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Abstract

This paper investigates the impacts of the BSE and Bird Flu on consumers' meat demand in Japan using the Almost Ideal demand system. BSE and Bird Flu scares bring about a fall in demand for beef and chicken respectively, and an upturn in demand for pork and fishery products, both of which are substitutes for beef and chicken in Japan. We also find that a Bird Flu outbreak has a negative impact on the market share for beef, although a BSE outbreak raises consumer demand for chicken. Empirical results also show that both impacts do not persist permanently, but remain for a period that might depend on the characteristics of the disease, such as incubation period, cure rate and infection risk, and on the differences in the government response to the particular disease crises.

Running Title: BSE and Bird Flu

Keywords: BSE, Bird Flu, Almost Ideal demand system, Meat Demand

JEL classification number: D12, Q13, L66.

1. Introduction

Since 1986, when the first Bovine Spongiform Encephalopathy (BSE, widely known as "mad cow disease") case was detected in the U.K., a number of BSE cases have also been reported around the world. These BSE outbreaks cause fear among consumers and dramatically reduce the demand for beef..

Leeming and Turner (2004) analyze the impact of BSE in the U.K. on consumer demands for lamb and pork, which are widely recognized as potential substitutes for beef using a log-linear specification. The impact of BSE on fresh meat consumption in Belgium is investigated by Verbeke and Ward (2001) through the specification of a three-equation Almost Ideal (AI) demand system.

In Japan, beef consumption has decreased in the short term since September 21st 2001, when the first domestic BSE case was detected in Chiba prefecture. However, we have no empirical research on the BSE impact on the shift in demand from beef to other meats in Japan. Japanese beef demand has almost recovered because of the strengthened epidemic prevention system: on-site examination of all cattle, on-site inspection of all cattle feed production plants, and the import ban from non-BSE-free countries of beef and beef products.

With regard to meat safety, Bird Flu (avian influenza), which is a contagious disease of birds caused by viruses, is considered as a greater threat than the BSE crisis among Asian countries including Japan. Bird Flu outbreaks were reported in eight Asian nations (the Republic of Korea, Viet Nam, Japan, Thailand, Cambodia, Lao People's Democratic Republic, Indonesia, and China) and these nations have slaughtered poultry to halt the spread of Bird Flu. In Japan, consumers have been avoiding chicken since the beginning of 2004, when the Bird Flu cases were detected in Yamaguchi and Kyoto prefecture (detected on January 12th and February 27^{th,} respectively).

There is a difference in infection risk between BSE and Bird Flu. For BSE, people who have eaten the Specified-Risk Material (SRM, originally comprised of brain, spinal cord, spleen,

thymus, tonsils and intestines of bovine animals) in BSE-infected cattle are thought to be at risk from variant Creutzfeldt–Jakob disease (vCJD, a rare and fatal human neurodegenerative disease). With Bird Flu on the other hand, it is safe to eat poultry and poultry products although there is a risk of direct infection when the virus passes from poultry to humans.

Is a negative impact on consumers' meat demand as a result of their skepticism toward food safety only temporary or permanent? And what is the shift of consumer preference from beef or chicken to other meats in Japan? Are there any impacts of the difference in infection risk between BSE and Bird Flu on consumer demand for meat?

In this paper, we analyze the impacts of BSE and Bird Flu on consumers' meat demand in Japan using the AI demand system. We estimate consumer demand of pork and fishery products that are recognized as general substitutes for beef and chicken in Japan. We also investigate how long these disease crises have affected meat demand structure using a gradual switching model.

In this paper we describe, in section 2, the Almost Ideal (AI) demand system and introduce gradual shift parameters to cope with the structural change in consumers' meat demand. In section 3, we estimate shift patterns to respond to each disease outbreak using Japanese data from the Family Income and Expenditure Survey. Finally, we conclude the empirical findings in section 4.

