Highly Pathogenic Avian Influenza Impacts on Japan's Import Demand for Cooked and Uncooked Poultry, Beef, Pork, and Other Meats

Fawzi A. Taha and William F. Hahn[1]
ERS-MTED-USDA, Washington, DC
Ftaha@ers.usda.gov, Whahn@ers.usda.gov

The authors are Economists with the Market and Trade Economic Division, Economic Research Service, USDA. Contact author 1800 M Street, NW, Washington, DC 20036

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Introduction

The outbreak of highly pathogenic avian influenza (HPAI) H5N1- virus in East and Southeast Asia in late 2003 had a worldwide impact on poultry production, consumption, prices, and trade patterns in both HPAI-infected countries and uninfected countries around the world. Concurrently, Bovine Spongiform Encephalopathy (BSE) or "mad cow disease" was confirmed in the United States December 2003. The HPAI (H5N1)-virus struck Japan in January 2004 and spread westward to countries in Asia, Central Europe, the Middle East, Africa, and Western Europe. In response, Japan imposed import bans on beef from the United States in December 2003 and on poultry from HPAI-infected Asian suppliers in January 2004. The United States was a major beef and other meat supplier to the Japanese market. The immediate trade response to the two diseases caused Japan's imports of poultry, beef, and other meat (largely beef offal) to decrease 31, 39, and 48 percent, respectively, from fourth-quarter 2003 to first-quarter 2004. After the initial demand shocks, however, consumer fears subsided and meat imports resumed, but meat import share patterns were different compared with the pre BSE-HPAI outbreaks period. By fourth-quarter 2008, Japan's imports of poultry, beef, and other meat were still below their pre-HPAI-BSE levels, while imports of pork and a new category designated as "cooked poultry meat" increased substantially by 30 and 34 percent, respectively, compared with fourth-quarter 2003.

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The major objectives of this paper are to evaluate the impact of both the HPAI and BSE outbreaks on Japan's meat markets and to model a meat import demand system. The analysis used the Consumer Bureau of Statistics (CBS) model and focused on possible structural change, triggered by consumers' rising preference for safer cooked poultry meat, challenging uncooked poultry, beef, pork and other meats. A novel feature of this analysis is differentiation of poultry meat into two distinct import products--cooked (safe) and uncooked (less safe)--and using both as variables in the model. The paper starts with a literature review, followed by description of Japan's meat imports, prices over the last 15 years, data description, methodology, the empirical results, and conclusion.

Literature Review

Several authors have studied the economic impacts of animal disease outbreaks and food safety incidents on consumer demand for meat. The two most serious diseases are BSE and HPAI that potentially are fatal to humans. More economic analysis of BSE outbreaks is available in the literature, in part because BSE was known much earlier. The case of "Mad-cow disease" or BSE was first recognized in 1986 in the UK and spread to other European countries (Mathews et al., 2004). The BSE discovery in the UK triggered a shift away from beef consumption toward pork, chicken, and lamb (Burton and Young, 1996; Henson and Mazzocchi, 2002; and Leeming and Turner, 2004). Consumers' fear of eating beef accelerated sharply after the British Government announced on March 20, 1996 the possible fatal link between BSE and a new variant, Creutzfeldt-Jakob disease (vCJD), in humans. This announcement had a substantial impact on beef consumption, production, prices, and trade around the world. In the UK, domestic sales of beef dropped 40 percent and consumption fell 26 percent below the previous year's level (Atkinson, 2003). In France, beef sales dropped 24 percent and consumers were willing to pay a premium for safer beef that does not transmit vCJD (Latouche et al., 1998). Sharp declines in fresh beef purchases and consumption were reported in many other countries, such as the Netherlands (Mangen and Burrell, 2001), Belgium (Verbeke et al., 2000; Verbeke and Ward, 2001), and the United States (Schlenker and Villa-Boas, 2008). In Japan, consumer response was instantaneous after the 1996 British Government announcement linking BSE with the Creutzfeldt-Jakob disease (vCJD); one out of four consumers stopped eating beef altogether, changing largely to poultry (Peterson and Chen, 2005). A similar reaction was also reported following the discovery of Japan's first BSE case in a dairy cow in September, 2001, when 25 percent of consumers stopped eating beef as of mid-October 2001, consumption declined 40-50 percent, and wholesale prices dropped 30-60 percent below the September level (Fox and Peterson, 2004). In just 2 months, beef consumption (domestic and imported) fell 70 percent, and customers were willing to pay more than a 50-percent premium for BSE-tested beef (McCluskey et al. (2003). Japanese consumers significantly moved away from both domestic and imported beef consumption toward less risky substitutes, such as pork and chicken, after the 2001 BSE outbreaks in Japan (Clemens, 2003; and Jin et al., 2003). The 2001 BSE outbreaks caused demand for pork and fishery products to rise as substitutes for the declining demand for beef Ishida et al. (2010**)**. Peterson and Chen, (2005), Jin and Koo (2003), and Jin et al. (2003) found a structural change in Japan's meat market following the September 2001 BSE outbreaks, which caused a shift from domestic and imported beef consumption toward less risky substitutes, such as pork and chicken.

The HPAI (H5N1) virus was found on a goose farm in Guangdong, China, and the first HPAI outbreaks were reported in poultry farms, live animal markets, and 18 human cases (six fatal) in Hong Kong 1997. In late 2003, the virus spread to other East and Southeast Asian countries, infecting Japan in January 2004, (WHO, March 23, 2009). Subsequently, only a few studies have addressed impacts of HPAI outbreaks on domestic meat markets and reported substantial disruption in poultry production, consumption, prices, and/or trade. In Vietnam, one month after HPAI struck Hanoi in January 2004, 74 percent of consumers initially stopped eating poultry meat and adopted alternative ways of selecting and preparing poultry meat to assure food safety (Figuie and Fournier, 2008). In Taiwan, consumers were well informed about health risks associated with the disease and substituted poultry meat consumption with more pork and aquatic products (Liu et al, 2007). In Korea, Park, Jin and Bessler (2008) reported that the December 2003 HPAI outbreak was simultaneous with the U.S. BSE case of 2003, caused poultry prices and consumption to decrease and demand for pork to increase. In Japan, Ishida et al (2010) reported that the 2004 HPAI outbreaks decreased domestic demand for chicken, increased demand for pork and fishery products as substitutes, and had no positive impact on beef's market share. In Italy, historical sales of fresh poultry meat decreased 79.8 percent and sales of frozen and processed poultry declined 14.7 percent, due to negative news about the HPAI outbreaks in domestic and international media (Beach, et al., 2008). In the United States, Paarlberg, et al. (2007) analyzed the economic impacts of a hypothetical HPAI outbreak under regionalization and non-regionalization. They concluded that the largest inverse impact occurred in the first quarter following the outbreaks. Under the non-regionalization scenario, U.S. poultry meat production, prices, and exports were estimated to decline by 21 percent, 9.6 percent, and 89 percent, respectively. Under regionalization, total impacts varied depending on the assumed outbreaks' region.

