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The Economic Impacts of Avian Influenza on World Poultry Trade and the U.S. Poultry Industry: A Spatial Equilibrium Analysis

Harjanto Djunaidi and Andrew C.M. Djunaidi

Simulation results showed that simultaneous outbreaks of highly pathogenic avian influenza (HPAI) in Asia, the United States, Brazil, and selected European countries will have significant impacts on world poultry trade. Assuming demand for chicken meat is constant, the global export price is simulated to increase by 9.63%. HPAI outbreaks in the United States, Economic Union, and Brazil will have a greater impact on export price than in any other possible three-region case. Outbreaks in the United States and Brazil would still lead to major impacts on world poultry trade, confirming large country effects.

Key Words: birds flu, Centers for Disease Control and Prevention, economic impacts, H5N1, HPAI disease, spatial equilibrium, U.S. poultry industry, world chicken trade

JEL Classifications: Q17, Q11, Q18, F14, F17, F47

Introduction

Avian influenza viruses occur naturally among wild birds and often cause only very mild symptoms from which the birds rapidly recover. However, there are many different subtypes of influenza. Highly pathogenic avian influenza (HPAI) is an extremely infectious and fatal form of the disease that affects multiple organs and can reach mortality rates of 90% or greater in domesticated poultry, often within 48 hours of infection (CDC). Most recently, one type of HPAI known as AH5N1 or H5N1 has been responsible for disease outbreaks in poultry and/or wild birds in 46 countries. The H5N1 strain was first identified in Hong Kong and has been spread from Asia to Europe and Africa

through the movement of migratory birds. Since 2003, tens of millions of birds (mostly chickens and ducks on farms) have died or been culled because of HPAI outbreaks, which has resulted in severe impacts on the poultry sector in multiple countries, primarily in Southeast Asia. In addition to the direct impacts of culling on poultry production, there are large effects on consumption as many consumers reduce poultry consumption because of the negative publicity and fears of contracting disease. FAO reported February 2006 declines in poultry consumption of 70% in Italy, 20% in France, and 10% in northern Europe related to European HPAI outbreaks in poultry (FAO 2006). Countries involved in poultry trade are being significantly impacted even if they have not experienced an outbreak of HPAI within their borders.

There is also concern that the H5N1 virus could mutate into a form that can be passed from human to human, which would pose a significant risk of leading to a global pandemic. Policymakers and industry decision

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makers are very concerned about preventing and controlling the disease because of its substantial economic impacts and the potential devastation beyond the agriculture sector. Livestock management is critical to controlling the spread of the disease in poultry as well as delaying, minimizing, or avoiding a potential global pandemic. Prevention and control strategies can help mitigate the economic impacts of HPAI, but there are significant costs associated with these strategies. Improved biosecurity practices are very important in preventing infection in domesticated poultry. Because the virus is highly contagious in poultry, the most common method of control after an outbreak has been discovered is depopulating the entire infected flock and possibly additional flocks located in proximity to the infected one. An important consideration is the structure of compensation programs to provide incentives for farmers to report outbreaks and cooperate when flock culling is necessary.

It is very important to assess the impacts of HPAI on poultry production and consumption as well as the costs and benefits of prevention and control strategies. This assessment enables us to better understand the magnitude of the problem and to inform policymakers regarding development of effective prevention and control policies and programs to minimize the negative economic impacts of the disease.

There are many possible approaches for analyzing the potential impact of HPAI on world chicken trade and an infinite number of potential scenarios. Given the complexities of the analyses, one strategy is to focus on variations in a single measure of outbreak severity while holding other factors constant. In this analysis, we examine the impacts of HPAI outbreaks in major poultry-producing regions on a 0/1 basis, i.e., there is either an outbreak in an individual region or not. This analysis does not attempt to account for differences in severity of HPAI outbreaks within a region. Chicken supply is divided into four major regions for the purpose of assigning outbreak status, which are the United States, EU, Asia, and Latin America (represented in the empirical model by Brazil). The United

States is the largest chicken exporter in the world market followed by Brazil, China, Thailand, and some EU countries such as Germany, France, Belgium, Denmark, and the Netherlands (Djunaïdi 2006). All possible combinations of outbreak status across the four regions are analyzed and compared.