2. AI demand system and gradual shifts

The Almost Ideal demand system (AI demand system) developed by Deaton and Muellbauer (1980) is widely used in applied demand analysis. Let q be the amount of goods, p_i be the price of good i, x_i be the consumption of good i, and w_i be the budget share of good i. Then, we have the budget shares as a linear function of logarithmic p and logarithmic X as follows:

$$w_i = \alpha_i + \sum_{j=1}^{q} \gamma_{ij} \ln p_j + \beta_i \ln(X / P) \qquad \text{i = 1,2,…, q,} \tag{1}$$

where α_i, β_i, γ_{ij}^* are parameters, X is the total expenditure given by:

$$X = \sum_{i=1}^{q} p_i x_i ,$$

and P is a price index defined by:

$$\ln P = \alpha_0 + \sum_{k=1}^{q} \alpha_k \ln p_k + \frac{1}{2} \sum_{k=1}^{q} \sum_{l=1}^{q} \gamma_{kl} \ln p_k \ln p_l \ . \tag{2}$$

We note that parameters of this model must satisfy the following conditions:

$$\sum_{k=1}^{q} \alpha_k = 1, \ \sum_{k=1}^{q} \beta_k = 0 , \ \sum_{i=1}^{q} \gamma_{ij} = 0 , \tag{3}$$

$$\sum_{j=1}^{q} \gamma_{ij} = 0 , \tag{4}$$

$$\gamma_{ij} = \gamma_{ji} , \qquad \text{for all } i \text{ and } j. \tag{5}$$

Condition (3), (4), and (5) indicate additivity, homogeneity and symmetry restrictions respectively. Note that (3) is automatically satisfied in estimating process.

We estimate parameters from q equations (1) to simultaneously satisfy (2), (4) and (5). That is, we estimate $q–1$ in q equations using a nonlinear seemingly unrelated regression (SUR) with restrictions on parameters. In particular, maximum likelihood estimates can be obtained by iterative computing the convergent covariance matrix of the residuals. (In this paper, we use LSQ command in TSP 4.3.)

As for the meat demand, this model is applied by Verbeke and Ward (2001). Of course, there are some other approaches to mead demand analysis, for example, Fousekis and Pantzios (2000), Marsh et al. (2004) and Piggot and Marsh (2004) use a CBS model, a Rotterdam model, and a generalized AI demand system, respectively. We consider the AI demand system popular and useful and adopted it in this paper.

Now, we set dummy variables to capture a gradual shift in parameters after BSE and Bird Flu outbreaks. We see a sharp plunge in demand for beef following the BSE outbreak (See Fig. 1). However, the Japanese beef market has been gradually recovering and is now almost recovered if we take into account the increase in beef prices shown in Fig. 2 (Data in Fig. 1 and 2 will be discussed in more detail in the next section).

We assume the gradual shift pattern shown in Fig. 3 to approximate a gradual recovery in demand after the disease outbreak in accordance with Ohtani and Katayama (1986) and Konno and Fukushige (2002). Since the dates t_1 on which both BSE and Bird Flu were detected are given, we estimate the beginning of a recovery in demand (t_2) and the time when the meat market was completely recovered (t_3). In this study, we select a pair of parameters t_2 and t_3 to maximize the likelihood.

We specify the constant term α_i (for all *i=1,2,…,q*) in equation (1) as:

$$\alpha_{i,t} = \theta_i + \delta_i D_{B,t} + \eta_i D_{F,t},$$

where $D_{B,t}$ (resp. $D_{F,t}$) is a dummy variable that indicates a gradual shift from the BSE (resp. Bird Flu) outbreak. This specification follows Verbeke and Ward (2001). Now, we set the conditions on the dummy variables $D_{m,t}$ (*m=B, F*) as follows:

$$D_{m,t} = 0, \text{ if } t < t_{m,1},$$

$$D_{B,t} = 1/3 \text{ and } D_{F,t} = 2/3, \qquad \text{if } t = t_{m,1},$$

$$D_{m,t} = 1, \text{ if } t_{m,2} \geq t > t_{m,1} \text{ and } t_{m,2} \neq t_{m,1},$$

