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by

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The Economic Impact of the 2015 Avian Influenza outbreak on U.S. Egg Prices

This study provides a partial equilibrium approach to quantifying the effect of the Highly Pathogenic Avian Influenza (HPAI) outbreak that occurred in the United States in late 2014 and early 2015. The quarterly model provides an estimate of egg prices that would have occurred over this period without the HPAI outbreak. This research also provides sensitivity analysis around the estimated retail demand elasticity based on a review of the literature surrounding the retail demand for eggs in the United States.

Keywords: partial-equilibrium model, eggs, price analysis, avian influenza

Introduction

In late 2014 the United States poultry industry faced one of the worst Avian influenza outbreaks ever seen. It started on December 19, 2014 with a H5N8 strain reported in Oregon. That first case began a shutdown of export markets for U.S. poultry products. A day later South Korea stopped U.S. poultry product exports. Perhaps most important was the reported case of the highly contagious H5N2 in a Washington flock on January 3, 2015. From there the spread expanded into California affecting commercial flocks by early February, thereby increasing the list of countries that turned off imports of U.S. poultry products. By early March, it was confirmed that the H5N2 strain had reached the upper Midwest as Iowa, Minnesota, Nebraska and Wisconsin, all whom declared a state of emergency by May. The map from USDA/APHIS shows the full timeline of the outbreak.

USDA/APHIS reported that 49.7 million birds from 211 commercial flocks and 21 backyard flocks were affected by the time the last detection was reported on June 17, 2015. This was not the first case of a Highly Pathogenic Avian Influenza (HPAI) in the U.S. according to USDA/APHIS.

USDA has experience in responding to HPAI outbreaks in the U.S. poultry industry. Before these current outbreaks, there were three HPAI outbreaks in commercial poultry in U.S. history – in 1924, 1983 and 2004. No significant human illness resulted from these outbreaks.

In 1924, H7 HPAI outbreak was detected in and contained to East Coast live bird markets. In years 1983-84 H5N2 HPAI bird outbreaks resulted in the destruction of approximately 17 million chickens, turkeys, and guinea fowl in the northeastern United States to contain and eradicate the disease.

According to USDA, “In 2004, USDA confirmed an H5N2 HPAI outbreak in chickens in the southern United States. The disease was quickly eradicated thanks to close coordination and cooperation between USDA, state, local, and industry leaders. Because of the quick response, the disease was limited to one flock.” (USDA, 2015.)

The majority of the 2014/2015 incidents took place in two of the top ten egg producing states Minnesota and Iowa, with 110 and 77 incidents respectively (USDA, 2015). Thirty-four of the total number of detections happened in Commercial Chicken Layer operations affecting over

35 million chickens (own calculations based on USDA data, 2015.) The main losses occurred in Iowa - 26,135,178 layers, Minnesota - 3,759,631 layers and Nebraska - 3,490,834 layers. This shows a loss of over 70 percent of the total flock numbers in Iowa, the main egg producing state, in the 2014-15 period.

The U.S. Egg Industry

U.S. egg production is highly concentrated; Iowa, Ohio, Indiana, Pennsylvania, and California account for over half of the U.S. laying hen flock (America Egg Board, 2016). The U.S. egg production sector has been concentrating and moving to the Midwest to reduce feed transportation costs and the cost of transporting the eggs from production centers to the consumer marketplace (Bell, 2002). Iowa and Minnesota are ranked as number 1 and 9 main egg-producing states with 36.7 and 8.9 million layers, respectively. The American Egg Board (AEB) also reports that 99 percent of U.S. egg production is controlled by approximately 190 companies with flocks of at least 75,000 layers (AEB, 2016). Location concentration of the U.S. egg production increases the vulnerability the industry faces related to disease outbreaks.

According to the AEB, U.S. egg consumption increased over the last decade. In 2014, Americans consumed 263.3 eggs per capita. The U.S. egg industry imports virtually no eggs and is therefore almost completely self-reliant on domestic egg production.

Literature Review

Research shows that the demand elasticity for eggs in the U.S. is very inelastic. The price elasticity of demand for eggs was estimated at -0.27, which was the lowest of all 14 considered food categories, and lower than demand elasticities for milk and cereals (Andreyeva, Long, & Brownell, 2010). It suggests that consumers purchasing eggs are very insensitive to price changes, and are likely to continue purchasing eggs even at very high prices.