Japan's Meat Imports and Prices

Japan is a good setting for meat import-demand analysis in that it is a key import market for all meat products, and the country relies on meat imports to cover meat requirements of its population. In 2008, about 56 percent of beef consumed was imported, compared with 48 and 31 percent in pork and broiler meats (ALIC, 2009). The Japanese are health conscious, and exhibit ready responses to food safety and health information concerns, as the literature review above demonstrates. Following the late 2003 BSE-HPAI outbreaks in Japan's major beef and poultry supplier and the 2004 HPAI outbreaks in Japan, the government imposed bans on beef imports and poultry from infected countries. As a result, imports of beef and poultry meat (cooked and uncooked) declined sharply in the first quarter of 2004, compared with the fourth quarter 2003. The reductions in Japan's poultry meat imports proved to be short-lived, as consumers gained confidence that poultry meat was safe if properly handled and cooked (OIE, October 2005; Swayne, 2006). Consequently, after lifting import bans in March 2004, Japan's meat imports resumed, but meat import share patterns were different; cooked poultry and pork imports were up while uncooked poultry, beef, and other meat were down. A pattern of Japan's changing import shares from 1994 to 2009 is shown in figure 1. Non-poultry meats carry the highest price in Japanese markets as indicated by average-weighted import value per unit, including freight, insurance and other charges. Also, cooked poultry meat values remained consistently higher than uncooked poultry; the highest premium of 148 percent recorded in February 2004, one month after the HPAI outbreaks in Japan, and the lowest of 24 percent in December 2008.

Data

Japan's meat imports were divided into five classes: cooked poultry, uncooked poultry, beef, pork, and all other meats. Data for each meat class were aggregated and a unit value ($US per kilogram) was calculated as a weighted average for each of the five classes. The cooked poultry class contained four major Harmonized Standards (HS) tariff code categories; chicken meat (HS 160232), turkey meat (HS 160231), other poultry (ducks, geese, and guineas) (HS 160239), and other poultry products (preserved in brine, salted, dried, smoked, etc. (HS 021099). The uncooked poultry class consisted of fresh, chilled, and frozen poultry meat, whole and in parts (HS 0207). The beef class consisted of fresh or chilled (HS 0201) and frozen (HS 0202). The pork class included fresh, chilled, and frozen (HS 203). Finally, all other meat class consisted of sheep, lamb, or goats (HS 0204), horse (HS 0205), and offal (HS 0206 and HS 0208). In 1994-2003, prior to HPAI outbreaks, imports of cooked meats as a percentage of totals

cooked and uncooked imports were small, accounting for 3, 11, and 0.52 percent for beef, pork, and other meat, respectively. After the HPAI outbreaks, imports of cooked beef and other meats rose only fractionally, cooked pork was up 5 percentage points. However, cooked poultry rose sharply 18 to 44 percent. Consequently, only poultry was disaggregated, while imports of cooked beef, pork, and other meats were added to their respective uncooked amounts, constituting the total amount imported for each class. Monthly data on import quantities and unit values were obtained from Japan customs data and the World Trade Atlas (2010).

The applied model

A demand system for five classes of imported meats is estimated using monthly data from January 1994 to September 2008, 177 observations. 121 of these observations occur before the Japanese Government's reaction to the BSE-HPAI outbreak. The system for these 5 meats is estimated under the assumption that these 5 meat's import demands can be separated from the demand for all other products; the demand system is condition on expenditures for the 5 meat classes. The demand model is based on a consumer demand system; meat imports are inputs into consumer products. However, Theil (1977) demonstrated that the demands for inputs subject to output meet the same restrictions as consumer demand functions.

The specific system used is the CBS (Central Bureau of Statistics) demand system which was developed by Keller and Van Driel (1985). One important advantage of differential systems is that it is easy to incorporate taste shifts into differential models. Alston, Chalfant, and Piggott (2000) briefly discussed the problems involved in adding advertisement-driven shifts to the "level" version of the Almost Ideal Demand System (AIDS) and successfully modeled these as taste-shifting. They found that incorporating taste-shifts in the level version of the AIDS while keeping it consistent with economic theory required one to make the price and expenditure coefficients functions of the advertising variables. One could add advertising variables directly to differential systems. All differential demand systems use the total differential of the budget constraint:

(1) $\partial\left(\sum_i q_i p_i = x\right) \rightarrow \sum_i w_i \partial \ln p_i + \sum_i w_i \partial \ln q_i = \partial \ln x$, where

q_i and p_i are the quantity and price of good i,, x the total expenditure, and ∂ln· stands for the change in the natural logarithm of the term "·". The term w_i is the budget share for product "i" defined below:

(2) $w_i = \dfrac{p_i q_i}{x}$

The terms in summations equation (1) are often replaced with divisia price and quantity indices, defined as below:

(3) $\partial P = \sum_i w_i \partial \ln p_i$

(4) $\partial Q = \sum_i w_i \partial \ln q_i$

Equations (3-4) can be inserted in (1) and rearranged to produce:

(1a) $\partial \ln x - \partial P = \partial Q$

In their development of the CBS model, Keller and Van Driel first focused on the price and expenditure derivatives. They started with a set of partial differential equations taking the form:

(5) $w_i \cdot \left[\partial \ln q_i - \partial Q\right] = \sum c_{i,j} \partial \ln p_j + b_i\left[\partial \ln x - \partial P\right]$, or

(5a) $w_i \cdot \left[\partial \ln q_i - \partial Q\right] = \sum c_{i,j} \partial \ln p_j + b_i \partial Q$

The forms in (5) and (5a) are equivalent; one simply uses different sides of (1a) in the specification. Keller and Van Driel used (5) in their discussion of the CBS; it is a more appealing version from the standpoint of consumer theory. Equation (5a) makes more sense in a derived demand context. Theil showed that changes in the divisia quantity index corresponded to changes in total output. The b_i and c_{ij} are coefficients that, along with the meat's share of total meat expenditure, determine the elasticities of demand. The c_{ij} determine how cost-minimizing demands change in response to prices and the b_i show how demands react to the scale of the output. In order to be consistent with optimization, the coefficients have to meet the following restrictions:

(6) $$\sum_i c_{ij} = \sum_j c_{ij} = \sum_i b_i = 0,$$

(7) $$c_{ij} = c_{ji}, \forall i, j$$

The restrictions in (6) make the price responses homogeneous of degree 0 add insure that the expenditures on the individual products sum to the total costs. Equation (7) is the symmetry constraint. In both the consumer and input demand contexts, optimization implies that compensated or cost-minimizing demand derivatives have to be negative, semi-definite (NSD) in prices. The CBS system is globally NSD when the matrix of c_{ij}, is itself NSD. These economic restrictions were imposed on all the estimates.

One can add other demand shifters by adding additional variables and coefficients. The CBS is usually estimated under the assumption that a differential system is well approximated by a difference-type model. Equation (8) below shows the most basic version of the CBS model estimated:

(8) $$y_{i,t} = \sum_j c_{ij} \ln\left(\frac{p_{j,t}}{p_{j,t-1}}\right) + b_i \Delta Q_t + a_i + \sum_k f_{ik} d_{k,t} + e_{i,t}\text{, where}$$

$$w^a_{i,t} = \frac{1}{2}\left[w_{i,t} + w_{i,t-1}\right], \Delta Q_t = \sum_j w^a_{j,t} \ln\left(\frac{q_{j,t}}{q_{j,t-1}}\right) \quad \text{and} \quad w^a_{i,t}\left[\ln\left(\frac{q_{i,t}}{q_{i,t-1}}\right) - \Delta Q_t\right] = y_{i,t}$$

The endogenous variable, $y_{i,t}$ is a non-linear function of current and lagged quantities, prices, and total costs. The terms $q_{i,t}$ and $p_{j,t}$ are quantities and prices for the month numbered "t." The term a_i is an intercept. In differential models, an intercept term induces a trend into the model. As this is a derived demand model, a trend in demand would be the result of shifts in the meat-processing technology and/or consumer tastes. The $d_{k,t}$ are a set of 12 seasonal dummies, f_{ik} are their coefficients. The 12 seasonal dummies are perfectly collinear with the intercept and are identified by requiring their coefficient estimates, the f_{ik}, to sum to 0 over the "k' for every "i." The seasonal dummies represent the deviation for the yearly average demand. Finally, $e_{i,t}$ is a random error term.