Given the magnitude of the effects that HPAI outbreaks can cause, many studies have examined ways to minimize the economic impacts of the disease. For instance, past studies have tried to link wild birds' migratory pattern with the possible spread of the disease. However, these studies were not very successful in predicting where and when HPAI outbreaks will occur in different regions of the world. Given the difficulties of predicting future occurrence of outbreaks and the inherent uncertainty in forecasting how nature might behave, one might instead identify possible combinations of cases in producing regions for analysis rather than attempting to predict the most likely outcome. The possible combinations will then be used as a basis to assess the potential economic impacts using a mathematical model. This will help decision makers to assess the range of potential economic impacts efficiently. Given our four major production regions and 0/1 definition of HPAI outbreak, there are 16 possible combinations of where outbreaks occur, as shown in Table 1. The most severe situation occurs where all four regions are affected by the disease, which is reflected in case 15. Case 16 (our baseline) is another extreme situation where no HPAI disease is found. This ideal situation occurred prior to 2000 before the first case of H5N1, the latest HPAI strain of concern, was found in Hong Kong and reappeared in China the following year.

Demand for chicken meat in each region in the model can either assumed to be constant, to decline because of consumer concerns about HPAI outbreak, or to experience positive growth over time because of population increases. Even though demand will typically react negatively to outbreaks, past experience has shown that it will likely recover relatively fast. For example, Japan reduced its imports from China when the first outbreaks

Table 1. Possible AI Outbreak Combinations^a

Case	Regions			
	U.S.	EU	Asia	Brazil
1	Y	N	N	N
2	N	Y	N	N
3	N	N	Y	N
4	N	N	N	Y
5	Y	Y	N	N
6	N	Y	Y	N
7	N	N	Y	Y
8	Y	N	Y	N
9	Y	N	N	Y
10	N	Y	N	Y
11	Y	Y	Y	N
12	N	Y	Y	Y
13	Y	N	Y	Y
14	Y	Y	N	Y
15	Y	Y	Y	Y
16	N	N	N	N

^a Y and N refer to yes and no, respectively, for AI outbreaks in certain regions

occurred there, but increased its imports from other countries that did not experience outbreaks. During the Asian HPAI disease outbreaks, Brazilian chicken exports to Japan increased tremendously. Because of the import substitutions that took place during the outbreaks in Asia, Brazilian chicken exports to the world market surpassed those of the United States. In these and other past outbreaks, demand for chicken meat may experience a downturn in the short run, but has not remained depressed in the long run. Therefore, constant demand consumption growth may be a reasonable assumption.

Objectives

The objective of this article is to examine the economic impacts of HPAI disease outbreaks in different broiler-producing regions in the world using a spatial equilibrium approach. The major broiler trade regions are divided into two groups; these groups are importing and exporting countries. A mathematical model will be utilized to capture the impacts of the disease by maximizing the social welfare function subject to production, demand, commodity prices, transportation, and trade

equilibrium conditions. Transportation costs are subtracted from the social revenue function to make the model more realistic and in line with the real-world situation. Chicken meat is assumed to be a homogeneous product throughout the analysis with zero cross-price elasticity due to quality differences. Applying such a model enables one to capture the potential impacts of HPAI outbreaks in major regions of the world. This information can help both private and public decision makers allocate resources more efficiently.

Data

The trade data used in this analysis were taken from the FAOSTAT database of the Food and Agriculture Organization of the United Nations (FAO) and the USDA Foreign Agricultural Service’s Production, Supply, and Distribution (PS&D) and Foreign Agricultural Trade of the United States (FATUS) databases. FAO reports on chicken trade contain aggregate data for chicken meat but do not differentiate the meat by parts. The PS&D and FAS report data disaggregated into different broiler parts. However, these data sets were not consistently available for the regions modeled for the entire period that FAO data could be obtained. Thus, this study utilized FAO data from 1960 through 2002. FAO reported chicken meat trade in more than two hundred countries in the world. However, some of these countries were not modeled because they have a small volume of trade and/or have not been reported consistently. In addition, countries that experienced changes in their political borders over time (e.g., countries of the former Soviet Union) were excluded. Considering these factors and practical considerations for the number of regions that can be modeled and described within the analysis, 41 major importing countries and eight exporting countries were chosen for use in this analysis.

