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Shocks to a Trading System: Northeast Asia Poultry Trade and Avian Influenza¹

Christopher G. Davis[Ⓐ] and John Dyck^ᵇ

^ᵃ *Economist, Markets and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture. 355 E Street, SW, Washington D.C. 20024, USA.*

^ᵇ *Economist, Markets and Trade Economics Division, Economic Research Service, U.S. Department of Agriculture. 355 E Street, SW, Washington D.C. 20024, USA.*

Abstract

Japan and South Korea, net importers of chicken meat, experienced high-pathogenic avian influenza (HPAI) in their domestic broiler populations and faced HPAI outbreaks in some of their principal suppliers in the last two decades. Both countries banned imports of frozen chicken meat from China and Thailand, beginning in 2004. Japanese data show that there was a structural break in import behavior at that time. Rotterdam models are estimated for Japan before and after the break and for Korea from 2005-2013. Results show that China and Thailand competed mostly with each other in the latter period, dividing up the cooked meat trade with few substitution effects evident with other suppliers. Brazil's exports dominate Japan's frozen chicken imports. Imports of both Korea and Japan have been rising. Imports from Brazil and China show the most elastic response to increased import expenditure, suggesting that the share of both countries in East Asian imports could grow in the future.

Keywords: chicken meat trade, Rotterdam model, avian influenza

[Ⓐ]Corresponding author: Tel: + 1. 202. 694-5167

Email: C. G. Davis: chrisdavis@ers.usda.gov

J. Dyck: jdyck@ers.usda.gov

¹ The views expressed here are those of the authors, and may not be attributed to the Economic Research Service or the U.S. Department of Agriculture.

Introduction

Japan and South Korea, neighboring countries in Northeast Asia, illustrate interesting changes in the market for broiler meat in the last two decades. Import supplies to these major importing countries have changed profoundly in product type and origin as avian influenza (AI) has affected broiler flocks around the world. Both countries have integrated, modern production of broilers, using imported feedstuffs. Demand for broiler meat has been increasing in both countries (USDA-FAS-PS&D 2014). Domestic production supplies all the demand for fresh and chilled chicken meat, while imports compete strongly with domestic products for frozen and processed chicken demand (Obara 2014; Choi and Myers 2014). Japan is the world's second-largest importer of broiler meat, by value and quantity, and South Korea is the eighth-largest importer (Global Trade Atlas 2015).² The two countries export little poultry meat. Northeast Asia, like other parts of Asia, has a consumer preference for 'dark' meat—legs, wings, etc.—as opposed to 'light' meat from the breasts. This naturally complements demand in North America, where breast meat has been preferred, and forms one basis for trade. Labor costs in Northeast Asia are high relative to other parts of the world, and the use of lower-cost labor in the rest of Asia and in South America to produce de-boned broiler cuts and processed chicken products has formed another basis for trade (Dyck and Nelson 2003). Poultry disease, especially AI, has complicated domestic production and trade in the last two decades.

Sanitary regulations strongly condition the trade in frozen broiler meat. Japan and South Korea require that exporting countries meet production, processing, and shipment standards before allowing imports. Until 2005, for example, South Korea did not recognize Brazil's standards, and trade was thus not possible (Phillips and Cheung 2005). Disease outbreaks interrupt normal trade, and, in particular, AI has affected the imports of Japan and South Korea. Both countries banned imports from several countries after outbreaks of highly pathogenic avian influenza (HPAI) in the last 20 years. Finally, disease outbreaks in Japan and South Korea affect those countries' own ability to produce domestic broiler meat. Serious outbreaks of HPAI occurred in both countries in the last 20 years (Figure 1).

Demand for processed broiler meat serves consumers' desire for convenience and variety, both in home meal preparation and in fast food restaurants. Processing can be done either in the country or outside. Processing in Japan and South Korea relies heavily on imports of frozen broiler meat (Obara 2014; Choi and Myers 2014). Domestic processed broiler products compete directly with imported processed products. Imports of processed (or cooked) broiler meat thus can be seen as substitutes both for imports of frozen meat and for domestic production of processed meat. General sanitary regulations apply to processed meat imports. However, diseases present in fresh, chilled, or frozen broiler meat are killed through heat treatment in processing the meat. Thus, processed meat imports are generally not blocked when HPAI or other diseases break out in exporting countries.

² For the United States, South Korea was the 10th-largest export market for chicken meat in 2014 by value, and 13th-largest by quantity. Japan was the 19th-largest by value and the 28th-largest by quantity. Together, the two markets represented about 3 percent of U.S. chicken meat export value in 2014.