High industry concentration and inelastic demand makes the U.S. egg market particularly vulnerable to price shocks. The idea is that large market shocks such as an HPAI outbreak, like the one experienced in 2015 which lowered the number of birds in laying flocks by 12 percent, can cause extremely large changes in all egg prices. The exact effects of such a shock can influence the structure of the industry and have a strong impact on the producers and consequently, the consumers.

According to Bell (2002), the cost of egg production was decreasing due to scaling up of production, concentration and increased productivity since the 1970s. At the same time, egg prices were steadily increasing from about \$0.60 per dozen in 1999 to \$1.20 in 2014. However, until recently they never crossed the threshold of \$1.50. Wholesale egg prices were in the \$1.25 per dozen range in the fall of 2014 but by August of 2015 they have risen to \$2.60 per dozen. The outbreak of HPAI has been identified as the primary driver of the large increase in egg prices.

There were several studies conducted in the 1970s and 1980s using econometric models to analyze and forecast egg prices (Chavas & Johnson, 1981; Miller & Masters, 1973; Roy & Johnson, 1973). Roy and Johnson (1973) presented a model for quarterly shell egg prices. The

prices used in the model are wholesale prices. They concluded that the model predictions were sufficient, especially for the first three quarters. The study also examined interdependencies in egg prices of shell and breaking eggs.

Chavas and Johnson (1981) also used a quarterly model; however, they concluded monthly or shorter time frames, might be needed to better understand the effects of speculation on storage.

A study by Paarlberg, Seitzinger, and Lee (2007) showed that based on a quarterly econometric model, an avian influenza outbreak would result in a decrease in the price of eggs. The study assumed that a 3 percent production shock from an avian influenza outbreak would cause an egg price drop from \$0.03 to \$0.30 per dozen depending on the region of the country. The decrease in price was attributed to regionalization and decrease in human consumption. The study also indicated that 4 to 8 quarters after the outbreak, consumption would be recovered.

At the same time Brown, Madison, Goodwin, and Clark (2007), based on a yearly FAPRI (Food and Agricultural Policy Research Institute) model, estimated that an outbreak of an avian influenza in the U.S. would result in a price increase of \$0.19 per dozen in the first year with the industry fully recovering after 4 years.

The actual outbreak of a similar scale to the events predicted in the above-mentioned articles happened in 2014-2015. The price received for a dozen table eggs was \$0.49 per dozen higher in the second quarter of 2015 than it was in the second quarter of 2014. In the third quarter of the 2015, 202 million dozen less table eggs were produced than the second quarter of 2014. This is an 11.1 percent drop in production compared to the year before (own calculation based on WASDE (USDA World Agricultural Supply and Demand Estimates) data.)

The above studies made a number of assumptions about the production effect of an avian influenza outbreak and its effects on egg markets. First, both papers assume that existing disease control mechanisms will control and contain the outbreak that would result in a drop in egg production of 2 to 3 percent. Second, there was an explicitly or implicitly stated assumption of a drop in egg demand. The drop in demand was expected to be a consequence of the consumer perceived risk associated with an HPAI outbreak.

According to Bell (2002), layer productivity has been increasing by about 2 eggs per layer per year since the 1970s. In 2000, the average layer productivity to 60 weeks of age was 223 eggs. Feed intake per layer has also decreased over the years. However, replacement pullets are the second highest cost of production, the largest being feed costs. The flock replacement described by Bell (Chapter 54) shows that new layers are production ready in about 20 weeks. This suggests that after an HPAI outbreak, production should recover within approximately 5 months.

Materials and Methods

The model uses publically available data for production, consumption, trade and prices. Production data is presented quarterly, which can give an adequate representation of the industry dynamics. The egg production cycle and flock dynamics happen quickly and require a time frame that is short enough to capture the quick supply dynamics.

The model uses historical data from the United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS) and Economic Research Service (ERS), the Bureau of Labor Statistics (BLS) and the World Bank.

Currently collected data on the U.S. egg industry is significantly less detailed than data available in the past. Data on production and disappearance provided by the USDA-ERS is aggregated quarterly. There are no flock numbers or per hen productivity numbers available that would allow for a more accurate representation of flock dynamics.

In this research the impact of the changing egg supply associated with the 2014/15 HPAI outbreak on U.S. egg prices is examined.

