AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

An Evaluation of the 2015 Outbreak of Avian Influenza in the U.S.

Lei Gao
Department of Agricultural Economics
Texas A&M University
padmagao@tamu.edu

James Richardson
Department of Agricultural Economics
Texas A&M University
jwrichardson@tamu.edu

Aleksandre Maisashvili
Agricultural and Food Policy Center
Texas A&M University
amaisashvili@email.tamu.edu

Selected Paper prepared for presentation at the 2016 Agricultural & Applied Economics Association Annual Meeting, Boston, Massachusetts, July 31-August 2

Copyright 2016 by Gao, Richardson, and Maisashvili. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

An Evaluation of the 2015 Outbreak of Avian Influenza in the U.S.

Lei Gao, James Richardson, and Aleksandre Maisashvili

Abstract

This study quantifies the impacts of the 2015 outbreak of the highly pathogenic avian influenza (HPAI) along the Pacific, Central and Mississippi flyways via a partial equilibrium sector-specific modeling system. Production shocks for egg and turkey sectors as well as trade shocks for egg, turkey, and broiler sectors are analyzed based on actual changes reported by USDA. Alternative scenarios for greater HPAI production losses were analyzed along with export demand reductions to test the combined impacts on prices of broiler, eggs, and turkey. The effects of the HPAI outbreak are examined by comparing the 10-year projection results for production, exports, prices, and per capita consumption for broiler, turkey, and egg. In all cases, the effects of the shock on production start to disappear after the second year while the effects of the shock on exports continue for 5 or more years.

JEL classification: Q11; Q18; Q17

Keywords: Highly pathogenic avian influenza (HPAI), poultry production, poultry trade, structural model, systems of equations, supply and demand

Introduction

The poultry industry is one of the most important agricultural sectors in the U.S. economy. As the world's second largest broiler meat exporter, nearly 20 percent of total broiler production has been exported to the international market during the past couple of years according to World Agricultural Supply and Demand Estimate (WASDE). Poultry products are also major staples for the American diet. In 2014, 58.4 pounds of broilers, 51.8 pounds of beef, 43.6 pounds of pork, and 12.5 pounds of turkey meat were consumed per capita according to WASDE. Animal health issues have brought a noteworthy shock to the U.S. poultry industry. The 2014-2015 highly pathogenic avian influenza (HPAI) outbreak affected poultry flocks along the Pacific, Central and Mississippi flyway and nearly 50 million birds were removed. Negative impacts on production as well as a hard hit for exports of U.S. poultry and poultry products resulted. The impacts are not limited to the poultry industry, but they will also affect the related agricultural markets as well as other social sectors.

The objective of this study is to evaluate the effects of the 2015 HPAI outbreak on the U.S. broiler, turkey, egg, and pork industries. The lasting effects of the AI outbreak are examined by comparing the 10-year projection results for production, exports, prices, and per capita consumption for the four industries with their baseline scenario projections.

Methodology

The econometric model that will be used is a partial equilibrium sector-specific system that includes a complete representation of the demand for meat from the consumer sector, the supply for meat from the livestock producers sector, and the assumption that markets clear

according to price adjustment. The model is maintained by the Agricultural and Food Policy Center, Texas A&M University.

