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Sub Title	
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Publisher	Keio Economic Observatory Sangyo Kenkyujo
Publication year	2007
Jtitle	KEO discussion paper No.107 (2007. 5)
JaLC DOI	10.14991/004.00000107-0001
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Notes	
Genre	Technical Report
URL	https://koara.lib.keio.ac.jp/xoonips/modules/xoonips/detail.php?koara_id=AA10715861-00000107-0001

Detecting Perception Gap, Discontinuity and Changes of the Consumer's Behaviour:

An Input-Output Approach to the Economic Impact of Infectious Diseases *

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Keio Economic Observatory Discussion Paper No. 107
May 2007

*This paper is prepared for the Sixteenth International Input-Output Conference held in July 2–6, 2007 at the Istanbul Technology University, Istanbul, Turkey.

We would like to express special thanks to Prof Kazushige Shimpo for his encouragement and comments on this research. All errors remain the authors' responsibilities.

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Abstract

In 2001, a BSE suspected cow found in Chiba Japan. Since then Japan has over 20 heads of cows and bulls were found to be BSE positive. On the other hand, from 2003, Japan banned all the beef import from the US and Canada. At the almost same time, in 2004 thousands chickens have been infected influenza virus and died in Kyoto but delivered to the market. These two events resulted extreme decreases of final demand from households in short run. This research calculates their effects on domestic production, and shows difference between consumer's risk perception by intuition and contaminated commodities suggested by input-output calculation. In addition, it will show the timing of delivery lag and quick recovery of the consumption within several months, as a simple application of input-output approaches.

1 Introduction

This preliminary study investigates how and to what extent information of the disease, such as bird flu or BSE, affects consumer's behaviour (consumption), and the economic activity through the input-output relation.

There are two things at least to be considered in advance starting the analysis.

First of all, the impact of the information dissemination and the actual impact of the disease must be strictly distinguish. We are dealing with the information dissemination of bird flu and BSE. The bird flu in 2004 and 2006 Japan actually kills thousands of chicken infected including suspected to be infected, but it has not yet transmitted to human beings. The information on bird flu has resulted in quick responses of the local governments and the farmers, but the then incomplete reactions gave rise to serious draws back, a bit panicky reactions of consumers.

Secondly, consumers might not recognize the contaminate foods lack of proper information. Since the input-output table covers almost complete transaction of economic activity, it can provide consumers with supplementary information for possible infection. It should be much strengthen along with distribution and transportation statistics, because the latter two enable to give us timings and places of the spill over. Recently Brockman, Hufnagel and Geisel [2006] provides a model of human travel, which describes dissemination of one dollar bank note, and the behaviour can be expressed by a Levy process. The Levy process implies that dissemination pattern has a long memory, depends on the past experience for a while. There are statistical models to estimate Levy processes, but its predictability remains to be further investigated. Ishida, Ishikawa and Fukushige [2006] estimates AIDs consumption system using the dummy variables that is the same as Verbeke and Ward [2001]. They found that demand for beef has been gradually recovered after sharp decline at the outbreak of the BSE in Japan, at the same time, demand for pork and fishery products has increased, and demand for chicken has also increased at the BSE outbreak, but demand for beef has decreased at the bird flu. The estimation of demand system is based on the similar functional form to Ishida, Ishikawa and Fukushige [2006], but we use daily consumption data rather than monthly data, and explore the time series anaysis on filtering techinique to detect the precise timing of the impacts.

We further incorporate the estimated results of demand system into the input-output framework, in order to calculate economy wide impact of BSE and bird flu. Whereas the input-output table can describe complete path dependency for goods and services but in average. The input-output analysis can be useful to find consumer's perception lag or ignorance on information of food products that use beef or chicken related meats as materials.

In 2001, a BSE suspected cow found in Chiba Japan. Since then Japan has over 20 heads of cows and bulls were found to be BSE positive. On the other hand, from 2003, Japan banned all the beef import from the US and Canada. At the almost same time, in 2004 thousands chickens

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2 Detection of changes of consumption patterns

In this section, we want to explain how to detect changes of consumption patterns, using daily time series data. The dates of the first Japanese government's announcement of BSE and bird flu are clear. It was 21st September 2001 for BSE, and 30th January 2004 for bird flu. The news have been spread immediately through the mass media such as TV, radio, and news papers, as well as websites. But we do not know how long the announcement effect persists in the consumption of beef or chicken.

One of the possible method is to estimate the consumption function using the data before the event, and the difference between the actual consumption series and the extrapolated series after the event using the estimated consumption function, which contains only the previous information and is not affected by the announcement. Unfortunately, we do not have enough observation before BSE, because the survey for daily consumption series began from 1st January 2000. It may contain more than 600 days, but we have to cope with serious seasonal pattern of consumption. It is impossible to incorporate seasonal fluctuations into the model.

2.1 Filtering method for the daily time series consumption

Pure statistical manipulations of time series analysis can apply to the consumption series, and has developed detection methods recently (Zurbenko et al. 1996, and Civerolo 2001). This detector is called a Kolmogorov Zurbenko filter or an adaptive Kolmogorov-Zurbenko filter (KZA). It is based on the moving average y_i, that is, following the paper of Zurbenko et al. (1996),

$$y_i = \frac{1}{2q+1}\sum_{j=-q}^{q} x_{i+j}$$

where x_i is the original time series at time i, q is the half-length of the simple moving average. y_i is the filtered series. The iterative simple moving average is further taking the moving average of y_i. If the number of the iteration is k, the filtered series can be expressed using the parameters q and k, as follows:

$$Z(t) = KZ_{q,k}[X(t)]$$

$X(t)$ is the original series just as x_i before. The operator $KZ_{q,k}$ means taking the moving average with length $2q$ and iterating k times with the same length q.

In order to increase the sensitivity to detect discontinuities, Zurbenko et al. (1996) recommend 'adapting' procedure just as follows. The absolute difference $D(t)$ of the filtered series $Z(t)$ is defined by

$$D(t) = |Z(t+q) - Z(t-q)|.$$

Further the rage of change of $D(t)$ is defined by

$$D(t)' = D(t+1) - D(t).$$

According to $D(t)'$ an indicator corresponds to the criterion, we can decrease the length q of the moving average, in turn, we can sharpen the moving average. The adaptive filter is defined by

$$Y_t = \frac{1}{q_H(t) + q_T(t)} \sum_{i=-q_T(t)}^{q_H(t)} X_{t+i}$$

where

$$q_H(t) = \begin{cases} q, & \text{if } D'(t) < 0 \\ f(D(t))q, & \text{if } D'(t) \geq 0 \end{cases}$$

$$q_T(t) = \begin{cases} q, & \text{if } D'(t) > 0 \\ f(D(t))q, & \text{if } D'(t) \leq 0 \end{cases}$$

and

$$f(D(t)) = 1 - \frac{D(t)}{\max[D(t)]}.$$

We have tried as many cases of the combination of q and k as possible, because there is no appropriate criterion how to choose q and k. There are many other filtering procedures, such as Hendrick-Prescott (HP) filter, Kalman filter. Though HP filter is a low pass filter often used by economists, but HP filter cannot detect any discontinuity in this case, it just smooths the series. Kalman filter requires a statistical model on the data generating mechanism. At the moment, we would like not to depend any model, so we have tried this KZA filter, and found the plausible shift of the series.

2.2 Data for the time series consumption

The Family Expenditure and Income Survey provides daily consumption pattern of typical household (with 2 or more members, for all family types) from 2000 in the detail types of commodities. *The Family Expenditure and Income Suaver* surveyed about 8,000 households during 2000 and 2001, and now surveys 9,000 households since January 2002. It comprises to survey from 1946, and is one of the most important statistics for the national consumption and weights for the consumer prices. It compiles about 500 items, the total outlay has about 2% sampling errors of its level.

2.3 Results of the KZA filter

Values of k and q relate to the frequency of the time series data, if the value of q is large, the filter eliminates both high frequency and middle frequency. Therefore, we need to tune which value can be most suitable for our cases. Table 1 shows the cases we have tried. We cannot find any discontinuity of consumption level, when we use the half of lag length is 365. This means that our estimation cannot filter seasonal variations. In case for the long lag length such as 90 days and many iterations like 20 times, the result shows the timing of discontinuity is well before the event announced. This is because the KZA filter is based on the simple moving average. If the gap before and after the event is large, the effect in lead part of the moving average affects the filtered series.

We concentrate our analysis using k is 3 times and q is 30 days, because the series filtered with $k = 3$ and $q = 30$ seem to show naturally the discontinuity before and after the events. Table 1 also shows that the news on a domestic BSE affects not only beef consumption, but also pork and chicken consumption as well. The columns of pork and chicken for BSE (2001) indicate that the

Table 1: KZA filtering for the various lag length and the number of iteration

				BSE (2001)		
No	k	q	Beef	Poke	Chicken	Lag*[1]
1	3	15	16 Sep decrease	28 Sep increase	7 Sep increase	22days
2	4	15	16 Sep decrease	26 Sep increase	8 Sep increase	19days
3	10	15	15 Sep decrease	18 Sep increase	12 Sep increase	7days*[2]
4	20	15	12 Sep decrease	17 Sep increase	23 Sep increase	12days
5	2	30	14 Sep decrease	16 Sep increase	13 Sep increase	4days*[3]
6	3	30	14 Sep decrease	18 Sep increase	19 Sep increase	6days*[4]
7	4	30	12 Sep decrease	17 Sep increase	24 Sep increase	13days
8	10	30	4 Sep decrease	14 Sep increase	29 Sep increase	26days
9	20	30	21 Aug decrease	9 Sep increase	6 Sep increase	36days*[5]
10	3	60	27 Aug decrease	10 Sep increase	25 Sep increase	30days
11	3	90	9 Jul decrease	3 Sep increase	21 Sep increase	76days*[5]
12	3	365	19 Apr decrease	17 Apr decrease	—*[15]	3days*[6]
				Bird flue (2004)		
No	k	q	Beef	Poke	Chicken	Lag*[1]
1	3	15	17 Jan decrease	12 Jan increase	19 Jan decrease	8 days*[7]
2	4	15	18 Jan decrease	13 Jan increase	20 Jan decrease	8days*[8]
3	10	15	24 Jan decrease	9 Jan increase	27 Jan decrease	19days*[9]
4	20	15	1 Feb decrease	29 Dec 2003 increase	30 Jan decrease	35days*[10]
5	2	30	29 Jan decrease	4 Jan increase	29 Jan decrease	26days*[11]
6	3	30	30 Jan decrease	4 Jan increase	30 Jan decrease	27days*[12]
7	4	30	1 Feb decrease	29 Dec 2003 increase	30 Jan decrease	35days*[13]
8	10	30	15 Feb decrease	8 Dec 2003 increase	6 Feb decrease	69days*[14]
9	20	30	—	25 Nov 2003 increase	17 Feb decrease	85days
10	3	60	—	25 Nov 2003 increase	16 Feb decrease	84days
11	3	90	—	22 Nov 2003 increase	15 Feb decrease	86days
12	3	365	—	—	—	—

date of consumption discontinuity found. Similarly, the columns of beef and pork for Bird flu (2004) show that the date of consummation discontinuity found.

Notes of Table 1 describes an additional information on the consumption discontinuity of the other meats especially beef and pork ground meat. There are discontinuities of ground meat consumption, but the timing is not simultaneous, but ground meat consumption decreases usually 2 times lag-length between pure meats after the event. This means it takes twice as much time for people to recognize that ground meat may be also contaminated by BSE.

The same tendency can be shown for the case of bird flu, but the lag-length is shorter than that of BSE. People react relatively quicker in the bird flu case than in the BSE case. This might be a result of learning by doing for the food safety recognition, but it is difficult to test statistically.

Figures 1–11 show the actual daily consumption and the filtered series with $q = 30$ (days) and $k = 3$ (times). The filtered series have clear seasonal patterns for beef and chicken consumption, whereas no clear seasonal pattern is found for pork consumption. Figure 1 detects discontinuities of consumption as shown Table 1, and one can easily find the discontinuity at least once even in the actual (original) consumption data.

Chicken consumption (Figure 2) does not have any discontinuity in the actual consumption data, but the filtered series have discontinuities around the events (21 September 2001 and 12 January 2004). The filtered chicken consumption jumped up on 21 September 2001 by BSE, which can be seen as a straight vertical line, and down on 12 January 2004 by bird flu. As we have found this possible substitution effect of BSE on chicken consumption, we need to investigate possibility of

Table 2: Notes for Table 1

q: the half-length of the simple moving average

k: the number of filtering iterations

*1: Time difference between beef, pork, and chicken consumption discontinuities detected by the KZA filter.

*2: 14 days between increase of chicken consumption and decrease of beef and pork ground meat consumption.

*3: 13 days between increase of chicken consumption and decrease of beef and pork ground meat consumption.

*4: 12 days between decrease of beef consumption and decrease of beef and pork ground meat consumption.

*5: no discontinuities has been found in the other fresh meats consumption.

*6: no discontinuities has been found in chicken and ground meat consumption.

*7: 11 days between increase of pork consumption and decrease of the other fresh meats.

*8: 13 days between increase of pork consumption and decrease of the other fresh meats.