The Baseline

Knowing the history of HPAI disease is important when deciding which period of data

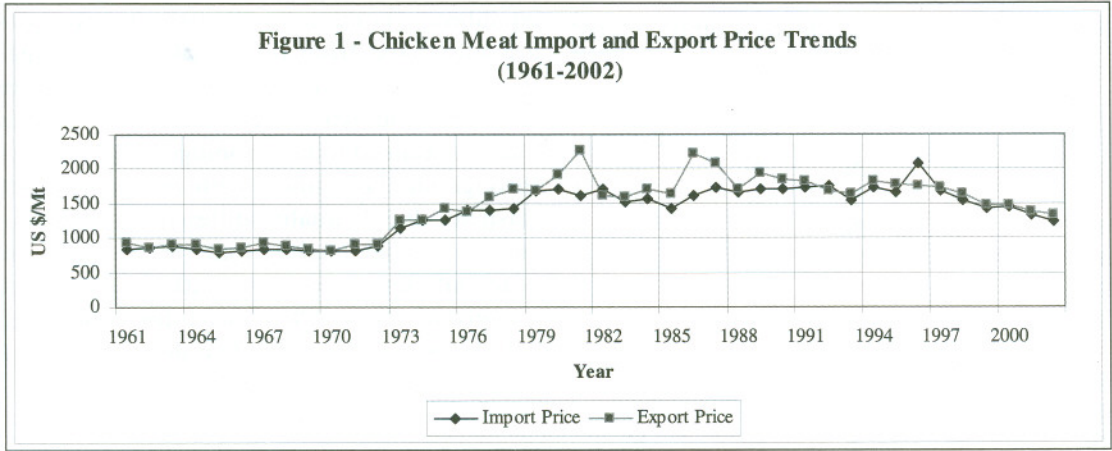


Figure 1. Chicken Meat Import and Export Price Trends

will be used to construct the baseline analysis. The data to be used in this analysis are available from 1961 to 2002. Therefore, some information contained in this data set has been affected by the HPAI disease that occurred in China and Hong Kong in the late 1990s and early 2000s. Therefore, appropriate adjustments potentially need to be made in order to construct a baseline data set that does not reflect effects of HPAI outbreaks. However, this correction does not appear too significant in this case for three reasons. The first is that only Hong Kong and China experienced H5N1 during the timeframe of the data used. The second reason is that the impact will be averaged out through the remaining years of data used to construct the baseline. Third, China’s global market share is relatively small compared to that of the United States or Brazil. Therefore, the impact of late 1990s and early 2000s HPAI disease on the baseline data set will be minimal.

As shown in Figure 1, there are three possible trends of the world chicken export and import prices. These prices are the actual representation of the equilibrium price in the world open economy. Knowing the behavior of such prices will also help to decide which of the years will be used to construct the baseline. This information along with knowing the history of the disease will help to build a representative baseline analysis. As one might see from Figure 1, there are three

possible price trends during the entire period of 40 years: stable, increasing, and decreasing price trends. Which of these data are reasonable to be used in constructing the baseline analysis? Three criteria can be used to find the answer. One, the baseline needs to cover a period during which disease was minimal. Second, the decision needs to be based on a statistical analysis that tests if the mean price is equal under the three price regimes. Third, the data need to portray the current situation facing by the industry. Analyzing Figure 1 thoroughly helps to identify three different periods associated with increasing, stable, and declining price trends. As a result, three possible sets of data theoretically can be utilized to generate the baseline analysis. The first trend showed a situation where the prices experienced a positive growth, while the second trend showed a mixed combination of export price or stable while the third situation showed a declining pattern.

