant breeder unknowingly imports contaminated seed. That seed is distributed to corn growers in Morgan County in Illinois which represents 0.19% of all U.S. coarse grain output in 2011. Data for 2011 is used because the severe 2012 drought may have distorted production relationships between these counties and national production. This county is assumed to be the initial point of detection. Detection occurs in the third quarter of 2013 – the 2012/13 crop year – which means the output reduction is realized in the fourth quarter of 2013 or the crop year 2013/14. Field yield losses for corn wilt reported in India and Egypt range from 40-70% (USDA/APHIS, Recovery Plan for Late Wilt of Corn). For this analysis the assumption is that corn production in the infested county is reduced by 50% since not all fields will be infested but losses in fields that are infested can be very high. Operations infested by corn wilt are assumed to be placed under quarantine with no corn sales outside of the county permitted for the remainder of the years simulated by the model. Thus, future corn supply for those counties is also reduced by 50%.

Since the pathogen survives in the soil and the stubble, the major vector for transmission is assumed to be via the movement of field equipment and trucks. Field equipment does not usually move long distances; staying within the county or moving to fields in neighboring counties. Thus, the neighboring county, Sagamon County, representing 0.33% of U.S. coarse grain production is assumed to be detected as infested in the summer of 2014 so affects output in the 2014/15 crop year. Trucks go between the field operations and local elevators which can be greater distances so a more distant county, Logan County, with 0.29% of U.S. coarse grain production also becomes infested for crop year 2014/15. Losses in county production are again set at 50%. Operations prohibited from selling corn outside the infested counties because of corn wilt remain under quarantine throughout the simulation years. Table 1 reports the annual loss in U.S. coarse grain output under these assumptions.

Spread of late wilt of corn continues. In year 2015/16, Cass, Menard, and Mason counties become infested – these counties represent an additional 0.38% of U.S. coarse grain output. In year 2016/17, Christian and Tazewell counties are added. This brings the total output loss to 0.85% of U.S. coarse grains production. In the final year of the simulation, 2017/18, Shelby and Fulton counties are infected, bringing the national share of production in the affected counties to 2.1%. As before the assumption is that 50% of those crops are lost to late wilt of corn so the national loss is just over 1% of U.S. coarse grain output.

Scenario Export Shocks

Export reductions are based on several factors. One factor is the location of the pest incursion and its subsequent spread in the United States. The current global distribution of the pest is another factor that influences the number of export markets impacted. Also important are potential treatments that could mitigate the risk of exporting a pest. In addition, export destinations and the means used to import from the United States play a critical role in determining the magnitude of U.S. export reduction. Export reductions are introduced in the model in the quarter of pest detection. In this scenario that is the third quarter of 2013 or the 2012/13 year.

H. maydis (Late wilt) is currently only reported in Egypt, India, Portugal, Hungary and Spain (Molinero-Ruiz, and Melero-Vara, 2010). Determining reductions in U.S. exports is complicated and requires balancing each importer's need for U.S. corn and the risk posed by imports that could contain late wilt of corn contamination. Detection is assumed to occur in early July. The immediate response of trading partners is to halt imports of U.S. corn for one month. A one-month moratorium allows time for the United States to impose a certification system that guarantees corn is exported from uninfected counties. Buyers of U.S. corn such as Japan and Korea have livestock feeding industries highly dependent on corn imports. The assumption is that these nations would continue to import corn from the United States because individual arriving ships could be inspected and shipments would be certified as free of late wilt of corn. They would replace some U.S. corn with purchases from Argentina, South Africa, Central Europe, and Thailand. They would substitute limited amounts of feed wheat, barley, and sorghum sourced from non-U.S. exporters such as the European Union and Australia. Except for Canada and Mexico, importers of U.S. corn are assumed to reduce imports in the initial year by 5% once the certification process is in place. In later years with increased production of coarse grains around the world the reduction of imports of coarse grains from the United States for these traders is assumed to be 10%.

Canada and Mexico need to be considered separately because of their unique trading situations. Both nations import substantial quantities of U.S. corn. Unlike other importing nations, Canada and Mexico can import via truck and rail. That means policing the quality and origin of shipments is more difficult. Canada imported 953 metric tons of corn (except seed) in 2011 (USITC). Corn imports from the United States for marketing year 2011/12 represented around 6% of its total use of corn. It is a large exporter of wheat, some 17 million tons compared to domestic use of about 10 million tons. Canada also exports 1.3 million tons of barley, 1.7 million tons of oats, and 493 thousand tons of corn (USDA/FAS. *PSD Trade Database)*. The assumption in this analysis is that Canada can replace all imports of U.S. corn. Mexico imports over 7-10 million metric tons of corn from the United States annually. Annual imports by Mexico in 2011 were 8.6 million tons. While corn is central to the Mexican agricultural economy and that nation would be wary of infection, Mexico is assumed to have less flexibility to replace imports from the United States. Presently imports of corn from the United States constitute around 34% of corn consumption (USDA/FAS. *PSD Trade Database*). Mexico could source corn from other nations, it could operate with lower carry-over stocks, and it could substitute wheat and sorghum. Nevertheless, Mexico would still likely need to import substantial volumes from the United States. The assumption in this analysis is that Mexico reduces annual corn imports from the United States from 8.6 million tons to 6.6 million tons.