*9: 28 days between increase of pork consumption and decrease of the other fresh meats.

*10: 52 days increase of pork consumption and increase of ground meats

*11: 30 days increase of pork consumption and increase of ground meats

*12: 42 days increase of pork consumption and increase of ground meats

*13: 52 days increase of pork consumption and increase of ground meats

*14: 82 days increase of pork consumption and increase of ground meats

*15: — no discontinuities found

side effects to the other meats.

Pork consumption (Figure 3) shows a jump up on 21 September 2001, and milder increase around 12 January 2004.

The similar pattern can be found in ground meat consumption (minced meats of beef and pork). Ground meat consumption significantly dropped at 21 September 2001, and gradually recovered since.

The other fresh meats includes horse meat, goose, edible frog, games, liver, tongue, and the other offal. The other fresh meats consumption dropped on 21 September 2001, but did not show any discontinuity after BSE.

As to processed meats, yakitori (grilled chicken) shows drastic decline of consumption around 12 January 2004 in the filtered series, but difficult to detect in the original consumption data. Hamburg steak consumption has a sever drop on 21 September 2001 in both the actual and filtered series. But hamburg steak (filtered) jumped up on 12 January 2004, attributable to bird flu and substitution effect of consecutive decline of chicken consumption.

On the contrary to hamburg steak, berger consumption has been steadily increased with several discontinuities. It is difficult to identify causes of these discontinuities.

All these commodities have beef related ingredients (inputs), which is suggested by forward linkage coefficients of the input-output analysis (Miller and Blair, 1985). Although there are many recent developments of measuring linkage coefficients (Suzuki, 2006), we have calculated traditional backward linkage coefficients (unit structure) for each commodities.

Let $\mathbf{f}_{(i)}$ denote a $n \times 1$ column vector with the i-th element of 1. $\mathbf{x}_{(i)}$ denotes a $n \times 1$ column vector of induced demand by one unit demand of the i-th commodity $\mathbf{f}_{(i)}$. $\mathbf{A}$ denotes the Leontief input coefficients matrix.

$$\mathbf{x}_{(i)} = (\mathbf{I} - \mathbf{A})^{-1} \mathbf{f}_{(i)}$$

After calculating every backward linkage coefficients $\mathbf{x}_{(i)}$ ($i = 1, \dots, n$), we have selected the commodities that induce beef demand i_{beef}, beef offal demand $i_{beefoffal}$, and chicken meat $i_{chicken}$, which should be related to BSE and bird flu. For example, feed $x_{i_{feed}}$ is induced by chicken meat, pork, eggs, beef, and meat products, which should be contaminated with BSE prion, however only bull or cow are affected by BSE as far as we know.

- Meat products $i_{meatproducts}$ is induced by frozen food (0.026), daily dish (0.019), school lunch meal (0.015), café and tea room (0.007). Figures in round brackets are amount of meat products induced by one unit of each commodity (final) demand.

$$\mathbf{x}_{(i_{frozen\ food})} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}_{(i_{frozen\ food})}$$

$$i_{meat\ products}\text{-th element of } \mathbf{x}_{(i_{frozen\ food})} = 0.026$$

$$\mathbf{x}_{(i_{daily\ dish})} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f}_{(i_{daily\ dish})}$$

$$i_{meat\ products}\text{-th element of } \mathbf{x}_{(i_{daily\ dish})} = 0.019$$

- Meat products, in turn, induces beef (0.150), slaughtering and meat processing (0.386), chicken (0.066), feed (0.115).

- Daily dish induces beef (0.025), slaughtering and meat processing (0.062), chicken (0.011).

- Frozen food induces beef (0.099), slaughtering and meat processing (0.099), chicken (0.017), and egg (0.010).

All these consumption have possible contamination.

Figure 12–16 show graphs of the aggregated consumption data. Meats consumption has been affected by BSE, shows irregular patterns around the event. It is not so clear that meats consumption has the similar effect of bird flu as BSE.

Other foods consumption does not show such irregularity around the events. Especially fish and fruits have regular seasonal pattern. It is not clear that there is any substitution from meats to fish consumption around the events. The same situation is applicable to vegetable consumption from meats. Vegetable consumption has irregularity around winter of 2002, but the weather condition could have irregular effect. We can assume that meats consumption is independent from the other food consumption. This is one of the reasons why we concentrate on substitution effects within meats consumption in the following sections.

2.4 Estimation of consumption models

We have examined two types of consumption functions, one is the linear expenditure system, and another is the almost ideal demand system (AIDS, Deaton, 1986, Deaton and Muellbauer, 1980). The estimation procedures for the demand system has a long analytical history of econometrics. Among them, as to demand for meat products, Eales and Unnevehr [1988] shows that demand for beef and chicken is not separable (the separability is defined in Leontief [1947], Goldman and Uzawa [1964]). Therefore, the linear expenditure system might not be suitable for this analysis, and AIDS requires in other words can test concavity condition that is not always satisfied. But we just choose quite typical these two functional forms.

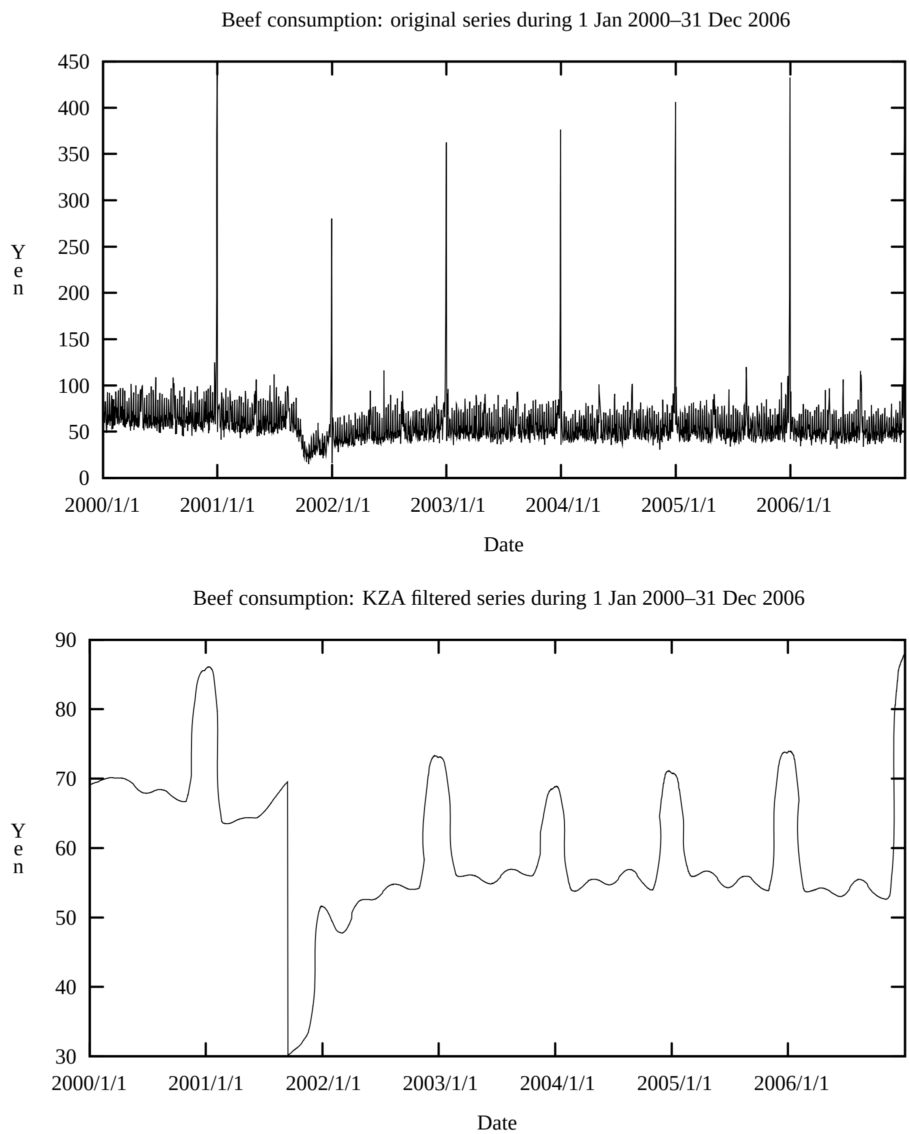


Figure 1: Beef consumption: original (top) and filtered (bottom)

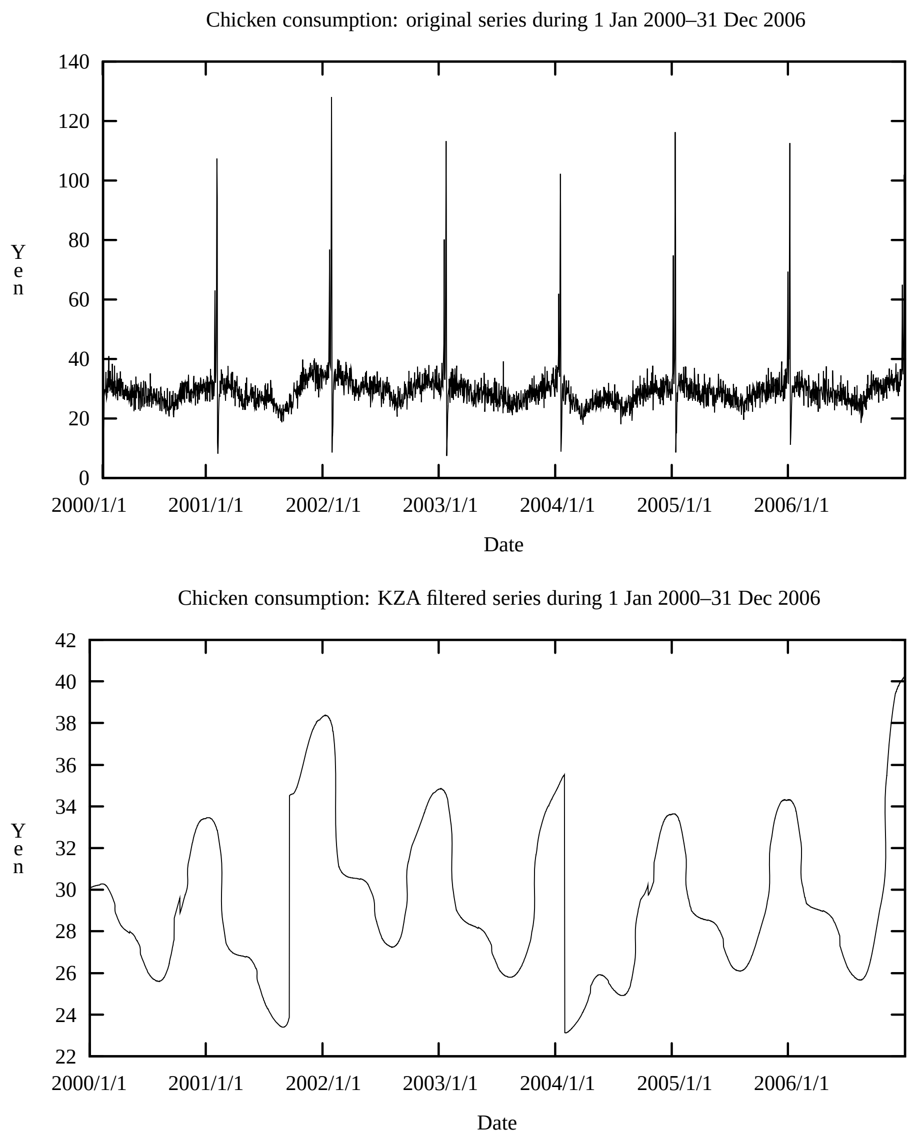
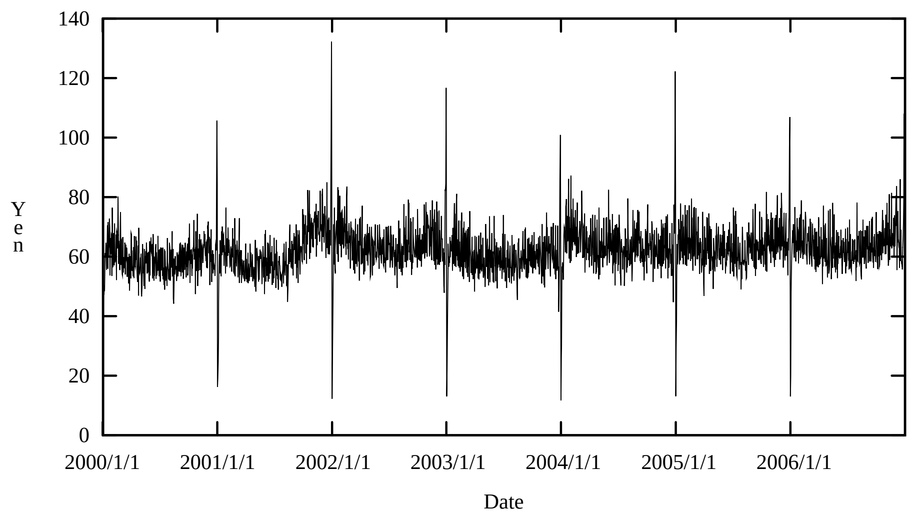