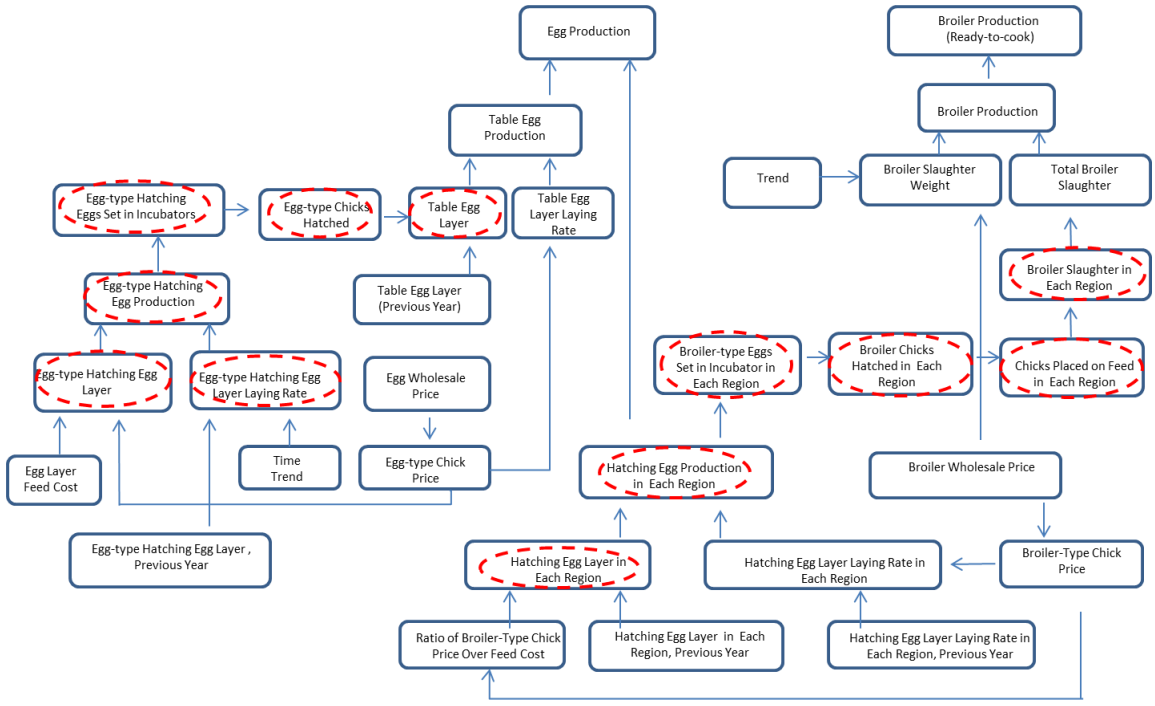

Figure 1 The Interaction Between Broiler Production and Egg Production

A regional-level description for the broiler production process is used for studying the poultry industry in more detail and modeling regionalized problems, such as disease outbreaks and policy changes, with more accuracy. According to Hatchery Production Annual Summary (USDA NASS), broiler production can be divided into six regions: South Atlantic (SA), North Atlantic (NA), South Central (SC), East North Central, West North Central, and West. Due to data availability, SA, NA, and SC are kept, and the rest of the U.S. are categorized into one region called the Other Regions (OTH). The production process is modeled following the actual production stages. In addition to regional production, total supply includes beginning stocks and imports; total demand comprises ending stocks, exports, and domestic disappearance. The egg sector and the broiler sector are closely related to each other from the production side, as depicted in Figure 1. The turkey sector is also closely correlated to the broiler sector, from the demand side, reflected

by the significant turkey-broiler cross price elasticity of the demand for turkey products estimated in the modeling system.

Literature Review

Several studies have analyzed the economic impacts of HPAI, including Djunaidi and Djunaidi (2007), Paarlberg, Seitzinger, and Lee (2007), Brown, Madison, Goodwin, and Clark (2007), and Saghaian, Özertan and Spaulding (2008). Among these studies, Paarlberg et al. (2007) and Brown et al. (2007) focused on the U.S. market. Paarlberg et al. (2007) addressed the importance of regionalization in measuring the real export and welfare losses of an HPAI outbreak. Brown et al (2007) studied the effects of two hypothetical HPAI outbreaks, the 8-county outbreak scenario and the 4-state outbreak scenario, by assuming a percentage decrease in production and exports based on historical data. In this study, the actual changes in 2015 poultry and egg production and trade published by USDA are used to shock the model.

USDA 2015 projections for production and exports for the poultry and egg industries before and after the AI outbreak are summarized in Table 1. Turkey and egg production decreased 5 percent and 6.3 percent, respectively. The primary impact for the broiler industry has been on broiler product exports. Broiler, turkey, and egg exports decreased 15.5 percent, 35 percent, and 10.5 percent, respectively. Since reductions in both the number of table egg layers and table egg layers' laying rate have been reported[1], the decreased egg production is attributed to the reduction of these two factors equally, each with a 3.2 percent decrease.

[1] Livestock, Dairy, and Poultry Outlook (USDA, January 2016, November 2015, October 2015).

Table 1 Actual Shocks on the Poultry and Egg Industries due to the 2015 AI Outbreak[2]

		Broiler	Turkey	Egg
		Million Lbs	Million Lbs	Million Dozen
Production	Projection Before AI	39630	5925	8430
	Projection After AI	39614	5628	7896
	Percentage Change	-0.04%	-5.01%	-6.33%
Export	Projection Before AI	7480	820	355
	Projection After AI	6319	533	317.6
	Percentage Change	-15.52%	-35.00%	-10.54%

The effect of the AI outbreak on consumer preference for meat products has been analyzed in several studies. Beach and Zhen (2008) studied the Italian consumers' response to AI outbreak and concluded that media coverage of AI outbreak either in Italy or in the rest of the world had net negative effects for fresh and frozen poultry and net positive effects on beef and pork consumption. Ishida et al (2010) investigated the impact of BSE and AI outbreak on Japanese consumers' demand for meat. For an AI outbreak, negative effects on the demand for chicken were found; and the estimated impact of the AI outbreak lasted for 6 months. However, studies of U.S. consumers' response to an AI outbreak found different results. The study of Piggott and Marsh (2004) found that the average consumer's response to food safety events is small; and even though there existed larger responses corresponding with prominent food safety events, they were short-lived with no lagged effects. Mu, McCarl, Hagerman, and Bessler (2015) studied the effects of the AI outbreak on domestic beef, pork, and broiler demand and reported that the number of confirmed human deaths by WHO significantly affects the consumers' preferences. The AI outbreak itself did not have a statistically significant effect on the U.S. consumers' demand for broiler or pork. In support of this result, the Livestock, Dairy, and Poultry Outlook (USDA, Feb 2015 to Jan 2016) reported no change in domestic consumers' preference for poultry and eggs after the AI outbreak. We follow Brown (2007) and make the