$$D_{m,t} = 1 - \frac{\left(t - t_{m,2}\right)}{\left(t_{m,3} - t_{m,2}\right)}, \qquad \text{if } t_{m,3} > t > t_{m,2},$$

$$D_{m,t} = 0, \text{ if } t \geq t_{m,3}.$$

Since the date on which the first BSE case was detected is the beginning of the last third of the month (September 21st) whereas the date on which the Bird Flu case was detected is the

beginning of the second third of the month (January 12th), we assume $D_{B,t} = 1/3$ and $D_{F,t} = 2/3$ respectively if t equals to $t_{m,1}$.

3. Empirical results

Let p_i be the monthly average price of good i and x_i be the purchased quantity of good i, both of which are available in the Family Income and Expenditure Survey (for two-or-more-person households) in Japan. We also note that the market share for each type of meat is calculated by:

$$w_i = \frac{p_i x_i}{\sum_{j=1}^{4} p_j x_j} \qquad \text{for all } i, j = 1, 2, 3, 4.$$

In this study, we include beef, pork, chicken and fishery products in our analysis. Namely, subscript 1 denotes beef, 2 denotes pork, 3 denotes chicken and 4 denotes fishery products. We also use the monthly data for 60 months from January 2000 to December 2004 because of the data availability.

We show summary statistics of the market share for four different kinds of meat in Table 1. It indicates that Japanese consumer demand for fish is larger than that for meat in terms of monetary amounts. We also note that the market share for fish is more stable than that for other meat.

We show the parameter estimates in Table 2 and 3. Table 2 shows that the estimated dummy variables are all statistically significant. That is, there exist gradual shifts in demand structure due to BSE as well as the Bird Flu crisis. With regard to the R-squared and the Durbin–Watson ratio shown in Table 2, we assume that parameter estimates are reliable.

Now, we examine the sign and size of dummy variables. We see the BSE and Bird Flu outbreak has a positive impact on consumer demand for pork and fishery products. That is,

consumer demand shifts to pork and fishery products, both of which are substitutes for beef and chicken due to the impacts of these two disease outbreaks.

It is particularly worth noting that a demand shift from beef to chicken also occurs after the BSE outbreak. It indicates that beef and chicken are also substitutes. However, the Bird Flu outbreak has a negative impact on demand for beef as well as chicken. It indicates that consumers' skepticism toward food safety, which is regenerated by the Bird Flu crisis, may trigger a fear of beef soon after the BSE outbreak.

Next, we discuss a measure of the impact of the disease crisis. The impact on demand for fishery products after the BSE outbreak is estimated at six times that after the Bird Flu outbreak, whereas the impact on demand for pork is almost the same for the BSE and Bird Flu crises. It indicates that the decrease in demand for beef soon after the Bird Flu outbreak may increase the demand for pork and not fishery products.

Although both of the major disease outbreaks have a negative impact on consumers' demand for beef, the BSE impact is estimated to be about three times larger than that of the Bird Flu. This gap may be brought about by a higher infection risk (there is a possibility of being infected by "eating" beef) and consumer skepticism toward food safety regenerated by the Bird Flu crisis.

The beginning and end of the periods of each gradual shift $(t_{B2}, t_{F2}, t_{F3}, t_{B3})$ are estimated and shown in Table 3. We see the impact of the BSE outbreak continues for sixteen months and then disappears. We also estimate that the impact of the Bird Flu outbreak continues for one month and disappears after eight months. That is, the impact of the BSE outbreak is about twice as long as that of the Bird Flu outbreak.

We show that the BSE and Bird Flu crises have different amounts of impact. The reason is due to the following three differences in character between BSE and Bird Flu. First, the incubation period for vCJD, which is recognized to have some link to BSE, may be as long as 30 years, whereas that for Bird Flu may be only two or three weeks. Second, Bird Flu is a

totally treatable and curable disease in spite of having a high fatality rate, while vCJD is a fatal disease. Third, there is a risk of being infected with BSE by eating beef or beef products infected with BSE but there is little risk of being infected with Bird Flu by eating poultry.