By its constitution, the CBS endogenous variables sum to 0 in each month; as a result the error terms also sum to 0 each month. It is not possible to invert the error-terms' covariance matrix. One can drop an equation from the model and invert the remaining equations' covariance matrix. If the model is estimated using maximum-likelihood methods, the estimates are independent of the equation dropped. The intercepts and dummies for the excluded equation can be estimated by making their coefficients, the a_i and f_{ik} also sum to 0 over "i".

Adding Structural Change and Disease Effects to the Applied Model

The major goal of this study is to measure what affect HPAI had on the Japanese meat imports: did the change in the policy produce any effect at all, a temporary effect, or a permanent one? Measuring the HPAI effect is complicated by another international meat disease incident that occurred almost simultaneously with HPAI, the discovery of BSE in the United States on December 23, 2003. For modeling purposes, the BSE event is assumed to start in January 2004. Japan's new HPAI policy went into effect in February 2004. Part of any measured HPAI effect could be related to BSE and vice versa. Measuring the impact of these diseases is done by modifying (8) to allow for structural changes. There are two common ways of including structural change in these types of models; both are used here. The first way is to add a set of variables associated with HPAI, for example, a set of dummy variables. The second is to allow the model's coefficients to change as a result of the outbreak. The most general version of the CBS equation estimated is below:

(8g)
$$y_{i,t} = s_{i,t} - s_{i,t-1} + \sum_j c_{ij,t} \ln\left(\frac{p_{j,t}}{p_{j,t-1}}\right) + b_{i,t}\Delta Q_t + a_{i,t} + \sum_k f_{ik} d_{k,t} + e_{i,t}$$
$$c_{ij,t} = m_t c_{ij}^{new} + (1-m_t) c_{ij}^{old}$$
$$b_{i,t} = m_t b_i^{new} + (1-m_t) b_i^{old}$$
$$a_{i,t} = m_t a_i^{new} + (1-m_t) b_i^{old}$$

In (8g) $s_{i,t}$ are disease shifters, generalization of dummy variables. We will refer to them as "state variables". These terms are explained below. The a, b, and c vary over time and are functions of the two sets of variables: the pre-HPAI or "old" ones and the post-HPAI or "new" ones. Both the new and old coefficient sets meet the optimization restrictions outlined above. The term "m_t" is a positive shifter, less than or equal to 1, that changes coefficients between the old and new values. It (m_t) is 0 in the months before January 2004. The explanation of m_t follows that of the $s_{i,t}$.

The state variables start with a set of 4 dummy variables; call them the "z," that are in table 1. Using just the changes in the dummies in the demand equation means that the market will adjust in 5 months to the shock. While some studies do show relatively quick adjustments to disease effects, some show longer adjustment. One can make adjustment longer by adding more "z" dummies to the model; we decided to use distributed lags of these dummies in creating the "s" terms:

(9) $s_{t,i} = \sum_k z_{t,k} g_{i,k} + h_1 s_{t-1,i} + h_2 s_{t-2,i}$, with the constraint:

(10) $\sum_i g_{i,k} = 0$, for all k.

Equation (9) show that the $s_{i,t}$ are driven by their dummies and t, and the once-and-twice-lagged state values. These are second-order Koyck lags on the dummy variables. They start at 0, and remain at 0 until January 2004 when the first z variable is non-0. The *changes* in the state variables in (8g) account for HPAI and/or BSE effects in shifting the demands for imported meats.

One can make the state variables for any meat or group of meats 0 for the entire sample by making all the "g" estimates 0. Equation (10) implies that one cannot make 4 meats' states 0 without making the 5^{th} meat's states 0. Also, making all the "g" 0 will make it impossible to identify the h. The disease effects will be temporary if the disease states go to 0 over time. A set of states or state will go to 0 if the ZEND variables' coefficients are 0 and if the "h" coefficients produce a stable process. Non-0 estimates for the ZEND coefficients imply that the disease outbreaks have a permanent effect on demand.

The second method for adding structural change to the model is to make the a_i, b_i, and c_{ij} functions of time as shown in (8g). The m_t is an estimated parameter whose function varies over the sample period. Before January 2004, m_t is 0; after April 2004 it is 1. We required that m_t be non-decreasing in the January-March 2004 transition period. The disease events have no effect on demand elasticities if the "old" parameters are the same as the "new" parameters. In this case, the evolution of m_t is not identified.

Testing issues

The models are estimated to test the stability of Japanese import demand by comparing restricted and unrestricted models using a likelihood ratio test. Under fairly general conditions, the likelihood ratio test is asymptotically chi-square. However, it is likely that the small sample distributions of tests are different than the large-sample ones. In most cases the small sample tests have fatter tails than their asymptotic distributions. Tests that are not significant under the chi-square distribution are likely to be non-significant under the true distribution. For tests that meet the regularity conditions, the chi-square is used as an initial screening tool. Tests that were rejected using the chi-square distribution were also evaluated using numerical methods. Further, there are some tests that violate the regularity conditions. The state variables coefficients are not identified when the states are required to be 0. The free m_t terms are also not identified if there are no elasticity shifts and these are bounded by 0 and 1. These types of hypotheses have to be evaluated with numerical techniques. This study used a form of bootstrapping based on error re-sampling. The errors of the least-restricted models are re-sampled. These errors along with the coefficients of the restricted model are used to generate alternative sets of data; the models re-estimated and re-tested and the test results saved.

The typical 5% rejection level was used in this study. It takes a large number of iterations to accurately estimate the 95^{th} percentile of a distribution. We modified the 5% test to a 0.1% chance of the test statistic being at the 5% level. We are not looking for the 5% level; we just want to make sure that the actual test statistic is either larger or smaller than the 5% value. For most of the tests done in this study, 200 iterations of the test were adequate. In 200 iterations, one will generally find about 10 tests above the true 5% level. Having none or only 1 exceed the 5% level would occur less than 0.1% of the time. If 1 or no bootstrap tests exceed the actual test, we conclude that the test is actually significant. 20 or more above the 5% level also occurs less that 0.1% of the time. If 20 or more bootstrap tests exceed the actual value, we conclude that the actual test is not statistically significant. When the results were ambiguous, we added iterations. The worse-case scenario for this type of testing procedure is a test that is close to its 5% value.

Test Results

The data were tested in three phases. The first phase focused on econometric issues other than those related to structural shifts. Phase 2 tested hypothesis about the koyck-lag-state variables; and phase 3 tested the changes in the c_{ij} and b_i. The study uses monthly data; autoregression is commonly found in high-frequency data. The model was initially estimated assuming that the errors were ARMA (1,1):

$$(11) \qquad e_{i,t} = \rho \cdot e_{i,t-1} + u_{i,t} + \alpha \cdot u_{i,t-1}$$

In equation (11) the $u_{i,t}$ are a vector of random errors, this vector is identically, and independently distributed over time. We tested the significance of both the ρ and α. Making $\rho=0$ had a likelihood ratio test of 2.44, an insignificant 11.9% value for a chi-square with 1 degree of freedom. Setting $\alpha=0$ had a test statistic of 66.81 which is highly significant based on the chi square[1]. The rest of the models were estimated assuming that ρ=0 and α is not. Making ρ=0 transforms the model from an ARMA to a "pure" moving-average (MA) error term.