[2] Source for projections before AI: USDA Agricultural Projections to 2024 (USDA, February 2015);
Source for projections after AI: World Agricultural Supply and Demand Estimates (USDA, February 2016).

assumption that there are no adverse or cross effects from the 2015 AI outbreak on domestic demand for meat.

Table 2 Shocks to the Poultry and Egg Industries Due to the 2015 AI Outbreak

	Year	Broiler	Turkey	Table Egg Laying Rate	Table Egg Layers
Production	2015	0.0%	-5.0%	-3.2%	-3.2%
	2016	0.0%	0.0%	0.0%	-1.6%
Export	2015	-15.5%	-35.0%	-10.5%	
	2016	0.0%	0.0%	0.0%	
Import	2015	0.0%	0.0%	70 Million Dozen	

Production shocks for the egg and turkey sectors as well as trade shocks for egg, turkey, and broiler sectors that were generated according to USDA publications are presented in Table 2 and referred to as Scenario 1. An assumption of 1.6 percent decrease in the number of table egg layers in 2016 is made based on the longer production cycle for table eggs compared to broilers. Since 90 percent of the laying flock reaches peak egg production at an age of 30 to 32 weeks, the reduction in the number of table egg layers in 2015 may last to 2016 but at a smaller scale. Also a shock of 70 million dozen increase in 2015 egg imports was added to incorporate the WASDE forecast since the estimated model cannot forecast the egg imports that high; in other words, a dummy variable was needed to include year 2015 in the period for model estimation.

Two hypothetical AI outbreak scenarios were analyzed for broiler production. In Scenario 2, the AI-outbreak regions have a 5 percent decrease in the number of broilers slaughtered in South Central Region and the Other Region. For Scenario 3 a 10 percent decrease in the number of broilers slaughtered in South Central Region and the Other Region is assumed.

The 2015 AI outbreak resulted in the quantity of exports demanded decreasing 15.5 percent. The decreased exports were due to a reduction in U.S. production of 0.6 percent and a decrease in the demand for U.S. exports. For Scenarios 2, it was assumed that production would

decrease 3.2 percent and combining this with a decrease in export demand we calculated a 17.9 percent decrease in broiler meat exports. Similarly, the exports of broiler meat were reduced 20.3 percent for Scenario 3.

Results

The results of simulating Scenarios 1, 2, and 3 are presented in Tables 3 to 6. The results are presented as absolute and percentage changes from the no AI outbreak Baseline.

Table 3 Effects of the 2015 and Two Hypothetical AI Outbreaks on the U.S. Broiler Industry