The percent reductions in U.S. coarse grains exports calculated from the above assumptions are reported in Table 1. Detection occurs in the third quarter of 2013. Because the 2011 export volumes are used to identify U.S. corn exports by quarter and destination the percent reductions are calculated relative to the total U.S. coarse grain exports for the corresponding quarters. Model shocks are applied to the quarters starting in the third quarter of 2013. Baseline U.S. coarse grains exports in the July-September quarter are 12.92 million tons of which Mexico buys 1.9 million tons and Canada buys 445,012 tons (USITC, *Trade Data Webb*). The assumption is that all exports are halted for 1 month after detection, so the July loss in corn exports is 4.2 million tons. Canada is assumed to replace all imports from the United States so those quantities are removed from the monthly figure. Mexico is assumed to reduce imports by 2 million tons annually. That means a loss of 155 and 143 thousand tons per month in August and September. For the remaining quarters, the reduction in Mexican imports of U.S. corn varies from 377 to 597 thousand tons. The remaining export destinations are assumed to cut corn purchases from the United States by 5%. Thus, compared to the quarter total, U.S. coarse grains exports fall 39%. In the fourth quarter of 2013, the certificate system applies in all months so there is some recovery in trade, a loss of 14%. Based on the methodology and assumptions, the first two quarters of 2014 have export reductions of 8% and 12%, respectively. Canadian and Mexican import behavior is assumed to continue in the remaining years while shifts in production and consumption in the rest of the world allow some more substitution so the decline is slightly larger. The third quarter U.S. export loss starting in 2014 is 14% and the fourth quarter loss in U.S. coarse grains exports is 15%. The first two quarters of 2015 have U.S. export losses of 12% and 17%. This pattern is assumed to persist.

World Trade Organization (WTO) rules allow for the possibility that an infected region within a nation is prevented from exporting while the remainder of the nation can continue to export – regionalization. Since the Late Wilt of Corn infestation is assumed confined to counties in Illinois, regionalization should be considered. In a second scenario, the regionalization assumption is that corn cannot be exported overseas from the State of Illinois. The export reductions described above are modified to recognize that Illinois supplies roughly 15% of U.S. corn exports. The reaction of trading partners in the detection month is assumed to be the same since the situation is unclear at that point. Once the certification system is in place, trade is regionalized. The export shock in the detection quarter is reduced to 34% and then is lowered to 2.1% for quarter 4. For the first quarter of calendar year 2014 the export loss is 1.2% and is at 1.8% in quarter 2 with 2% for the remaining quarters of 2014. Subsequent years repeat that pattern.

Results

Table 2 reports the supply, use and price for U.S. coarse grains with and without trade regionalization. The critical drivers of the results are the assumed reductions in exports of coarse grains and the reduction in corn output. These drivers affect the price of corn in opposite directions with the export reduction acting to lower the price of corn while the output reduction acts to increase the price. As can be seen from Table 1, the export reduction dominates in the first marketing year. Thus, the price of corn falls (Table 2). In year 1, marketing year 2012/13, there are only the lost exports in the final quarter. The average corn price is $3.17 per metric ton lower in the absence of regionalization and $2.79 per metric ton lower with trade regionalization. The small difference in results for marketing year 2012/13 reflects the assumption that when late wilt is first detected all trading partner halt imports of corn for the United States in the first month -- July. Trade regionalization only eases the export reduction starting in August and September of 2012/13 so has little impact that first year. In subsequent years in the absence of trade regionalization price declines increase by over $13 per metric ton. The larger price declines reflect increased carry-in stocks as export growth slows and increases in domestic demand are not sufficient to offset the exports lost (Table 2).Trade regionalization strongly alters the magnitudes of the price effects and the pattern. The price declines moderate in marketing years 2013/14 and 2014/15 and then prices rise above the baseline for the remaining years of the simulation period as the supply effects become increasingly stronger. Because the loss in U.S. corn exports with trade regionalization is small – only about 1 million metric tons – the decline in corn output leads to reduced carry-in stocks in the last two years – 2016/17 and 2017/18. Tighter supplies cause higher prices, $2-$4 per metric ton.

The total impacts for the coarse grains sector are reported in Table 3. As for the price results there are strong differences with and without trade regionalization. There is very little difference for 2012/13 since the trade losses are similar. Without trade regionalization U.S. coarse grain growers lose $890 million in returns to capital and management. That loss does not include changes in payments to land owners. With trade regionalization, the decline in returns to coarse grain growers is slightly smaller -- $779 million. In subsequent years loses to coarse grain producers become greater when trade is not regionalized. The decline in returns to capital and management for growers with crops rise to over $4.7 billion per year while losses to growers with crop infested by late wilt of corn increase to over $600 million per year. In the absence of trade regionalization, the loss in the coarse grains sector is $21.8 billion over the six crop years. Trade regionalization does not alter the losses by growers infested with late wilt of corn but does change the impact on coarse grain producers who are not infested with late wilt of corn. For the last three years of the period analyzed those growers benefit since market prices rise as more corn is lost to the disease. For the six year period growers with crops not infested by late wilt of corn increase their return to capital and management by $169 million. Thus, the total sector loss is $1.5 billion.

