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Analysis of Hypothetical Highly Pathogenic Avian Influenza Outbreak in Texas on the Supply Chain¹

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Background and Objectives

A domestic outbreak of highly pathogenic avian influenza (HPAI), a contagious disease of poultry, could have many economic impacts on the U.S. poultry sector and on related sectors. Previous analyses of poultry disease outbreaks separate the impacts into producers and consumers to look at the industry as a whole (Paarlberg, Seitzinger, and Lee, 2007; Brown, et al., 2007). However, the poultry supply chain consists of several actors and the effects of an HPAI outbreak as transmitted along the supply chain—from contract growers, processing firms, retailers, and consumers - are asymmetric because margins change in response to market shocks (Floyd, 1965; Gardner, 1975; Holloway, 1991). Changing margins mean changes in economic welfare by various economic agents along the supply chain are not uniformly distributed.

To understand the economic impacts of an HPAI outbreak it is important to decompose the impacts along the supply chain between various groups. This analysis does that decomposition for a hypothetical HPAI outbreak assumed to occur in Texas, which produces roughly 10% of U.S. poultry. When an outbreak occurs, there is production loss and potential domestic demand disruption. Additionally, export demand may be disrupted which is a key source of demand for US poultry products. Paarlberg, Seitzinger, and Lee (2007) found that an HPAI

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outbreak utilizing a regionalization strategy could reduce the economic losses by allowing unaffected regions to continue to export poultry and poultry products. However, regionalization shifts the burden of economic impacts to the isolated region which can alter the region's supply chain. Therefore, this analysis also considers regionalization as a response strategy in an attempt to reduce export demand disruptions.

Results from decomposition of economic impacts along the supply chain show that processing firms experience larger losses than contract growers because processing firms assume the price risk by using production contracts. Contract growers face production and income risk. Regionalization alters the pattern. Regionalization dampens effects in the rest of the United States, while increasing effects within the infected region for both contract growers and processing firms. Retailers experience gains in the value added at the retail level with and without regionalization. Consumers gain economic welfare from lower prices as exports decline without regionalization. Consumers outside of Texas lose consumer surplus while consumers in Texas benefit from low priced meat.

Methodology and Assumptions

National Quarterly Livestock Model

This study uses an updated version of the quarterly livestock model developed by Paarlberg, et al. (2008). A more complete discussion of the model is in Appendix A. Critical for this analysis is separating poultry meat into chicken and turkey. Chicken-meat production occurs within one quarter but because the production cycle for turkey meat exceeds one-quarter, dynamic adjustment is incorporated.

The economic model determines changes in prices, quantities, and economic welfare from a quarterly baseline for several commodities due to changes in domestic demand, export demand, and supply resulting from a disease event. The model captures the vertical and horizontal linkages among livestock products, livestock, and crops. The commodities included in the model are: beef, pork, lamb meat, chicken meat, turkey meat, eggs, milk, cattle, hogs, chickens, turkeys, sheep and lambs, coarse grains, wheat, rice, soybeans, soybean meal, soybean oil, forage, and pasture.

Assumptions for Responses and Strategies

There are three key impacts from an HPAI outbreak at the sector level. The first is the depopulation of birds due to disease in the infected state plus measures to reduce the risk of disease spread. The second impact is the reaction of U.S. consumers to the disease event, and the third is the response from trading partners. These impacts are introduced into the national quarterly model as shocks to the baseline.

Production Response

Depopulation of birds occurs in the first month of 2010 based on short durations found using disease spread models for HPAI outbreaks in the U.S. (Patyk, et al, 2013). Because of lagged production effects a shock to output is introduced into the model in both quarters 1

and 2 of 2010. This time period is used because when the study began data for 2010 represented the most recent quarters available so reflected current market conditions. The magnitudes of impacts would differ some for different quarters and years, but the general results remain valid. In this analysis a hypothetical HPAI outbreak affecting broiler and broiler breeder (parent farm) inventories in Texas lasts 1 month beginning January 1, 2010.