Scenarios	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Broiler Production, Ready-to-cook, Million lbs. (% Change)										
Baseline	38,846	39,763	40,581	41,315	42,009	42,686	43,373	44,075	44,783	45,508
1	-250 (-0.6)	-290 (-0.7)	-294 (-0.7)	-277 (-0.7)	-247 (-0.6)	-212 (-0.5)	-178 (-0.4)	-148 (-0.3)	-122 (-0.3)	-102 (-0.2)
2	-1232 (-3.2)	-195 (-0.5)	-222 (-0.5)	-226 (-0.5)	-212 (-0.5)	-188 (-0.4)	-161 (-0.4)	-136 (-0.3)	-113 (-0.3)	-93 (-0.2)
3	-2265 (-5.8)	-87 (-0.2)	-139 (-0.3)	-165 (-0.4)	-170 (-0.4)	-159 (-0.4)	-141 (-0.3)	-120 (-0.3)	-100 (-0.2)	-83 (-0.2)
Broiler Exports, Million lbs. (% Change)										
Baseline	7,336	7,487	7,673	7,861	8,031	8,183	8,311	8,428	8,541	8,653
1	-1137 (-15.5)	-747 (-10.0)	-515 (-6.7)	-370 (-4.7)	-274 (-3.4)	-209 (-2.6)	-163 (-2.0)	-128 (-1.5)	-102 (-1.2)	-82 (-0.9)
2	-1311 (-17.9)	-842 (-11.3)	-559 (-7.3)	-386 (-4.9)	-278 (-3.5)	-207 (-2.5)	-158 (-1.9)	-123 (-1.5)	-97 (-1.1)	-77 (-0.9)
3	-1492 (-20.3)	-941 (-12.6)	-603 (-7.9)	-401 (-5.1)	-279 (-3.5)	-202 (-2.5)	-151 (-1.8)	-116 (-1.4)	-90 (-1.1)	-71 (-0.8)
Broiler Retail Price, Cents/lb. (% Change)										
Baseline	202	200	201	203	206	210	214	218	222	226
1	-10 (-5.0)	-6 (-2.8)	-2 (-1.2)	-1 (-0.5)	0 (-0.1)	0 (0.0)	0 (0.1)	0 (0.1)	0 (0.1)	0 (0.1)
2	-1 (-0.6)	-7 (-3.5)	-4 (-1.9)	-2 (-0.9)	-1 (-0.3)	0 (-0.1)	0 (0.0)	0 (0.1)	0 (0.1)	0 (0.1)
3	9 (4.4)	-9 (-4.4)	-5 (-2.7)	-3 (-1.3)	-1 (-0.6)	0 (-0.2)	0 (0.0)	0 (0.0)	0 (0.1)	0 (0.1)
Broiler Per Capita Consumption, Lbs. (% Change)										
Baseline	84.4	85.8	86.9	87.6	88.3	89.0	89.8	90.6	91.4	92.3
1	2.3 (2.7)	1.2 (1.5)	0.6 (0.7)	0.2 (0.3)	0.1 (0.1)	0 (0.0)	0 (0.0)	-0.1 (-0.1)	-0.1 (-0.1)	-0.1 (-0.1)
2	0.3 (0.3)	1.6 (1.9)	0.9 (1.0)	0.4 (0.5)	0.2 (0.2)	0 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
3	-1.9 (-2.2)	2 (2.3)	1.2 (1.4)	0.6 (0.7)	0.3 (0.3)	0.1 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Broiler Ending Stocks, Million lbs. (% Change)										
Baseline	723	756	779	796	809	820	830	841	852	865
1	28 (3.9)	12 (1.6)	2 (0.2)	-3 (-0.3)	-4 (-0.5)	-5 (-0.6)	-4 (-0.5)	-4 (-0.5)	-3 (-0.4)	-3 (-0.3)
2	-22 (-3.0)	19 (2.5)	8 (1.0)	1 (0.1)	-2 (-0.3)	-3 (-0.4)	-4 (-0.4)	-3 (-0.4)	-3 (-0.3)	-3 (-0.3)
3	-76 (-10.5)	27 (3.5)	14 (1.8)	5 (0.6)	0 (0.0)	-2 (-0.2)	-3 (-0.3)	-3 (-0.3)	-2 (-0.3)	-2 (-0.3)

Under Scenario 1, the production shock is limited (less than 1 percent) and exports were reduced by 1137 million pounds in 2015, resulting in a decrease in price and increase in ending stocks and per capita consumption. Broiler retail price decreases by 10 cents per pound and broiler per capita consumption increases by 2.3 pounds in 2015. Under Scenario 2, a greater reduction in production and a slightly greater decrease in exports were assumed. Broiler prices decrease and domestic consumption increases under Scenario 2, but at a more moderate level compared to Scenario 1. Under Scenario 3, broiler production decreases more than broiler exports, causing prices to rise and domestic consumption to drop. Broiler production recovers quickly for all three AI outbreak scenarios. Starting from 2016, the reduction in broiler production is less than 1 percent of the baseline projection under all three scenarios. The impact on broiler exports lasts longer. Starting from 2016, the reduction in broiler exports is 10 to 12.6 percent which causes the projected broiler retail price to be lower than the baseline projection in all scenarios. As a result, broiler per capita consumption is higher than the baseline projection. Broiler retail price and per capita consumption return to their baseline levels after 5 years (with the differences fluctuating within 1 percent of the baseline).

For the egg industry, a greater reduction in production than in exports causes prices to be much higher and per capita consumption is expected to be lower than baseline projections under all three scenarios (Table 4). Under Scenario 1, 2015 reduction in egg production is 487 million dozens, which is greater than the decrease of egg exports (39 million dozens) and causes the egg wholesale price to increase by 81 cents per dozen in 2015 (75.8 percent higher than the baseline). As a result, 2015 domestic consumption of eggs decreases by 13.2 eggs per person (5 percent).