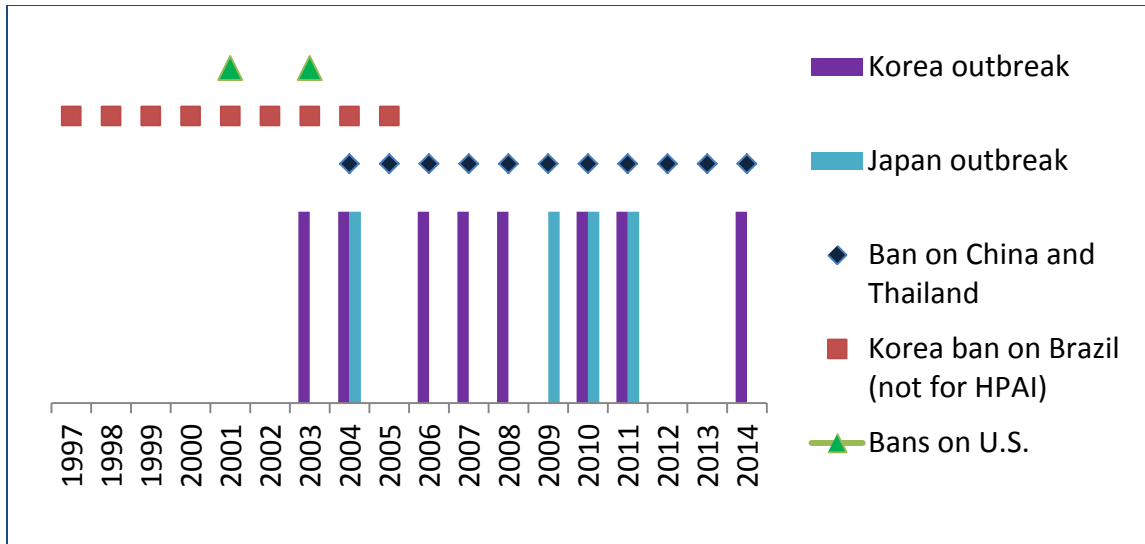


Figure 1. South Korea and Japan HPAI Outbreaks and Trade Bans
Source. USDA-FAS, Selected Gain Reports.

The ability to switch to some extent between exporting frozen and processed broiler products helps explain the continuation of export trade by Thailand and China, two major broiler-exporting countries in Asia (USDA-ERS-PS&D 2014). Relatively low Thai and Chinese labor costs apparently support the ability of firms to export into the global market. Cutting up and deboning fresh chicken is labor-intensive, and even more labor is needed to process broiler cuts into various cooked products.

HPAI outbreaks in 2004 severely affected exports by China and Thailand (Figure 2). Exports recovered to some extent, with Thai exports exceeding pre-2005 record levels in recent years. Both China and Thailand have exported primarily processed broiler meat since 2004 (Preechajarn 2014; Scott, Duerr, and Zhang 2014). However, Thailand regained the right to export frozen meat to the European Union in 2012, and begun exporting frozen meat to Japan again in 2014 (Preechajarn 2012; Obara 2014).

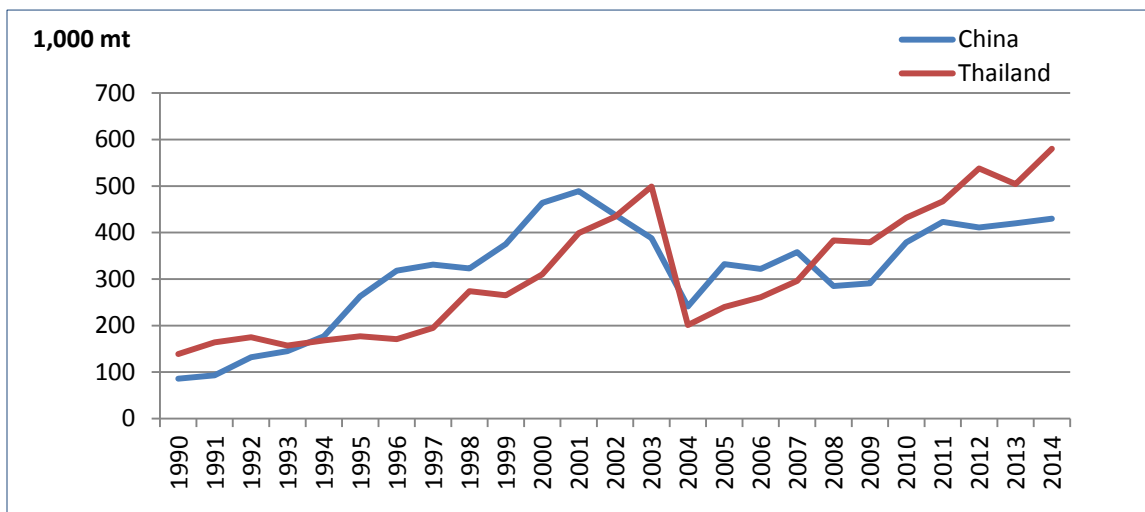


Figure 2. Broiler Meat Exports of China and Thailand
Source. USDA-FAS, PSD Database 2014. September 26.

Imports have provided 32-40 percent of Japan’s broiler meat supply since 1995 (USDA-ERS-PS&D 2014). The frozen imports increasingly have been dominated by Brazil, which supplied over 93 percent of Japan’s imports in the frozen cuts category (HS020714) in 2013. The United States was a distant second source of imports. Thailand’s re-entry into the frozen market in 2014 is expected to provide a new source of competition. Over time, Japan’s broiler meat imports have shifted toward processed, or cooked, meat (Figure 3). In cooked meat (HS160232), China and Thailand have competed for the largest import flow into Japan. China and Thailand supplied 50 percent and Thailand 49 percent, respectively, of Japan’s cooked chicken meat imports in 2013 (Figure 4).