It is important to remember that the direct losses from the assumed outbreak of late wilt of corn are concentrated in a small group of corn growers in Central Illinois. Table 4 uses yields from anticipated 2013 Central Illinois crop budgets for corn following soybeans to examine the change in returns to 500 acres of corn (Schnitkey). Depending on the land productivity, during a late wilt of corn outbreak in Central Illinois, 500 acres of corn infested with late wilt in 2013 returns $112 - $120 thousand less when trade is not regionalized, a decline of over 55%. The same amount of acres in the same part of Central Illinois that is not infested has returns of $10 −

$19 thousand less, 8.8% less. Trade regionalization does little to help the grower with infested crops. The infested 500 acres shows returns lower by $103 − $111 thousand with trade regionalization, a decline of 51%. The slightly smaller loss is because trade regionalization reduces the export loss so growers with late wilt receive a higher return on the corn they are able to harvest. Trade regionalization makes considerable difference to growers who have corn not infested by late wilt. On those 500 acres returns are only about $6 thousand lower during the outbreak, a decline of 2.8%.

In the absence of trade regionalization, spillover effects to other crops cause their price to fall in sympathy with the decline in the corn price (Figure 3). The lower price of corn encourages feeding of corn so demands for other competing feeds fall. Reduced corn output means added production of alternative crops. Forage and soybeans show the strongest substitute effects, followed by wheat.

The total loss in returns to capital and management for producers of the commodities modeled from crop years 2012/13 to 2017/18 is $41.3 billion. The largest losses occur for producers of coarse grains, forage and pasture, and wheat. Large losses are incurred by forage and pasture growers, $16.42 billion. Those crops are only used for feed and prices are not supported by U.S. Government programs. A decline in the price for the competing feedstuff, corn, means forage and pasture is less valued. Wheat growers lose $646 million. Rice growers lose $19 million. Even though the soybean price is lower (Figure 3), returns to soybean growers increase by $377 million over the 6 years as land shifts into soybean production. Land owners experience a loss in payments to land of $9.9 billion.

Lower feed costs mean that livestock producers benefit. The largest gain in the returns to capital and management (sales receipts less feed costs) occurs for beef cattle, $5.2 billion, followed by swine, $769 million, and Milk and dairy, $180 million. Returns to egg, lamb and sheep growers also rise as feed costs fall.

Meat and poultry production sectors experience gains in returns to capital and management. Over the simulation period meat and poultry processors gain $582 million on a base value of $48.2 billion.

Because the export demand reduction for coarse grains dominates the supply reduction crop prices fall. Consumer economic welfare is measured as consumer surplus which is the difference between the price consumers would be willing to pay and the market price for each unit consumed. There are two components to this measure. One component is the difference between the willingness to pay and the price for each unit. The second component is the number of units consumed. Consumers benefit from falling prices (Table 5). For the period of crop years 2012/13 to 2017/18, U.S. consumer surplus rises by $35.3 billion.

The gains in consumer economic welfare highlight the critical nature of the shocks assumed. In this scenario less than 2 percent of output is lost, but the export disruption ranges from 8 to 39%. Thus, the reduction in excess demand dominates, so prices for all commodities fall. If the certification system leads to regionalization of U.S. coarse grains exports such that there is little export loss from the infestation, the gains in economic welfare for consumers shown in Table 5 disappear and consumer surplus falls $1.4 billion.

Regionalization of U.S. exports also sharply alters the results for the changes in producer welfare for producers in sectors other than coarse grains because the regionalization assumed brings the export reductions for coarse grains in line with the output reductions. That means the supply shift and the excess demand shift shown in Figure 1 largely offset, leaving the equilibrium prices slightly higher over the simulation period. In the early quarters of the simulation period, the export loss dominates, but later quarters have stronger assumed output reductions. The increases in returns to capital and management for livestock growers estimated in the situation without export regionalization disappear or shrink. Growers with crops that can be sold gain a total of $737 million instead of losing $36.7 billion. The loss to infested growers remains at $1.7 billion, so a small group of corn growers continues to bear the bulk of the economic effects.