Table 4 Effects of the 2015 and Two Hypothetical AI Outbreaks on the U.S. Egg Industry

Scenarios	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Egg Production, Million dozens (% Change)										
Baseline	8,407	8,514	8,615	8,713	8,813	8,913	9,015	9,121	9,228	9,337
1	-487 (-5.8)	-125 (-1.5)	-86 (-1.0)	-59 (-0.7)	-43 (-0.5)	-32 (-0.4)	-25 (-0.3)	-19 (-0.2)	-17 (-0.2)	-12 (-0.1)
2	-464 (-5.5)	-117 (-1.4)	-86 (-1.0)	-60 (-0.7)	-44 (-0.5)	-32 (-0.4)	-25 (-0.3)	-19 (-0.2)	-16 (-0.2)	-12 (-0.1)
3	-437 (-5.2)	-109 (-1.3)	-85 (-1.0)	-61 (-0.7)	-45 (-0.5)	-33 (-0.4)	-25 (-0.3)	-20 (-0.2)	-15 (-0.2)	-12 (-0.1)
Egg Exports, Million dozens (% Change)										
Baseline	375	361	351	344	339	335	332	330	329	329
1	-39 (-10.4)	-38 (-10.7)	-34 (-9.7)	-29 (-8.4)	-23 (-6.9)	-19 (-5.6)	-15 (-4.4)	-12 (-3.5)	-9 (-2.8)	-8 (-2.3)
2	-39 (-10.4)	-38 (-10.6)	-34 (-9.7)	-29 (-8.4)	-24 (-7.0)	-19 (-5.7)	-15 (-4.5)	-12 (-3.6)	-9 (-2.8)	-8 (-2.3)
3	-39 (-10.4)	-38 (-10.4)	-34 (-9.6)	-29 (-8.4)	-24 (-7.1)	-19 (-5.8)	-15 (-4.6)	-12 (-3.6)	-10 (-2.9)	-8 (-2.3)
Egg Wholesale Price, Cents/dozen (% Change)										
Baseline	107	104	104	105	106	107	108	109	110	111
1	81 (75.8)	16 (15.2)	8 (8.1)	5 (4.7)	2 (2.3)	1 (1.2)	1 (0.5)	1 (0.7)	0 (0.2)	1 (0.9)
2	75 (70.7)	15 (14.5)	9 (8.3)	5 (5.1)	3 (2.6)	2 (1.5)	1 (0.7)	1 (0.7)	0 (0.1)	1 (0.9)
3	69 (65.0)	14 (13.6)	9 (8.6)	6 (5.6)	3 (2.9)	2 (1.7)	1 (0.8)	0 (0.2)	1 (0.5)	1 (0.5)
Egg Per Capita Consumption, Eggs (% Change)										
Baseline	264	266	268	270	271	272	274	276	277	279
1	-13.2 (-5.0)	-3.1 (-1.2)	-1.7 (-0.6)	-1 (-0.4)	-0.5 (-0.2)	-0.3 (-0.1)	-0.1 (0.0)	-0.1 (-0.1)	0 (0.0)	-0.2 (-0.1)
2	-12.4 (-4.7)	-3 (-1.1)	-1.7 (-0.6)	-1.1 (-0.4)	-0.6 (-0.2)	-0.3 (-0.1)	-0.1 (-0.1)	-0.1 (-0.1)	0 (0.0)	-0.2 (-0.1)
3	-11.6 (-4.4)	-2.8 (-1.0)	-1.8 (-0.7)	-1.2 (-0.4)	-0.6 (-0.2)	-0.4 (-0.1)	-0.2 (-0.1)	-0.1 (0.0)	-0.1 (0.0)	-0.1 (0.0)
Egg Ending Stocks, Million dozens (% Change)										
Baseline	24	25	25	26	27	28	28	29	30	31
1	-5 (-23.0)	-1 (-5.2)	-1 (-3.2)	-1 (-2.1)	0 (-1.3)	0 (-0.9)	0 (-0.7)	0 (-0.5)	0 (-0.4)	0 (-0.4)
2	-5 (-21.7)	-1 (-4.9)	-1 (-3.2)	-1 (-2.1)	0 (-1.4)	0 (-1.0)	0 (-0.7)	0 (-0.5)	0 (-0.4)	0 (-0.3)
3	-5 (-20.3)	-1 (-4.5)	-1 (-3.2)	-1 (-2.2)	0 (-1.5)	0 (-1.0)	0 (-0.7)	0 (-0.5)	0 (-0.4)	0 (-0.3)

The 2015 reduction in egg production is 464 and 437 million dozens under Scenarios 2 and 3, respectively. And the 2015 increase in egg wholesale price is 70.7 and 65 cents per dozen under Scenarios 2 and 3 respectively, which is more moderate than under Scenario 1. As a result, the 2015 decrease in domestic consumption is smaller, 4.7 percent and 4.4 percent under Scenarios 2 and 3, respectively. For all three scenarios, the impact on egg production recovers quickly and the projection returns to the baseline level within 4 years. By 2024, egg production is only 12 million dozens lower than the baseline projection, which is 0.1 percent of the baseline. The impact on egg exports vanishes much more slowly than on egg production: by 2020, egg

exports are greater than 5 percent lower than the baseline projection and by 2024 the difference drops to 2.3 percent.