A spreadsheet determines production impacts associated with reductions in bird inventory. Spreadsheet assumptions include:

- 1) Meat birds and breeder birds have an equal chance of contracting the disease and thus being depopulated.
- 2) All meat broilers grown in Texas are from hatching eggs produced by breeder birds within Texas.
- 3) All breeder birds within Texas are supplied as day-old chicks from outside the State.
- 4) Eggs in hatcheries at the start of the outbreak would be allowed to hatch, and the resulting meat chicks would be placed on Texas farms.
- 5) Given the cost to raise grandparent birds, poultry genetic companies typically require commercial broiler companies to place their breeder bird orders approximately six months in advance. Consequently, the supply of day-old breeder chicks is assumed to be set for approximately 6 months in advance.

Production impacts are constrained to just two quarters because other regions of the country are assumed to increase production to compensate for lost production in Texas. Because of the assumptions about eggs in hatcheries, production in the first quarter falls by less than the depopulation. Lost production in the second quarter matches the inventory reduction due to depopulation

The number of birds depopulated is a critical driver of economic outcomes. Within Texas the disease control strategy is to depopulate all meat and breeder birds within quarantine zones, resulting in an assumed 10 percent reduction in Texas inventory for January 2010. In months 2 and 3 of the first quarter of 2010, production resumes so lost Texas production in the first quarter is 6.7 percent. In the second quarter, the effect of the lost breeding inventory due to the outbreak is realized, and production falls 10 percent.

Texas production losses are transformed into national losses by multiplying Texas' lost production by its share of the national production. Lost national production is 0.68 and 0.98 percent for quarters 1 and 2 and these production shocks are used in the national livestock model.

Consumer Response

Another potential impact from an HPAI outbreak is a reduction in demand by U.S. consumers. A discussion by Beach, et al. (2008) examines differences between Italian and U.S. consumers' food-risk perceptions. The comparison suggests any demand reductions in the United States would be minor. Consequently, this analysis assumes U.S. domestic consumers do not respond by lowering their preference for poultry products. No consumer shocks are used in the national livestock model.

Regionalization Strategy

Regionalization facilitates and maintains international trade in the event of a disease outbreak. Under regionalization, a region experiencing a disease outbreak can be treated as a separate part of a nation. The remainder of the nation can continue to export, so regionalization offers a strategy to dampen export losses.

With regionalization, Texas is assumed to be isolated from the rest of the U.S. for the first two quarters of 2010 because the disease outbreak occurs in the first month of the first quarter.² Surveillance control zones and movement restrictions are assumed to prevent poultry products from moving outside the state of Texas.

For the regionalization analysis, separate Texas models for chicken, turkey, and egg (table and hatching) sectors are used for the two quarters of the HPAI outbreak. The Texas models use the same parameter values as the national model. Since Texas is isolated, Texas producers and consumers of chicken, turkey, and eggs are removed from the national model based on the shares of Texas in national production and consumption.³ Texas producers and consumers are removed from the national model by introducing additional production shocks and consumer shocks, as shown in Table 1. Because Texas is a net exporter to the rest of the U.S., when Texas is regionalized those sales are blocked. Thus, Texas consumers which are 8.14 and 8.17 percent of the U.S. population in quarters 1 and 2 are removed from the national model because Texas production can only be consumed within Texas. Because Texas represents 9.85 percent of U.S. broiler and chicken meat production, the regionalization strategy production shocks take that percent of U.S. production out of the U.S. national model for both quarters 1 and 2 of 2010. Production shocks for turkey meat production in quarters 1 and 2 are -3.44 and -3.42 percent, respectively. Production shocks for egg production are -5.25 percent for both quarters.

International Trade Response

Exports are a large share of the demand for U.S. poultry, and the assumed trade response is critical. Trade shocks introduced into the model represent the decrease in export demand for U.S. poultry and poultry products in response to the outbreak. Trade shocks are developed for chicken, turkey, and egg exports for both the strategy that regionalizes Texas and the one that does not.