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Figure 1: Conceptual Impacts of an Infestation

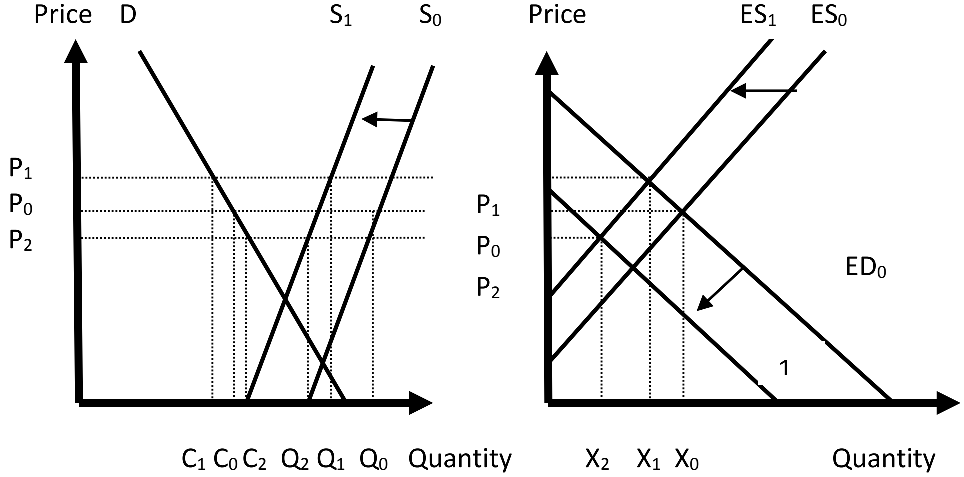

Figure 2: Risk maps for maize wilt based upon climate and host for growth of *H. maydis* causal agent of maize wilt during May and June.

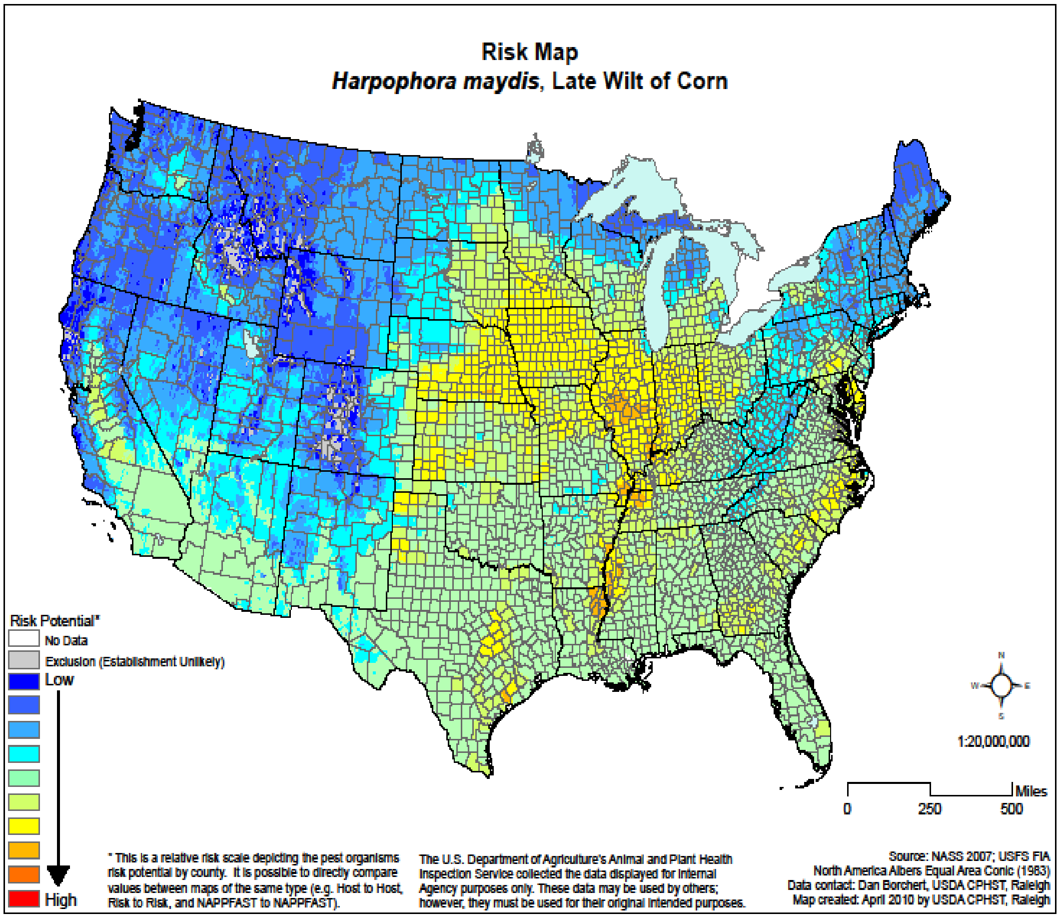

Table 1: Potential Coarse Grains Production and Export Shocks due to Hypothetical Introduction of Late Wilt of Corn