The model uses OLS regression results estimated over the 1999-2014 period. The partial equilibrium model is used to forecast egg prices with and without an HPAI outbreak over 2015 to 2018 period.

The supply side of the model incorporates the historical production numbers for table eggs, prices, feed costs, and indicator variables accounting for seasonal variability in production. Imports, given their constant value over time and relatively small share in the market, are exogenous to the model.

The demand for eggs is broken down into two equations representing domestic and export demand for U.S. eggs. Both include price coefficients as well as trends and indicator variables accounting for seasonality in egg consumption.

The table below presents own price and income elasticities for eggs used in the model. Own price elasticities for domestic supply and demand are very small which suggest a very inelastic supply and demand.

Lack of demand elasticity can be partially attributed to lack of substitutes and a relatively small share of eggs in food expenditures.

Scenarios

Two scenarios were examined to quantify the impact if the 2014-15 HPAI outbreak. The baseline case was created based on the actual data representing the HPAI outbreak. The two scenarios created are comparing the HPAI outbreak baseline with a situation where no HPAI occurred (Scenario 1) and a situation where the HPAI outbreak occurred with half the severity of the actual outbreak (Scenario 2).

The elasticities estimated and used in the model as coefficients corresponding to own price as well as income are shown in the Table 1.

The 2015 HPAI outbreak caused an 11 percent reduction in the egg supply relative to the previous year. As a result, the egg prices increased over two fold in the course of only a few weeks. In January of 2015 the price of eggs was \$1.36 per dozen and by July the price rose to \$2.06 per dozen.

A significant drop was observed in the supply, however the domestic demand for eggs did not drop significantly in response to high prices. Increased prices for table eggs were also a

result of competing demand between table eggs and breaking stock and eggs for hatching to replace the laying flock combined with limited supply.

According to USDA-AMS in June 2015, the producer price for large eggs was \$2.27 per dozen and breaking stock price was \$2.23 per dozen which was a record high compared to \$0.63 per dozen in June 2013. Use of eggs for hatching placed additional stress on the supply. Hatching use increased by 11.75 million dozen in the third quarter of 2015 compared to 2014.

Figure 2 shows the difference in prices received in U.S. dollars per dozen between years 2013-2014 and 2015-2016. Prices in the beginning of 2015 are higher than in the same period in 2013 and 2014.

Results

Under Scenario 1, the simulation predicted egg prices in 2015-2018 without the HPAI outbreak and compared them to the baseline created based on the actual data from 2015 and 2016.

The results show that without the AI outbreak the egg prices would be significantly lower compared to the prices resulting from the supply decreases due to the outbreak.

The most striking difference can be observed in the third quarter of 2015 when egg prices reached \$2.06 per dozen compared to \$1.04 per dozen in 2013 and \$1.12 per dozen in 2014. By the beginning of 2016, the actual prices after the outbreak were higher than the predicted prices for 2016 without the AI outbreak. By mid-2016, the model showed the prices will begin to converge, showing less than 0.05 cents per dozen difference (Figure 2).

In terms of the egg production in the Scenario 1 (with no HPAI), the number of eggs produced would be 6 percent higher in second quarter of 2015, 11 percent higher in the third quarter and 10 percent higher in the fourth quarter (Figure 3).

Unlike in the papers written in 2007 (Paarlberg, Seitzinger, and Lee; Brown et al.) about a possible HPAI outbreak consequences that assumed a significant decrease in egg demand as a result of an HPAI outbreak, in reality egg consumption decreased only by about 9 percent in 2015 compared to the no HPAI scenario and demand seemed unresponsive to the outbreak (Figure 4.)

The model showed the biggest changes in the egg exports. The model predicted that without the AI outbreak egg exports would be about 28 percent higher in the beginning of 2016 compared to the baseline. Such a delayed effect on exports between the Scenario and the baseline was due to the assumption of exports being contracted in advance which was represented by a lagged price in the exports equation. The full results of Scenario 1 are shown in Appendix 1.

Scenario 2 represents a situation where the outbreak was better contained, and showed only half the severity of the one that actually occurred. This scenario showing similar albeit more moderate effects compared to Scenario 1. The results of Scenario 2 are shown in Appendix 1.

Demand sensitivity analysis

Based on previous literature, a sensitivity analysis is performed. The elasticities used for the sensitivity analysis are based on a number of previous studies. Table 2 presents own price elasticities from several studies that were used to determine the high and low bound for the further analysis shown here.