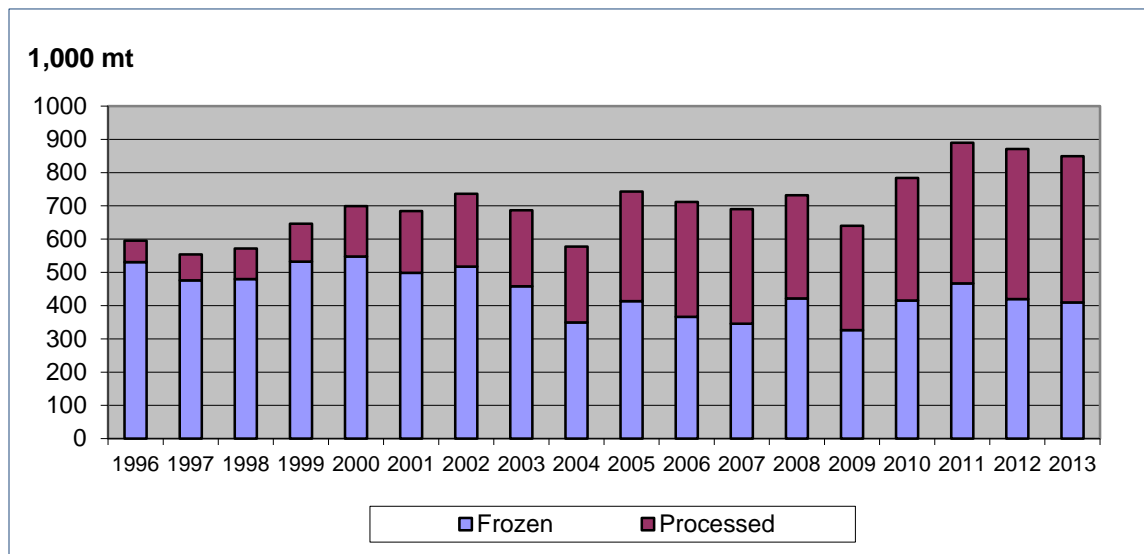


Figure 3. Japan Broiler Meat Imports
Source. ERS data using World Trade Atlas, 2014.

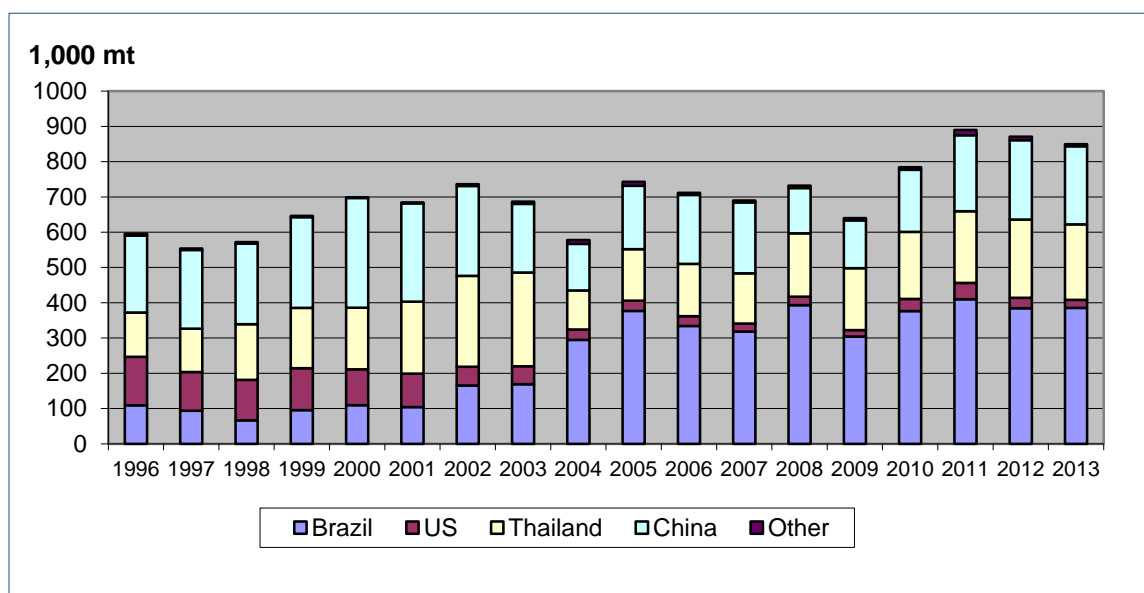


Figure 4. Japan Poultry Meat Imports
Source. ERS data using World Trade Atlas, 2014.

South Korea’s import patterns differ from those of Japan in some respects. Imports are less important, varying between 10 and 18 percent of total supply since 1999 (USDA-ERS-PS&D 2014). Processed meat imports are a lower share of imports than in Japan, about 13 percent of total imports, in quantity terms, in recent years, and about 20 percent of import value (Figure 5). Frozen imports from Brazil now supply the majority of Korean imports, but, unlike Japan, imports from the United States maintain a large share—36 percent in quantity and 24 percent in value. Thailand is the supplier of most of Korea’s imports of processed meat, with China a distant second, unlike the Japanese pattern of nearly even competition. Finally, again unlike Japan, the EU is a consistent exporter of frozen broiler meat to South Korea (Figure 6).

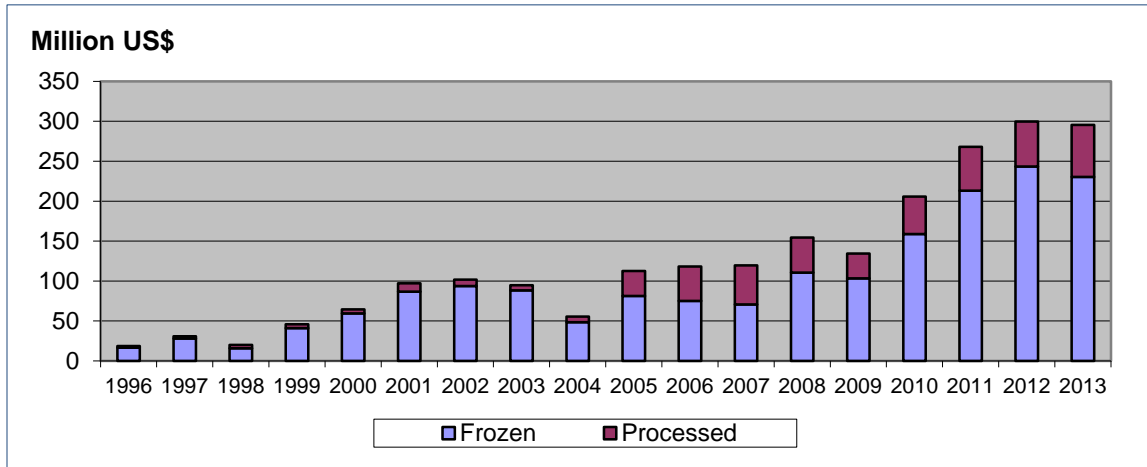


Figure 5. South Korea Broiler Meat Import

Source. ERS data using World Trade Atlas, 2014.