However, it is premature to conclude that the period affected by the disease crises reflects a measure of disease risk. We also have to take into account the difference between government responses to the two disease crises. The Japanese government announced an end to the Bird Flu epidemic three months after its outbreak (on April 2004). However, when it comes to BSE, the BSE-infected cows still continue to be found during inspection. The difference between epidemic prevention may have a huge impact on the psychology of consumer behavior and it makes a difference in the period affected by the disease crises. This result remains basically the same for the impact of negative press on fresh meat consumption (Verbeke and Ward 2001).

4. Conclusion

In this study, we clarify gradual shifts in consumer demand structure due to BSE and the Bird Flu crisis. That is, BSE and Bird Flu scares bring about a fall in demand for beef and chicken respectively, and an upturn in demand for pork and fishery products, both of which are substitutes for beef and chicken. Although the BSE outbreak raises consumer demand for chicken, the Bird Flu outbreak has a negative impact on the market share of beef. This may result from consumers' skepticism towards food safety, which is regenerated by the Bird Flu crisis.

We also estimate that the period in which the impact of a BSE outbreak on consumer demand structure has continued and ended is twice as long as that for a Bird Flu outbreak. It may be induced by the difference in character of infection risk and government responses to the disease crises. Taking into account a sharp plunge in demand soon after the Bird Flu outbreak, government responses to the disease crises rather than infection risk is likely to affect the

psychology of consumer behavior and make a difference in the period affected by the disease outbreaks.

We conclude the following two issues posed by this study. First, it is important to clarify the relationship between a shift in demand to substitutes and consumer awareness of risk through the questionnaires like what was conducted by Setbon et al. (2005), Verbeke and Viaene (1999), and Verbeke et al. (2000). This type of studies can also clarify the relationship between consumer awareness of food safety risk and the period affected by the disease crises.

We also note that there may be some difference in risk awareness between adults and children, pointed out as "equivalence scales" in Gould and Villarreal (2002). However, compiled data have limitations in estimating equivalence scales since we have to compare household budget categorized by family structure type.

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Table 1. Summary statistics

Shares	Mean	Standard deviations
beef	0.1861	0.0254
pork	0.1931	0.0201
chicken	0.0914	0.0081
fish	0.5294	0.0216

Table 2. Parameter estimates of AI demand system

Parameter	Coefficients	t-statistic
α11	0.163342	2.404
δ1	–0.078663	–14.422
η1	–0.026725	–3.343
α12	1.165990	8.797
δ2	0.028380	9.223
η2	0.030621	7.001
α13	0.217872	4.663
δ3	0.016158	5.674
η3	–0.009154	–2.185
α14	–0.547204	***
δ4	0.034125	***
η4	0.005258	***
α0	0.855123	0.471
β1	0.004540	0.536
β2	–0.120842	–10.009
β3	–0.015832	–2.530
γ11	0.044030	1.498
γ12	–0.024779	–1.939
γ13	0.002616	0.202
γ22	–0.011048	–0.738
γ23	–0.014927	–1.099
γ33	0.008292	0.515

Equations	R-squared	Durbin-Watson Ratio
beef	0.7846	0.925
pork	0.9295	1.164
chicken	0.4527	0.700

*α_{14}, δ_4 and η_4 were calculated from the adding-up conditions.