Both sets of intercepts and the second-order state coefficient, h_2, had small values; these were tested and found to be statistically insignificant based on the chi-square tests. The test for eliminating both sets of intercepts was 14.06 with 8 degrees of freedom, an 8.0% value; making the Koyck lag first order had a test value of 0.16 with 1 degree of freedom, a 69.1% value (insignificant). Non-0 intercepts induce a type of non-linear trend in the demand for imports and in this case would represent some kind of trend in tastes and/or meat processing technology. The rest of the models were estimated and bootstrapped using a common, first-order moving average error term[2], no intercepts and first-order state variables.

1- Testing the disease state variables

The disease state variables are treated by two types of hypothesis tests. The most constraining hypothesis is that the disease states do not mater at all. It is possible to eliminate a single meat's state variable by making all of its "g" coefficients 0 in equation (9). For a single meat, that is a 4 degree-of-freedom restriction. Eliminating the states for 2 and 3 meats are 8 and 12 degree-of-freedom restrictions. If one eliminates the states for 4 meats, the state for the fifth is automatically eliminated, and h_1 is not identified. The constraint one meat's states have only a temporary effect on the demand is a 1-degree-of-freedom restriction. The no-state-at-all cases are a more restricted

[1] The bootstrap tests also found that this was significant.

[2] The CBS endogenous and exogenous variables are functions of this month's and last months prices, quantities, and expenditures. We lost the first observation in our sample for estimation. When estimating the models, we acted as if we assumed that the first period's "u" error is 0. When bootstrapping, the models with first-order MA terms, we generated a "u" vector for period 1 and used it to make the "e" vector for period 2.

version of the reversible case. As before, making 4 states reversible makes the 5^{th} state reversible. There are no identification problems in making all the states reversible.

Table 2 summarizes state variable tests. The first hypothesis examined was the most restrictive one, that a meat's states are all 0. Each meat was tested by itself and all five were tested simultaneously. We treated the no-meat-has-states case as if it were a 16-degree-of-freedom restriction. Based on the chi-square distribution, cooked poultry, pork, and other meat's state variables were statistically significant, while uncooked poultry and beef's states were not. Eliminating both the uncooked-poultry and beef states was also insignificant (Table 2). This is surprising as these two products are the higher-risk items for disease transmission; imports declined after the BSE-HPAI outbreaks, then quickly recovered after the import bans were lifted in March 2004. This unexpected result might be contributed to several opposing forces in poultry and beef markets. In the case of poultry, it might be the case that consumer concerns about the safety of uncooked poultry were offset by the change in government policy of lifting the ban, assuring consumers that uncooked poultry imports were coming from safe sources. It might also be the case that consumer concerns about the safety of uncooked poultry were partially offset by the need to import more poultry to make up for domestic production losses after the virus infected Japan. It could be due to disaggregating poultry into two products consistent with disease concerns and rising demand for safer cooked poultry. Together, these changing market forces lead to declining Japan's actual imports of uncooked poultry in the post-HPAI era. In the case of beef, Japan was quickly able to divert beef-imports from the United States to BSE-free suppliers. It might also be that rising demand for cooked poultry and pork, the "safer" meats came at the expense of the "less safe" beef and uncooked poultry.

Accepting beef and uncooked poultry have no states; the remaining 3 meats were tested for states' reversibility. Results indicate that pork and other meat states are irreversible and cooked poultry is reversible. The states will be reversible if they go toward 0 when moving away from the disease-outbreak months. After the shock period, shifts in pork and other meat imports were irreversible while those in cooked poultry were reversible. The impact was significant in the first 3 months on all 3 meats and rapidly disappeared vanishing in October 2004. This length of time between the HPAI outbreaks and the stabilization of cooked poultry imports is consistent with that found for Japan's domestic chicken found by Ishida et al (2010). Both studies found that HPAI impact was strong in January 2004 and vanished by October 2004.

The 2003 BSE outbreaks in the United States had an insignificant impact on import demand for cooked poultry in January 2004, but a significant positive effect on pork and a significant negative impact on other meat. The substitution of pork, chicken (and fishery products) for beef following the BSE-outbreaks was reported in several countries and in Japan as mentioned above in the literature review. Because of the concurrent HPAI –outbreaks, poultry (uncooked or cooked) was not substituted for beef and vice-versa, during the shock-period. However, the substitution between beef and cooked poultry was statistically significant in the post-HPAI after the shock period.

2- Testing shifts in the elasticities

The changes in the elasticity parameters were checked next given the constrained pattern of state-variable shifts. Each equation's c_{ij} and b_i parameters were tested to see if the "old" and "new" estimates were the same in each meat by itself, as well as in every combination of 2 and 3 meats. Because of the symmetry of the c_{ij} fixing one equation's coefficients fixes its cross-price terms in the other equations. Due to the economic constraints, once 4 meats are required to have no elasticity shifts, the fifth has no elasticity shifts. The least significant single meat was uncooked poultry, while the other 4 meat's individual tests are significant based on the 5 percent chi-square. Table 3 also shows the least significant pair of meats is uncooked poultry and pork; the least group of three is uncooked poultry, pork, and other meats.

We accepted that the uncooked-poultry elasticities were unchanged and then bootstrapped the model with pork and uncooked poultry elasticities fixed. We used a double hurdle approach here: the test against a totally unconstrained model has to be non-significant and the test for adding another equation has to pass as well. The total test in this case is 22.11 (Table 3); the step test is 16.20.[3]

We bootstrapped the model where uncooked poultry and pork's elasticities did not change; testing it against a model where all the elasticities were allowed to change and against alternatives where only 1 equation's elasticities changed. In 200 bootstraps there are 136 cumulative and 153 step tests larger than the actual values. We conclude that the changes in pork's elasticities are not statistically significant. When testing three meats not changing elasticities, only 1 of the cumulative tests exceeded the actual and only 2 of the step tests exceeded the actual. The step test count falls in our ambiguous range, the cumulative test is not. We conclude that the changes in other meat's elasticities (along with cooked poultry's and beef's) are statistically significant.

One of the surprising results of this analysis is that uncooked poultry's structural shifts are not significant: it has neither elasticity changes nor disease state variables. Beef also lacks disease state variables, although it has elasticity changes. Both of these products are higher risk items and one might expect that these two products ought to show larger disease-related impacts. As

[3] Sure, it looks like it ought to be 16.19 but not all the decimal points are displayed in the table.

previously discussed, we attributed contradicting market forces for reducing the BSE-HPAI impact, turning state variables non-significant. Is it possible that some factors other than BSE-HPAI are causing structural changes in demand? We tested two alternative models that allowed for earlier shifts in demand. The first alternative model adds three new dummy variables to the s_{it} generation; these dummies are for October, November, and December 2003. We maintained the hypothesis that only cooked poultry, pork, and other meats had state variables and required cooked poultry's effect to reverse. Each dummy adds two degrees of freedom to the model; we tested for October-December, November-December, and December dummies. Allowing the state variables to start early did not significantly improve the likelihood (Table 4). The second alternative model allowed the elasticity shifts to start in January 2002, by adding 4 sets of early shifters, E1-E4; their weights were required to be positive and sum to less than 1, as shown in table 5. This test is not significant, concluding that the structural changes in Japanese import demand are associated with BSE-HPAI outbreaks in January 2004.