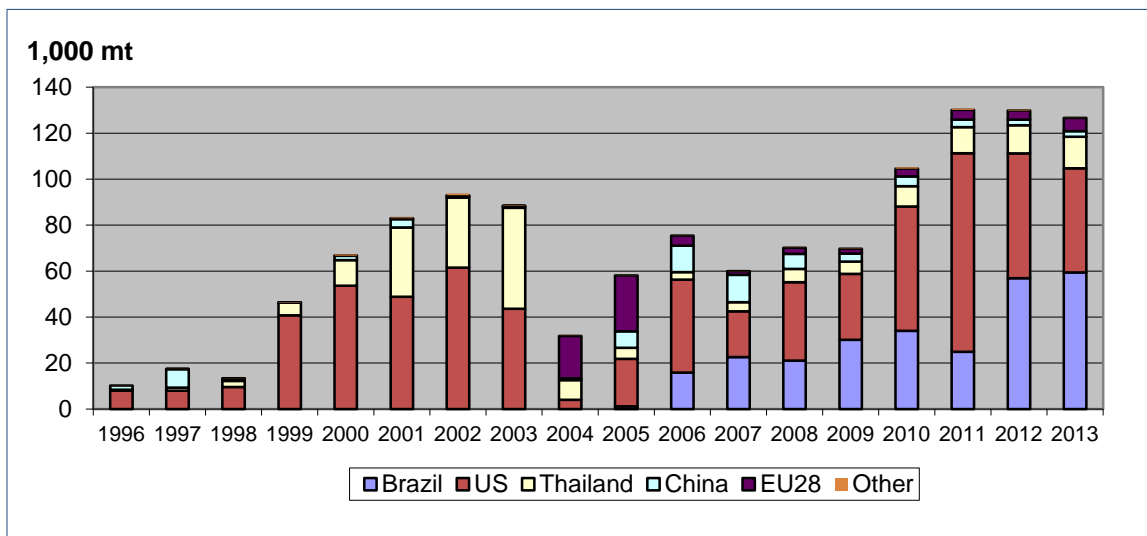


Figure 6. South Korea Poultry Meat Imports

Source. ERS data using World Trade Atlas, 2014.

The East Asia broiler market is based on a relatively homogeneous product, the modern broiler chicken, raised in similar ways in the exporting and importing countries. The underlying preference for broiler meat is for legs and other dark meat in both Japan and South Korea (Obara 2014; Choi and Myers 2014).

Both Japanese and South Korean broiler import markets dipped sharply in 2004 as HPAI outbreaks roiled markets. South Korea's import contraction was more pronounced, likely because the range of possible suppliers did not include Brazil in 2004, while Brazil (not affected by HPAI) was already a large supplier to Japan, and could substitute for suddenly-absent imports from Asian suppliers.

In this article, we test the competitive position of the exporting countries in the Japanese and Korean markets. A particular question is the degree of competition between Thai and Chinese cooked products with uncooked products from other exporters, after HPAI outbreaks led to the ban on frozen chicken imports from Thailand and China. Import behavior in Japan is compared, before and after the ban on Thai and Chinese frozen products. Import behavior in Japan and South Korea is compared, after the bans were imposed. Taha and Hahn (2011) found significant changes in the kinds of meat imported by Japan, before and after major disease outbreaks. This study looks at the changes in origins for one meat type, poultry, in the wake of HPAI outbreaks, and examines whether inter-country competition for Korean and Japanese imports intensified or otherwise changed.

The article next reviews some pertinent literature on AI and trade. Then the Rotterdam approach to modeling import demand is explained, and the data for the variables are documented. Results are presented and discussed for each of the three models estimated (Japan, 1996-2003; Japan, 2004-2013; and South Korea, 2005-2013). Inferences revealed by the estimation are highlighted and implications from them discussed in the concluding section.

Related Studies

This study focuses on a period in which AI was an important problem for poultry production and world poultry trade. While other studies have analyzed the effects of AI outbreaks on poultry trade, no study, to our knowledge, has estimated price and expenditure elasticities before and after an outbreak for Japan and South Korea import demand for poultry. Wieck, Schlueter, and Britz (2012) examined the impact of avian influenza related regulatory policies on poultry meat trade and welfare and found that significant trade diversion took place in countries that experienced an AI outbreak. Their findings also suggested that a trade ban is not the most appropriate measure to resolve the spread of the AI virus. Taha and Hahn (2011) analyzed HPAI impacts on Japan's import demand for cooked and uncooked poultry, beef, pork, and other meats. They discovered that after HPAI and Bovine Spongiform Encephalopathy (BSE) outbreaks, Japan's import demand for meat shifted toward rising demand for cooked poultry and pork meats, and declining demand for uncooked poultry, beef, and other meats. Taha (2007) also investigated how HPAI has affected world poultry meat trade. His findings suggested that the consumers' fear of infection has affected poultry consumption in many countries, causing a reduction in domestic prices, production, and poultry meat exports.