Table 3. Estimated turning points in gradual shifts

	BSE		Bird Flu	
t_1	2001:9	} 2 months	2004:1	} 1 month
t_2	2001:10		2004:1	
t_3	2003: 2	} 16 months	2004: 9	} 8 months

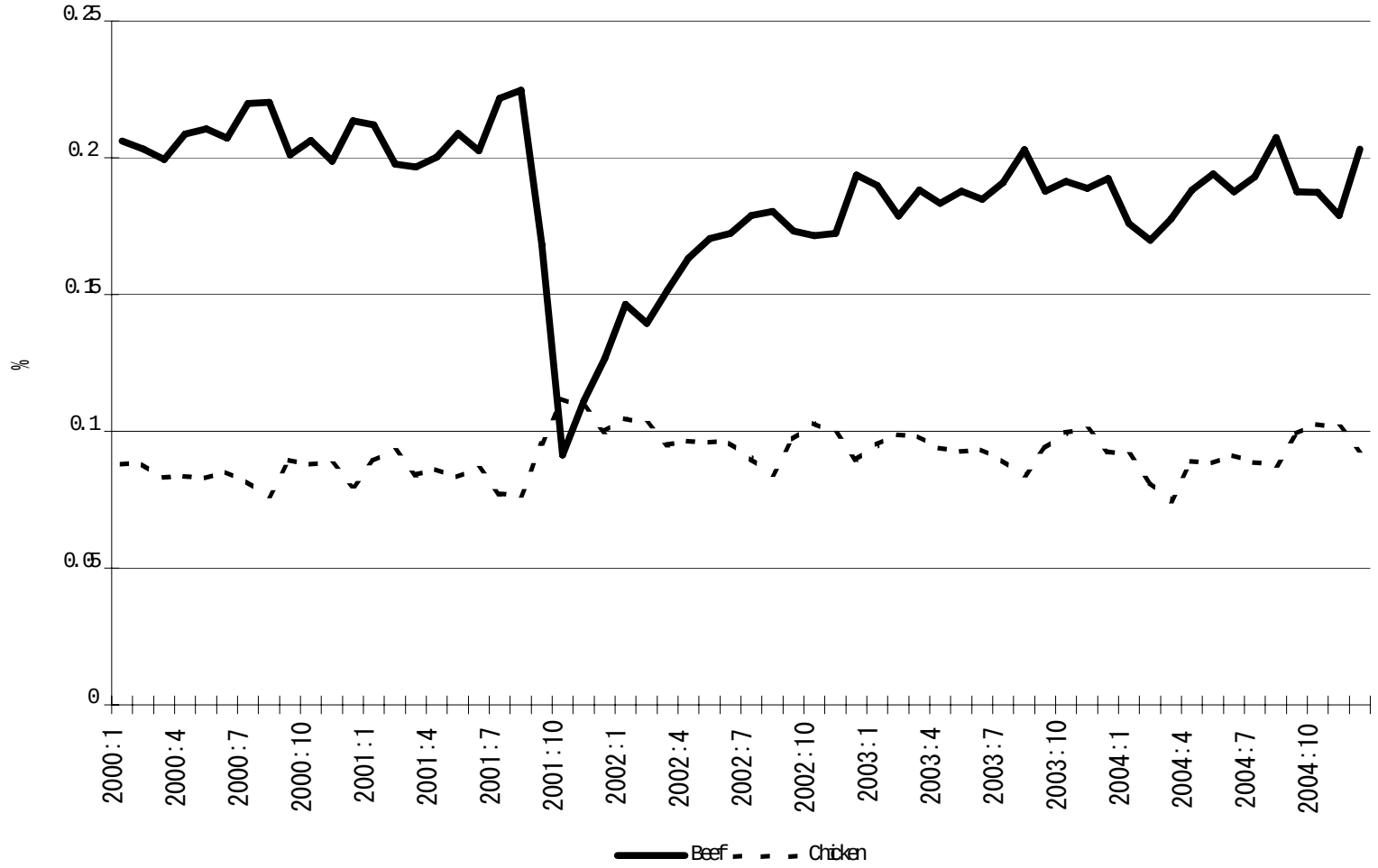

Fig. 1. Shares of beef and chicken