The estimated own price elasticity for eggs was -0.09011. From the study by Andreyeva, Long, and Brownell (2010) a slightly lower, even more inelastic elasticity was adopted. An elasticity of -0.18022 (twice the value of the estimated elasticity) was created based on the value corresponding to the one from the study by Huang and Lin (2000). The last elasticity representing the most elastic market was adopted based from the average result of the meta-analysis done by Andreyeva, Long, & Brownell (2010) equal to -0.27. The results of the sensitivity analysis are presented in Appendix 1.

The price spike observed in 2015 as a result of the supply shock due to an avian influenza outbreak and a relatively small (average of 11 percent drop in consumption) combined with a 50 percent price increase suggests that the U.S. egg market is very inelastic. The sensitivity analysis compared the price behavior under different assumptions about the market elasticity.

Figure 4 compares the Scenario 1 results ran using three of the assumed elasticities with the baseline. The results show that the more elastic the market, the smaller the price differences are between each of the scenarios and the baseline. Observed differences are the most pronounced in the second, third and fourth quarters of 2015. In the third quarter of 2015, the price difference between Scenario 1 and the baseline was \$1.49 per dozen lower than the baseline for the assumed domestic demand elasticity of -0.06 (0.06DDE), \$0.73 per dozen for the assumed domestic demand elasticity of -0.18 (0.18DDE) and \$0.52 per dozen for assumed domestic demand elasticity of -0.27 (0.27DDE.)

The sensitivity analysis shows a decrease of the egg production of over 180 million dozen for all three elasticity options compared to the baseline. It also shows similar increases in per capita disappearance for 0.06DDE, 0.18DDE and 0.27DDE compared to the baseline. For the second, third and fourth quarters of 2015, the egg consumption would increase under no AI scenario by 6 percent, 11 percent and 9 percent, respectively. Similar but less pronounced increases were observed under Scenario 2 with 2-3 percent, 5 percent, and 4-5 percent differences for the three quarters, respectively.

Discussion

One of the suggested reasons for a drastic change in the egg prices is the fact that limited supply is subject to competition between different uses, such as table, breaking and hatching. One of the reasons to suspect this effect is that table and breaking egg prices followed the same price trend during the period of the outbreak, with the increase in breaking egg prices even more pronounced than that for table eggs. The absolute increase for breaking stock was even more significant than was the case for table eggs.

Conclusions

Based on the historical data model, the results show that an AI outbreak will cause an increase in egg prices compared to the no AI scenario. Depending on the assumed price elasticity of demand, the price effect of the supply shock will be different with price changes from only a few cents to \$1.50 per dozen. Very inelastic egg market creates large price changes of more than 50 percent as a result of an only 11 percent supply shock. The experience with the 2014-2015 HPAI outbreak showed that consumers' demand for eggs did not decrease over the concern of HPAI.

More research can be conducted to better incorporate the trade change effects due to countries stopping trade with the U.S. as a precautionary measure during an HPAI outbreak.

Moreover, a better representation of the competing egg use between table and breaking eggs could be included in the model if better data can be identified to examine breaking versus table egg use.

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Table 1 Model elasticities.

<i>Elasticities</i>			
	Own Price	Own Price Long Run	Income
<i>Supply</i>	0.025	0.521	
<i>Domestic Demand</i>	-0.090		-0.030
<i>Export Demand</i>	-0.324*		

*calculated over period 1999-2014.

Table 2 Overview of own price elasticities for eggs.

<i>Food and Beverage Category</i>	<i>Absolute Value of Mean Price Elasticity (Range)</i>	<i>Source</i>
Eggs	-0.27 (-0.06, -1.28)	Andreyeva, Long, & Brownell, 2010
	-0.24	ERS, USDA, 2012
	-0.11	Huang, 1993
	-0.145	Huang, 1986
	-0.057	Huang, 2000
	-0.185	Huang and Lin, 2000
	-0.150	Wohlgenant, 1989
	-0.121	You, 1996

As a result three additional elasticities were used in the analysis.

Table 3 Elasticities used in the sensitivity analysis.