Understanding consumer response to HPAI outbreak is important when predicting impacts within the poultry market. Mu and McCarl (2010) evaluated how consumers' consumption patterns are affected by AI media coverage. Their findings suggested that AI media coverage had a positive effect on poultry demand in the short-term, while BSE had a negative effect on beef demand. Beach et al. (2008) examined the effects of avian influenza news on consumer

purchasing behavior. Their estimated poultry demand, as influenced by the volume of newspaper reports on AI, reveals the magnitude and duration of newspaper articles' impacts on consumers' food choices. A significant number of news reports on AI have given rise to large reductions in poultry purchases.

Disease outbreaks in red meats, particularly pork and beef, have had similar impacts on trade. Yang and Saghaian (2010) looked at what happens to U.S. pork exports when foot-and-mouth disease (FMD) is discovered in other countries importing U.S. pork. Findings reveal that FMD outbreaks in foreign countries have a positive impact on U.S. pork exports. Jin and Koo (2003) examined the effects of BSE outbreak in Japan on the import demands for U.S. beef in Japan and South Korea. Findings show that BSE outbreak in Japan influenced Japanese meat import demand from the U.S., but not South Korean meat import demand.

Similarly to Taha and Hahn (2011), this study will evaluate the impact a trade restriction (shock) has on chicken imports. More specifically, the study will explore the impacts of Japan's restriction on chicken imported from China and Thailand and competitive relationships among suppliers in the neighboring Japanese and Korean markets.

Rotterdam Model

Demand for chicken meat imports is modeled as the third stage of consumer choice to allocate expenditures. In the first stage, following the findings of Chung et al. (1993) and Seale et al. (1992), chicken meat expenditure is assumed separable from expenditures on other groups of goods. In the second stage, expenditure for chicken meat is allocated between domestically produced and imported chicken meat. Finally, expenditure on chicken meat imports is allocated among import sources. In this study, we estimated the import demand for chicken meat (both uncooked and cooked) by source according to the importing country. By incorporating the differential approach to consumer demand, it is possible to derive the conditional demand equation for imported chickens by source. Let $W_i^* = W_i/W_g$ and $\alpha_i^* = \alpha_i/\alpha_g$, where W_i^* is the (conditional) trade share of imported chicken meat from country I , W_i is the budget share of imported chicken meat from country I , C_g is the imported chicken meat group such that $W_g = \sum_{i \in C_g} W_i$ is the budget share of the group C_g , and α_i represents the marginal share of imported chicken from country I . Following Weatherspoon, Davis, and Olorunnipa (1999) and Weatherspoon and Seale (1995), the conditional demand equation for imported chicken by source can be written as:

$$(1) \quad W_i^* d(\log q_i) = \alpha_i^* d(\log Q_g) + \sum_{i \in C_g} \delta_{ij}^* d(\log p_j)$$

where p_j is the price of imported chicken meat from sources j , q_i is the quantity of imported chicken from I , δ_{ij}^* are (conditional) Slutsky price parameters, and $d(\log Q_g) = \sum_{i \in C_g} W_i^* d(\log q_i)$ is the Divisia quantity index for C_g (Theil and Clements, 1987). The d in equation (1) is a derivative for discrete changes from one month to the next. In this analysis, we assume that α and the δ_{ij}^* are constant so that we can obtain the conditional absolute version of the Rotterdam model (Theil and Clements, 1987). Two Rotterdam models were used to analyze chicken meat imports by Japan and South Korea. The models were estimated without imposing any restrictions and with homogeneity restrictions imposed. Laitinen's (1978) exact homogeneity test did not reject homogeneity at the 0.05 significance level for the Japan and South Korea models.

Symmetry restrictions were tested using likelihood ratio tests comparing the symmetry and homogeneity restricted models to those of the homogeneity restricted ones (Bewley 1986). Symmetry and homogeneity could not be rejected for either the Japanese or Korean models at the significance level of 0.05.

Two Rotterdam models (uncooked and cooked chicken meat combined) are analyzed for two sizable import markets for U.S. broiler meat using Time-Series Processor (TSP). Monthly observations from 1996 to 2013 are analyzed for Japan and 2005 to 2013 for South Korea. Price and expenditure elasticities were estimated for each market. The elasticities estimated reflect the market for imported chicken meat. Based on assumed separability of consumer decision-making, domestic chicken meat and other consumer goods are not part of the analysis. Expenditures in this analysis are the total value of imported chicken meat. Import unit values are treated as prices in the analysis.

Data

The data are import expenditures, quantities, and import unit values obtained from a proprietary database of official Japanese and Korean import statistics (GTIS 2014). The original Korean data are in U.S. dollars, and have not been converted. The Japanese data are in Japanese yen. The data represent the major exporters. In the case of Japan, remaining imports from minor exporters were aggregated into a Rest of World (ROW) variable. For Korea, imports from other countries were omitted from the analysis, because there were too many months with no trade, and the aggregate volume of the imports was always quite small.

Results

To measure the impact of the trade ban, a preliminary test was conducted to determine if there was structural change after Japan imposed trade restrictions against the U. S., Thai, and Chinese poultry exports in 2003 and 2004. The test statistics³ reveal that there was a structural break in chicken trade flows between the periods January 1996 to December 2003 and January 2004 to December 2013, corresponding to the events in the timeline in Figure 1. Due to these findings, estimation of Japan's chicken trade is divided into two separate data periods: before and after the restriction was enforced.