	Production Shock Calculation		Export Shock without Trade Regionalization Percent Reduction	Export Shock with Trade Regionalization Percent Reduction
	Base Output in Affected Counties (MMT)	Production Shock as a Percent of Total US Production		
2013 - Q1				
- Q2				
- Q3			-39	-34.0
- Q4	0.62	-0.1	-14	-2.1
2014 - Q1			-8	-1.2
- Q2			-12	-1.8
- Q3			-14	-2.0
- Q4	2.64	-0.41	-15	-2.0
2015 - Q1			-12	-1.2
- Q2			-17	-1.8
- Q3			-14	-2.0
- Q4	3.86	-0.59	-15	-2.0
2016 - Q1			-12	-1.2
- Q2			-17	-1.8
- Q3			-14	-2.0
- Q4	5.48	-0.85	-15	-2.0
2017 - Q1			-12	-1.2
- Q2			-17	-1.8
- Q3			-14	-2.0
- Q4	6.76	-1.04	-15	-2.0

Table 2: Supply, Use, and Price for U.S. Coarse Grains for a Late Wilt of Corn Infestation in Central Illinois with and without Trade Regionalization

Beginning Stocks	Units	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Base	mmt	31.1	25.2	62.0	66.1	55.6	51.9
No Regionalization	mmt	31.1	26.9	67.0	73.8	64.7	61.3
Regionalization	mmt	31.1	26.7	63.4	66.8	55.5	50.7
Production							
Base	mmt	285.8	382.1	359.4	346.5	358.6	367.1
No Regionalization	mmt	285.8	381.7	357.4	343.8	354.8	363.2
Regionalization	mmt	285.8	381.7	358.1	344.7	356.3	364.3
Imports							
Base	mmt	5.1	2.5	2.5	2.5	2.5	2.5
No Regionalization	mmt	5.1	2.5	2.5	2.5	2.5	2.5
Regionalization	mmt	5.1	2.5	2.5	2.5	2.5	2.5
Exports							
Base	mmt	22.6	48.3	53.1	55.5	56.7	58.6
No Regionalization	mmt	20.1	42.5	45.4	47.4	48.4	50
Regionalization	mmt	20.5	47.4	52.2	54.5	55.7	57.5
FSI Use							
Base	mmt	157.3	161.5	166	166.7	167.8	169.5
No Regionalization	mmt	157.9	163.2	168.7	170.2	171.7	173.3
Regionalization	mmt	157.8	162	166.2	166.5	167.2	168.3
Feed Use							
Base	mmt	116.7	137.5	138.8	137.4	140.4	143
No Regionalization	mmt	116.8	138	139.6	138.5	141.5	144
Regionalization	mmt	116.8	137.6	138.8	137.2	140.1	142.5
Ending Stocks							
Base	mmt	25.2	62.0	66.1	55.6	51.9	50.5
No Regionalization	mmt	26.9	67.0	73.8	64.7	61.3	59.8
Regionalization	mmt	26.7	63.4	66.8	55.5	50.7	48.3
Farm Price							
Base	$/mt	270.89	212.59	161.41	169.28	173.22	177.16
No Regionalization	$/mt	267.72	205.07	152.64	157.08	159.85	163.65
Regionalization	$/mt	268.1	210.2	160.74	169.8	175.49	181.33

Table 3: Economic Welfare Impacts of a Hypothetical Late Wilt of Corn Outbreak on U.S. Coarse Grains Growers

	Units	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Return to Capital & Mgmt							
Base	mil $	32527.3	29482.6	22880.4	24112.4	25037.6	26035.0
No Regionalization	mil $	31636.9	26867.8	19811.4	19931.5	20416.9	21271.6
Regionalization	mil $	31748.7	28685.3	22623.5	24215.9	25684.2	27287.0
Crop loss							
Base	mil $	0	0	0	0	0	0
No Regionalization	mil $	0	71.2	214.3	316.2	475.9	614.7
Regionalization	mil $	0	71.2	214.3	316.2	475.9	614.7

Table 4: Change in Return to 500 Acres of Central Illinois Corn in a Corn after Soybeans Rotation for 2013

	No Regionalization		Regionalization	
	Infested	Unifested	Infested	Unifested
	thd $	thd $	thd $	thd $
High Productivity Farmland	-119.6	-18.9	-110.7	-6.2
Low Productivity Farmland	-111.8	-9.8	-103.4	-5.8