Figure 2: Chicken consumption: original (top) and filtered (bottom)

Pork consumption: original series during 1 Jan 2000–31 Dec 2006



Pork consumption: KZA filtered series during 1 Jan 2000–31 Dec 2006

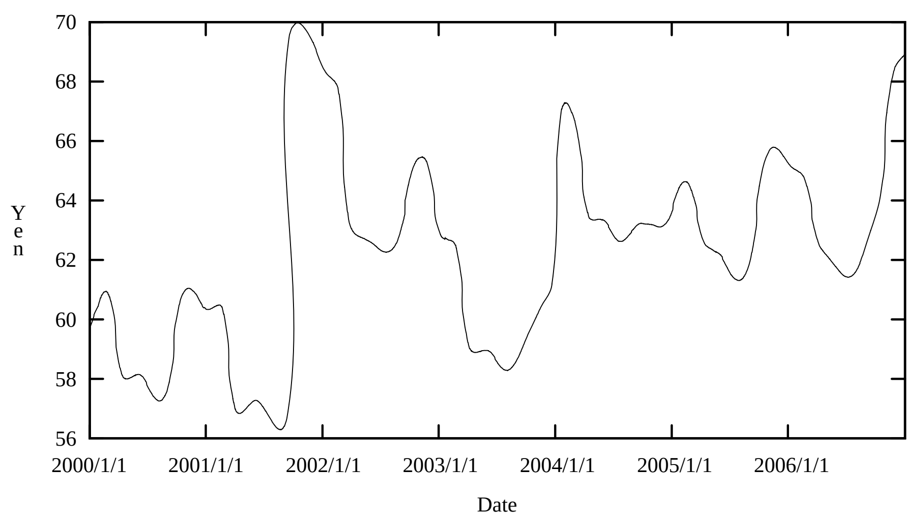


Figure 3: Pork consumption: original (top) and filtered (bottom)

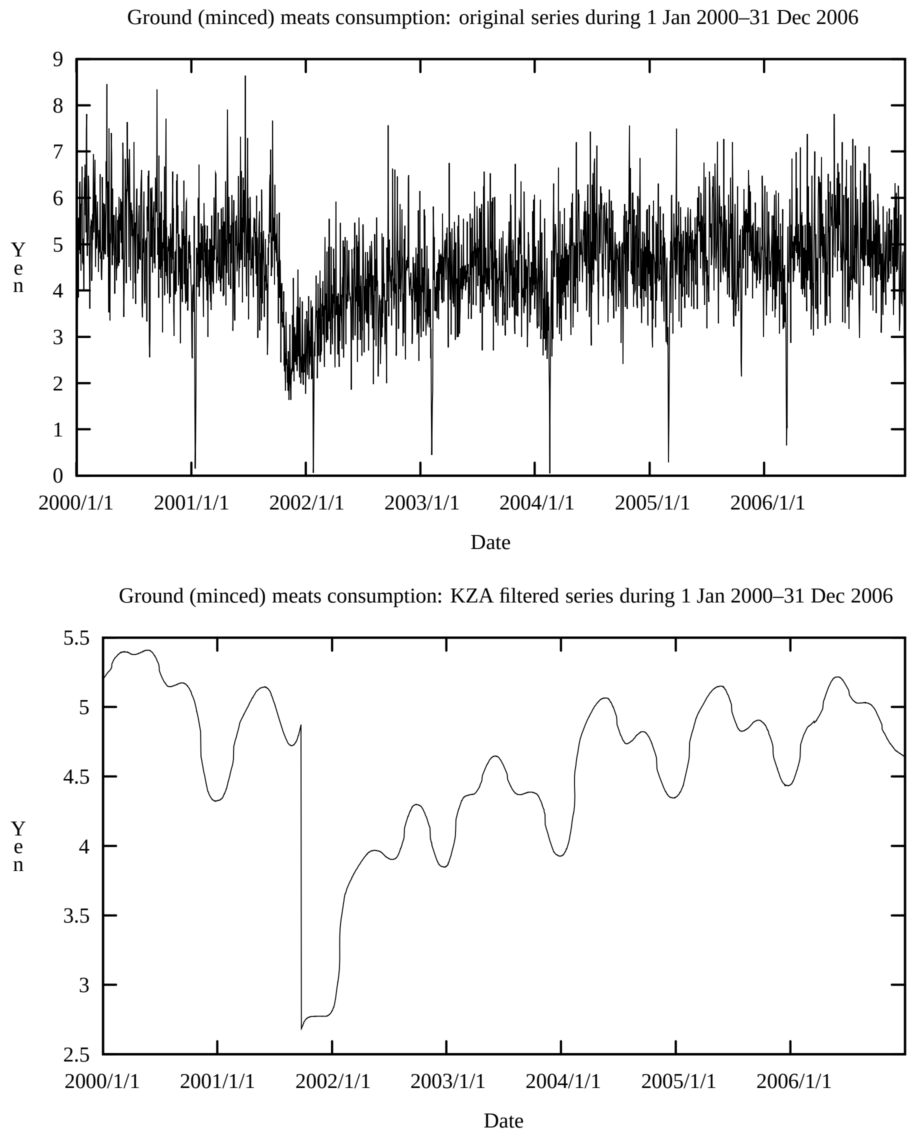
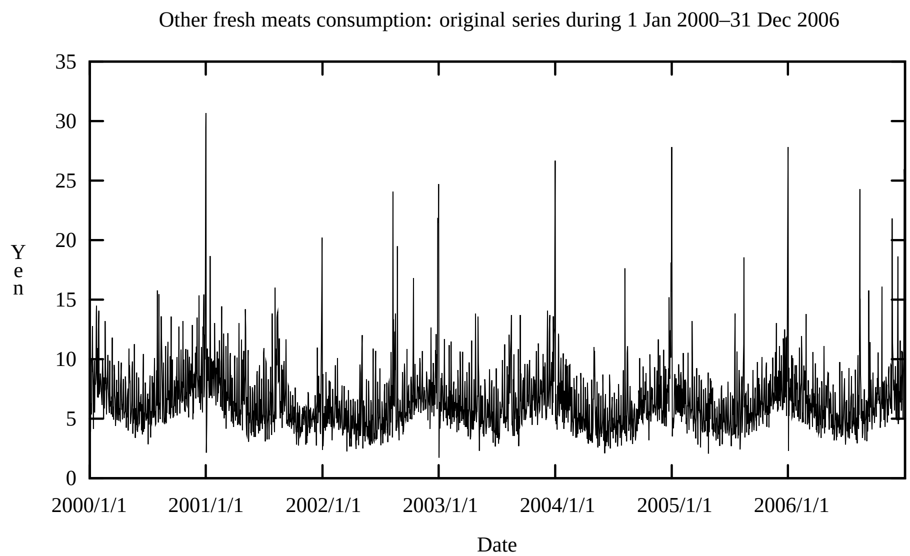


Figure 4: Ground meats consumption: original (top) and filtered (bottom)



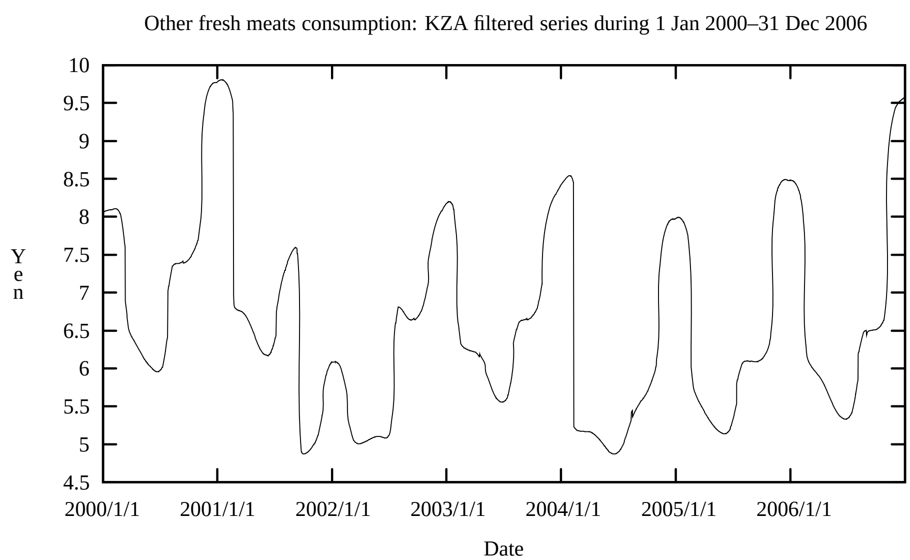
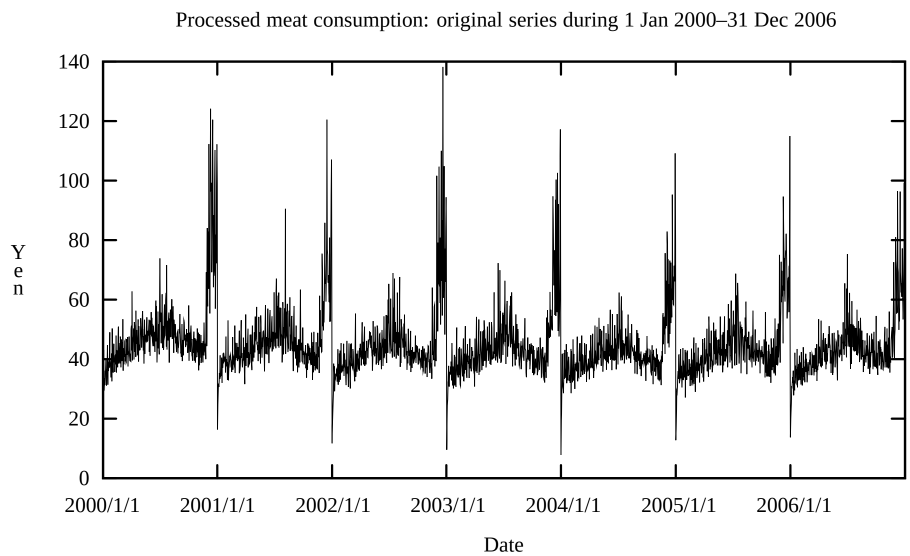


Figure 5: The other fresh meats consumption: original (top) and filtered (bottom)



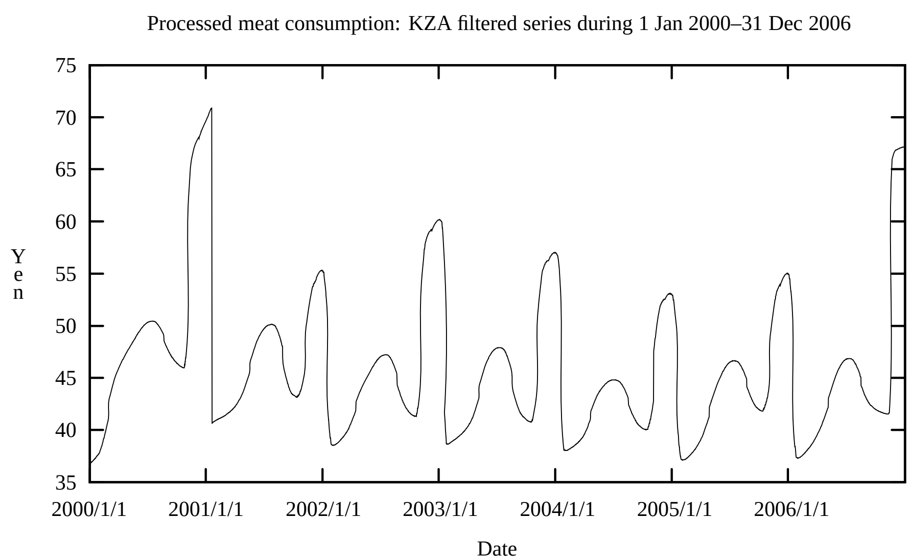


Figure 6: Processed meat consumption: original (top) and filtered (bottom)