Table 5 Effects of the 2015 and Two Hypothetical AI Outbreaks on the U.S. Turkey Industry

Scenarios	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Turkey Production, Ready-to-cook, Million lbs. (% Change)										
Baseline	5,896	5,985	6,074	6,169	6,270	6,380	6,501	6,636	6,782	6,942
1	-291 (-4.9)	-75 (-1.3)	-69 (-1.1)	-59 (-1)	-49 (-0.8)	-40 (-0.6)	-32 (-0.5)	-25 (-0.4)	-19 (-0.3)	-15 (-0.2)
2	-291 (-4.9)	-47 (-0.8)	-51 (-0.8)	-47 (-0.8)	-41 (-0.7)	-35 (-0.5)	-28 (-0.4)	-23 (-0.3)	-18 (-0.3)	-14 (-0.2)
3	-291 (-4.9)	-16 (-0.3)	-30 (-0.5)	-34 (-0.5)	-33 (-0.5)	-29 (-0.5)	-25 (-0.4)	-20 (-0.3)	-16 (-0.2)	-13 (-0.2)
Turkey Exports, Million lbs. (% Change)										
Baseline	814	841	862	883	907	931	958	989	1023	1062
1	-285 (-35.0)	-80 (-9.6)	-36 (-4.2)	-22 (-2.5)	-16 (-1.8)	-12 (-1.3)	-10 (-1.0)	-8 (-0.8)	-6 (-0.6)	-5 (-0.5)
2	-285 (-35.0)	-72 (-8.6)	-27 (-3.1)	-16 (-1.9)	-13 (-1.4)	-10 (-1.1)	-9 (-0.9)	-7 (-0.7)	-6 (-0.6)	-4 (-0.4)
3	-285 (-35.0)	-63 (-7.5)	-17 (-2.0)	-10 (-1.1)	-8 (-0.9)	-8 (-0.8)	-7 (-0.7)	-6 (-0.6)	-5 (-0.5)	-4 (-0.4)
Turkey Retail Price, Cents/lb. (% Change)										
Baseline	165	164	167	170	172	175	178	180	181	183
1	-9 (-5.6)	-6 (-3.7)	1 (0.7)	2 (0.9)	1 (0.6)	1 (0.5)	1 (0.4)	1 (0.3)	1 (0.3)	0 (0.2)
2	-2 (-1.0)	-8 (-4.9)	-1 (-0.5)	1 (0.4)	1 (0.3)	1 (0.3)	1 (0.3)	1 (0.3)	0 (0.3)	0 (0.2)
3	7 (4.2)	-10 (-6.2)	-3 (-1.7)	0 (-0.2)	0 (0.1)	0 (0.2)	0 (0.2)	0 (0.2)	0 (0.2)	0 (0.2)
Turkey Per Capita Consumption, Lbs. (% Change)										
Baseline	16	16	16	16	16	17	17	17	17	17
1	0 (-0.2)	0 (0.0)	-0.1 (-0.5)	-0.1 (-0.7)	-0.1 (-0.6)	-0.1 (-0.5)	-0.1 (-0.4)	-0.1 (-0.3)	0 (-0.2)	0 (-0.2)
2	0 (0.0)	0 (0.2)	-0.1 (-0.3)	-0.1 (-0.5)	-0.1 (-0.5)	-0.1 (-0.4)	-0.1 (-0.4)	0 (-0.3)	0 (-0.2)	0 (-0.2)
3	0 (0.3)	0.1 (0.4)	0 (-0.1)	-0.1 (-0.4)	-0.1 (-0.4)	-0.1 (-0.4)	-0.1 (-0.3)	0 (-0.3)	0 (-0.2)	0 (-0.1)
Turkey Ending Stocks, Million lbs. (% Change)										
Baseline	253	260	262	265	268	272	276	281	286	292
1	-1 (-0.5)	3 (1.1)	-3 (-1.3)	-3 (-1.2)	-3 (-0.9)	-2 (-0.7)	-2 (-0.6)	-1 (-0.5)	-1 (-0.4)	-1 (-0.3)
2	-8 (-3.2)	6 (2.2)	-1 (-0.4)	-2 (-0.8)	-2 (-0.7)	-2 (-0.6)	-1 (-0.5)	-1 (-0.4)	-1 (-0.3)	-1 (-0.2)
3	-16 (-6.3)	9 (3.3)	2 (0.6)	-1 (-0.3)	-1 (-0.4)	-1 (-0.4)	-1 (-0.4)	-1 (-0.4)	-1 (-0.3)	-1 (-0.2)

For the turkey industry, the 2015 reduction in ready-to-cook turkey production (291 million pounds) is at a similar level to the reduction in turkey exports (285 million pounds); however, because of the big differences in the change of broiler price under three different scenarios and the significant turkey-broiler cross price elasticity of the demand for turkey

products (0.21)[3], per capita consumption of turkey tends to be affected differently corresponding to different changes in broiler prices. As a result, turkey prices have to adjust differently to clear the market.