² The time period selected for regionalization is 2 quarters because the disease outbreak occurs in the first month of the first quarter, cleaning and disinfection occurs in the second month, and implementing restocking plans takes at least 1 month. World Organisation for Animal Health (OIE) guidelines would not consider the United States free of HPAI until 3 months after the last reported case. In the hypothetical outbreak analyzed, the United States would likely be considered free of HPAI on May 31, 2010, since a stamping-out response strategy (including disinfection of all affected establishments) is used (OIE, 2012).

³ The production shares are calculated from USDA/National Agricultural Statistics Service (NASS) data and adjusted to reflect national seasonal variation. The consumption in Texas is calculated by multiplying U.S. per capita consumption by the Texas population. That process assumes that the population in Texas consumes chicken, turkey, and eggs at the U.S. average. The supply and use calculated for Texas shows that the State is an exporter of chicken, but an importer of turkey and eggs. U.S. Department of Agriculture, National Agricultural Statistical Service (USDA/NASS). Agricultural Statistics, 2012. Website: www.nass.usda.gov accessed June 6, 2013.

The decision as to the time to export market recovery is influenced by historical evidence of HPAI outbreaks in other countries (Johnson, et al., 2011). Examples from previous outbreaks, suggest that U.S. trade partners would close their borders to U.S. poultry and poultry products for two quarters. Analysis of previous poultry disease outbreaks indicates that export markets recover quickly (Johnson, et al., 2011).

Historical export data are used to determine the percentage of poultry and poultry products banned each quarter under both the regionalization and no-regionalization strategies.⁴ Trade shares are paired with the stated trade embargo responses to an HPAI outbreak in the United States from trade partners. Texas exports account for a small percentage of total U.S. exports of birds, eggs, and egg products. Under the no-regionalization strategy, export losses are 93 percent in the first quarter and 31 percent in the second. Under the regionalization strategy, trade losses are assumed to be 29 percent in the first quarter and 6 percent in the second.

Model Results

While the model calculates economic impacts for many livestock, meat products, and crop commodities, the results presented focus on impacts to chicken along the supply chain. Model results are interpreted by comparing the baseline (without disease) to the strategies available in response to a disease outbreak, no-regionalization and using regionalization.

Chicken Meat Prices

The interaction between demand shocks and supply shocks drives the price results in each quarter. Declines in exports lower demand for chicken, turkey, and eggs. Depopulating birds reduces supply. Prices using the no-regionalization-strategy are lower in the first two quarters due to the banned exports flooding the domestic market (Figure 1). Prices move closer to the baseline as exports recover and the effects of the supply disruption dissipate.

Regionalization of Texas creates different price movements in Texas and the rest of the U.S. With regionalization, prices in the rest of the United States fall slightly below the baseline in quarter 1 and then increase slightly above the baseline in quarter 2. States not infected by the outbreak experience small price changes because disease-free regions can export products. Since Texas is an exporter to the rest of the United States, and because these exports are now blocked, export losses for other states are offset by reduced availability of chicken from Texas. In the rest of the United States, chicken prices rise above the baseline in quarter 2 because international exports recover to 6 percent below the

⁴ The 5-year average quantity of meat and edible offal exported by the United States from 2008 - 2012 is used to calculate trade shares for all possible importers of U.S. poultry and poultry products (U.S. Department of Commerce). The sum of trade shares from countries that would ban all poultry and poultry products from the United States as a result of a HPAI outbreak influences decisions on how much product would be banned from export. In addition, the type of product slated for export also influences trade decisions. For example, fresh and/or frozen poultry would more likely be banned during a trade embargo than processed (cooked) poultry products. The vast majority of exported U.S. poultry products (average 94.2 percent) are fresh or frozen. The remaining percentage of exported poultry products is processed. U.S. Department of Commerce, Bureau of Census. Texas and US annual exports of birds, eggs, and egg products accessed through Global Trade Information Systems, Inc, 2008 – 2012.

baseline while Texas is still quarantined. This circumstance results in a shortage of chicken in the rest of the United States because Texas represents 10 percent of U.S. chicken-meat production.