<i>Estimation</i>	<i>Lower</i>	<i>Medium</i>	<i>Upper</i>
-0.09011 (Baseline)	-0.06 (0.06DDE)	-0.18022 (2*DDE)	-0.27 (0.27DDE)

*DDE-domestic demand elasticity

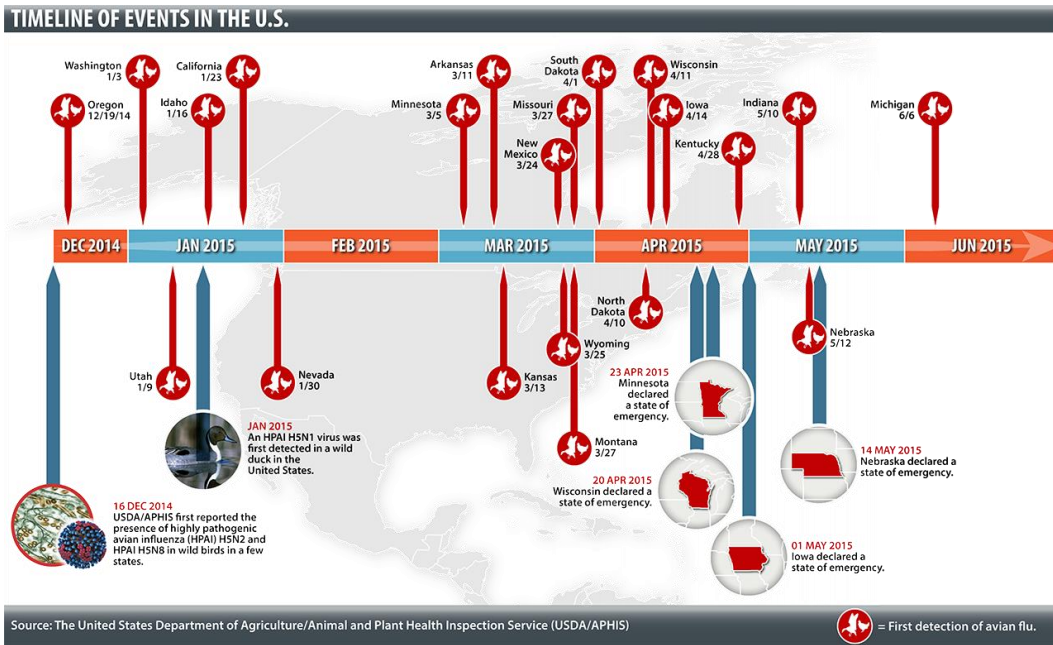


Figure 1 HPAI outbreaks in the U.S. (Source: USDA/APHIS)