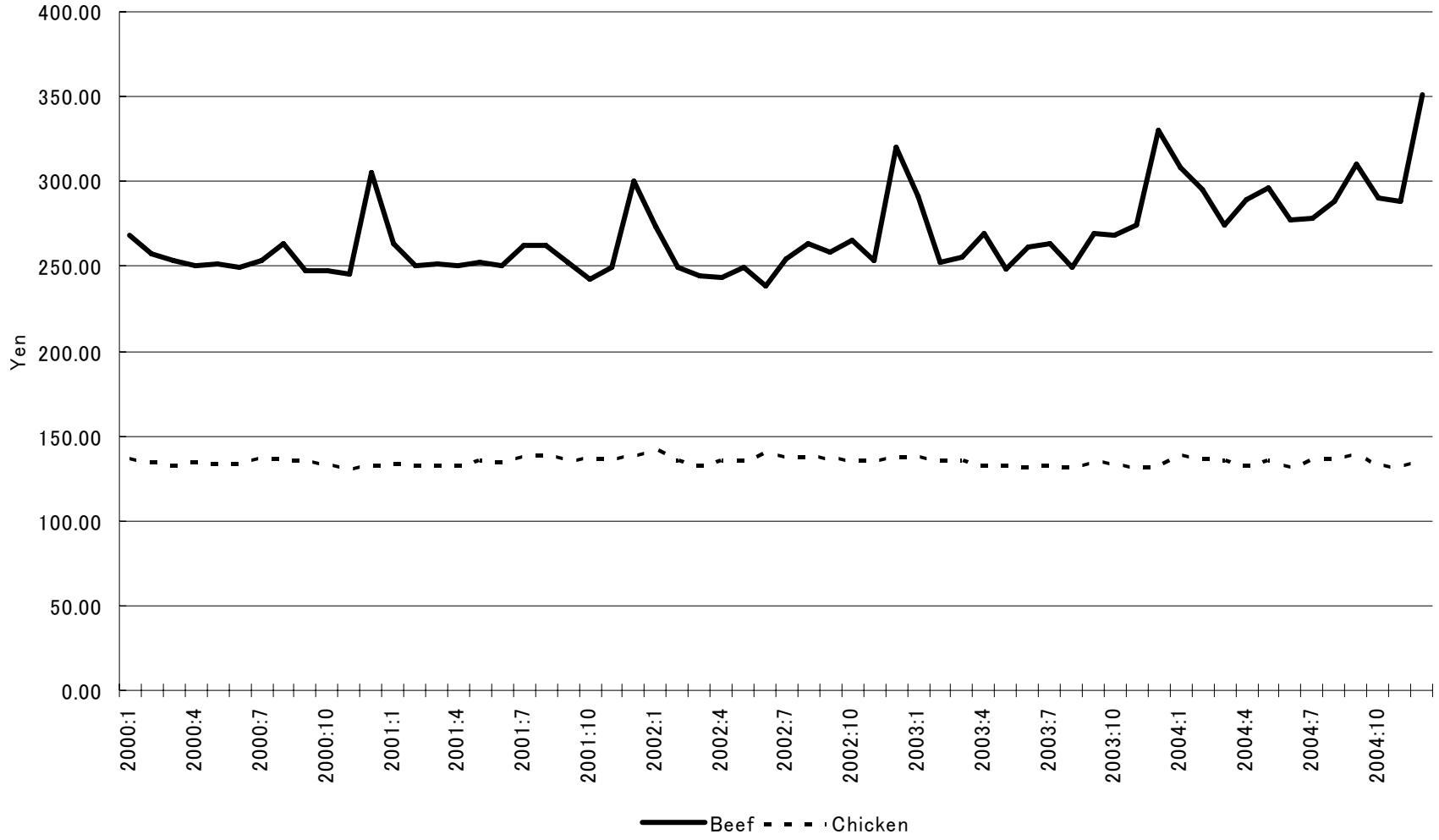

Fig. 2. Prices of beef and chicken

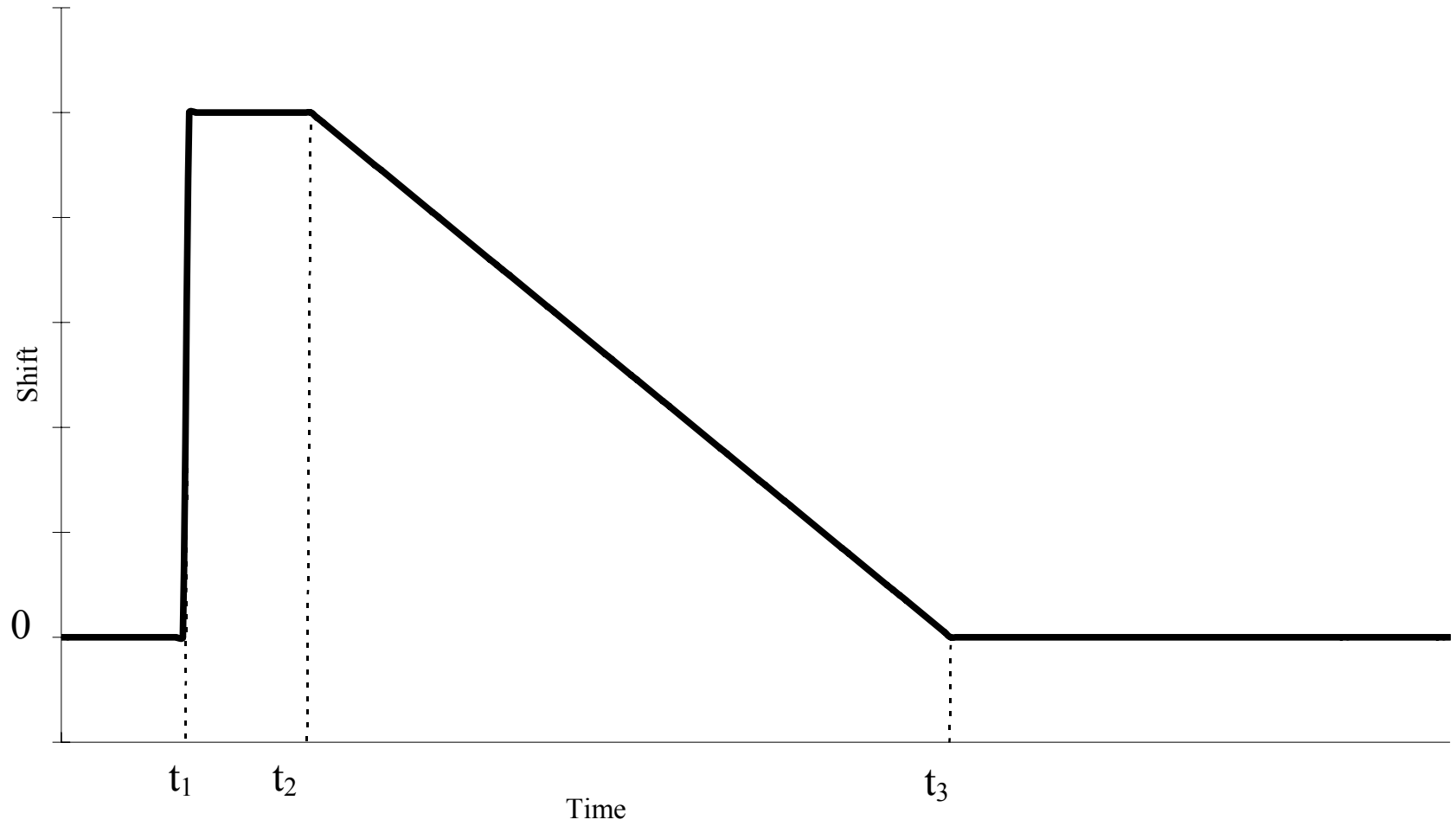

Fig. 3. Gradual shift pattern