Model Interpretation

The final model has no disease states for beef and uncooked poultry, reversible disease states for cooked poultry, and irreversible demand elasticities for other meat and pork. We created 5,000 bootstrap iterations to calculate the standard errors for the model. Measures of model fit, elasticities implied by the estimates, and summary statistics for the model's estimates are shown in the tables 6-8. The hypothesis tests indicated that the two disease events changed Japan's meat imports, except for uncooked poultry meat; the other 4-meat imports had either elasticity shifts or disease-states or both. One obvious question to ask is "What impact did these structural shifts have on Japanese import demand?" One problem in evaluating CBS model results is that the CBS endogenous variables are a nonlinear function of changes in quantities. We developed a simulation model that turns predicted CBS endogenous variables into quantities. We used the shifts in demand implied by the model's estimates to simulate what demand would have been had it not been for the disease-related shifts. The endogenous and exogenous variables in this CBS model are based on changes from last month to this one. Any shift in quantity demanded in one month is going to affect demand in the following months. For example, a change that decreases demand by 1% in January 2004 will decrease February 2004's demand by something close to 1% and so on. The changes in demand caused by changes in elasticities had to be cumulated over the sample period. The no-shift-in-demand cases are estimated by starting with the actual quantities demanded and subtracting off the shift effect. Uncooked poultry demand's shifts are not statistically significant. One of the notable results of the estimates is that the error term for uncooked poultry in February 2004 is large and negative. Beef demand, whose state variables are not significant, shows a large, negative error in January 2004 as well. These large negative errors are the result of lower-than-expected quantities demanded, meaning that low quantities in these months result in lower demands in the following months. We have another set of simulations where we excluded the errors from the first quarter of 2004 from the analysis. It indicated that beef demand would have been much higher if it were not for the first Q 2004. Figure 3 shows the actual and simulated cooked poultry demands starting in January 2004. Cooked poultry demand was unusually low between February and June 2004. Most of this drop in demand is due to the negative value of its state variable. This state variable drops to 0 in October, when demand for cooked poultry was driven by elasticity upward changes due to price difference of cooked poultry relative to uncooked poultry, beef, pork and other meat prices. In the post-HPAI period, import demand for cooked poultry was much higher than in the transition period (January-March 2004) and the pre-HPAI period. Figure 3 shows the actual and simulated cooked poultry demands starting in January 2004.

Cooked poultry demand was unusually low between February and June 2004. Japan's actual import demand for cooked and uncooked poultry meats show reversal patterns over 1994-2009 (figure 2). Figure 4 shows the demand for uncooked poultry has no statistically significant shifts; however, the cumulative effects of the error terms from the first quarter of 2004 reduce demand in the post-HPAI period compared to the pre-HPAI period.

All the estimated changes in beef demand can be attributed to elasticity shifts. While the elasticity shifts are statistically significant, the combination of elasticity changes with the price and scale changes makes the no-shift-beef demand little different from the actual beef demand (figure 5). The errors from first quarter of 2004 have a larger effect on beef demand than the elasticity shifts; without these errors beef imports would have been higher. Pork imports gained the most from the changes in demand following the disease events (figure 6). Pork has a non-zero state that starts and stays positive throughout the sample period. It has no elasticity changes, so we attribute all the difference in pork demand to the state variable. Other meat imports had a negative state variable that did not reverse and it also had elasticity changes. The gains to pork demand, caused by its positive state variable, are offset by the losses to other-meat demand (figure 7). Imports of other meat class are by far the smallest of the five groups, while imports of pork are the largest. Therefore, small percentage gains in pork imports are translated to large percentage losses in other meat imports.

Conclusions

Two different methods were used to analyze changes in Japanese import demand caused by HPAI-BSE outbreaks. One method allowed price and scale coefficients to shift in response to the event. The second used Koyck lags to generalize the disease dummy-variable approach, creating state variables. The Koyck-lag approach allows the disease effects to reverse. The statistical significance of all the shifts was tested for individual equations and for the system as a whole. Allowing structural changes to start before the HPAI-BSE was not statistically significant, which supported the hypothesis that disease outbreaks caused the import-demand shifts in January 2004.

Analysis of Japan's import demand system indicated that the HPAI-BSE events led to statistically significant shifts in Japan's import demand for all meats, except for uncooked poultry. Cooked poultry demand's price and scale coefficient shifts were statistically significant, and had significant state effects. Beef demand had only price and scale coefficient changes, but no state effects. Pork state effects were statistically significant and positive, reflecting increasing pork demand in all periods following the disease events. However, pork price and scale coefficients were non significant. Other meat's price and scale coefficients were statistically significant and also have a negative significant state effect that caused their imports to decrease. After the shock period, shifts in pork and other meat imports were irreversible while those in cooked poultry were reversible. The BSE-HPAI impact was significant on imports of cooked poultry, pork, and other meat in the first 3 months, gradually declining to stabilize in all 3 meats within another 6 months.

Market reaction to BSE-HPAI could have changed the total volume of meats that Japan imported; though our estimated impacts are all conditional on the total scale of Japan's import demand. Measuring the impact of BSE-HPAI on total market scale would require a different type of statistical modeling approach. Explaining scale of imports is more complicated than explaining the allocation of imports into classes partially because import scale depends on both domestic demand and domestic supply. An informal examination of the data suggests that further investigation might be warranted.

The final analysis indicated that the demand shifts increased imports of cooked poultry and pork, and decreased those of uncooked poultry, beef and other meat. These trends were consistent with Japan's actual import shares of cooked poultry, which rose from 10 percent in 2003 (the pre-HPAI-BSE year) to 15 percent in 2009, and pork which rose from 37 to 42 percent. The beef import share declined from 26 to 23 percent, uncooked poultry share from 21 to 16 percent, and other meat's from 6 to 4 percent.

Poultry meat disaggregation and inclusion of both cooked and uncooked poultry meats in modeling Japan's meat demand system revealed two opposing trends never before reported in economic literature. Without disaggregating, it would have been impossible to detect the up and down movements in Japan's imports of cooked and uncooked poultry meats. Cooked poultry imports continued to accelerate, due to rising demand for safe cooked poultry in Japan and other global markets. Worldwide, cooked poultry exports more than doubled from 2004 to 2009.