The null hypothesis of no import or export price difference in the mean (with unequal price variance assumption) of the first (1961–1980) and the third periods (1990–2002) is rejected at a 1% level. However, the statistical test results revealed that the null hypothesis of the second (1981–1989) and the third period is failed to be rejected. The conclusive statistical test results enable one to use theoretically any period from 1981 to 2002 data to construct the baseline. The results of hypothesis tests for

Table 2. Hypothesis Tests on Three Export Price Regimes

Explanation	Price Regimes ^a					
	I and II		I and III		II and III	
Mean price	882.1957	1,733.794	882.195684	1,570.149	1,733.794	1,570.149
Variance	1,014.37	67,426.12	1,014.36965	32,180.01	67,426.12	32,180.01
Observations	11	20	11	8	20	8
Hypothesized mean difference	0		0		0	
Df	20		7		19	
t Stat	-14.4702		-10.7247909		1.903128	
P(T ≤ t) one-tail	2.33E-12		6.7321E-06		0.036143	
t critical one-tail	1.724718		1.8945786		1.729133	
P(T ≤ t) two-tail	4.66E-12		1.3464E-05		0.072287	
t critical two-tail	2.085963		2.36462425		2.093024	
Conclusions	Rejection		Rejection		Fail to reject	

^a Regimes I, II, and III are from 1961–1980, 1981–1989, and 1990–2002, respectively.

export and import prices are presented in Table 2 and 3, respectively.

Beginning in 1990 the world chicken market became more volatile and showed a strong trend of declining prices. Several major events contributed to declining prices, including an increasing volume of chicken meat from nontraditional chicken exporters such as China and Thailand, overinvestment in the industry in major producing countries, Russian tariff trade policy against imports of U.S. leg quarters, and increasing U.S. exports of excess dark meat to the world market due

to a strong domestic demand for the white meat.

The potential for a continuing trend of decreasing export price needs to be taken into consideration when structuring the baseline analysis. In this study the baseline is structured to closely match the current event in the market as well as the long-run outlook in the industry. Therefore, trade data from the 1990 to 2002 period were used to construct the baseline analysis upon which simulation of the HPAI impacts on the world and U.S. chicken trade were based. The reason for using this

Table 3. Hypothesis Tests on Three Import Price Regimes

Explanation	Price Regimes ^a					
	I and II		I and III		II and III	
Mean price	838.2712	1,570.513	838.271187	1,549.893	1,570.513	1,549.893
Variance	899.9326	24,403.34	899.932557	69,824.22	24,403.34	69,824.22
Observations	11	20	11	8	20	8
Hypothesized mean difference	0		0		0	
Df	21		7		9	
t Stat	-20.2933		-7.58167406		0.206742	
P(T ≤ t) one-tail	1.4E-15		6.4112E-05		0.420406	
t critical one-tail	1.720743		1.8945786		1.833113	
P(T ≤ t) two-tail	2.8E-15		0.00012822		0.840813	
t critical two-tail	2.079614		2.36462425		2.262157	
Conclusions	Rejection		Rejection		Fail to Reject	

^a Regimes I, II, and III are from 1961–1980, 1981–1989, and 1990–2002, respectively.

Table 4. World Chicken Meat Trade Basic Statistics

Explanation	Price		Trade Volume	
	Import	Export	Import	Export
Mean	1,603.14	1,640.89	6,084,944.75	6,988,163.25
Standard error	60.73	48.51	211,482.25	255,287.47
Minimum	1,232.69	1,328.88	5,556,463	6,309,301
Maximum	2,078.75	1,834.30	6,429,328	7,443,412
Kurtosis	0.79	−1.04	−2.48	−0.44
Skewness	0.32	−0.62	−0.63	−0.93
Range	846.05	505.42	872,865	1,134,111

Source: FAO.

period is that it satisfies all necessary conditions for constructing the baseline.

Measures of price volatility and the volume of trade are presented in Table 4. This information is important to understand the nature of the baseline and to get a better understanding of the basic statistics of the data used in this analysis, which is helpful in interpreting simulated scenario results. One can see that the import prices are more volatile than export price as measured by the standard errors and the range. Although the means were similar, the range of the import price data used in the baseline analysis was \$846.05, while it was only \$505.42 for the export price. However, export volumes have higher standard errors compared to those of import volume. The export price data are spread out more to the left, while the import prices are skewed to the right as measured by the skewness. Moreover, both the import and export trade volumes are spread out more to the left. This indication may suggest that the data used to construct the baseline may not have a normal distribution, except for the import trade volume, which is −2.48 as measured by the kurtosis.¹ One implication is that the results of simulations of the export volume may deviate from the means.