The Japanese Chicken Imports before Restrictions (1996-2003)

In the Japanese market, the major competitors are Brazil, China, Thailand, and the United States. Table 1 shows the price and expenditure elasticities for the Japanese market which are the conditional Slutsky price parameters for the Rotterdam model (symmetry and homogeneity imposed). Three of the five own-price parameters had the expected negative sign and were significantly different from zero (at the significance levels of 0.01 and 0.10) with the exception of ROW and U.S. Of the four countries analyzed, China and Brazil own-price elasticities have

³ We used the dummy variable approach to test if the parameters were significantly different in the two time periods. The likelihood ratio test indicates that the parameters were different. Test Statistic: 269.497, Upper tail area: 0.0000.

the greater impact and more significant role in explaining changes in Japanese imports of chicken meat than do the Thai, U.S., or ROW own prices. A 1% change in the own-price of China and Brazil chicken meat will cause Japan's import demand of chicken meat from that country to increase or decrease by almost 1%. A 1% change in the Thai own price leads to a change of 0.63% in imports from Thailand.

Table 1. Japan's Price and Expenditure Elasticities for Chicken Imports before the Restrictions were Applied on U.S., Thailand, and China (1996-2003).

	ROW	Thailand	U.S.	China	Brazil	Exp. Elasticity
ROW	-0.277 (-1.331)	0.006 (0.414)	-0.015 (-0.705)	0.005 (0.579)	-0.003 (0.114)	0.704 *** (1.988)
Thailand	0.336 (0.414)	-0.628 *** (-4.179)	-0.301 (-1.597)	0.487 *** (6.472)	0.274 (0.909)	0.465 *** (7.578)
U.S.	-0.296 (-0.705)	-0.107 (-1.597)	-0.122 (-0.535)	0.194 *** (2.757)	-0.202 (-0.879)	0.601 *** (3.297)
China	0.320 (0.579)	0.611 *** (6.472)	0.682 *** (2.757)	-0.994 *** (-6.293)	0.899 *** (2.106)	1.250 *** (11.532)
Brazil	-0.083 (-0.114)	0.118 (0.909)	-0.360 (-0.879)	0.309 *** (2.106)	-0.967 * (-1.770)	1.858 *** (5.634)

Note. T-Statistics are in parentheses. *** Represent significant levels at 1% * Represent significant levels at 10%.

Source. Authors' calculation using the GTIS data.

In the Japanese market, the Slutsky cross-price elasticities suggest that most of the major markets exporting chicken to Japan before the HPAI outbreaks served as substitutes for one another within the Japanese market place (Table 1). Of the 20 cross-price elasticities estimated, six are statistically significant. All six significant cross-price elasticities suggest a substitute relationship (plus sign). The eight cross-price elasticities involving the ROW do not significantly differ from zero. This is unsurprising, since the ROW is an aggregate of a shifting set of minor exporters, and strong substitution effects with the major exporters might not be occurring, or might be masked by sporadic entry and exit of minor exporters. The largest substitution effect occurs between Brazil and China. A 1% increase in the Brazil chicken price will cause Japan to increase imports of China chicken by .90%, which suggests an almost proportional change in quantity imported to a change in price. The U.S. and China as well as Thailand and China are also competitors in the Japanese market; a 1% increase in the price of U.S. chicken would cause Japan to import 0.68% more of China's chicken, while a 1% increase in the price of Thailand's chicken would cause Japan to import 0.61% more of China's chicken. Thailand, Brazil, and the U.S. also would benefit if China should increase the price of its chicken exported to Japan.

The expenditure elasticities are all positive as expected and statistically significant at the 0.01 level (Table 2). Brazil and China expenditure elasticities estimates suggest that the two are elastic and growing overall import demand has a strong impact on Japan's chicken imports from those countries. If the Japanese market expands its expenditure on imported chicken by 1%, Thailand and China's market shares will increase more than proportionately, 1.86% and 1.25%, respectively. Given the same scenario, Thailand, ROW, and U.S. market shares would increase by less than 1%.

The Japanese Chicken Imports after Restrictions (2004-2013)

Table 2 displays Japan's price and expenditure elasticities for chicken after a restriction was enforced on the U.S., Thailand, and China chicken exports. This impediment to trade was short

lived for the U.S., lasting only six months, but is still in place for China and was in place through 2013 for Thailand. The own-price elasticities shown in Table 2 are all negative with four of the five being statistically different from zero. After the restriction, the U.S. and the ROW own-price elasticities are elastic (1.14 and 1.99, respectively) and statistically significant, which is different from the elasticities estimated before the restriction. A moderate decrease in U.S. and ROW chicken prices would give rise to a more than proportional increase in the quantity of chicken imported by Japan from those countries. Differences are also seen in the own-price elasticities of Thailand, China, and Brazil. Findings suggest that imports from China became more price sensitive than those from Thailand after the restriction, and that imports from Brazil became less sensitive to own-price movements than before the restrictions (Tables 1 and 2). Similar to our study, differences in Japanese import demand elasticities before and after Japan's 2004 HPAI-outbreak and U.S. 2003 BSE-outbreak are also found by Taha and Hahn (2011). Findings show that cooked poultry own-price elasticity (-0.120 to -0.744) and beef own-price elasticity (-0.923 to -1.432) became more sensitive to changes in prices after the outbreak.

Table 2. Japan's Price and Expenditure Elasticities for Chicken Imports after the Restrictions were Applied on U.S., Thailand, and China (2004-2013).