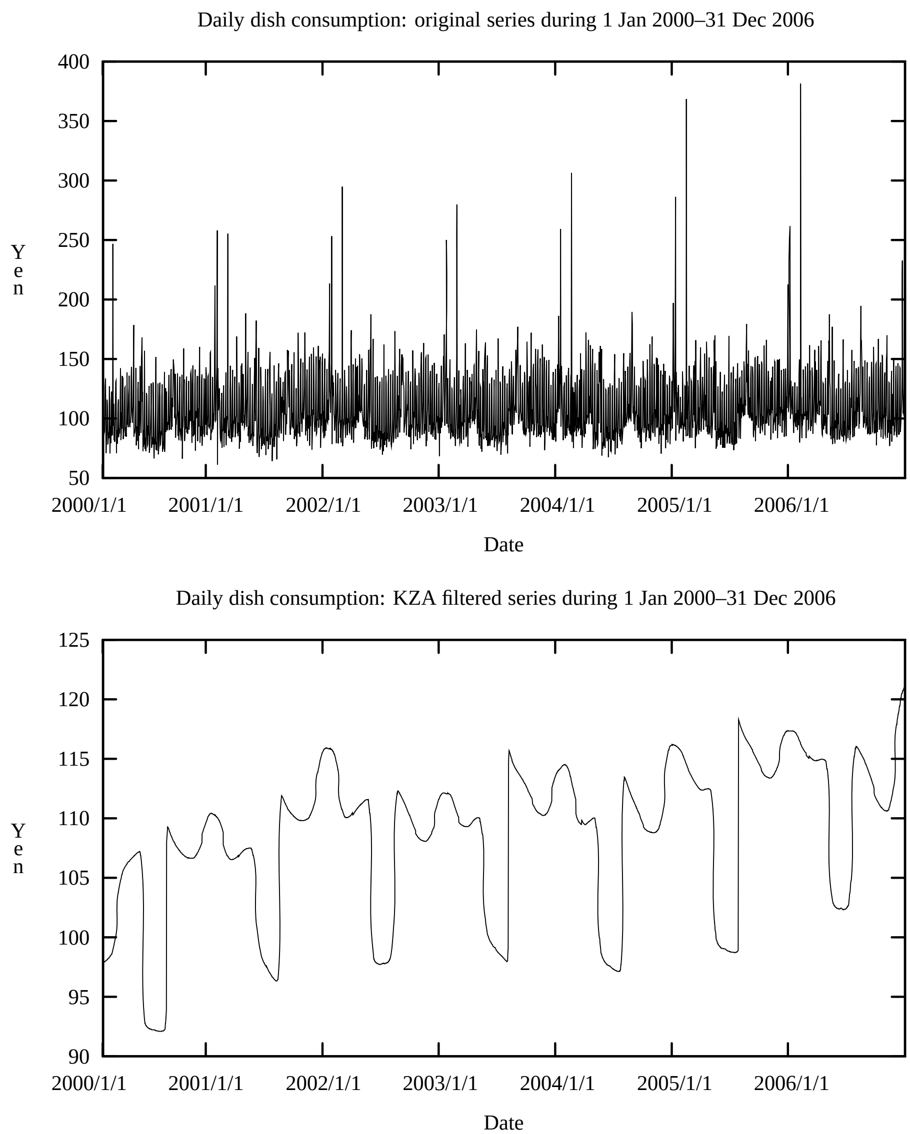
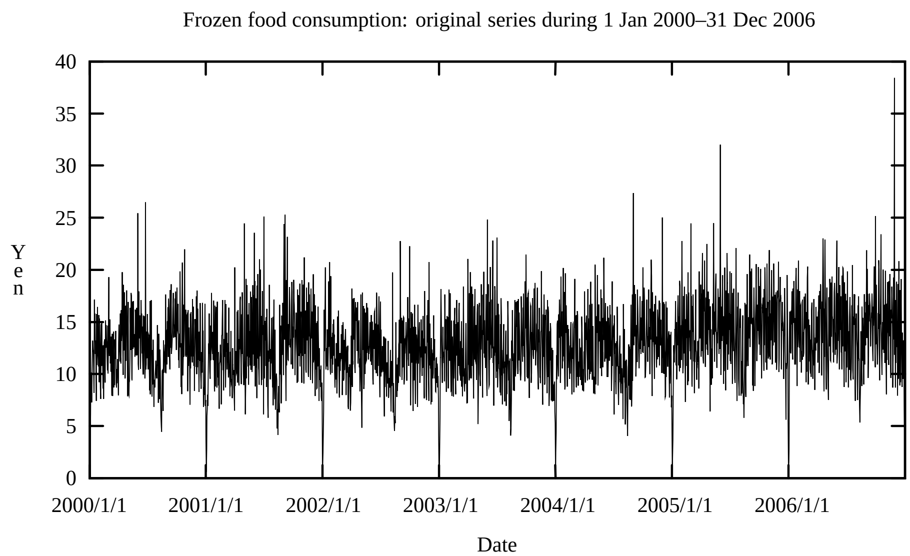


Figure 7: Daily dish consumption: original (top) and filtered (bottom)



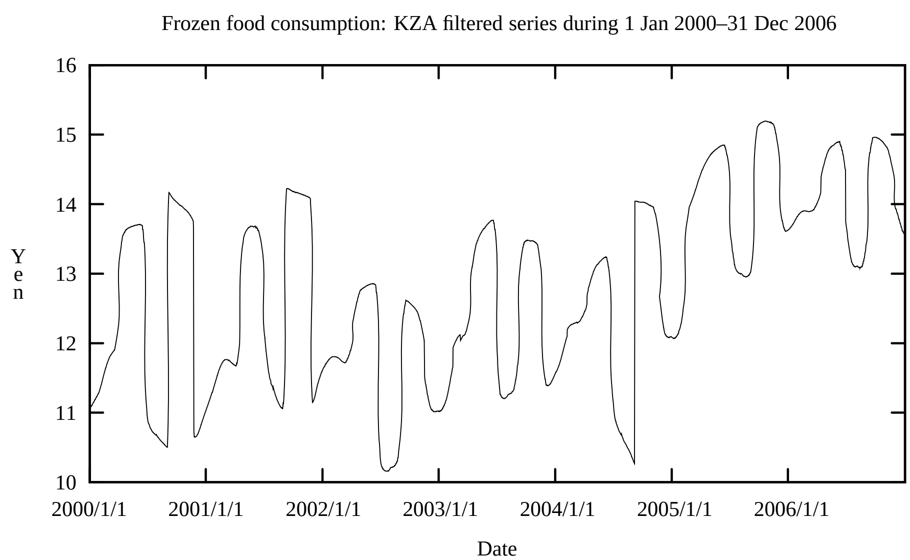


Figure 8: Frozen food consumption: original (top) and filtered (bottom)

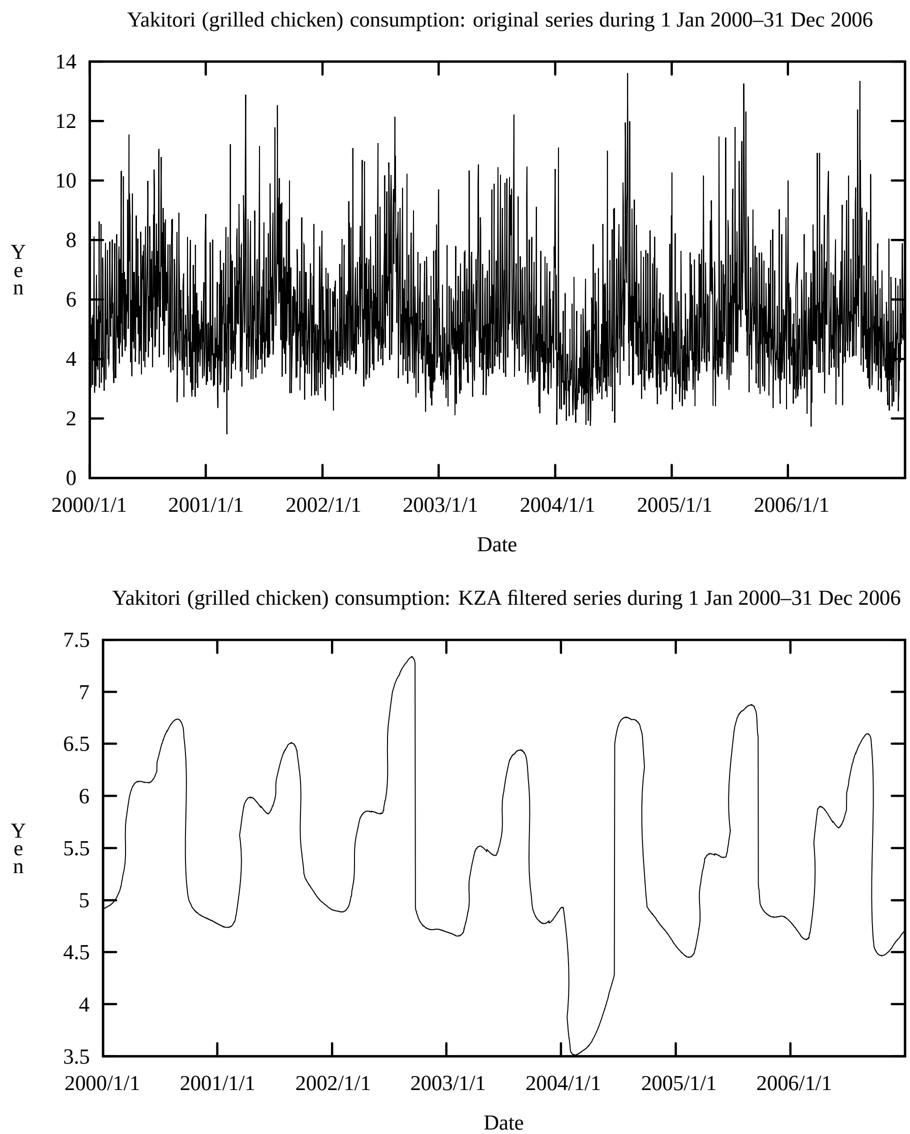


Figure 9: Yakitori (grilled chicken) consumption: original (top) and filtered (bottom)

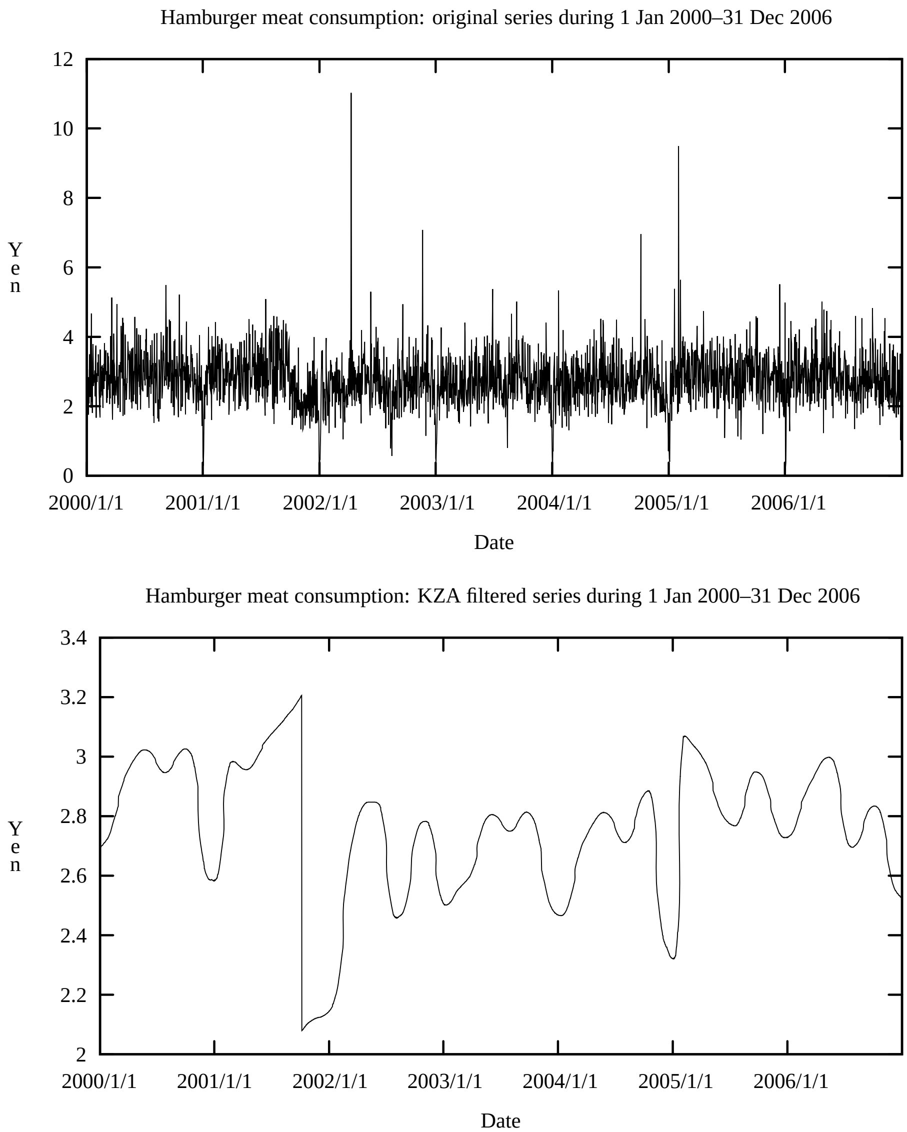


Figure 10: Hamburger meat consumption: original (top) and filtered (bottom)