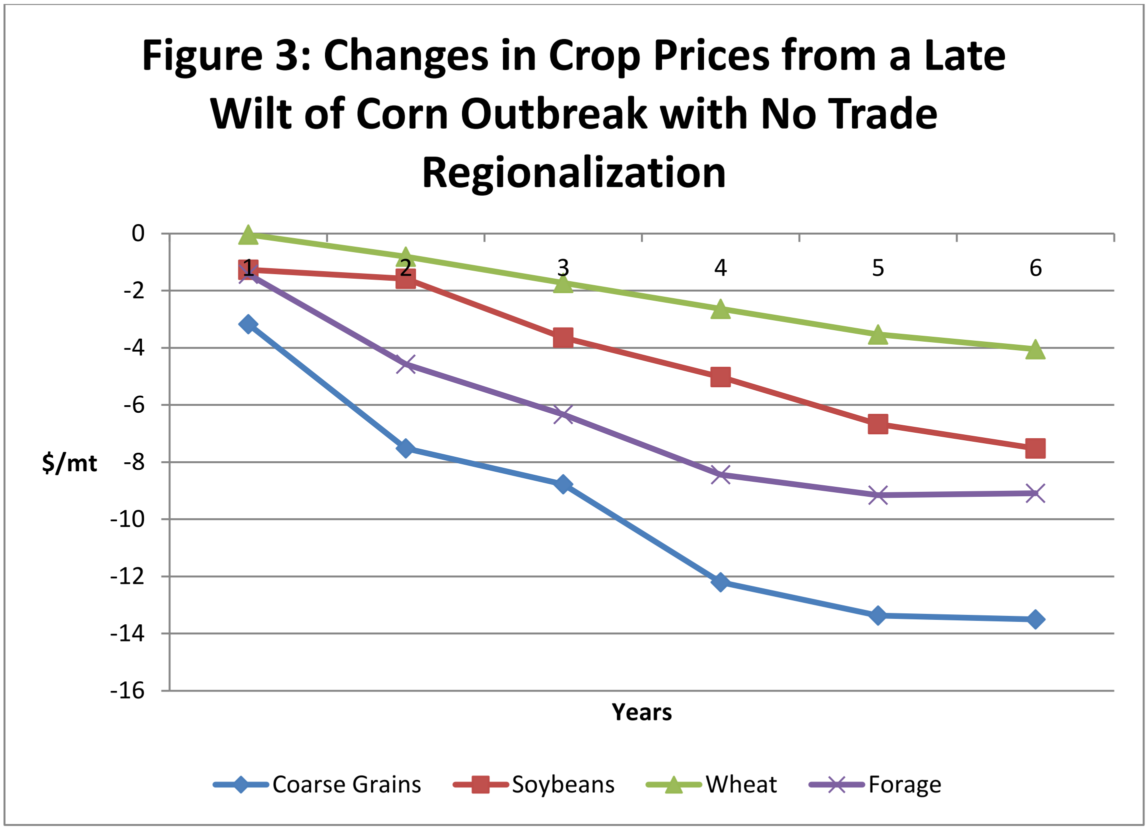
Figure 3: Changes in Crop Prices from a Late Wilt of Corn Outbreak with No Trade Regionalization
0
-2
-4
-6
-8
-10
-12
-14
-16
$/mt
1
2
3
4
5
6
Years
Coarse Grains
Soybeans
Wheat
Forage

Table 5: Changes in Economic Welfare with a Hypothetical Late Wilt of Corn Outbreak, No Trade Regionalization

	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	Total
			-- million $ --				
Meat Processing	57	104	74	106	120	121	582
Eggs	23	44	39	53	60	64	283
Dairy and Milk	143	126	44	7	-47	-93	180
Beef Cattle	168	521	835	1155	1269	1278	5226
Hogs	33	77	124	162	184	189	769
Lambs and Sheep	1	3	4	5	6	6	25
Coarse Grains	-890	-2686	-3283	-4497	-5097	-5378	-21832
Forage and Pasture	-720	-1814	-2589	-3484	-3939	-3838	-16384
Wheat	-4	-47	-88	-133	-176	-198	-646
Soybeans	-4	-2	50	71	117	145	377
Rice	0	-1	-3	-4	-5	-6	-19
Soybean Processing	-44	-5	11	15	27	35	39
Land	0	-843	-1336	-2109	-2703	-2937	-9928
Total Production	-1237	-4523	-6118	-8653	-10184	-10612	-41328
Consumer Surplus	1290	3746	5504	7640	8482	8646	35308

Appendix A: Modeling Approach

The general modeling approach follows that of Jones (1981) and Sanyal and Jones (1982). The model and application are based on several key assumptions: Agents are assumed to be price-taking maximizers of well-defined objective functions. Consumers determine consumption by maximizing a well-defined, homothetic utility function, given income and prices. Producers select a netput vector that maximizes profits subject to a well-defined, constant-returns-to-scale production function. There are four types of inputs, or factors of production. One type of input is mobile among production activities and is in perfectly elastic supply. A second set of factors of production are sector-specific intermediate goods. A third type of factor is sector-specific capital. The final factor is land, which is mobile across crop production. Thus, the model has the structure of a Ricardo-Viner or Specific-Factors model where perfect competition prevails. The original model is described in Paarlberg, Hillberg Seitzinger, Lee, and Mathews, Jr.

Total consumption of final goods (beef, pork, poultry meat, lamb and sheep meat, eggs, milk, wheat, coarse grains, rice, and soybean oil) in the current quarter depends on per capita consumption and population during the quarter. Per capita consumption is driven by retail prices.

Goods (meats, eggs, milk, animals, and crops) are produced by separate industries (sectors). Production of meats, eggs, and milk is assumed to occur during the current quarter, while production of animals and crops are lagged according to biological limitations. Three types of production factors are used; factors in perfectly elastic supply, animal intermediate inputs, and sector specific primary factors. Markets clear at prices determined by market clearing identities that are consistent across time with biological lags.

Breeding and replacement decisions reflect the expected relative profitability of producing animals or products for future sale plus salvage values and previous period livestock inventories. During a disease outbreak, these inventories (and values) are adjusted to reflect disease-induced losses.