Theoretical Approach

Following Takayama and Judge, a spatial equilibrium model is developed and applied to

address the research questions. The objective function in this model is the net quasi-welfare function, which will be maximized subject to a set of linear constraints. Mathematically the model can be written as

(1)
$$\text{Max } \sum_i^I \sum_j^J C_{ij} * P_{ij} - \sum_i^I \sum_j^J TC_{ij}$$

subject to

(2) $C_{ij} \geq 0,$

(3) $P_{ij} \geq 0,$

(4) $TC_{ij} \geq 0,$

(5)
$$\sum_i^I \sum_j^J C_{ij}^S = \sum_i^I \sum_j^J C_{ij}^D,$$

where

- C_{ij} = The quantity of commodity i in region j
- P_{ij} = Commodity price for commodity i in region j
- TC_{ij} = Total transportation cost

C^S and C^D , respectively, are quantity supplied and quantity demanded.

The first term in Equation (1) is the total revenue from selling commodity i in region j multiplied by its respective price of commodity i in region j . The second term is the total transportation cost of shipping commodity i from producing to consumption region j . Equations (2) to (4) respectively are nonnegativity constraints placed on commodity i , commodity price, and total transportation cost. Equation (5) is a balance or equilibrium

¹ Data with a normal distribution will have kurtosis equals to 3.

Table 5. Simulated World and U.S. Chicken Trade Volumes under Different Scenarios (Metric Tons)

Case	World Trade	U.S. Exports
1	6,130,328	4,387,231
2	6,424,345	5,097,830
3	6,435,002	5,063,652
4	6,370,401	5,133,201
5	6,106,277	4,441,467
6	6,389,587	5,090,676
7	6,363,537	5,153,419
8	6,119,957	4,410,823
9	6,071,402	4,521,071
10	6,351,929	5,185,401
11	6,095,681	4,465,449
12	6,344,845	5,206,377
13	6,059,963	4,547,092
14	6,044,440	4,582,123
15	6,032,420	4,609,467
Average	6,222,674	4,793,019

trade quantity condition. When certain regions experience an HPAI outbreak, then the world supply curve will shift to the left by Δ*X*. As a result, one can rewrite Equation (1) as

(6)
$$\text{Max} \sum_i^I \sum_j^J (C_{ij} - \Delta C_{ij}) * P_{ij} - \sum_i^I \sum_j^J TC_{ij}.$$

The results of such an outbreak will cause the world price to increase, and the quantity of chicken meat traded in the world market will decrease.

In this analysis, the chicken meat traded is assumed to be homogeneous. This assumption may not be realistic since broiler meat can be traded in many forms such as dark meat, i.e., wings, leg quarters, legs, thighs, drumsticks, or it can be in white meat form such as BSB (boneless skinless breast) and its related derivative products. For example, most of U.S. broiler exports to the world market are in the form of dark meat such as leg quarters and wings because the dark meat is considered to be a by-product of white meat production and is available abundantly in the U.S. market (Djunaidi 2004a). This is because U.S. con-

Table 6. Simulated Export Prices under Different Possible Scenarios^a

Country	Case															Average	Base
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Belgium	939.7	877.8	864.7	873.6	946.3	879.7	875.4	942.5	955.9	888.4	949.1	890.3	959.1	963.3	966.6	918.2	863.0
Brazil	918.9	847.7	847.4	862.0	925.5	849.1	863.8	921.8	935.3	866.7	928.4	868.5	938.4	942.7	946.0	897.5	845.6
China	933.6	866.7	866.5	870.2	940.2	871.5	877.2	936.5	949.9	874.9	945.7	882.1	953.0	957.3	960.6	912.4	861.9
Denmark	932.6	865.5	862.4	871.3	941.3	867.4	873.1	935.5	948.8	876.1	946.8	877.9	952.0	958.4	961.7	911.4	860.6
France	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0	1,063.0
Germany	957.0	941.5	941.5	941.5	968.4	941.5	941.5	959.9	973.3	941.5	971.2	941.5	976.4	982.8	986.1	957.7	941.5
Netherland	928.0	860.9	857.7	866.7	939.3	862.7	868.5	930.8	944.2	871.4	942.2	873.3	947.4	953.7	957.0	906.9	856.0
Thailand	933.6	866.7	866.5	870.2	940.2	871.5	877.2	936.5	949.9	874.9	945.7	882.1	953.0	957.3	960.6	912.4	861.9
United Kingdom	932.6	865.5	862.4	871.3	943.9	867.4	873.1	935.5	948.8	876.1	946.8	877.9	952.0	958.4	961.7	911.6	860.6
United States	924.5	852.7	849.5	858.4	931.1	854.5	860.3	927.4	940.7	863.2	934.0	865.1	943.9	948.1	951.4	900.3	847.8
Average	946.4	890.8	888.2	894.8	953.9	892.8	897.3	948.9	961.0	899.6	957.3	902.2	963.8	968.5	971.5	929.1	886.2