Since Texas consumes 60 percent of the chicken it produces, the price in Texas declines because of oversupply in that state. Once Texas is allowed to send chicken to the rest of the United States and the world, the price recovers. Small price differences in quarters 3 and 4 occur because the meat inventories accumulated must be worked down.

Chicken Industry Welfare Impacts

Figure 2 shows changes in U.S. chicken industry welfare, measured in returns to capital and management plus the loss in value of birds depopulated. The value of depopulated birds is calculated by multiplying the number of birds depopulated in Texas by \$1.30⁵, the lost value per bird.

Returns with and without regionalization decline in the first quarter because the export bans cause an oversupply of chicken on the domestic market resulting in lower prices. With no regionalization, quarterly returns to capital and management for chicken production fall roughly \$300 million. The change in returns remains below the baseline in the second quarter, a decline of around \$100 million. In the third quarter because exports recover and there are reduced carry in stocks of poultry returns are slightly above the baseline. Returns realign to baseline levels in the fourth quarter.

The chicken industry has first quarter returns below the baseline with regionalization, but the decline is less than without regionalization because the export loss is less. The first quarter loss under the regionalization strategy is approximately \$141 million and \$43 million in quarter 2.

The total change presented in Figure 2 disguises differences between the chicken industry in the rest of the United States and the industry in Texas. The distribution of losses for the chicken industry in Texas and the rest of the United States with and without the regionalization are presented in Table 2. The total base U.S. returns for chicken are \$671 million in quarter 1 of 2010, of which \$66 million accrue to the chicken industry in Texas and \$604 to the chicken industry in the rest of the United States. In the second quarter total U.S. baseline returns rise to \$822 million due to lower feed prices and higher poultry prices. Texas chicken industry returns are \$81 million with returns to the rest of the U.S. of \$741 million.

With the hypothetical HPAI outbreak in Texas total U.S. returns for the chicken industry are lower than the base levels for both quarters. However, they are still positive under the no-regionalization and regionalization strategies. The distribution of losses is different under each strategy, as compared to the baseline. For example, in quarter 1 the chicken industry in the rest of the United States experience returns of \$341.2 million without regionalization - a decline of \$263.3 million. With regionalization the chicken industry in the rest of the U.S. experience returns of \$527 million - a decline of \$77 million. Also in quarter 1, without regionalization the chicken industry in Texas experiences returns of \$37.4 million

⁵ Veterinary Services' appraisal values for broiler and breeder birds were used to determine a weighted average bird value based on mix of broilers and breeders depopulated and their average age.

plus a loss of \$7.5 million in depopulated birds for a net return of \$29.9 million, a \$36.2 million decline compared to the baseline. With regionalization the chicken industry in Texas experiences returns of \$10.1 million plus a loss of \$7.5 million in depopulated birds for a net return of \$2.6 million, a \$48.5 million decline. When these values are compared to baseline returns of \$66 million, the Texas chicken industry experiences a much larger percentage loss in returns than the chicken industry in the rest of the U.S. The same pattern follows in quarter 2. Of these losses, only the \$7.5 million loss due to bird depopulation is eligible for Federal indemnity. Indemnity payments are not considered in the calculation of chicken industry impacts; however they are expected to occur in the event of a HPAI outbreak. The remaining losses are borne by the industry itself.