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Table 1—Disease outbreak dummy variables

ame:		BSE	AI0	AI1	ZEND
	ımber	BSE month	HPAI month	nonth following HPAI	long-term effect
January-2004	121	1			
February-2004	122		1		
March-2004	123			1	
April-2004	124				1
May-2004	125				1
June-2004	126				1
…	127-177				1

Table 2—Testing the meat's state variables

constrained meats	***likelihood ratio test***	***degrees of freedom***	***chi-square significance***
	Testing that the states are 0		
Cooked poultry	167.67	4	0.00%
Uncooked poultry	5.20	4	26.76%
Beef	8.89	4	6.39%
Pork	31.62	4	0.00%
Other meats	25.68	4	0.00%
All five meats	211.40	16	0.00%
Uncooked poultry & beef	13.80	8	8.71%
add beef to uncooked	8.60	4	7.18%
Testing that the states are reversible given uncooked poultry & beef have no states			
Cooked poultry	0.06	1	81.34%
Pork	7.20	1	0.73%
Other meats	12.97	1	0.03%
Cooked, pork & other	13.01	2	0.15%

Table 3—Least-significant groups of elasticity tests

least-significant group	*likelihood ratio test*	*degrees of freedom*	*chi-square significance*
testing least-significant single			
cooked poultry	41.79	5	0.00%
uncooked poultry	5.9	5	31.59%
beef	30.14	5	0.00%
pork	17.87	5	0.31%
other meats	27.06	5	0.01%
all 5	67.49	14	0.00%
testing least-significant pair			
uncooked and pork	22.11	9	0.85%
testing least-significant triple			
uncooked, pork, and other meats	41.62	12	0.00%
testing all five meats			
all 5	67.49	14	0.00%

Table 4-Allowing disease dummies to start before January 2004

disease effects start:	*test*	*degrees of freedom*	*chi square alpha*
Oct-03	10.57	6	10.25%
Nov-03	9.33	4	5.33%
Dec-03	5.29	2	7.11%

Table 5—The pattern for the dummies testing for a pre BSE-HPAI shift in the elasticities

	dummy variable			
month	E1	E2	E3	E4
Jan-02	1	0.0833		
Feb-02	1	0.1667		
Mar-02	1	0.2500		
Apr-02	1	0.3333		
May-02	1	0.4167		
Jun-02	1	0.5000		
Jul-02	1	0.5833		
Aug-02	1	0.6667		
Sep-02	1	0.7500		
Oct-02	1	0.8333		
Nov-02	1	0.9167		
Dec-02	1	1		
Jan-03	1	1	1	0.0833
Feb-03	1	1	1	0.1667
Mar-03	1	1	1	0.2500
Apr-03	1	1	1	0.3333
May-03	1	1	1	0.4167
Jun-03	1	1	1	0.5000
Jul-03	1	1	1	0.5833
Aug-03	1	1	1	0.6667
Sep-03	1	1	1	0.7500
Oct-03	1	1	1	0.8333
Nov-03	1	1	1	0.9167
Dec-03	1	1	1	1

Table 6- R squares relative to Naïve (no change from previous month) model, in percents

	CBS endogenous variable	Actual import quantities[1]	share of meat in total import costs[1]
cooked poultry	82.6	74.0	76.2
Uncooked poultry	63.1	34.6	58.6
Beef	66.1	71.9	55.3
Pork	76.9	94.1	72.2
Other meat	71.4	63.5	68.2

[1] estimated by simulation model using predicted demand without that month's error.

Table 7—Demand elasticities implied by CBS estimates and average budget shares
Price elasticities given fixed scale of imports

	Cooked poultry	Uncooked poultry	Beef	Pork	Other meat	Scale Elasticity
Quantities	***before shifts***					
Cooked poultry	-0.120	0.004	-0.034	0.014	0.158	0.497
Uncooked poultry	0.006	-0.023	-0.042	0.040	-0.039	0.189
Beef	-0.131	-0.104	-0.923	0.683	-0.135	0.516
Pork	0.080	0.149	1.037	-0.794	0.320	1.769
Other meat	0.165	-0.026	-0.037	0.058	-0.305	0.182
After special highlighting for the ones that change						
Cooked poultry	-0.744	0.004	0.298	0.014	-0.460	0.087
Uncooked poultry	0.006	-0.023	-0.042	0.040	-0.039	0.189
Beef	1.137	-0.104	-1.438	0.683	0.533	0.537
Pork	0.080	0.149	1.037	-0.794	0.320	1.769
Other meat	-0.479	-0.026	0.145	0.058	-0.353	0.496
mean share for period	7.6%	11.7%	28.9%	43.9%	7.9%	

Table 8—CBS estimates1 and Z Statistics based on 5,000 bootstrap iterations						
	Cooked	Uncooked	Beef	Pork	Others	Scale
Pre HPAI and BSE						
Cooked	**-0.0091**	0.0005	-0.0099	0.0125	0.0125	-0.0381
	-0.72	0.07	-1	1.59	1.59	-8.43
Uncooked		**-0.0027**	-0.0122	0.0175	-0.0031	-0.0951
		-0.27	-0.82	1.03	-0.52	-10.46
Beef			**-0.267**	0.2998	-0.0106	-0.1401
			-6.93	7.58	-0.99	-7.19
Pork				**-0.3486**	0.0252	0.3378
				-6.9	2.18	14.41
Others					**-0.024**	-0.0645
					-2.62	-12.2
Post HPAI and BSE						
Cooked	**-0.0564**	0.0005	0.0861	-0.0363	-0.0363	-0.0692
	-2.36	0.07	3.44	-3.57	-3.57	-7.13
Uncooked		**-0.0027**	-0.0122	0.0175	-0.0031	-0.0951
		-0.27	-0.82	1.03	-0.52	-10.46
Beef			**-0.4157**	0.2998	0.042	-0.1337
			-8.67	7.58	2.4	-6.11
Pork				**-0.3486**	0.0252	0.3378
				-6.9	2.18	14.41
Others					**-0.0114**	-0.0398
					-2.44	-4.58
Difference for the ones that change						
Cooked	**-0.0473**		0.0961		-0.0488	-0.0311
	-1.86		3.61		-3.88	-3.23
Beef			**-0.1487**		0.0526	0.0063
			-4.38		2.96	0.53
Others					**-0.0038**	0.0248
					-0.28	3.19

1 Symmetry implies that $c_{ij} = c_{ji}$; redundant terms are not displayed.

Note : Numbers below the estimate values indicate the Z-statistic

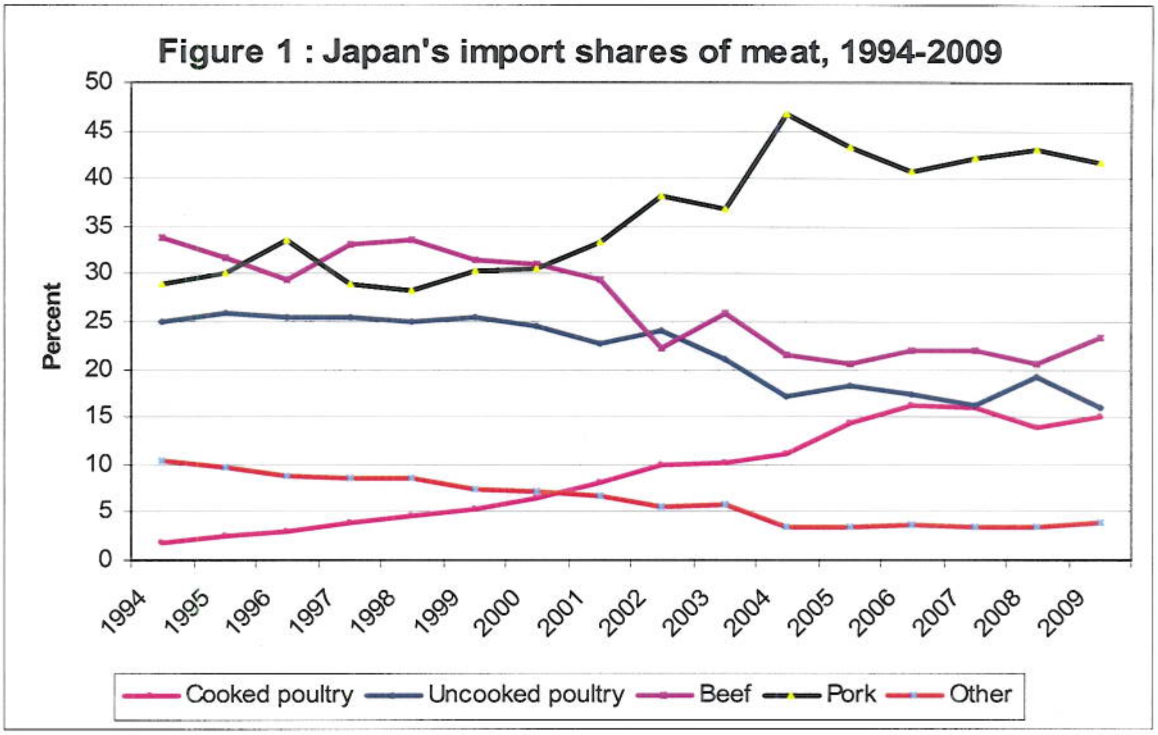
Figure 1 : Japan's import shares of meat, 1994-2009
Percent
50
45
40
35
30
25
20
15
10
5
0
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
Cooked poultry
Uncooked poultry
Beef
Pork
Other