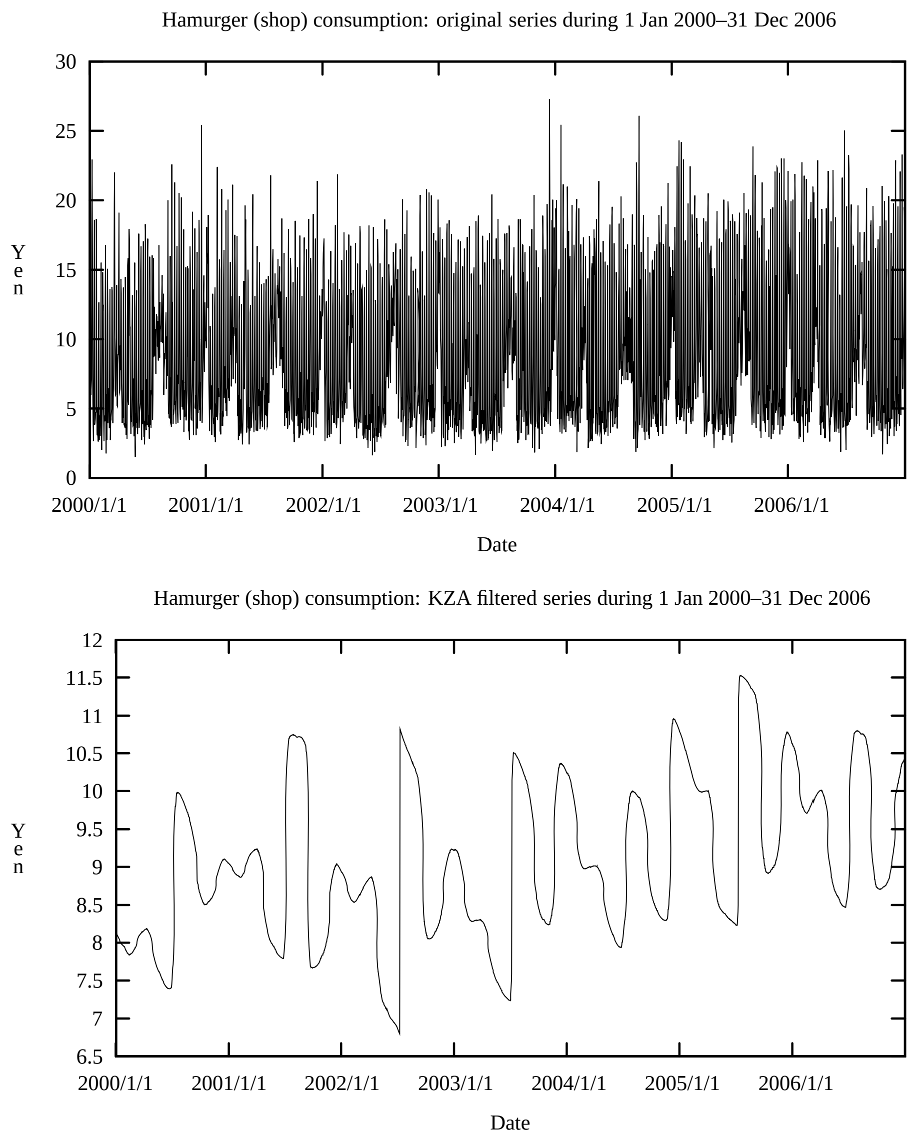


Figure 11: Hamburger (shop) consumption: original (top) and filtered (bottom)

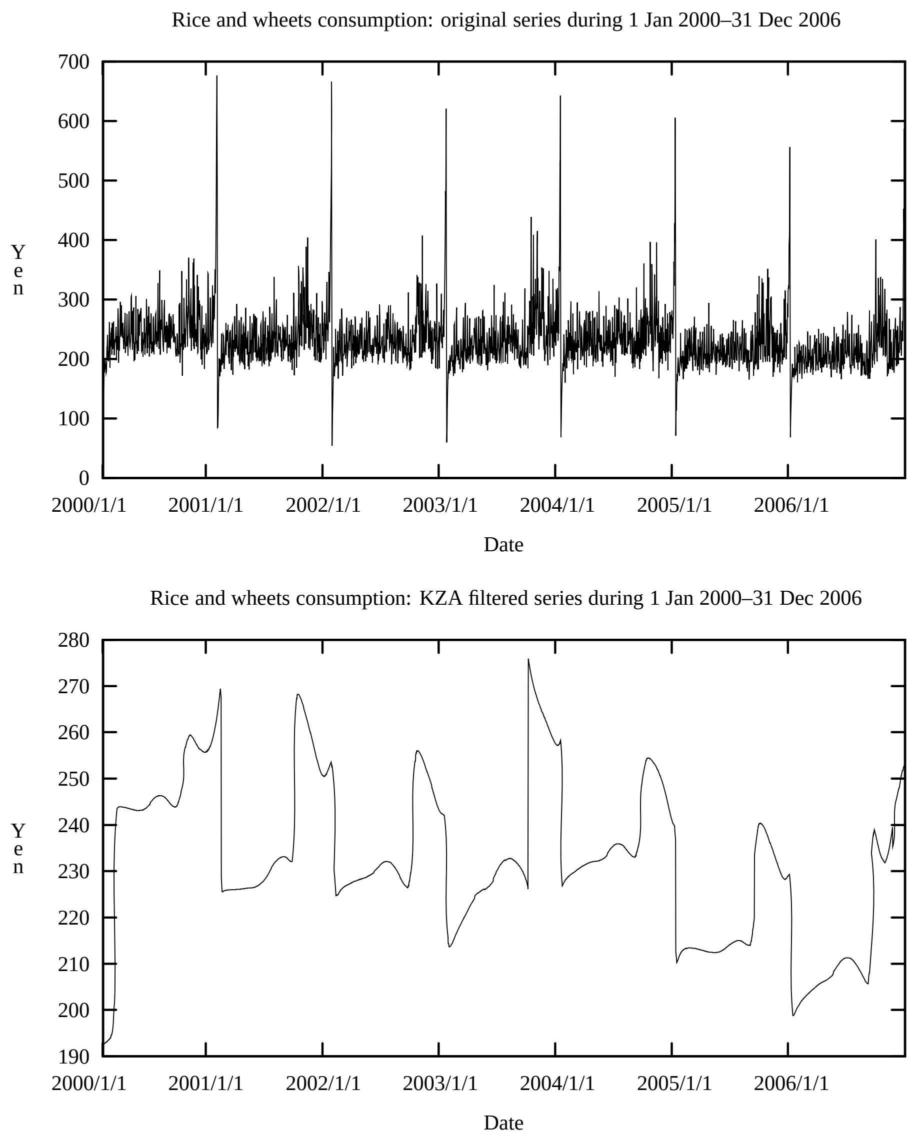


Figure 12: Rice and wheats (crops) consumption: original (top) and filtered (bottom)

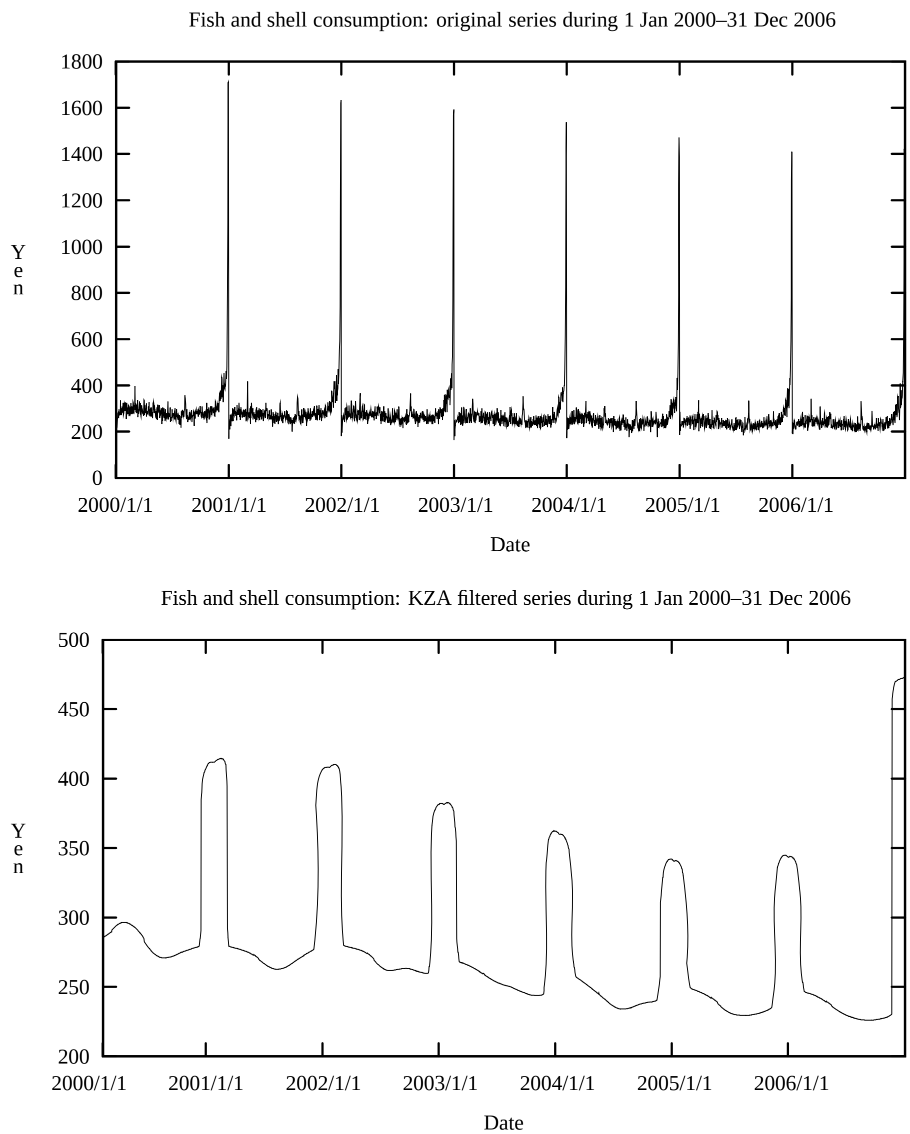


Figure 13: Fish and shell consumption: original (top) and filtered (bottom)

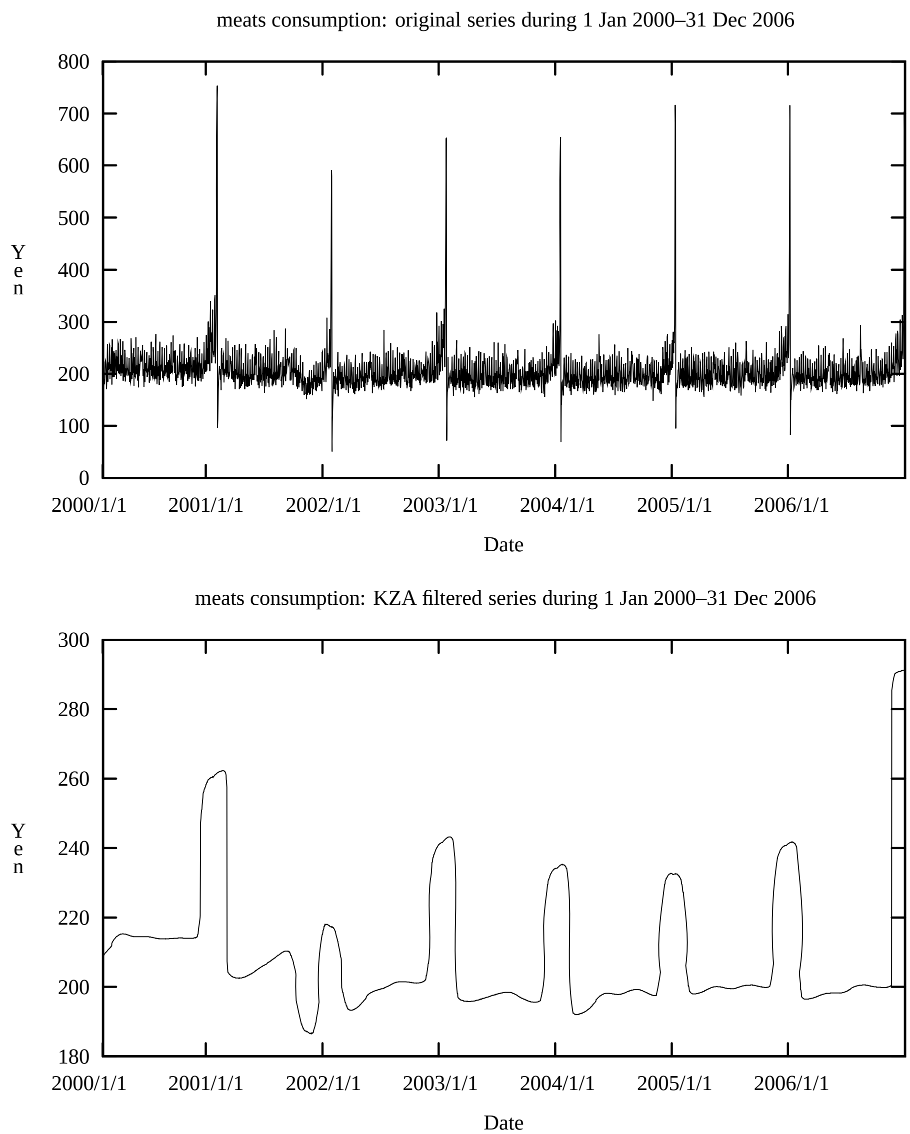


Figure 14: Meats consumption: original (top) and filtered (bottom)