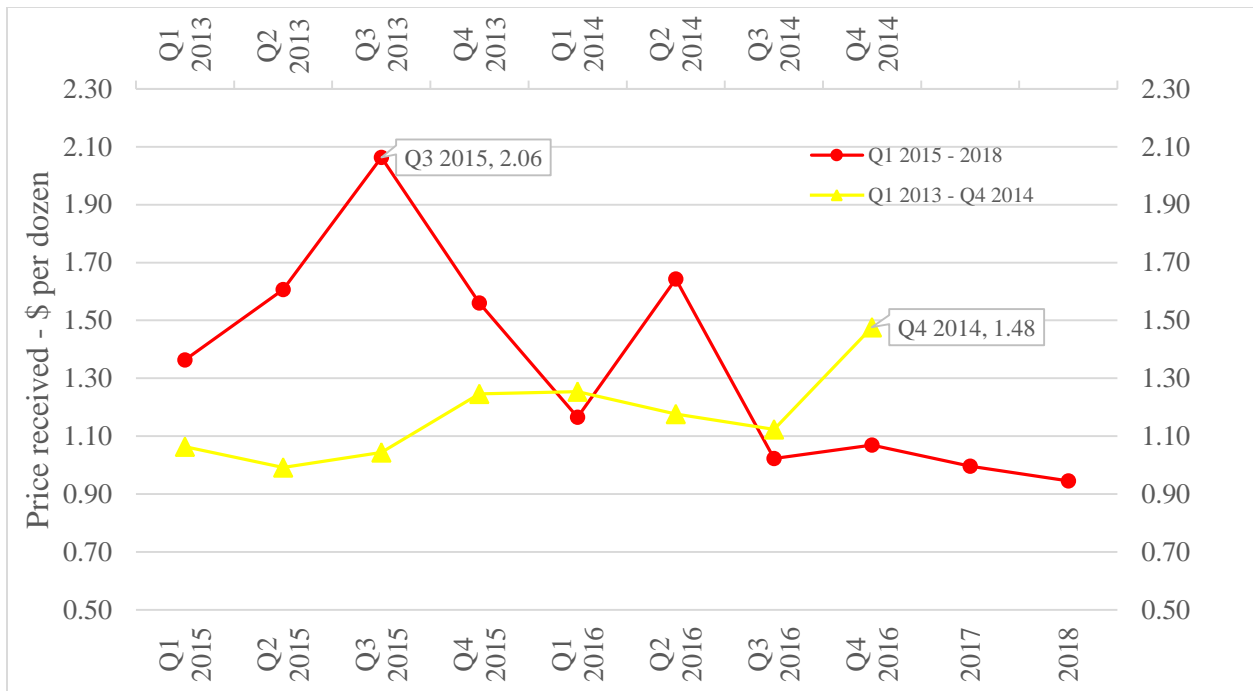


Figure 2 Table egg price received years 2013-2016.

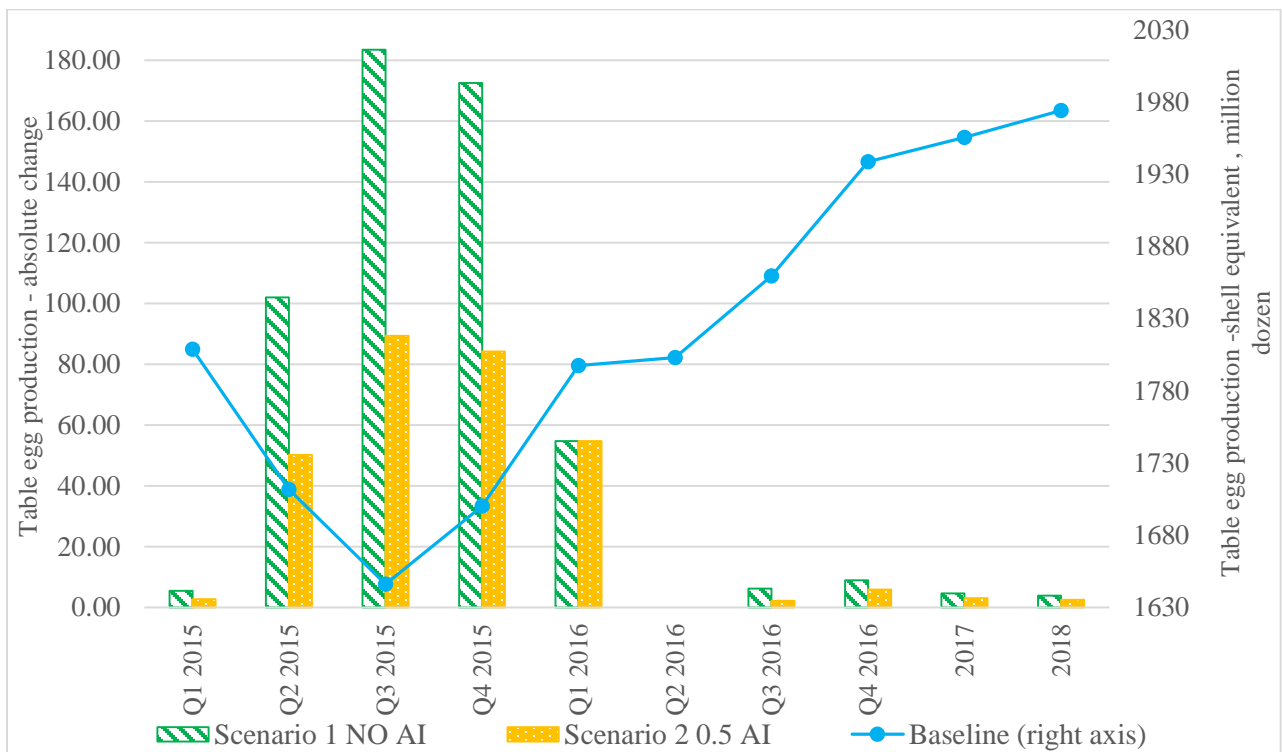


Figure 3 Egg production in million dozen for Scenario 1 and Scenario 2.