Four types of feed are wheat, coarse grains, soybean meal, and forages and pasture. Each livestock species has unique derived demands for feed. Use of each feed ingredient is a function of the feed prices and the number of animals consuming feed in each stage. The model reflects the fact that cattle, hogs, sheep, and lambs have production cycles spanning more than one quarter.

The structure of the model's dairy component differs from those of other livestock species because the model determines milk production using the zero profit and specific factor market clearing conditions. Milk output is determined directly because production costs for milk include the feed costs, but not the cost of replacement heifers. Due to their fast production process poultry have kills determined in the current quarter using zero profit and specific factor market clearing. The model determines egg production using the zero profit and specific factor market clearing conditions. Trade is linked to U.S. market prices, trade policy, and disease outbreaks. Trade policy intervention is modeled as a specific trade intervention during the current quarter, with trade determined by the U.S. domestic price less the specific trade intervention.

In addition to the intermediate feedstuff demands, there are final (retail) demands for crops. Crops included are wheat, coarse grains, soybeans, rice, and forage and pasture. Focusing on the supply side, crop production occurs at set times and then becomes carry-in stocks in subsequent quarters until a new crop is harvested. Crop supplies in a given quarter are any production in that quarter, plus carry-in stocks. Another key feature is that, due to the dynamics of production, production decisions are made well before harvest based on expectations of returns for the crops. Except for forage and pasture, all of the crops included in the model are program crops. This means the influence of the various U.S. Government price and income supports must be incorporated. Acreage allocations are based on expected returns for each crop at harvest, with expected returns being the previous harvest prices plus appropriate government payments. The computations are done in quarter 1 so that acreage allocations consistent with one crop cycle can be imposed. Since there are both winter and spring crops in the model, this is a simplification of the actual decision process. Soybeans and rice are spring single crops (planted in the second quarter of the current year and harvested in quarters 3 (rice) or 4 (soybeans)), coarse grains (corn, sorghum, millet, barley, rye, and oats) are planted in quarter 2 and harvested in quarters 3 and 4. Barley is planted in both winter and spring and is assumed to be harvested in quarter 3. Spring wheat is planted in quarter 2 and harvested in quarter 3. Winter wheat is planted in the fourth quarter of the previous year and is assumed to be harvested in quarter 2. The acreage (production) decision for that second-quarter harvest is assumed to be made in the first quarter of the year and is based on returns to second quarter wheat in the previous year. This is done to create a consistent use of land because it requires arranging inputs earlier in the year and constrains cropping decisions in the spring.

Forage and pasture poses problems similar to wheat. Production occurs in quarters 2 and 3. Forage and pasture acreage is assumed determined in quarter 1 based on the quarter 2 and 3 prices of the previous year.

The return to land captures the negotiation process between farmer and landlord for land rent on the upcoming crop season. Thus, the expected return to physical and human capital is determined by the expected zero profit condition. Expected returns for crops consist of several parts and vary depending on market conditions. The price expected in quarter 1 is that prevailing in the harvest quarter of the previous year. The returns also reflect U.S. Government payments of which there are several. There is some debate about how they affect production, for example, the decoupling issue (Goodwin and Mishra).

The farmer is assumed to receive loan deficiency payments (LDPs) equal to the difference between the loan rate (LR) and market price when the LR exceeds the quarterly market price. Payments are made on the full amount of production. Direct payment rates (DPs) are established in law. Total payments are the rate multiplied by 85 percent multiplied by program yield and base area. Additionally, the 2008 farm bill provides for counter cyclical payments (CCPs) calculated from an announced target price (TP). The payment rate is the difference between the target price, less any direct payment, and the market price when the market price is above the loan rate. If LDPs are paid, they are deducted from the CCP calculation. The payments are 85 percent of the payment rate times the eligible production, which is program yield times crop base acreage. The expected return is the expected price on the previous crop plus CCP payments, LDPs, and direct payments.

The 2008 farm bill introduced the ACRE program designed to stabilize farm crop revenue using historical average prices, production, and income relative to current year values. The program operates from crop year 2009 onward. This program is modeled using a simulator for the program to generate schedules of payments related to price changes from baseline values. Participation by crop is set according to the crop year 2009/10 rates reported by the U.S. Department of Agriculture.

Loan deficiency payments are coupled payments. A critical issue is whether direct payments and CCPs are de-coupled or not. Returns to human and physical capital and to land cannot be adequately modeled without including these payments, so they are reflected in the model and affect the dynamics of the model solutions. The payments are modeled to affect relative per-acre returns among program crops. Since forage and pasture are not program crops, there is no direct price adjustment, but there is a relative price effect.

Sector-specific, factor-market-clearing conditions using expected rent and factor prices in quarter 1 determine crop output for the harvest quarter. Land is mobile among the crops with a return determined in quarter 1 by the expected return for the upcoming crops. While crop output is determined based on the expected returns to sector-specific factors, actual returns to the sector-specific factors can differ. Actual market prices are determined in the market-clearing identities. Once the crop market prices are known, the LDP and CCP payment rates and total payments can be calculated. The actual return to the program crop is found with the addition of the payments. The return to forage and pasture is the market price since there is no program.