^a Assume demand for chicken meat is constant and a 25% drop on chicken production.

Table 7. Simulated Import Prices under Different Possible Scenarios

Country	Case															Average	Base
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Angola	945	878	877	881	951	882	888	947	961	886	957	893	964	968	972	923	873
Argentina	949	877	874	883	956	879	885	952	965	888	958	890	968	973	976	925	872
Belgium	961	889	886	894	967	891	896	963	977	899	970	901	980	984	987	936	884
Benin	954	883	879	888	961	884	890	957	971	893	964	895	974	978	981	930	878
Canada	940	868	865	874	947	870	876	943	956	879	950	881	960	964	967	916	863
China	965	893	890	899	971	895	900	968	981	903	974	905	984	988	992	940	888
Congo	948	876	873	882	954	878	883	951	964	886	957	888	967	971	975	924	871
Croatia	955	883	880	889	962	885	891	958	971	894	965	896	975	979	982	931	878
Denmark	937	869	866	875	945	871	877	939	953	880	951	882	956	962	966	915	865
Estonia	968	905	902	911	968	907	913	968	968	916	968	918	968	968	968	941	900
France	977	905	902	911	983	907	912	979	993	915	986	917	996	1,000	1,004	952	900
Germany	963	896	893	902	974	898	903	966	979	906	977	908	982	989	992	942	891
Guatemala	947	875	872	881	954	877	883	950	964	886	957	888	967	971	974	923	871
Haiti	954	883	880	888	961	885	890	957	971	893	964	895	974	978	981	930	878
Hungary	651	651	651	651	651	651	651	651	651	651	651	651	651	651	651	651	651
Ireland	979	908	908	917	986	910	919	982	996	922	989	924	999	1,003	1,006	956	906
Jamaica	951	879	876	885	957	881	886	954	967	889	960	891	970	974	978	927	874
Japan	967	895	892	900	973	897	902	969	983	905	976	907	986	990	993	942	890
South Korea	964	892	889	898	971	894	900	967	980	903	974	905	984	988	991	940	887
Kuwait	953	891	878	887	959	893	889	956	969	901	962	903	972	976	980	931	876
Latvia	948	876	876	891	954	878	893	951	964	895	957	897	967	971	975	926	874
Macedonia	949	882	879	885	955	884	889	952	965	890	961	894	968	972	976	927	877
Malaysia	964	892	889	898	971	894	900	967	980	903	974	905	983	988	991	940	887
Mexico	953	881	878	887	959	883	889	956	969	891	962	893	972	976	980	929	876
Namibia	927	856	855	870	933	857	872	930	943	875	936	876	946	951	954	905	854
Netherland	977	905	902	911	983	907	913	980	993	916	986	918	996	1,001	1,004	953	900
Oman	962	891	887	896	969	892	898	965	979	901	972	903	982	986	989	938	886
Philippines	965	893	890	899	971	895	900	968	981	903	974	905	984	988	992	940	888
Poland	953	886	886	889	959	891	896	956	969	894	965	901	972	977	980	932	881
Qatar	953	886	883	892	962	888	894	956	969	897	967	898	972	979	982	932	881
Romania	975	903	903	918	981	905	920	978	991	922	984	924	994	998	1,002	953	901

Table 7. (Continued)