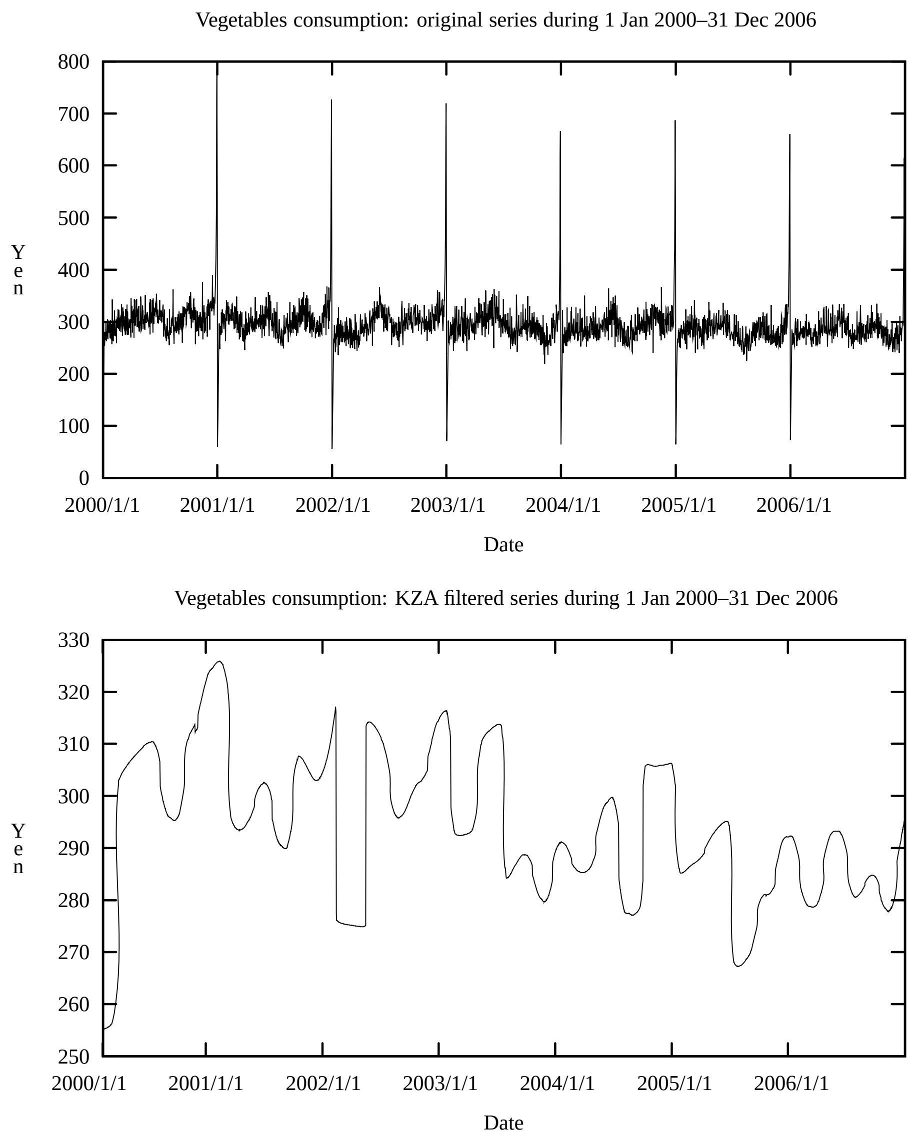


Figure 15: Vegetables consumption: original (top) and filtered (bottom)

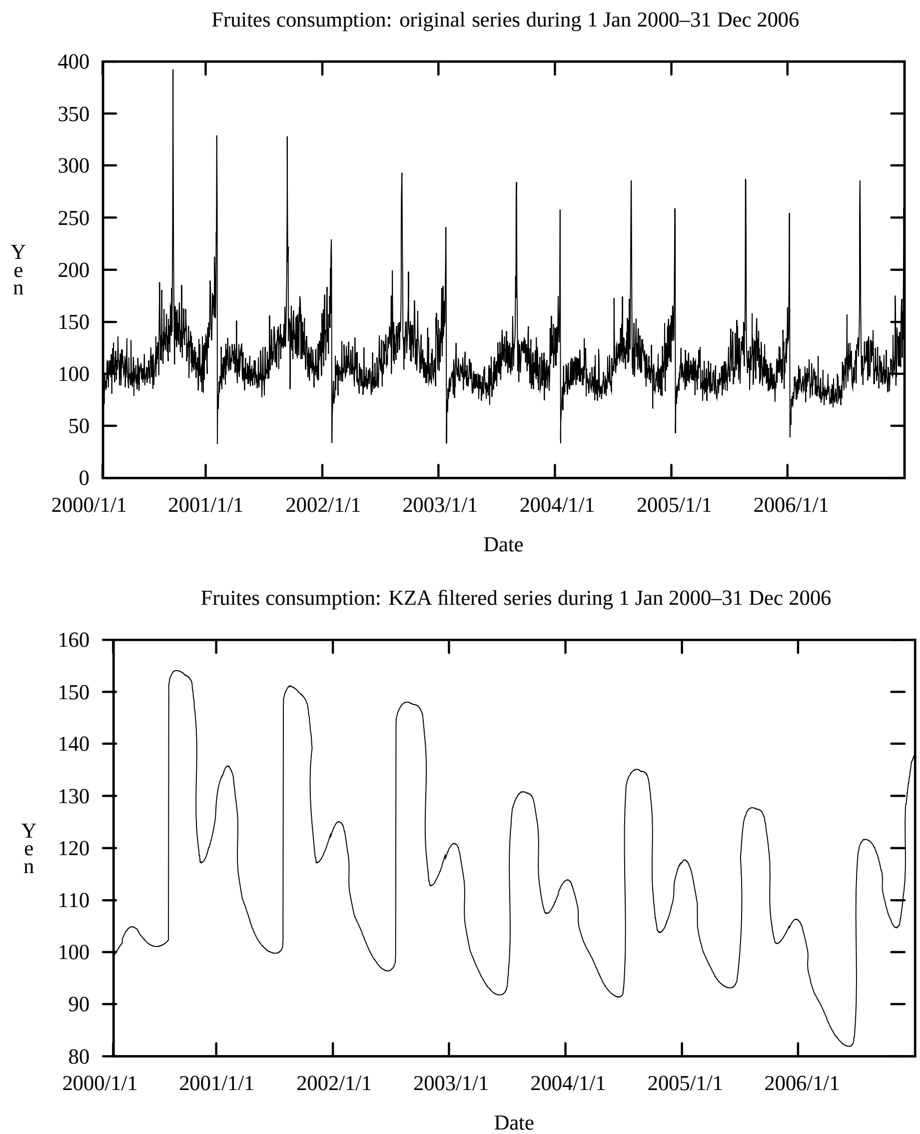


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Figure 16: Fruits consumption: original (top) and filtered (bottom)

We assume the expenditure to meats (total) is given when the consumer decides to purchase some kind of meats. Then the optimization can be formulated as follows:

$$\max F[U(x_1, x_2, \dots, x_m) + U_{\text{other}}(x_{m+1}, \dots, x_n)]$$

subject to

$$I = \sum_{i=1}^{m} p_i x_i + \sum_{i=m+1}^{n} p_i x_i,$$

where $x_1, \dots, x_m$ are meats, and $x_{m+1}, \dots, x_n$ are other than meats, I is income, and p_is are prices for each good, $U()$ is the utility for meats, and U_{other} is the utility for goods other than meats. $F[]$ is a increasing monotone function, plays no role to optimization other than the Lagrange multiplier λ. Both U and U_{other} are satisfying with twice differentiable, quasi concave function.

Under the separability condition, we can aggregate into two groups of commodities. And the optimization is divided two separate stages. Firstly, the consumer decides how much one purchases meats and others, which depends on income I and aggregated meat prices P_m and aggregated others prices P_o.

Secondly, the consumer can calculate optimal consumption for each meat $x_1, \dots, x_m$, given the meat budget M with aggregate meat prices P, and real meat consumption rM, ie,

$$\begin{aligned} M &= P \cdot rM \\ &= \sum_{i=1}^{m} p_i x_i \end{aligned}$$

Meat consumption can be determined by the first order condition

$$\frac{\partial U}{\partial x_i} = \lambda p_i, \quad i = 1, \dots, m \tag{1}$$

where λ is a Lagrange multiplier. And the budget constraint for meat expenditure should be

$$M = \sum_{i=1}^{m} p_i x_i$$

Solving the first order condition, we have the demand system for meats consumption.

But this is the normal situation. If an information of BSE contamination has been spread through media or Internet, the consumer will change their behaviour whether the information is certain or not. When it comes to be true, the consumer may be suffered from sever risk of disease. Modeling an extreme situation of the consumer behaviour has not been developed to a standard model, as far as we know. Tsujimura (1975, 1981) and Tsuzuki (1975) investigate a situation as the acute negative polyopsony. The acute negative polyopsony has been observed at the first oil crisis, then people purchase toilet papers for fear of shortage of its stocks. The information of stock shortage for toilet papers could be false or true, but the behaviour of consumers was in a typical panic situation. After the several weeks of panic, they found enough stocks of papers. The similar but much milder situation has been observed in the Heisei rice turmoil, when Japan had cold summer and rice crops had not grown well in 1993.

Our situation is just opposite of these stock shortages. Tsujimura (1975, 1981) formulate the general situation of consumer behaviour in a abnormal situation, using the price elasticity of supply

ν and consumer's sensitivity to a market μ. The equation (1) should be modified by introducing a market reaction,

$$\frac{\partial U}{\partial x_i} = \lambda p_i \left(1 + \frac{\mu_i}{\nu_i}\right), \quad i = 1, \ldots, m, \tag{2}$$

$$\nu_i = \frac{p_i \partial X_i}{X_i \partial p_i}$$

$$\mu_i = \frac{X_i \partial x_i}{x_i \partial X_i}$$

where X_i is the market demand for i-th commodity. We can express a panic behaviour as large fluctuations of μ_i and ν_i. As ν_i is defined by the price elasticity of supply, its value is positive, whereas μ_i can be positive or negative. When $\mu_i > 0$, the market demand increase (decrease) derives individual demand increase (decrease). In this case, the consumer behaves as if the individual's demand increase induces the market demand, therefore the consumer purchases less than in the price given (normal) situation.

When the bird flu has found in a area, the chickens and the hens in the district must be slaughtered by the law under the direction of the local governor (Article 17, the Livestock Diseases Prevention Act, Revised 21 October 2005). In the case of BSE, the slaughter policy applies to affected cow and ox. As a result, supply of chicken (or beef) should decrease when the bird flu is found. Combined effect of demand decrease and supply decrease results rapid decrease of transaction turnover. This effect cannot be incorporated in a model in advance, and it is unpredictable. We have to introduce as an event dummy to cope with the events, this remains further investigations.

2.5 Model Specification for meat consumption(1): LES

The utility function should be

$$U = A \prod_{i=1}^{m} (x_i - \alpha_i)^{\beta_i}$$

where $\sum_{i=1}^{m} \beta_i = 1$, and $\beta_i > 0$, for all i. The demand system can be expressed as

$$p_i x_i = p_i \alpha_i + \beta_i (M - \sum_j p_j \alpha_j) \quad i = 1, \ldots, m$$

$$M = \sum_{i=1}^{m} p_i x_i$$

We treat the discontinuity points judged from the KZA filter as the dummy variables in the consumption demand function. The BSE and bird flu have the time lag in the consumption. The BSE is recognized at 21st September 2001, and bird flu is at 30th January 2004. Both starting points have big shock on the consumption of fresh meat.

The dummy variables are set as follows:

- D_1: BSE dummy (appearance), from 14th September 2001 and after D_1 sets 1, otherwise 0.
- D_2: BSE dummy (disappearance), from 8th December 2001 and after D_2 sets 1, otherwise 0, representing extinguished effects of D_1.
- D_3: bird flu dummy (appearance), from 30th January 2004 and after D_3 sets 1, otherwise 0.

- D_4: bird flu dummy (disappearance), from 26th March 2004 and after D_4 sets 1, otherwise 0.

We observed the a few months' large fluctuations of demand after an event.

$$p_i x_i = p_i \alpha_i + \beta_i (1 + \sum_k^4 \delta_{ik} D_k)(M - \sum_j p_j \alpha_j) \quad i = 1, \ldots, m.$$

Because of the identity of summability condition to M, the restriction for the parameters is

$$\beta_m = 1 - \sum_i^{m-1} \beta_i,$$

and

$$\sum_{i=1}^m \sum_k^4 \delta_{ik} D_k = 0.$$

This implies that one of the m equations is derived from the other $m-1$ equations.

Following Tsujimura and Tsuzuki, we may introduce μ_i and ν_i as in the previous subsection.

$$p_i x_i = p_i \alpha_i + \frac{\frac{\beta_i}{\left(1+\frac{\mu_i}{\nu_i}\right)}}{\sum_{j=1}^m \left\{ \frac{\beta_j}{\left(1+\frac{\mu_j}{\nu_j}\right)} \right\}} (M - \sum_j p_j \alpha_j) + \sum_k^4 \delta_{ik} D_k \quad i = 1, \ldots, m.$$

Let

$$b_i^* = \frac{\frac{\beta_i}{\left(1+\frac{\mu_i}{\nu_i}\right)}}{\sum_{j=1}^m \left\{ \frac{\beta_j}{\left(1+\frac{\mu_j}{\nu_j}\right)} \right\}},$$

we have the same equation as before

$$p_i x_i = p_i \alpha_i + b_i (1 + \sum_k^4 \delta_{ik} D_k)(M - \sum_j p_j \alpha_j) \quad i = 1, \ldots, m,$$

where $\sum_{i=1}^m b_i = 1$ and $\sum_{i=1}^m \sum_k^4 \delta_{ik} D_k = 0$.