	ROW		Thailand		U.S.		China		Brazil		Exp. Elasticity	
ROW	-1.993 (-7.491)	***	-0.094 (-5.827)	***	-0.066 (-0.997)		0.176 (9.837)	***	0.003 (0.215)		0.470 (2.487)	***
Thailand	-2.377 (-5.827)	***	-0.537 (-2.814)	***	1.700 (2.815)	***	0.889 (5.209)	***	-0.294 (-1.768)	*	0.618 (6.063)	***
U.S.	-0.126 (-0.997)		0.128 (2.815)	***	-1.137 (-4.211)	***	-0.010 (-0.189)		-0.213 (-0.457)		0.807 (1.971)	**
China	4.408 (9.837)	***	0.877 (5.509)	***	-0.137 (-0.189)		-1.567 (-5.660)	***	0.396 (1.903)	*	0.721 (5.934)	***
Brazil	0.089 (0.216)		-0.374 (-1.768)	*	-0.360 (-0.456)		0.511 (1.903)	*	-0.084 (-0.302)		1.544 (12.959)	***

Note. T-Statistics are in parentheses. *** Represent significant levels at 1% **Represent significant levels at 5% * Represent significant levels at 10%

Source. Authors' calculation using the GTIS data.

Findings suggest a stronger substitution relationship among exporting countries than before the restriction was established. One reason for this stronger substitution across countries after the restriction is that importers may no longer see it beneficial to rely on a single or a few exporting countries to supply chicken meat. The strategy of many suppliers helps importers obtain more competitive chicken prices and it reduces the chances of domestic demands being disrupted for long periods if there is an AI outbreak in one or two poultry exporting countries.

In the Japanese market, China and the ROW chicken products became substitutes as well as the U.S. and Thailand after the restriction. All of the chicken substitutions among countries that existed before the restriction continue to exist except for those between China and the U.S. In addition, Thailand's chicken exports and Brazil chicken exports became complements to each other after the restriction.

Similar to Table 1, the expenditure elasticities in Table 2 are all positive and statistically significant at the 0.01 level. The expenditure elasticities estimated after the restriction are smaller, overall, than those estimated before the restriction. Brazil's expenditure continues to be more sensitive to changes in Japan's expenditure on imported chicken meat than other exporting

countries. This is consistent with the increasing share of Brazil in Japan's imports during this period. Findings suggest that China's expenditure elasticity is inelastic and changes in Japan's chicken imports have less of an impact than before the restriction.

As anticipated, the two models yielded somewhat different results. The results after the restriction are statistically stronger than the derived results before the restriction. One reason that the model examining Japanese chicken imports from 2004 -2013 is statistically stronger, is due to the sustained growth in world poultry trade during this period. Brazil and the U.S., the world's largest poultry exporters experienced exceptional growth within this period of consideration. Between 2001 and 2012, Brazilian exports more than doubled, increasing from 1.2 million metric tons (mmt) to 3.5 mmt. Total U.S. broiler meat exports grew by 31 percent between 2001 and 2012, and only by 9.2 percent between 1997 and 2002 (Davis et al. 2013). In addition, our results reveal that there was a structural break in chicken trade flows that separated the two periods.

Table 3. South Korea's Price and Expenditure Elasticities for Chicken Imports (2005-2013).

	Thailand		U.S.		EU-28		China		Brazil		Exp. Elasticity	
Thailand	-1.313 (-3.999)	***	-0.167 (-2.447)	***	-0.381 (-0.917)		0.692 (1.954)	**	0.437 (7.598)	***	0.337 (3.655)	***
U.S.	-0.369 (-2.447)	***	-0.928 (-3.294)	***	-1.092 (-1.557)		0.158 (0.351)		0.940 (5.932)	***	0.827 (4.775)	***
EU-28	-0.093 (-0.917)		-0.120 (-1.557)	***	-0.590 (-1.128)		0.275 (1.325)		0.099 (1.686)	*	1.670 (3.505)	***
China	0.587 (1.954)	**	0.060 (0.351)		0.959 (1.325)		-2.094 (-3.890)	***	0.302 (2.106)	***	1.145 (4.201)	***
Brazil	1.188 (7.598)	***	1.154 (5.931)	***	1.105 (1.686)	*	0.969 (2.922)	***	-1.777 (-11.277)	***	1.279 (11.603)	***

Note. T-Statistics are in parentheses. ***Represent significant levels at 1% **Represent significant levels at 5% * Represent significant levels at 10%

Source. Authors' calculation using the GTIS data.

The South Korean Market (2005 - 2013)

Table 3 displays the price and expenditure elasticities for South Korea import demand for chicken. All own-price elasticities are negative as expected and significantly different from zero (at the 0.01 significance level) with the exception of the EU-28. Findings suggest that the Korean market is most sensitive to changes in China's chicken prices. A percentage decrease in China's chicken price will give rise to twice that percentage increase in quantity imported from China. Brazil and Thailand imports were sensitive to own-price movements in the Korean market as well. A 1% change in the own-price of Brazil and Thailand will cause trade (Korea's import demand of chicken from those countries) to increase or decrease more than proportionately. Of the four statistically significant own-price elasticities, the U.S. had the smallest elasticity (but still near -1). Given a 1% change in the U.S. own-price, U.S. imports would have changed by 0.93% in the opposite direction.

Most of the Slutsky cross-price elasticities (14) suggest that the chicken exports from various countries to the Korean market are primarily substitutes. Ten of the 14 cross-price elasticities suggesting a substitute relationship are statistically significant. Of the five major chicken

exporting countries, Brazil stands to gain the most in Korea given an increase in other competitors' chicken prices. The largest substitution effects exist between Thailand and Brazil. A percentage increase in Thailand, U.S., EU-28, and China chicken prices will yield a 1.19%, 1.15%, 1.11%, and 0.97% increase in Korea's chicken import from Brazil. U.S. benefits almost proportionally if Brazil were to increase its chicken price by 1% and Thailand gains market shares if China and Brazil were to increase their chicken prices. China gains if Thailand and Brazil were to increase their chicken prices and EU-28 profits only if Brazil's chicken price increases.