An outbreak of HPAI in Texas has spillover effects on other sectors through substitution effects in demand and through feed costs. Model results show that the largest declines in economic welfare occur for crop producers and land owners, as reduced feed demands lower crop prices. In the no regionalization strategy, returns to U.S. coarse grains growers fall about 2 percent. Producers of other crops also experience declines in returns. On an annual basis, owners of crop land lose 0.7 percent. Returns to capital and management in other meat-processing industries experience small reductions, largely in the turkey industry. Sectors that benefit, such as beef cattle, swine, lambs, and dairy, are those using lower priced feeds.

Decomposition of Welfare Changes Along the Supply Chain

The previous results for the chicken industry are an aggregated impact for contract growers and processing firms. This section separates the changes in economic welfare along the supply chain for chicken. Changes in the economic welfare for contract growers, processing firms, and retailers of chicken can be identified from the results. The changes in economic welfare highlight asymmetric impacts along the supply chain and across regions. The change in aggregate economic welfare for consumers is estimated.

Contract growers are assumed to be paid for production delivered under preset contract terms so face production and income risk for non-delivery but not price risk. A payment rate based on proprietary information is set per pound of carcass weight for birds delivered. Contract growers experiencing depopulation because of an HPAI outbreak are unable to deliver birds and receive no payment. Contract growers who do not have birds depopulated can experience a loss in economic welfare if processing firms reduce the quantities of birds contracted (placed) due to reduced poultry availability from the depopulation of breeder birds.

The processing firms' economic welfare is measured as a return to capital and management on birds slaughtered for meat. That return is the difference between production value and costs for variable inputs. Variable inputs include feed costs for grains and protein feeds plus costs for labor, fuel, and other material. The residual is available to cover payments for capital, taxes, other sunk costs, and accounting profits. This structure reflects the integration of the industry in which processing firms own the birds.

Returns to retail sales are measured as the change in value added on retail sales of chicken. The per-unit margin is the difference between the retail price and the wholesale

price. That margin is multiplied by the quantity consumed to determine the value added. Value added is the amount remaining to retailers to cover other costs associated with chicken sales. Consequently, this measure includes both a change in margin component and sales quantity.

The change in economic welfare for U.S. consumers is measured as the change in consumer surplus. Because consumers purchase a set of goods, the total across the goods included in the model is reported.⁶

The economic welfare changes for contract growers are given in Table 3. In the absence of regionalization, the loss to U.S. contract growers in the first quarter is \$69.2 million. Regionalization lowers the first quarter total loss to \$22 million because the loss of exports is smaller so the price decline and the reduction in birds contracted are smaller. The distribution of economic welfare effects in the United States is altered whether or not regionalization occurs. Regionalization increases the welfare loss for contract growers in Texas from \$6.6 million to \$13.6 million in quarter 1. The loss to contract growers in the rest of the United States falls from \$62.6 million without regionalization to \$8.4 million with regionalization.

While contract growers face production and income risk, processing firms absorb the price risk. Table 3 also shows processing firms suffer larger losses in economic welfare than contract growers. In the no-regionalization strategy contract-grower welfare falls \$69.2 million in quarter 1. During that same quarter processing firm welfare is \$230.4 million lower. Of that decline, \$222.8 million is from lower returns to capital and management, while \$7.5 million is the lost value of depopulated birds owned by processing firms. Since all of the lost-bird value occurs in Texas, processing firms in that state bear a comparatively larger welfare decline. Just as for contract growers, regionalization lowers the total loss for processing firms and alters the pattern. For example, the decline in the return to capital and management for Texas processing firms in the absence of regionalization is \$22 million but the decline increases to \$42.4 million under regionalization. When compared to the baseline the welfare for processing firms outside of Texas without regionalization is \$200.8 million lower, but only \$69.0 million lower with regionalization.