2.6 Model Specification for meat consumption (2): AIDS

As we try to estimate a bit more flexible functional from than the linear expenditure system, we introduce the Almost Ideal Demand System (AIDS) by Deaton and Muellbauer(1980). The AIDS expenditure function is expressed as the following.

$$\log M = \alpha_0 + \sum_i \alpha_i \log p_i + \frac{1}{2} \sum_i \sum_j \gamma_{ij}^* \log p_i \log p_j + V \beta_0 \prod_k p_i^{\beta_k},$$

where p_i is the price of commodity i, V is the utility level, α_0, α_i, β_0, and $beta_k$ are parameters of the expenditure function. And the corresponding share functions are

$$s_i = \alpha_i + \sum_j^m \gamma_{ij} \log p_j + \beta_i \log \frac{M}{P}, \quad i = 1, \ldots, m,$$

where s_i is the share of i-th commodity, p_j the price of j-th commodity, M the total meat expenditure and P the price index of meats.

The price index P is specified to the Stone's price index. It is the weighted average of commodity prices with their share.

$$\log P = \sum_{k}^{m} s_k \log p_k$$

Linear homogeneity to prices restricts parameters as follows:

$$\sum_i \alpha_i = 1$$
$$\sum_i \gamma^*_{ij} = 0$$
$$\sum_j \gamma^*_{ij} = 0$$
$$\sum_j \beta_j = 0.$$

For the second order condition of optimization, the expenditure function needs to be quasi-concave. So Hessian of the expenditure function is required to be non-positive definite.

$$\begin{aligned}
\frac{\partial^2 M}{\partial p_i^2} &= \frac{M}{p_i^2}\left(\frac{\partial^2 \log M}{\partial \log p_i^2} + \left(\frac{\partial \log M}{\partial \log p_i}\right)^2 - \frac{\partial \log M}{\partial \log p_i}\right) \\
&= \frac{M}{p_i^2}\left(\gamma^*_{ii} + s_i^2 - s_i\right) \\
\frac{\partial M^2}{\partial p_i \partial p_j} &= \frac{M}{p_j^2}\left(\frac{\partial^2 \log M}{\partial \log p_i \partial \log p_j} + \frac{\partial \log M}{\partial \log p_i}\frac{\partial \log M}{\partial \log p_j}\right) \\
&= \frac{M}{p_i p_j}\left(\gamma^*_{ij} + s_i s_j\right)
\end{aligned}$$

Here s_i is the share of i-th commodity's expenditure. The diagonal matrix of prices is defined as $\mathbf{P}$. Hessian $\mathbf{H}$ is decomposed as following.

$$\mathbf{H} = C\mathbf{P}^{-1}\mathbf{B}\mathbf{P}^{-1}$$

To prove that Hessian is quasi-concave, we show that Hessian is non-positive definite.The parameter matrix **B** is required to be non-positive definite. Because, the expenditure M is positive and the prices are also positive, non-positive definiteness of Hessian need that **B** is non-positive definite.

Here we impose the restriction to **B**. From the Cholesky decomposition of **B**,

$$\mathbf{B} = -\mathbf{U}'\mathbf{U}$$

Because **U** is the upper triangular matrix, **U'U** is positive definite. Using this relation, we substitute the element u_{ij} of **U'U** into γ^*_{ij} to estimate the expenditure function.

The restricted expenditure function is estimated with the share function simultaneously using Seemingly Unrelated Regression (SUR).

$$
\begin{aligned}
\log M &= \alpha_0 + \sum_i \alpha_i \log p_i \\
&+ \frac{1}{2}\sum_i \sum_{j \neq k} \left(\sum_k -u_{ki}u_{kj} - s_i s_j \right) \log p_i \log p_j \\
&+ \frac{1}{2}\sum_i \sum_k \left(-u_{ki}^2 - s_i^2 + s_i \right) \log p_i^2 + \log \frac{x}{P} \\
s_i &= \left(\sum_k -u_{ki}^2 - s_i^2 + s_i \right) \log p_j + \sum_{j \neq i} \left(-\sum_k u_{ki}u_{kj} - s_i s_j \right) \quad i = 1, \ldots, m
\end{aligned}
$$

From optimization of the consumer behaviour, the level of utility V is a function of the price index P and the total expenditure M.

We introduced the same dummy variables as LES, let them $D_1, \ldots, D_4$.As a result, a system of the share functions becomes

$$
s_i = \alpha_i + \sum_j \gamma_{ij} \log p_j + \beta_i \log \frac{x}{P} + \sum_k \delta_{ik} D_k \quad i = 1, \ldots, m.
$$

As before,

$$
\sum_i^m \sum_k^4 \delta_{ik} D_k = 0.
$$

2.7 Data for the time series consumption

We use meats consumption data, which include beef, pork, chicken, ground meats, the other meats, Yakitori, hamburger steak and hamburger. The first seven of the series contain price and quantity for each, but hamburger can be derived from the residual of the six items and the total meat outlay that is assumed to be given for our model.

There are daily data for the consumption value, but no daily data available for their prices. We have interpolated the daily prices for these series using the spline method from the monthly price data reported in the same survey.

And we define the dummy variable as follows:

- x_1: beef consumption in real (physical) term
- x_2: pork consumption in real (physical) term
- x_3: chicken consumption in real (physical) term
- x_4: ground meats consumption in real (physical) term
- x_5: other meats consumption in real (physical) term
- x_6: ham in real (physical) term
- x_7: sausages in real (physical) term
- x_8: bacon in real (physical) term

- x_9: other meat products in real (physical) term
- x_{10}: yakitori consumption in real (physical) term
- x_{11}: hamburger steak consumption in real (physical) term
- x_{12}: hamburger consumption in real (physical) term
- D_1: BSE dummy (appearance), from 14th September 2001 and after D_1 sets 1, otherwise 0.
- D_2: BSE dummy (disappearance), from 8th December 2001 and after D_2 sets 1, otherwise 0, representing extinguished effects of D_1.
- D_3: bird flu dummy (appearance), from 30th January 2004 and after D_3 sets 1, otherwise 0.
- D_4: bird flu dummy (disappearance), from 26th March 2004 and after D_4 sets 1, otherwise 0.

Descriptive statistics of these series are given in Table 3 and 4. Nothing particular

2.8 Estimation procedure and the estimated results

We first estimate LES with four dummy variables using seemingly unrelated regressions (Feasible GLS). From the KZA filtered seires, the dummy variables are set in the equation of the commodies except for meat products. Including meat products into the demand system, the theoretical conditions of β are satisfied.

Table 6 shows the parameter estimated. αs and βs except for β_4 and β_{11} are statistically significant and all βs satisfy the theoretical condition. δ_{13}, δ_{24}, and coefficients of minced meats are not statistically significant. δ_{13} and δ_{14} are impact of bird flu to beef consumption. The beef consumption does not return its previous level even after bird flu. $\delta_{11} = -0.286$ is the impact of BSE on beef, and $\delta_{12} = 0.168$ is the return effect for beef. The timing of δ_{13} and δ_{12} are very close, therefore, δ_{12} may absorb most of positive effect to beef.

The same estimation for AIDS are shown in Table 7 and Table 8. These results are very preliminary, we are trying to obtain a result with quasi-concave expenditure function.

3 Calculation of the input-output relations

Table 9 shows that the estimated changes of meat consumption, which can be obtained the difference between the actual consumption and the estimated consumption using LES function without the dummies.

$$\Delta\{p_i x_i(t)\} = \{p_i x_i(t)\} - \{\widehat{p_i x_i(t)}\}, \quad i = 1, \ldots, m$$
$$\{\widehat{p_i x_i(t)}\} = p_i \hat{\alpha}_i + \hat{\beta}(M - \sum_j p_j \hat{\alpha}_j) \quad i = 1, \ldots, m.$$

$\hat{\alpha}_i$, and $\hat{\beta}_i$ are estimated coefficients.

The change of consumption is evaluated in the purchaser's price, hence it must be decomposed into the producer's price, the transportation margin, the commercial margin. After $p_i x_i$ is divided into the producer's price and the margins, the final demand vector $\Delta\mathbf{f}$ is the column vector with the elements of their values. The economic impact $\Delta\mathbf{x}$ of the BSE and bird flu events is calculated as simply

$$\Delta\mathbf{x} = (\mathbf{I} - (\mathbf{I} - \hat{\mathbf{M}})\mathbf{A})^{-1}(\mathbf{I} - \hat{\mathbf{M}})\Delta\mathbf{f}.$$

Table 3: Descriptive statistics

	p_1	p_2	p_3	p_4	p_5	p_6
mean	1.03	0.98	0.97	1.00	0.89	1.08
stdv	0.10	0.02	0.03	0.04	0.08	0.06
min	0.88	0.95	0.91	0.92	0.70	0.98
max	1.36	1.03	1.07	1.11	1.06	1.35
sample	2557	2557	2557	2557	2557	2557

	p_7	p_8	p_9	p_{10}	p_{11}	p_{12}
mean	0.95	0.97	1.00	1.00	1.00	0.77
stdv	0.02	0.03	0.02	0.00	0.01	0.05
min	0.90	0.89	0.97	1.00	0.98	0.69
max	1.01	1.07	1.05	1.01	1.00	1.06
sample	2557	2557	2557	2557	2557	2557

Correlation matrix

	p_1	p_2	p_3	p_4	p_5	p_6
p_1	1.00	0.07	0.34	0.55	0.14	0.07
p_2	0.07	1.00	0.54	0.13	0.09	0.13
p_3	0.34	0.54	1.00	0.02	0.05	0.26
p_4	0.55	0.13	0.02	1.00	0.01	-0.31
p_5	0.14	0.09	0.05	0.01	1.00	0.45
p_6	0.07	0.13	0.26	-0.31	0.45	1.00
p_7	-0.32	0.16	0.06	-0.38	0.42	0.50
p_8	-0.02	0.25	0.23	-0.04	0.16	0.29
p_9	0.17	0.01	-0.18	0.28	-0.02	-0.04
p_{10}	0.63	-0.14	-0.14	0.68	-0.06	-0.36
p_{11}	0.39	-0.28	-0.31	0.52	0.36	-0.09
p_{12}	0.05	0.10	0.01	0.15	-0.20	-0.19

	p_7	p_8	p_9	p_{10}	p_{11}	p_{12}
p_1	-0.32	-0.02	0.17	0.63	0.39	0.05
p_2	0.16	0.25	0.01	-0.14	-0.28	0.10
p_3	0.06	0.23	-0.18	-0.14	-0.31	0.01
p_4	-0.38	-0.04	0.28	0.68	0.52	0.15
p_5	0.42	0.16	-0.02	-0.06	0.36	-0.20
p_6	0.50	0.29	-0.04	-0.36	-0.09	-0.19
p_7	1.00	0.36	0.22	-0.48	-0.07	0.07
p_8	0.36	1.00	0.38	-0.07	-0.01	0.03
p_9	0.22	0.38	1.00	0.51	0.43	0.13
p_{10}	-0.48	-0.07	0.51	1.00	0.76	0.06
p_{11}	-0.07	-0.01	0.43	0.76	1.00	-0.05
p_{12}	0.07	0.03	0.13	0.06	-0.05	1.00

Table 4: Descriptive statistics

	x_1	x_2	x_3	x_4	x_5	x_6
mean	57.86	63.32	30.44	4.58	7.42	15.32
stdv	24.80	8.38	7.28	1.08	3.03	8.36
min	14.89	8.61	7.18	0.05	1.00	3.12
max	440.76	128.18	32.58	8.85	30.86	94.26
sample	2557	2557	2557	2557	2557	2557

	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}
mean	18.87	6.06	4.62	5.36	2.78	11.72
stdv	3.06	1.13	1.91	1.87	0.76	7.12
min	2.13	0.15	0.72	1.47	0.08	1.90
max	31.16	11.42	28.71	13.51	11.18	34.86
sample	2557	2557	2557	2557	2557	2557

Correlation matrix

	x_1	x_2	x_3	x_4	x_5	x_6
x_1	1.00	0.28	0.55	-0.07	0.65	0.28
x_2	0.28	1.00	0.61	0.13	0.34	0.23
x_3	0.55	0.61	1.00	-0.04	0.48	0.39
x_4	-0.07	0.13	-0.04	1.00	-0.17	-0.08
x_5	0.65	0.34	0.48	-0.17	1.00	0.27
x_6	0.28	0.23	0.39	-0.08	0.27	1.00
x_7	0.38	0.51	0.30	0.14	0.31	0.13
x_8	-0.01	0.42	0.22	0.37	-0.02	-0.01
x_9	0.37	0.12	0.20	0.02	0.26	0.27
x_{10}	0.47	0.06	0.08	-0.15	0.38	0.12
x_{11}	-0.11	0.11	-0.02	0.34	-0.14	-0.07
x_{12}	0.44	0.19	0.06	-0.25	0.45	0.15