Country	Case															Average	Base
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Russia	974	903	902	917	980	904	919	977	990	922	983	923	993	998	1,001	952	901
South Africa	953	886	883	892	962	888	894	956	969	897	967	898	972	979	982	932	881
Saudi Arabia	979	907	904	913	986	909	915	982	996	918	989	920	999	1,003	1,006	955	903
Singapore	953	886	886	889	959	891	896	956	969	894	965	901	972	977	980	932	881
Spain	919	848	847	858	925	849	860	922	935	863	928	865	938	943	946	897	846
Sweden	954	887	883	892	965	888	894	957	970	897	968	899	973	979	983	933	882
Switzerland	974	903	902	917	980	904	919	977	990	922	983	923	993	998	1,001	952	901
United Kingdom	974	902	899	908	980	904	910	977	990	912	983	914	993	997	1,001	950	897
Ukraine	979	907	904	913	986	909	915	982	996	918	989	920	999	1,003	1,006	955	903
United Arab Emirate	979	907	904	913	986	909	915	982	996	918	989	920	999	1,003	1,006	955	903
Yemen	979	908	908	917	986	910	919	982	996	922	989	923	999	1,003	1007	956	906
Average	952	883	881	890	958	885	892	954	967	894	961	897	970	974	978	929	928

sumers prefer to consume the white meat instead of dark meat (Goodwin, McKenzie, and Djunaidi). Therefore, U.S. exporters are more likely to export dark meat to the world markets instead of whole broiler or the BSB (Djunaidi 2004b). Brazil is more likely to export either whole broilers or broiler parts depending on the export destination. For example, Brazil has exported more high-value broiler parts to the Japanese market, and its part exports have increased by 26% in volume (2.4 million metric tons), with the value of the exports U.S. \$2.6 billion.

Transportation cost also is accommodated in the model to make the analysis more realistic (Wailes, Fuller, and Djunaidi). Both excess demand and excess supply will be generated from domestic demand and supply econometric and time series estimations. Once the excess supply and demand elasticities are estimated, a spatial equilibrium mathematical model is developed and solved using GAMS software. The international chicken markets were grouped into two separate regions, i.e., importing and exporting countries. Data from more than 50 countries were utilized in this analysis to find the trade flows and import and export prices such that the quasi-welfare function as shown in Equation (1) will be maximized as discussed in Takayama and Judge. In this analysis several important assumptions are made. First, the quality of traded chicken meat in the world market is homogenous. Consequently, the cross-price elasticities due to different quality attributes and commodity origin among different producers are zero. Another important assumption that was used here is that there are no trade barriers among the trading nations. These assumptions are a bit strong but are necessary to simplify this first attempt to study the impacts of HPAI outbreaks on the global chicken trade—both to generate the baseline as well as to run different scenarios.

Results

The results of the baseline and the other 15 scenarios are reported in Tables 5, 6, and 7. These results are simulated based on the

assumption of 25% production reduction in the affected regions. The tables show the impacts of the AI disease outbreaks on the world and U.S. chicken export volumes. Table 5 shows the impact of AI outbreaks on the volume of trade under 15 cases. The world trade volume in any of the scenarios will reach well above 6 million metric tons (mmt). As an important player in the world chicken export market, the United States will export well above 4 mmt and in some cases more than 5 mmt. As one might have expected, the world chicken trade hits its lowest level under case 15 when all four regions modeled experience outbreaks. Under such a case, the volume of trading is around 6.03 mmt. The disease will have less significant impact to the trade volumes under cases 2, 3, 4, 6, 7, 10, and 12. The world volume of trade in these five cases is well above 6.22 mmt (the average volume). Comparing these findings with the information presented in Table 1, one might be able to see the general pattern and therefore can make a conclusion in that the United States does not experience an outbreak in any of these cases. This finding is interesting because, in the real world, the United States is perhaps the most prepared exporter and has both the resources and abilities to deal with such outbreaks efficiently. The predicted volume of trade found in this study is consistent with the USDA (2005) baseline projection. For example, the USDA has reported that the world and the U.S. trade volume for ready-to-cook chicken reached a level of 6.451 and 2.47 mmt, respectively, in 2004. The average U.S. chicken exports generated from the simulations is around 4.79 mmt. This number is much higher than the actual volume. One of the reasons to cause such a difference is due to highly skewed data used to construct the baseline.