The change in value added for chicken at retail gives an indication of the change in economic welfare obtained for moving chicken to retail sale for the first two quarters of 2010 (Table 4). Value added increases with and without regionalization. There are two sources of change. First, loss of exports puts downward pressure on prices for chicken products in quarters 1 and 2. As prices fall, the margin between retail price and wholesale price expands because the decrease in the retail price is less than the decrease in the wholesale price. Second, lower prices induce greater quantities consumed, which expands sales volume. The largest increases in value added—\$189.7 million for the first quarter— occur under the no-regionalization strategy because the export loss is larger so the margin increase is greater and the domestic increase in consumption is greater. Regionalization reduces the loss in exports

⁶ The goods included are: chicken, turkey, eggs, beef, pork, lamb meat, milk and products (milk fat basis), coarse grains, wheat, rice, and soybean oil.

and the price decline, so the welfare gains in retail value added are \$24.9 million in the first quarter.

Second quarter increases in value added are smaller because exports are recovering and because of the lagged effect of depopulating breeder birds. Both effects provide support for wholesale prices (Figure 1). The increase in the retail-wholesale margin compared with the baseline is small, as is the increase in consumption. When Texas is not regionalized, the welfare gain in second quarter value added is \$61.7 million. The relationship between the welfare gains in second quarter value added with regionalization differs from those without regionalization. The retail value added gain is \$24.6 million.

Changes in consumer surplus result from changes in prices for all goods as determined by the model results (Table 5). Chicken is just one of those commodities. Compared with the total U.S. consumer surplus of \$60-70 billion each quarter, the changes shown in Table 5 are small. When there is no regionalization of the outbreak, the large loss of exports in quarters 1 and 2 dominate the output reductions from HPAI, so prices for chicken and competing commodities fall. In quarter 1, consumers gain \$599.4 million. Regionalization of the outbreak in Texas results in declines in total U.S. consumer surplus in the first quarter of \$265.5 million. The decline in consumer surplus reflects a price increase, as the U.S. export loss is smaller and Texas, which is a net exporting region, is prohibited from selling to the rest of the United States. The national total disguises a pattern in which consumers in Texas gain from very low priced meat while consumers in the rest of the United States experience a loss in consumer surplus.

Conclusions

This analysis examines a depopulation response to a hypothetical HPAI outbreak lasting 1-month resulting in a 10 percent reduction in the January 2010 inventory in Texas. Compared with the national flock the number of birds lost is small, so export losses are the driver of the economic impacts. Since regionalization allows exports to continue from uninfected parts of the United States, estimates are compared using no-regionalization and regionalization strategies. In the absence of regionalization, U.S. exports in the first quarter of 2010 fall 93 percent with recovery to a 31 percent loss in quarter 2. Regionalization isolates Texas from the rest of the United States and lessens the assumed U.S. export losses to 29 percent in quarter 1 and 6 percent in quarter 2.

The chicken industry in the rest of the U.S. experience a smaller decrease in prices and loss in returns. Overall, regionalization mitigates the loss but means Texas is isolated from the rest of the United States, so the changes in price and returns are separated for the chicken industry in Texas. Prices in Texas fall more than prices in the rest of the United States, so the losses are concentrated on the chicken industry in Texas.

Decomposition of the economic impacts along the supply chain reveals that processing firms experience larger losses than contract growers because processing firms assume the price risk by using production contracts. Contract growers face production and income risk. Contract growers that cannot deliver on the contract because their birds have been depopulated are not paid. Contract growers whose birds are not depopulated experience

losses as reduced chicken prices cause processing firms to reduce production. Regionalization dampens effects in the rest of the United States, while increasing effects within the infected region for both contract growers and processing firms. Retailers experience gains in the value added at the retail level with and without regionalization. Consumers gain economic welfare from lower prices as exports decline without regionalization. Regionalization alters the pattern. Consumers outside of Texas lose consumer surplus because the export decline is smaller and supplies from Texas are embargoed. Consumers in Texas benefit from low priced meat, and national consumers experience a loss in consumer surplus.