Under Scenario 1, the 2015 turkey retail price decreases by 9 cents per pound (when broiler retail price decreases by 10 cents per pound) (Table 5). Under Scenario 2, the price drops by 2 cents per pound (when broiler retail price decreases by 1 cents per pound) which is much lower than the decrease under Scenario 1. Under Scenario 3, the change in 2015 turkey retail price is in the opposite direction (7 cents per pound higher) because broiler retail price is now 7 cents per pound higher than the baseline. Total domestic consumption remains near the before-shock level. Under all three scenarios, turkey production recovers from the AI shock gradually and by 2019 the decrease in turkey production is within 1 percent of the baseline projection. It takes longer (8 years) for turkey exports to return to the baseline level.

The effects of the 2015 AI outbreak on the U.S. pork industry are also simulated, and the results are listed in Table 6. Very little change is induced to the pork industry. Under Scenario 1, the largest adjustment is the 0.4 percent decrease in pork retail price in 2015. The AI outbreak does not affect the pork industry directly, but because of the big decrease in broiler price and the pork-broiler cross price elasticity of the demand for pork products, per capita consumption for pork tends to decrease slightly and pork retail price decreases to clear the market. The spill-over effect from the broiler industry lasts till 2016 after which the decrease in broiler retail price is less significant. The 0.4 percent decrease in pork retail price in 2015 leads to the 0.1 percent decrease in pork production in 2016 due to the production lag caused by the long production period for the pork sector. The 2016 pork per capita consumption is 0.1 percent lower than the

[3] Estimated in the partial equilibrium system we are now using.

baseline projection due to the decrease in pork production. All projections for the pork industry return to their baseline levels after 2016.

Table 6 Effects of the 2015 and Two Hypothetical AI Outbreaks on the U.S. Pork Industry

Scenarios	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Pork Production, Million lbs. (% Change)										
Baseline	23,482	24,514	25,059	25,490	25,856	26,227	26,619	27,056	27,506	27,972
1	-6 (0.0)	-16 (-0.1)	-11 (0.0)	-6 (0.0)	-2 (0.0)	0 (0.0)	2 (0.0)	2 (0.0)	3 (0.0)	3 (0.0)
2	-1 (0.0)	-6 (0.0)	-11 (0.0)	-8 (0.0)	-4 (0.0)	-1 (0.0)	0 (0.0)	1 (0.0)	2 (0.0)	2 (0.0)
3	5 (0.0)	7 (0.0)	-12 (0.0)	-9 (0.0)	-7 (0.0)	-3 (0.0)	-1 (0.0)	0 (0.0)	1 (0.0)	1 (0.0)
Pork Exports, Million lbs. (% Change)										
Baseline	5001	5210	5432	5663	5900	6142	6390	6646	6910	7182
1	0 (0.0)	-1 (0.0)	-1 (0.0)	-2 (0.0)	-2 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)
2	0 (0.0)	0 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)
3	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)	-1 (0.0)
Pork Retail Price, Cents/lb. (% Change)										
Baseline	397	376	371	372	377	383	392	399	405	411
1	-2 (-0.4)	0 (-0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
2	0 (-0.1)	-1 (-0.3)	0 (-0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
3	1 (0.4)	-2 (-0.5)	-1 (-0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Pork Per Capita Consumption, Lbs. (% Change)										
Baseline	47	49	49	49	49	49	49	49	49	49
1	0 (0.0)	0 (-0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
2	0 (0.0)	0 (0.0)	0 (-0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
3	0 (0.0)	0 (0.0)	0 (-0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Pork Ending Stocks, Million lbs. (% Change)										
Baseline	580	625	646	661	671	681	689	699	710	722
1	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
2	0 (0.0)	1 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
3	-1 (-0.2)	1 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)

All changes in the pork industry under Scenarios 2 and 3 due to the hypothetical AI outbreak follow the same pattern as Scenario 1. 2015 pork retail price decreases by 0.1 percent under Scenario 2, and increases by 0.4 percent under Scenario 3. The changes lead to a 6 million pound decrease and a 7 million pound increase in 2016 pork production under Scenarios 2 and 3, respectively. Because of the decrease in 2016 broiler retail price (7 cents per pound under

Scenario 2 and 9 cents per pound under Scenario 3), pork retail price also decreases in 2016 by 1 cent per pound under Scenario 2, and 2 cents per pound under Scenario 3. The 2016 reduction in pork price decreases the 2017 pork production and the 2017 pork per capita consumption is 0.1 percent lower than the baseline. All projections for the pork industry return to their baseline levels after 2017.