In Table 3, findings indicate that the expenditure elasticities are all positive, adhering to economic theory. Each country's expenditure elasticity is significantly different from zero at the 0.01 level (Table 3). If Korea were to expand its chicken import expenditure, the EU-28 would capture the most market share followed by Brazil and China. Findings also suggest that the U.S. and Thailand stand to gain the least of the five chicken exporters and their market shares would increase by less than 1%, given a 1% rise in chicken import value.

Conclusion

Analysis of chicken meat trade data for 1996-2013 for Japan and 2005-2013 for South Korea allows comparison of trade behavior between the two countries and of trade behavior during a period of serious HPAI outbreaks and especially of a ban on frozen exports from two major suppliers.

HPAI outbreaks in China and Thailand ended the exports of frozen chicken meat from those countries to Japan and South Korea, but cooked meat was still exported. The two countries dominate the cooked meat imports of Japan and South Korea, and their trade with Japan and Korea after 2004 can be seen as a good approximation of cooked meat imports, while the trade of other suppliers constituted the frozen imports. A statistical test indicated that the parameter values, as a set, were different before and after 2004, for Japan.

Before 2004, China and Thailand were major suppliers of frozen chicken meat, in addition to some cooked meat. Expenditure elasticities for China and Thailand with respect to Japan's total import value for chicken meat show that the expenditure elasticity for Thailand increased somewhat after 2004, and the expenditure elasticity for China decreased sharply (from 1.25 to 0.72). Own-price elasticity for Thailand fell, while that for China rose. These results do not offer strong indication of a shift in demand as the product switched from mostly frozen to entirely cooked.

However, the cross-price elasticities between China and Thailand rose after 2004, consistent with their position as virtually the only competitors for cooked product trade. Cross-price elasticities with other suppliers in the Japanese market after 2004 were not significant or were negative (indicating complementarity rather than competition), except for the Thai elasticity with respect to the U.S. price. Similarly, for Korean imports, China and Thailand had robust, positive cross-price elasticities, while cross-price elasticities with other countries were 0 or negative, except for Brazil, whose frozen product apparently competes with cooked chicken in that market. Overall, the results support strong competition between China and Thailand for cooked meat imports of

Japan and Korea, and much less competition with other suppliers. The higher expenditure elasticity for Chinese products than for Thai products may indicate that China's share of cooked meat may rise in the future, compared to Thailand's share.

In general, the developments in the two large Asian importing markets, Japan and Korea, in the wake of the HPAI outbreaks show that cooked product imports can successfully replace frozen products. Both Thai and Chinese suppliers were able to make this transition. This could be relevant for other major import markets in the future, if HPAI outbreaks again occur.

In both Japan and Korea, 3 of 5 own-price elasticities exceed 1, since 2005. Trade shares are thus sensitive to price, in general. Expenditure elasticities for most exporting countries are high in both Japan and Korea. However, expenditure elasticities for Thailand are relatively low, suggesting that the Thai share of chicken meat imports could drop in the future.

A rise in Brazil's price has strikingly little impact on its trade with Japan, according to these estimates. The own-price elasticity and the cross-price elasticities are not significant, except with regard to the U.S., in which case complementarity is evident. Brazil's dominance of the frozen meat trade with Japan may continue, since the expenditure elasticity for Brazil is the highest measured for Japan in the post-2004 period. However, the end of the ban on Thai frozen chicken in 2014 (outside the data used here) may bring some new competition for Brazil. In Korea, Brazil's price changes are much more important. The own-price elasticity is high (almost -1.8) and cross-price elasticities are positive and significant. As with Japan, the expenditure elasticity for Brazil is the highest of the exporting countries.

U.S. expenditure (about 0.8) and own-price elasticities (about -1) in the post-AI ban periods in Japan and Korea are quite similar. In both countries, there are few significant cross-price elasticities involving U.S. trade. The U.S. price is quite important for Brazil's trade with Korea, and vice versa. In Japan, the U.S. price affects only Thai imports, while the Thai import price is the only one that affects U.S. trade. U.S. trade with Japan is virtually only in bone-in legs, and this product differentiation may explain the lack of competition involving the U.S. Korea imports more chicken meat from the U.S. than Japan does, but, as with Japan, competition with other suppliers does not appear widespread for U.S. trade with Korea.

Rotterdam models, applied to a segment of trade in Japan and South Korea, appear to provide demand parameters that correspond well to market behavior in a period of considerable turmoil related to HPAI outbreaks. The estimates may be useful in assessing future competition for the chicken meat imports in East Asia.

Firms involved in supplying consumers with chicken meat have the option of importing cooked meat, when AI disrupts the supply of fresh or frozen chicken. The Japanese and Korean experience demonstrates that cooked chicken is a viable alternative to frozen chicken imports. Policymakers should consider how consumer needs for meat will be met, as policies to deal with HPAI or other animal diseases are formulated. In South Korea, broiler meat consumption dropped below earlier levels in 2004 and 2005 (by 10 percent, in 2004). In Japan, consumption in 2004 was 7 percent less than in 2003. In both countries, these declines were among the most abrupt in the last 20 years. Policies that spell out in advance protocols that can maintain more

supply, such as defining regional markets within supplying countries that can be treated as distinct when addressing disease risk, or that automatically exempt cooked products from import bans, can alleviate consumption shocks. HPAI shocks continue to occur: a 2015 outbreak in the United States and other countries has again affected trade. In response, Korea banned frozen poultry meat imports from the United States (Meatingplace 2015). Results from this study suggest that Brazil will substitute for Korean imports from the United States. If Brazil were also affected, the results indicate that processed poultry meat imports from Thailand and China would rise.

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