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Table 1. Regionalization Strategy Shocks

	Broiler and Chicken Meat Production	Turkey Meat Production	Egg Production	Broiler Meat, Turkey Meat, and Egg Consumption
Quarter 1	-9.85	-3.44	-5.25	-8.14
Quarter 2	-9.85	-3.42	-5.25	-8.17

Table 2. Chicken industry returns in quarters 1 and 2 of 2010, millions of dollars

Chicken Industry Returns	2010 Quarter 1 (\$ mil)	2010 Quarter 2 (\$ mil)
Base		
Texas returns	66.1	81.0
Rest of U.S. returns	604.5	741.4
Total U.S. returns	670.6	822.4
No regionalization		
Texas returns	37.4	65.4
Texas value of depopulated birds	- 7.5	-----
Rest of U.S. returns	341.2	653.2
Total U.S. returns	371.1	718.6
Change in returns from base	- 299.5	- 103.8
Regionalization		
Texas returns	10.1	17.8
Texas value of depopulated birds	- 7.5	-----
Rest of U.S. returns	527.1	762.0
Total U.S. returns	529.7	779.8
Change in returns from base	- 140.9	- 42.6

Table 3. Change in welfare for contract growers and processing firms, 2010, quarters 1 and 2

	No Regionalization		Regionalization	
	2010 Quarter 1 (\$ mil)	2010 Quarter 2 (\$ mil)	2010 Quarter 1 (\$ mil)	2010 Quarter 2 (\$ mil)
Contract grower payments	Contract grower payments			
Texas	-6.6	-6.5	Texas	-13.6
Other US	-62.6	-19.0	Other US	-8.4
Total	-69.2	-25.5	Total	-22.0
Processing firm rents	Processing firm rents			
Texas	-22.0	-9.1	Texas	-42.4
Other US	-200.8	-69.2	Other US	-69.0
Total Rent	-222.8	-78.3	Total Rent	-111.4
Cull	-7.5	0.0	Cull	-7.5
Total	-230.4	-78.3	Total	-118.9

Table 4. Change in value added at retail for chicken and percentage change, United States, 2010, quarters 1 and 2

Quarter	No Regionalization		Regionalization	
	(\$ mil)	(%)	(\$ mil)	(%)
1	189.7	6.0	24.9	0.8
2	61.7	2.1	24.6	0.8

Table 5. Change in consumer surplus, United States, 2010 and 2011¹

Year	Quarter	No Regionalization	Regionalization
		(\$ mil)	(\$ mil)
2010	1	599.4	-265.5
	2	285.7	-289.6
	3	199.2	317.6
	4	56.7	114.6
2011	1	58.2	92.9
	2	74.8	127.1
	3	73.6	116.2
	4	24.3	41.7

¹Commodities included are: chicken, turkey, eggs, beef, pork, lamb meat, milk (milk fat basis), coarse grains, wheat, rice, and soybean oil.