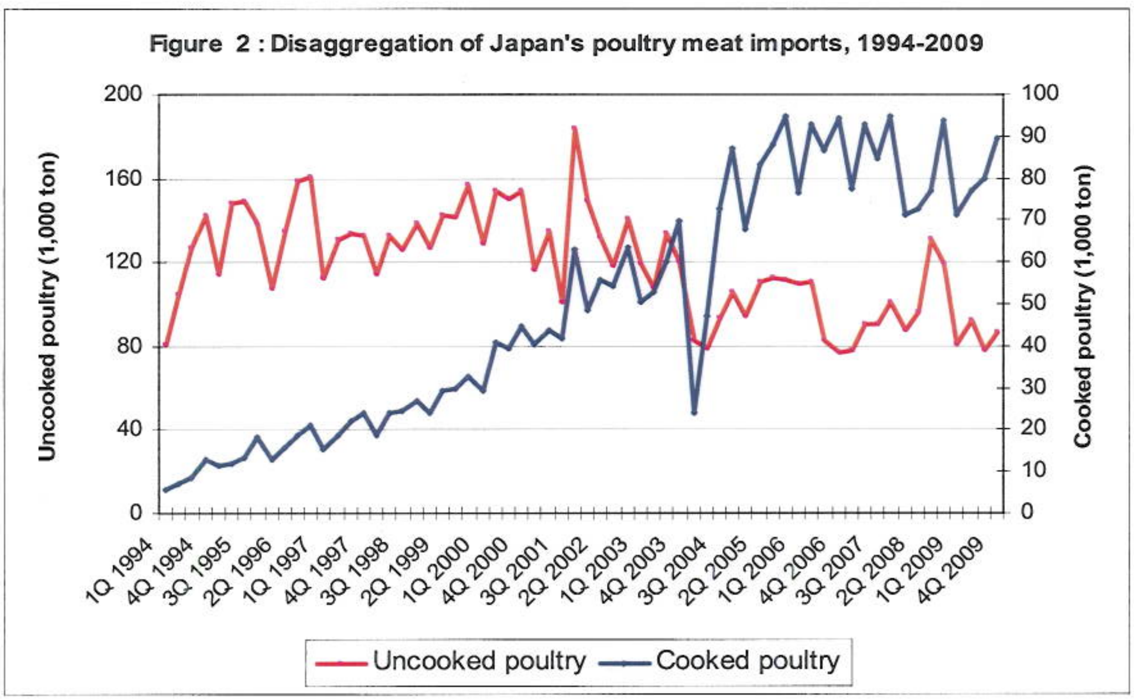
Figure 2 : Disaggregation of Japan's poultry meat imports, 1994-2009
Uncooked poultry (1,000 ton)
200
160
120
80
40
0
Cooked poultry (1,000 ton)
100
90
80
70
60
50
40
30
20
10
0
1Q 1994
4Q 1994
3Q 1995
2Q 1996
1Q 1997
4Q 1997
3Q 1998
2Q 1999
1Q 2000
4Q 2000
3Q 2001
2Q 2002
1Q 2003
4Q 2003
3Q 2004
2Q 2005
1Q 2006
4Q 2006
3Q 2007
2Q 2008
1Q 2009
4Q 2009
Uncooked poultry
Cooked poultry