The soybean complex is included because soybean meal is a major feed and soybeans compete with other crops for acreage. In addition to the soybean production as a crop, there are demands for soybean meal in feeding and soybean oil for food. Thus, soybean processing, or crushing, into the joint products of meal and oil, is modeled as a function of the current period crushing margin.

Model closure requires domestic and international market-clearing relationships for quantities and prices. Exports depend on prices and trade interventions and, in some cases, on the disease outbreak. For many agricultural goods the United States is an exporter and does not intervene in the market. While many agricultural goods are imported into the United States without restriction, beef and dairy products are subject to tariff-rate quotas, TRQs. To facilitate model solution, it is assumed that the quotas are not filled, and the below-quota specific interventions apply. The remaining imports are explained by an excess supply to the United States.

Numerical solution of the economic agricultural sector model is facilitated by a total logarithmic differential version of the model described. The logarithmic differential version has several advantages. One advantage is that the differential version is driven by elasticities, which are easier to obtain than specific functional forms and are also more intuitive than partial derivatives. Another advantage is that the elasticity version can be applied to observed historical data.

Meat, milk, and egg production are described by the zero profit equations and specific factor market clearing conditions. Totally differentiating the zero profit conditions, applying the envelope property, and with quantity normalization on the unit isoquant, the percentage change in the price is a linear combination of the factor price changes. With the mobile factor price exogenous, the mobile factor market clearing identity is dropped so the specific factor market clearing conditions can be partitioned into two sets of equations, the per-unit use of physical and human capital and the derived demand for animals for beef cattle, swine, lamb, sheep, and poultry slaughter and for dairy cow and poultry layer production inventories.

Completing this part of the model requires specifying the changes in per unit factor uses with a matrix of Morishima elasticities of substitution (e.g., Chambers, 1988, p. 96) between mobile factors and capital and between animals and capital under constant returns to scale. Logarithmic differentiation links changes in the ratio of per unit factor use to change in factor prices via the elasticities of substitution.

The feed demands reflect the age distribution and flow of animals. Because the per unit feed demands are responsive to changes in relative feed prices, the percentage changes in the derived demands for feeds also use elasticities of substitution between each feedstuff and each category of each species of feed-consuming livestock.

The next component to the model consists of logarithmic differentiation of the crop production structure to determine changes in expected returns for each crop and changes in production of each crop, including changes in land allocations, which determines the land rent. Soybean crushing depends on the margin which depends on the prices of soybean meal, soybean oil, and soybeans. With assumed constant meal and oil yields, differentiating the crush demand and the margin identity gives changes in supplies of meal and oil.

Closure requires logarithmically differentiating the remaining equations. The excess demand and excess supply equations include trade policy interventions. Since several commodities do not have trade interventions, the logarithmic change is not defined. Thus, trade policy interventions are treated as specific (per-unit) policies and the differential form differs from the other equations. In addition, each commodity has a market clearing condition in which the total differential includes derived demands for animals and for feed ingredients and maintains the linkages through the total differentials of the margin-markup equations. This vertical linkage improves the numerical accounting of the impacts, but does not affect model response to shocks.

Elasticities are critical parameters and are grouped into several sets. Most own- and cross-price elasticities of retail demand are based on estimates from econometric models. These values indicate the willingness of consumers to alter purchases in response to short-run price changes. The own-price elasticity gives the percentage change in the quantity consumed of a commodity given a 1 percent change in its price. The cross-price elasticity gives the percentage change in the quantity consumed of a commodity given a 1 percent change in another commodity's price. Cross-price elasticities are non-negative, implying that the commodities involved are substitutes, and small, which affects how the model reacts to disease outbreaks that alter prices. There are some spillover effects in meat consumption, but not many elsewhere.

Substitution elasticities describe derived demand behaviors and affect supplies of the output commodities. Substitution elasticities describe the percentage change in the ratio of inputs used in the production of a good in response to a 1 percent change in the input price ratio. For example, the change in the ratio of chemical use to land in wheat production as the price of chemicals changes relative to the land rent is described by an elasticity of substitution.

Revenue shares appear in the logarithmic differential equation form of the competitive profit conditions. Factor shares appear in the logarithmic differential equation form of the land market clearing. Cost-of-production data for corn, wheat, soybeans, rice, hogs, cattle, and milk are divided by production revenue to find the revenue shares. Crop revenue includes U.S. Government payments since they are necessary for land, capital, and management to show positive returns. For live animals the major revenue share is allocated to feed costs followed by the residual return to capital and management. Milk is an exception because the animal value is implicit as the milk costs include feed and veterinary costs. Meat industries show low residual returns to capital and management because the bulk of revenue is allocated to animal costs. The exceptions are poultry meat and eggs. Poultry meat and eggs are treated as vertically integrated industries with firms capturing the difference between meat and egg sales and feed costs.