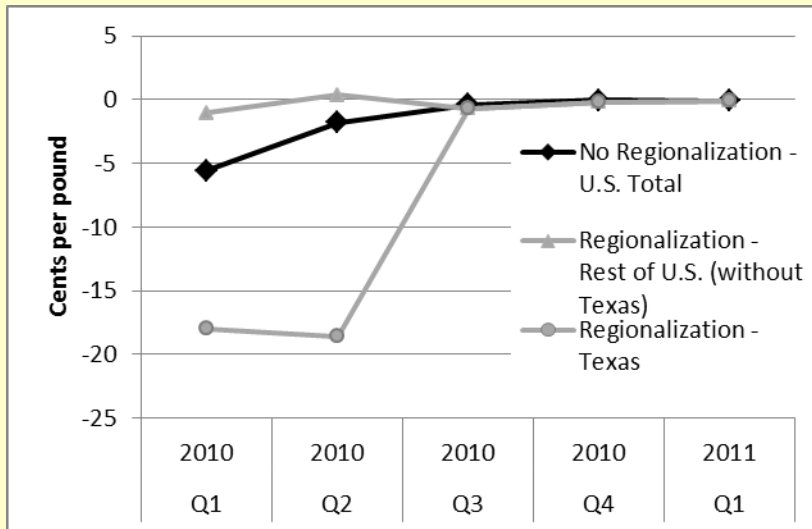


Figure 1. Change in broilers wholesale price

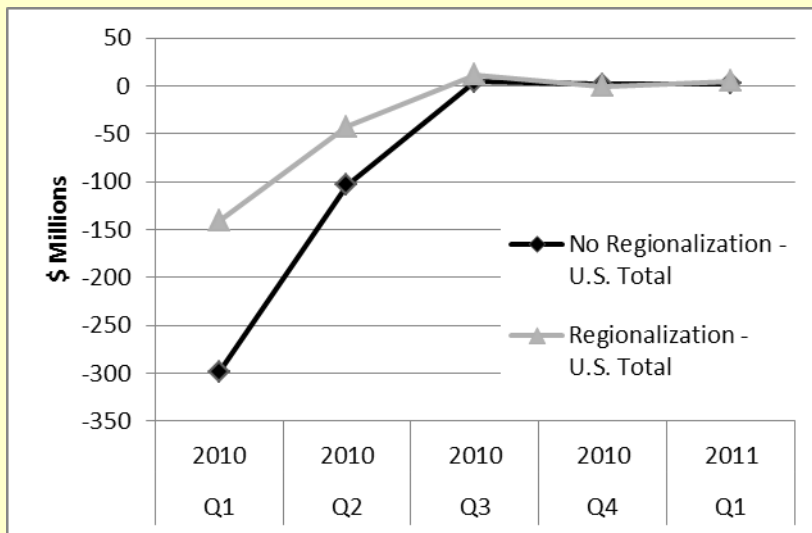


Figure 2. Change in chicken industry returns

Appendix A: National Quarterly Livestock Model

This study utilizes an updated version of the quarterly livestock model developed by Paarlberg, et al (2008). A key update for this analysis is the separation of poultry meat into chicken and turkey. Chicken-meat production retains the assumption of occurring within one quarter. Because the production cycle for turkey meat exceeds one-quarter, a dynamic adjustment is incorporated.

Using a quarterly baseline, the economic model determines changes in prices, quantities, and economic welfare for several commodities due to changes in domestic demand, export demand, and supply resulting from a disease event. The model is designed to capture the vertical and horizontal linkages among livestock products, livestock, and crops. The commodities included in the model are: beef, pork, lamb meat, chicken meat, turkey meat, eggs, milk, cattle, hogs, chickens, turkeys, sheep and lambs, coarse grains, wheat, rice, soybeans, soybean meal, soybean oil, forage, and pasture.

Changes from the baseline are described by dynamic differential equations constructed from elasticities and unit revenue shares. The differential equation specification arises from a theoretically consistent vertical production structure using a specific factors model. Logarithmic differentiation of the specific factors models creates consistency in behavior among derived demands and derived supply as demonstrated by Shephard's lemma. Primary demands are from logarithmic differentiation of demand functions in general form. The baseline combines observed quarterly market outcomes from 2005-2012, with a quarterly version of the annual USDA baseline released in February 2013. In this analysis, the outbreak is assumed to begin in the first quarter of 2010 so that results are benchmarked to observed data.

Since the analysis looks at changes in economic welfare, understanding the definitions for economic welfare in the model is critical. Economic welfare for consumers is measured as the change in consumer surplus or the difference between consumers' willingness to pay and the price consumers must pay - the market price. The economic welfare of producers is a combination of two metrics. Economic welfare for producers who can market meat is measured as a return (payment) to capital and management. That payment is a residual value allocated to capital and other nonvariable inputs, including payment to contract growers. For producers with depopulated birds, economic welfare is measured as the value of birds depopulated in response to the HPAI outbreak. Since producers have already incurred the cost of producing the birds, those costs are now sunk, and quasi fixed. A traditional measure of economic welfare, such as producer surplus, assumes that producers can adjust variable inputs. In this case, that is not possible.

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