Table 6 shows the simulated export prices. Brazil is the most competitive exporting country among the major chicken exporters (i.e., lowest export price) followed by the United States. On average, the Brazilian exporters can sell chicken \$2.80 per metric ton cheaper than their U.S. counterparts. These simulation results are consistent with

the USDA projection. As expected, the highest export price, \$971.5 per metric ton, is generated under scenario 15. The lowest export price of \$888.2 per metric ton would occur under scenario 3 where only the Asian region is affected by the outbreaks. This finding confirms the fact that Asia is not an important player in the current world chicken trade. Surprisingly, when Brazil alone is assumed to experience the outbreaks (see case 4), then the average export price is \$894.8 per metric ton, which is only \$8.6 above the average baseline price. This might suggest that if Brazil experiences such an outbreak, then importers can easily shift their imports from other countries such as the United States. Table 7 shows the effects of different HPAI disease scenarios on the import price. Ireland and Yemen will both pay the highest import price, which is \$956 per metric ton. Saudi Arabia, the United Arab Emirates, and Ukraine will pay a dollar less than the highest import price. Hungary will pay the lowest import prices.

Conclusions

The simulation results showed that the volume of chicken world trade will be affected significantly if an HPAI outbreak occurs in the United States. As expected, the export price will hit its highest point if all producing regions are affected by the outbreaks. Assuming demand for chicken meat is constant, global export price will increase by 9.63% from the baseline if the outbreaks occur in all regions. The impact of such a disease will be less dramatic on the world volume of trade under scenarios 1–12. HPAI disease outbreaks in the United States, EU, and Brazil will have a greater impact on export price than in any other possible combination of cases in three regions. In the case of two affected regions, outbreaks in the United States and Brazil would have the largest economic impact on world trade, confirming large country effects.

References

- Centers for Disease Control and Prevention. Department of Health and Human Services. Internet site: <http://www.cdc.gov/flu/avian/gen-info/facts.htm> (Accessed November 7, 2006).
- Djunaidi, H. "Strategic Analysis and Market Competition in the International Chicken Market." *Economic of Agriculture and Natural Resources*. Cordelia L. Frankhouse, ed. New York: Nova Science Publishers, 2006.
- . "Econometrics and Time Series Model Selections: A Choice between Two Possible Approaches to Access Linkages between the U.S. and Export Chicken Markets." Paper presented at the Southern Agricultural Economics Association Annual Meetings, Little Rock, Arkansas. February 4–6, 2004a.
- . "Assessing the Linkages between the U.S. and Export Chicken Markets." Poster presented at Southern Agricultural Economics Association Annual Meetings, Little Rock, Arkansas. February 4–6, 2004b.
- Food and Agricultural Organization of the United Nations. Internet site: <http://faostat.fao.org> (Accessed June 5, 2005, and February 6, 2006).
- Goodwin, H.L., Andrew McKenzie, and HarjantoDjunaidi. "Which Broiler Part Is the Best Part?" *Journal of Agricultural & Applied Economics* 35(2003):483–95.
- Takayama, T., and G.G. Judge. *Spatial and Temporal Price and Allocation Models*. Amsterdam: North Holland Publishing Company, 1971.
- U.S. Department of Agriculture. Internet site: <http://www.ers.usda.gov/publications/oce501/oce2005lg.pdf> (Accessed February 5, 2006).
- . Internet site: http://www.fas.usda.gov/livestock_arc.aspr (Accessed March 11, 2006).
- . Internet site: <http://www.fas.usda.gov/psdonline/psdDownload.aspx> (Accessed March 18, 2006).
- . Internet site: <http://www.ers.usda.gov/Data/FATUS> (Accessed March 19, 2006).
- Wailles, E.J., Frank Fuller, and HarjantoDjunaidi. "Regional Trade Agreements in the Americas: Impacts on Rice Trade. Paper presented at Free Trade of the Americas, the WTO, and New Farm Legislation Conference, San Antonio, Texas. May 23–24, 2002.