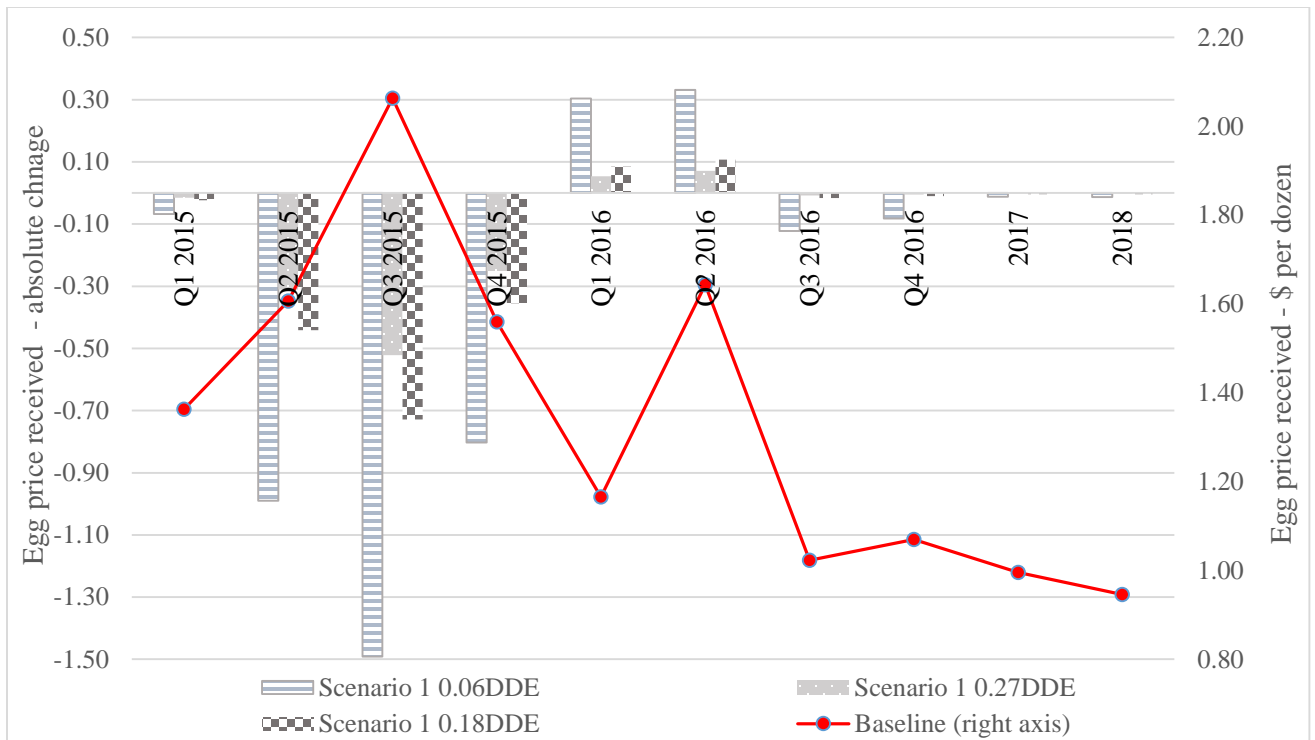


Figure 4 Egg price received Scenario 1 sensitivity analysis.

Appendix 1

Results of Scenario 1 and 2 (Absolute change in \$)

	Q1 2015	Q2 2015	Q3 2015	Q4 2015	Q1 2016	Q2 2016	Q3 2016	Q4 2016	2017	2018
PRICE										
Baseline	1.36	1.61	2.06	1.56	1.17	1.64	1.02	1.07	1.00	0.95
Scenario 1 NO AI	-0.05	-0.76	-1.19	-0.61	0.19	0.22	-0.06	-0.04	-0.01	-0.01
Scenario 2 0.5 AI	-0.02	-0.44	-0.72	89.30	-0.10	0.24	-0.02	-0.04	-0.01	-0.01
PRODUCTION										
Baseline	1808.83	1711.8 3	1646.08	1700.2 5	1797.6 0	1802.9 6	1859.5 9	1938.56	1955.5 3	1974.03
Scenario 1 NO AI	5.43	101.96	183.45	172.50	54.75	0.00	6.20	8.96	4.66	3.83
Scenario 2 0.5 AI	2.71	50.24	89.30	84.16	54.75	0.00	2.24	5.89	3.06	2.48
PER CAPITA CONSUMPTION										
Baseline	65.08	62.31	61.13	64.64	67.43	66.53	69.07	71.76	71.79	72.33
Scenario 1 NO AI	0.20	3.78	6.55	5.81	1.47	-0.17	0.30	0.38	0.16	0.13
Scenario 2 0.5 AI	0.10	1.85	3.16	2.82	1.71	-0.13	0.09	0.26	0.10	0.08
EXPORTS										
Baseline	99.32	82.35	71.48	64.44	55.62	80.46	72.72	77.78	80.48	81.55
Scenario 1 NO AI	0.00	0.52	8.15	17.00	15.44	3.72	-2.36	-0.57	0.47	0.30
Scenario 2 0.5 AI	0.00	0.26	4.36	9.37	8.48	4.02	-0.89	-1.05	0.32	0.21