Figure 3: Japanese cooked poultry imports

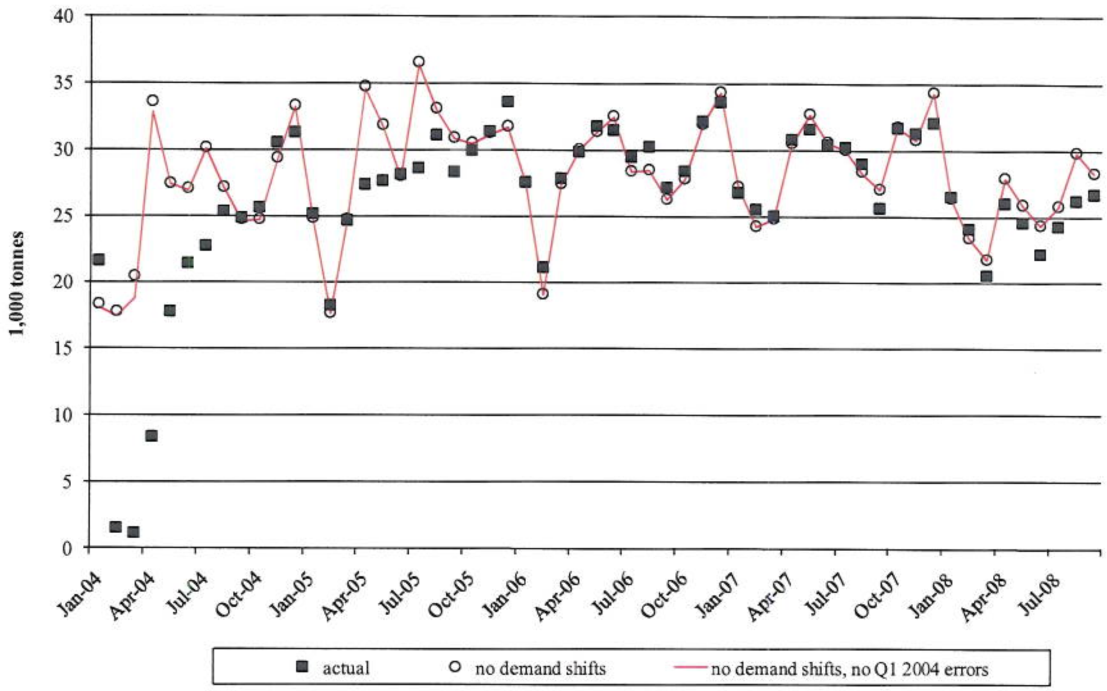

Figure 4: Japanese raw poultry imports

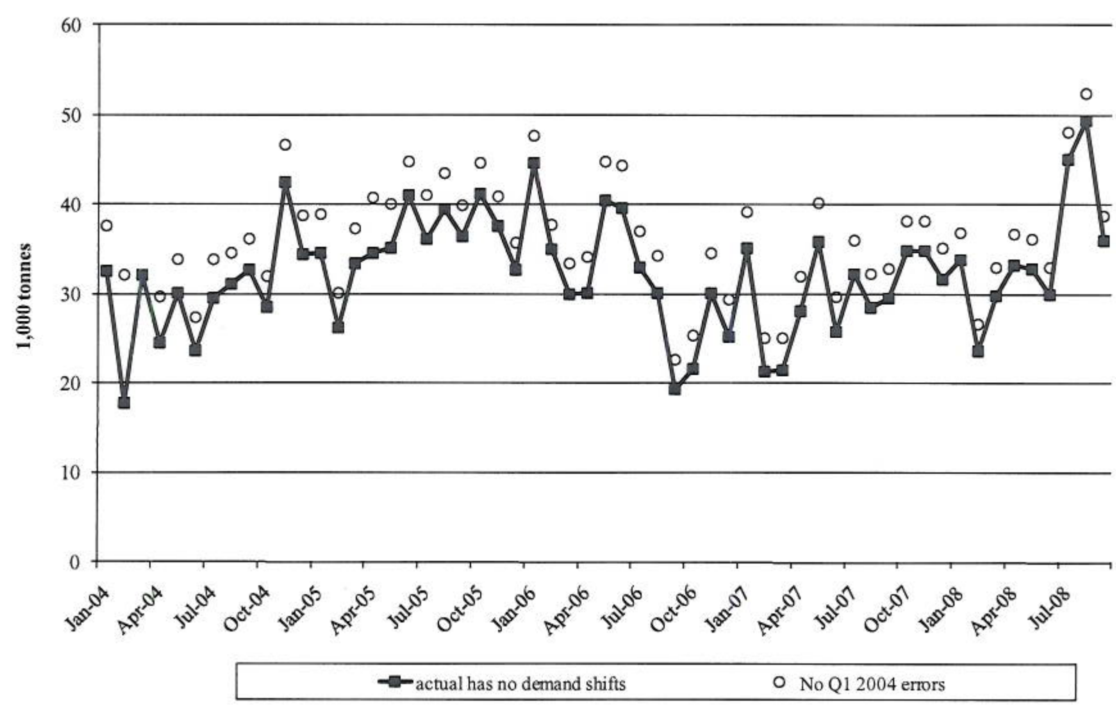

Figure 5: Japanese beef imports

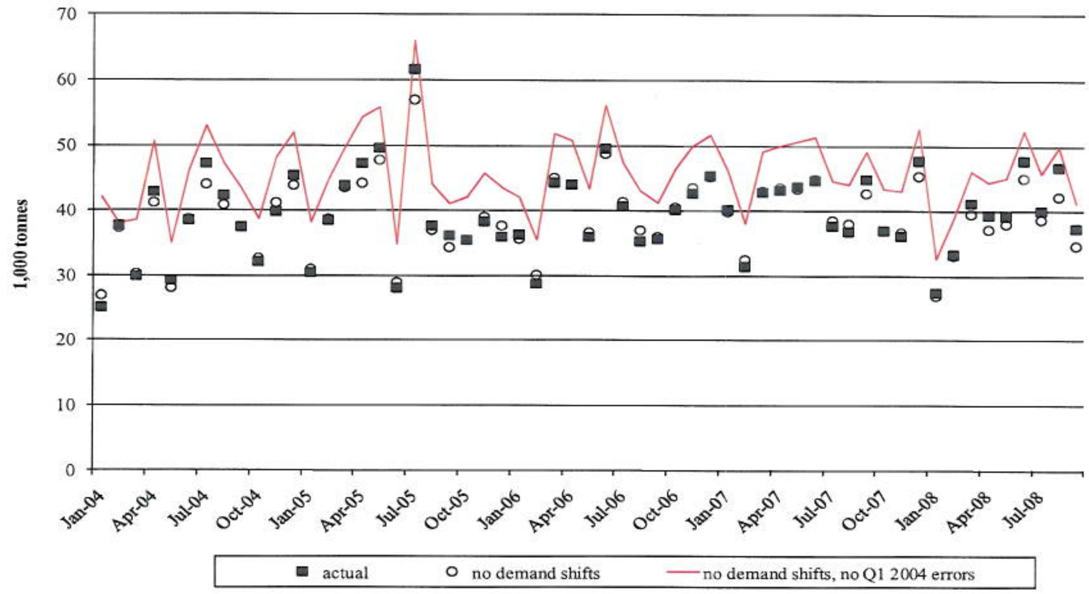

Figure 6: Japanese pork imports

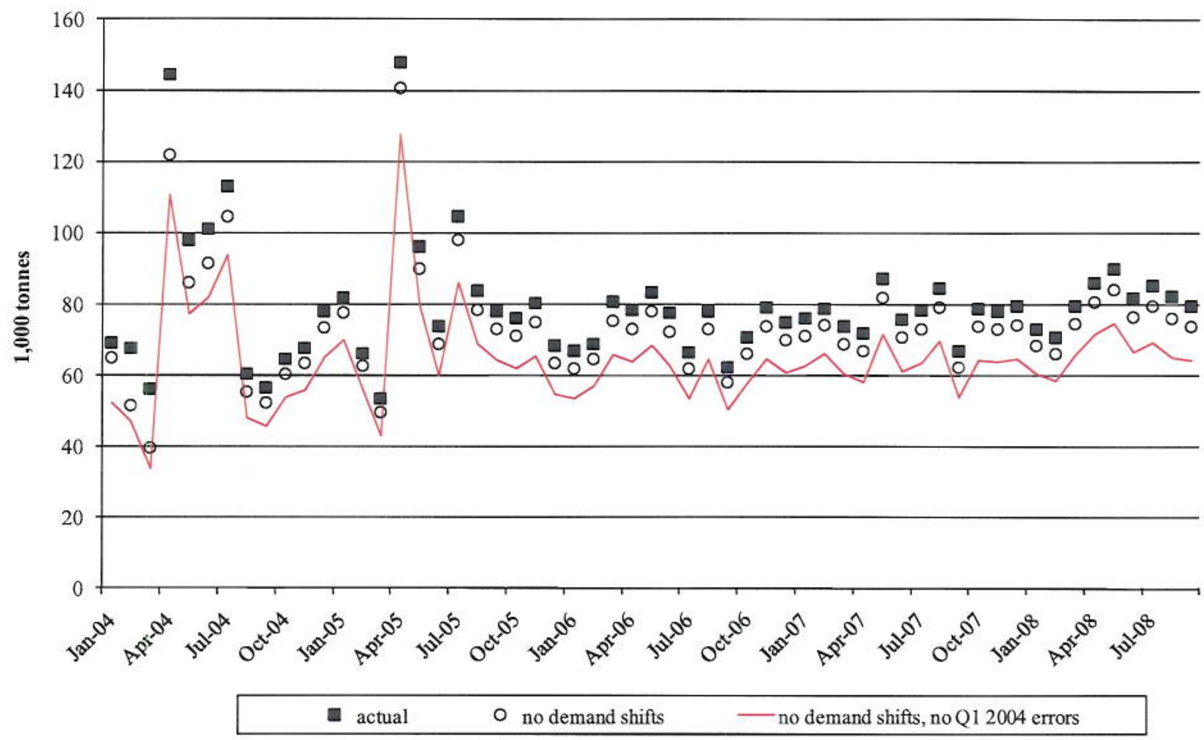

Figure 7: Japanese other meat imports