Conclusion

This study evaluates the effects of the 2015 AI outbreak and two hypothetical AI outbreaks on the U.S. poultry and egg industries. To quantify the impacts, production shocks for egg and turkey sectors as well as trade shocks for egg, turkey, and broiler sectors are assumed based on actual changes reported by USDA. Different levels of shocks were assumed for broiler production in the AI-outbreak regions. The shocks were used in a sector specific partial equilibrium model quantifying the supply and demand for the U.S. poultry and pork industries. The lasting effects of the AI outbreak are examined by comparing the 10-year projection results for production, exports, prices, and per capita consumption for broiler, turkey, egg, and the related pork industry with their baseline projections. In all cases, the effects of the shock on production started to disappear after the second year while the effects of the shock on exports lasted longer. Shocks on the broiler industry have larger effects on the other two poultry sectors than on the pork sector since the three poultry industries are closely correlated either from the supply side (broiler and egg) or from the demand side (broiler and turkey).

References

Beach, Robert H., and Chen Zhen. "Consumer purchasing behavior in response to media coverage of avian influenza." *Selected Paper prepared for presentation at the Southern Agricultural Economics Association in Dallas, TX* (2008).

Brown, Scott, et al. "The potential effects on United States agriculture of an avian influenza outbreak." *Journal of Agricultural and Applied Economics*39.02 (2007): 335-343.

Gao, Lei. *A System Approach to Study the U.S. Poultry and Pork Industries*. Diss. 2016, Texas A&M University.

Ishida, Takashi, Noriko Ishikawa, and Mototsugu Fukushige. "Impact of BSE and bird flu on consumers' meat demand in Japan." *Applied Economics* 42.1 (2010): 49-56.

Maisashvili, A. 2014. *Three Essays on the Effect of Biofuels on U.S. Agriculture*. Diss. 2014, Texas A&M University.

Mu, Jianhong E., et al. "Impacts of bovine spongiform encephalopathy and avian influenza on US meat demand." *Journal of Integrative Agriculture* 14.6 (2015): 1130-1141.

Paarlberg, Philip L., Ann Hillberg Seitzinger, and John G. Lee. "Economic impacts of regionalization of a highly pathogenic avian influenza outbreak in the United States." *Journal of Agricultural and Applied Economics* 39.02 (2007): 325-333.

Piggott, Nicholas E., and Thomas L. Marsh. "Does food safety information impact US meat demand?." *American Journal of Agricultural Economics*86.1 (2004): 154-174.

Rhew, Chanhee. *Economic Impact Analysis of Exchange Rate, RFS2, and Farm Program Support Changes on the US Crop Sector*. Diss. 2014, Texas A&M University.

Saghaian, Sayed H., Gokhan Ozertan, and Aslıhan D. Spaulding. "Dynamics of price transmission in the presence of a major food safety shock: impact of H5N1 avian influenza on the Turkish poultry sector." *Journal of Agricultural and Applied Economics* 40.3 (2008): 1015-1031.

Appendix

Estimates of Pork Demand Elasticities From Literature						
Own Price Elasticity	**Cross Price Elasticity with Chicken**	**Cross Price Elasticity with Beef**	**Study**	**Data**	**Period**	**Model Specification**
-0.730	0.0908	0.1910	Huang (1985)	Annual	1953-1983	Differential-form Demand System
-0.691	0.059	0.398	Menkhaus et al. (1985)	Annual	1965-1981	Budget Share Translog Indirect Utility Function with Habit Formation
-1.403	-19.608	-4.673	Buhr (1993)	Quarterly	1973-1989	Approximate Almost Ideal Inverse Demand System
-0.610	-3.257	-1.453	Dahlgran (1988)	Annual	1950-1985	Income-constrained Utility Maximization Model
-0.762	0.007	0.314	Eales and Unnevehr (1988)	Annual	1965-1985	Dynamic AIDS
-0.818	-9.804	-15.152	Huang (1988)	Annual	1947-1983	Rotterdam
-1.010	-3.145	-2.849	Eales and Unnevehr (1992)	Quarterly	1966-1988	Inverse AIDS
-0.502	-0.141	-0.011	Tonsor and Marsh (2007)	Quarterly	1976-2001	Generalized AIDS
-0.740	0.008	0.030	Tonsor, Mintert, and Schroeder (2010)	Quarterly	1982-2007	Weighted First Difference Double-log Function with Demand Shifters
-0.512	**0.2372**		**Gao (2016)**	**Annual**	**1985-2014**	**Double-log**
Estimates of Turkey Demand Elasticities From Literature						
Own Price Elasticity	**Cross Price Elasticity with Broiler**		**Study**	**Data**	**Period**	**Model Specification**
-0.680	-0.170		Huang (1985)	Annual	1953-1983	Differential-form Demand System
-1.332	3.968		Buhr (1993)	Quarterly	1973-1989	Approximate Almost Ideal Inverse Demand System
-0.535	-0.077		Huang (1993)	Annual	1953-1990	Differential-form Demand System
-0.237	**0.213**		**Gao (2016)**	**Annual**	**1985-2014**	**Double-log**