AI – Avian Influenza; NO AI – situation where there is no Avian Influenza outbreak

Results of Scenario 1 and 2 Sensitivity Analysis (Absolute change)

		Q1 2015	Q2 2015	Q3 2015	Q4 2015	Q1 2016	Q2 2016	Q3 2016	Q4 2016	2017	2018
PRICE											
Scenario 1	0.06DDE	-0.07	-0.99	-1.49	-0.80	0.30	0.33	-0.12	-0.08	-0.01	-0.01
	0.27DDE	-0.02	-0.31	-0.52	-0.25	0.05	0.07	-0.01	0.00	0.00	0.00
	0.18DDE	-0.02	-0.44	-0.73	-0.36	0.08	0.11	-0.02	-0.01	0.00	0.00
Scenario 2	0.06DDE	-0.62	-0.18	-0.58	0.11	-0.32	0.83	-0.09	-0.21	0.00	-0.01
	0.27DDE	-0.01	-0.16	-0.28	-0.13	-0.04	0.08	0.00	0.00	0.00	0.00
	0.18DDE	-0.02	-0.44	-0.72	-0.34	-0.10	0.24	-0.02	-0.04	-0.01	-0.01
PRODUCTION											
Scenario 1	0.06DDE	5.43	101.58	183.45	172.50	54.75	0.00	9.31	12.87	5.16	4.01
	0.27DDE	5.43	102.46	183.45	172.50	54.75	0.00	1.98	3.08	2.29	2.09
	0.18DDE	5.43	102.34	183.45	172.50	54.75	0.00	3.00	4.57	3.12	2.78
Scenario 2	0.06DDE	2.71	39.30	89.30	84.16	54.75	0.00	7.61	19.28	10.41	9.01
	0.27DDE	2.71	50.49	89.30	84.16	54.75	0.00	0.64	1.93	1.42	1.30
	0.18DDE	2.71	50.24	89.30	84.16	54.75	0.00	2.25	5.89	3.06	2.49
PER CAPITA CONSUMPTION											
Scenario 1	0.06DDE	0.20	3.77	6.49	5.69	1.39	-0.18	0.45	0.53	0.16	0.13
	0.27DDE	0.20	3.81	6.64	6.03	1.65	-0.10	0.10	0.12	0.08	0.07
	0.18DDE	0.20	3.81	6.61	5.96	1.59	-0.12	0.16	0.19	0.11	0.10
Scenario 2	0.06DDE	0.10	1.34	3.02	2.93	1.82	0.05	0.31	0.84	0.36	0.31
	0.27DDE	0.10	1.88	3.23	2.94	1.84	-0.09	0.03	0.09	0.05	0.04
	0.18DDE	0.10	1.86	3.17	2.81	1.71	-0.13	0.10	0.26	0.10	0.08
EXPORTS											
Scenario 1	0.06DDE	0.00	-0.68	-9.56	-19.82	-17.98	-4.06	3.59	0.68	-0.71	-0.38
	0.27DDE	0.00	-0.31	-5.53	-11.02	-10.08	-2.68	0.77	0.24	-0.13	-0.10
	0.18DDE	0.00	-0.37	-6.29	-12.82	-11.70	-3.02	1.15	0.33	-0.21	-0.16
Scenario 2	0.06DDE	0.00	-4.54	-6.72	-7.08	-5.40	-2.87	2.69	3.68	-0.75	-0.50
	0.27DDE	0.00	-0.15	-2.78	-5.56	-5.09	-2.70	0.31	0.36	-0.08	-0.07
	0.18DDE	0.00	-0.26	-4.36	-9.37	-8.48	-4.02	0.89	1.05	-0.32	-0.21