	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}
x_1	0.38	-0.01	0.37	0.47	-0.11	0.44
x_2	0.51	0.42	0.12	0.06	0.11	0.19
x_3	0.30	0.22	0.20	0.08	-0.02	0.06
x_4	0.14	0.37	0.02	-0.15	0.34	-0.25
x_5	0.31	-0.02	0.26	0.38	-0.14	0.45
x_6	0.13	-0.01	0.27	0.12	-0.07	0.15
x_7	1.00	0.35	0.27	0.42	0.16	0.44
x_8	0.35	1.00	0.05	-0.08	0.26	-0.12
x_9	0.27	0.05	1.00	0.32	0.02	0.24
x_{10}	0.42	-0.08	0.32	1.00	-0.11	0.56
x_{11}	0.16	0.26	0.02	-0.11	1.00	-0.16
x_{12}	0.44	-0.12	0.24	0.56	-0.16	1.00

Table 5: Unit root test statistics

Elliott, Rothenberg and Stock test			
p_1x_1	-7.059	p_1	-1.845
p_2x_2	-3.518	p_2	-3.447
p_3x_3	-5.512	p_3	-2.779
p_4x_4	-4.207	p_4	-2.255
p_5x_5	-7.641	p_5	-2.949
p_6x_6	-6.152	p_6	-1.873
p_7x_7	-3.775	p_7	-1.495
p_8x_8	-3.686	p_8	-0.505
p_9x_9	-7.867	p_9	-0.552
$p_{10}x_{10}$	-11.196	p_{10}	-0.825
$p_{11}x_{11}$	-5.128	p_{11}	-0.712
$p_{12}x_{12}$	-22.655	p_{12}	-0.801
	1pct	5pct	10pct
critical values	-3.48	-2.89	-2.57
Augmented Dicky-Fuller test			
	$\tau3$	$\phi2$	$\phi3$
p_1x_1	-23.539	184.843	277.218
p_2x_2	-27.893	259.374	389.022
p_3x_3	-24.530	200.625	300.900
p_4x_4	-21.440	153.265	229.897
p_5x_5	-25.043	209.090	313.608
p_6x_6	-13.179	57.9043	86.847
p_7x_7	-30.396	307.993	461.975
p_8x_8	-26.081	226.769	340.141
p_9x_9	-28.447	269.756	404.625
$p_{10}x_{10}$	-29.432	288.756	433.134
$p_{11}x_{11}$	-28.170	264.544	396.817
$p_{12}x_{12}$	-41.484	573.667	860.500
p_1	-40.072	538.780	806.237
p_2	-35.579	422.702	633.571
p_3	-32.893	361.139	541.244
p_4	-35.782	427.321	640.726
p_5	-33.398	371.850	557.742
p_6	-41.313	573.645	860.382
p_7	-22.560	169.861	254.763
p_8	-30.760	319.349	477.016
p_9	-7.001	16.812	24.9249
p_{10}	-8.269	22.818	34.1944
p_{11}	-8.819	26.047	38.905
p_{12}	-40.018	544.723	813.377
Critical values for test statistics			
	1pct	5pct	10pct
$\tau3$	-3.96	-3.41	-3.12
$\phi2$	6.09	4.68	4.03
$\phi3$	8.27	6.25	5.34

Table 6: Estimated parameters for LES

Parameter	Estimate	s.e.	t-statistic	p-value
α_1	14.627	4.624	3.163	[.002]
α_2	55.011	1.480	37.157	[.000]
α_3	20.441	1.105	18.505	[.000]
α_4	4.367	0.379	11.509	[.000]
α_5	2.960	0.480	6.163	[.000]
α_6	7.459	0.866	8.615	[.000]
α_7	15.839	0.322	49.145	[.000]
α_8	5.378	0.358	15.041	[.000]
α_9	3.182	0.159	20.003	[.000]
α_{10}	3.913	0.165	23.738	[.000]
α_{11}	2.847	0.057	49.850	[.000]
α_{12}	4.460	0.781	5.707	[.000]
β_1	0.571	0.014	42.195	[.000]
β_2	0.055	0.013	4.169	[.000]
β_3	0.094	0.004	22.879	[.000]
β_4	0.006	0.005	1.193	[.233]
β_5	0.045	0.005	9.780	[.000]
β_6	0.102	0.004	26.522	[.000]
β_7	0.032	0.002	16.628	[.000]
β_8	0.006	0.005	1.380	[.167]
β_9	0.016	0.001	23.502	[.000]
β_{10}	0.017	0.001	18.912	[.000]
β_{11}	0.001	0.001	0.945	[.344]
β_{12}	0.053	0.006	8.300	[.000]
δ_{11}	-0.286	0.041	-7.015	[.000]
δ_{12}	0.168	0.035	4.863	[.000]
δ_{13}	0.043	0.034	1.252	[.211]
δ_{14}	-0.083	0.035	-2.342	[.019]
δ_{21}	1.563	0.579	2.701	[.007]
δ_{22}	-1.005	0.441	-2.277	[.023]
δ_{23}	1.257	0.540	2.328	[.020]
δ_{24}	-0.566	0.412	-1.371	[.170]
δ_{31}	1.116	0.186	6.012	[.000]
δ_{32}	-0.800	0.151	-5.283	[.000]
δ_{33}	-0.755	0.157	-4.807	[.000]
δ_{34}	0.655	0.154	4.259	[.000]
δ_{41}	-5.052	4.101	-1.232	[.218]
δ_{42}	3.962	3.226	1.228	[.219]
δ_{43}	-0.372	0.534	-0.697	[.486]
δ_{44}	0.664	0.683	0.971	[.332]
δ_{51}	-0.068	0.093	-0.735	[.463]
δ_{52}	0.160	0.098	1.628	[.103]
δ_{53}	-0.001	0.110	-0.011	[.991]
δ_{54}	-0.193	0.115	-1.675	[.094]
δ_{101}	-0.051	0.154	-0.332	[.740]
δ_{102}	0.091	0.155	0.589	[.556]
δ_{103}	-1.458	0.272	-5.359	[.000]
δ_{104}	1.336	0.263	5.082	[.000]
δ_{111}	-16.202	16.575	-0.978	[.328]
δ_{112}	12.321	12.844	0.959	[.337]
δ_{113}	-3.105	3.951	-0.786	[.432]
δ_{114}	5.308	5.944	0.893	[.372]
δ_{121}	0.325	0.191	1.701	[.089]
δ_{122}	-0.119	0.181	-0.657	[.511]
δ_{123}	0.118	0.211	0.560	[.575]
δ_{124}	-0.093	0.209	-0.443	[.658]

Table 7: Estimated changes of meat consumption: AIDS

Parameter	Estimate	Standard Error	t-statistic	P-value
α_1	0.275	0.015	18.316	[.000]
α_2	0.458	0.012	36.997	[.000]
α_3	0.229	0.011	21.235	[.000]
α_4	0.022	0.003	6.726	[.000]
α_5	0.015	0.004	4.000	[.000]
β_1	0.065	0.007	8.636	[.000]
β_2	-0.065	0.005	-12.442	[.000]
β_3	-0.001	0.003	-0.377	[.706]
β_4	-0.011	0.001	-12.646	[.000]
β_5	0.013	0.001	9.123	[.000]
γ_{11}	0.179	0.018	9.731	[.000]
γ_{12}	-0.186	0.013	-14.308	[.000]
γ_{13}	-0.013	0.009	-1.455	[.146]
γ_{14}	-0.013	0.003	-4.812	[.000]
γ_{15}	0.033	0.004	7.768	[.000]
γ_{22}	0.262	0.017	15.544	[.000]
γ_{23}	-0.083	0.015	-5.581	[.000]
γ_{24}	0.041	0.006	6.912	[.000]
γ_{25}	-0.034	0.005	-6.802	[.000]
γ_{33}	0.184	0.017	10.636	[.000]
γ_{34}	-0.076	0.005	-14.577	[.000]
γ_{35}	-0.013	0.005	-2.482	[.013]
γ_{44}	0.047	0.004	10.595	[.000]
γ_{45}	0.001	0.002	0.280	[.780]
δ_{11}	-0.159	0.007	-24.249	[.000]
δ_{12}	0.102	0.007	15.622	[.000]
δ_{13}	-0.012	0.008	-1.476	[.140]
δ_{14}	-0.005	0.008	-0.691	[.490]
δ_{21}	0.115	0.005	24.767	[.000]
δ_{22}	-0.072	0.005	-15.596	[.000]
δ_{23}	0.044	0.006	7.780	[.000]
δ_{24}	-0.022	0.005	-4.002	[.000]
δ_{31}	0.056	0.003	19.444	[.000]
δ_{32}	-0.039	0.003	-13.951	[.000]
δ_{33}	-0.029	0.004	-8.248	[.000]
δ_{34}	0.028	0.003	8.317	[.000]
δ_{41}	-0.007	0.001	-8.296	[.000]
δ_{42}	0.005	0.001	6.259	[.000]
δ_{43}	0.000	0.001	-0.246	[.805]
δ_{44}	0.002	0.001	2.397	[.017]
δ_{51}	-0.005	0.001	-3.995	[.000]
δ_{52}	0.004	0.001	3.122	[.002]
δ_{53}	-0.003	0.002	-1.711	[.087]
δ_{54}	-0.003	0.002	-1.783	[.075]

Table 8: Estimated changes of meat consumption: AIDS with restriction

Parameter	Estimate	Standard Error	t-statistic	P-value
α_0	75.3049	1324.76	.056844	[.955]
α_1	.257248	.288822	.890680	[.373]
α_2	.477526	.467922	1.02052	[.307]
α_3	.246440	.475116	.518695	[.604]
α_4	.021644	.353208	.061280	[.951]
α_5	-.285844E-02	.050368	-.056752	[.955]
β_1	.203548E-02	.035963	.056599	[.955]
β_2	.480142E-02	.085190	.056362	[.955]
β_3	.659214E-03	.017007	.038761	[.969]
β_4	.521797E-02	.092111	.056649	[.955]
β_5	-.012714	.223122	-.056983	[.955]
β_{P0}	-71.7477	1322.87	-.054237	[.957]
γ_{11}	.212339	.326273	.650800	[.515]
γ_{12}	-.199160	.332675	-.598662	[.549]
γ_{22}	.225451	.958117	.235306	[.814]
γ_{13}	-.019719	.353316	-.055813	[.955]
γ_{23}	-.058887	.731468	-.080506	[.936]
γ_{33}	.208805	.856182	.243879	[.807]
γ_{14}	-.806310E-02	.314723	-.025620	[.980]
γ_{24}	.055832	.637749	.087546	[.930]
γ_{34}	-.078492	.554180	-.141637	[.887]
γ_{44}	.063644	.668398	.095218	[.924]
δ_{11}	-.162992	.120795	-1.34933	[.177]
δ_{12}	.099206	.117367	.845264	[.398]
δ_{13}	-.019525	.144246	-.135361	[.892]
δ_{14}	-.217993E-02	.140047	-.015566	[.988]
δ_{21}	.117507	.123072	.954783	[.340]
δ_{22}	-.070475	.118548	-.594482	[.552]
δ_{23}	.049884	.148504	.335911	[.737]
δ_{24}	-.026178	.143247	-.182749	[.855]
δ_{31}	.050779	.123447	.411339	[.681]
δ_{32}	-.040600	.118759	-.341865	[.732]
δ_{33}	-.030140	.150596	-.200136	[.841]
δ_{34}	.032417	.140793	.230249	[.818]
δ_{41}	-.879813E-02	.121488	-.072420	[.942]
δ_{42}	.373853E-02	.118025	.031676	[.975]
δ_{43}	-.123837E-02	.148227	-.835457E-02	[.993]
δ_{44}	.406730E-02	.141229	.028799	[.977]
δ_{51}	.350409E-02	.237902	.014729	[.988]
δ_{52}	.813009E-02	.232677	.034941	[.972]
δ_{53}	.101911E-02	.284437	.358292E-02	[.997]
δ_{54}	-.812656E-02	.282228	-.028794	[.977]

where **I** is the identity matrix, **A** is the input coefficient matrix, **M** is the input coefficient vector and "^" means diagonal matrix.

Table 9 show that more than half of the deduction of beef consumption have been substituted by the increase of pork consumption, and chicken consumption. Table 10 shows the estimated economic impact of the BSE and bird flu, using the result of Table 9. We have to estimate the effects of the total meat consumption, which is given at the moment. But this calculation shows that most of substitution effects can be calculated in the consumption function. Therefore we think large part of the critique that the input-output calculation over-estimates the economic impact can be overcome by estimating consumption function as this example shows.

Needless to say we need further analysis on the decline process of information dissemination, and also the filtering procedure to detect the discontinuity, and the estimation of consumption equations.

Table 9: Estimated changes of meat consumption $\Delta\{p_i x_i(t)\}$: LES

unit million yen

	Beef	Pork	Chicken	Ground meat	Other fresh meat
2001	-997.8	423.5	504.1	-21.4	-10.1
2002	-1231.3	682.7	664.8	-35.4	-0.7
2003	-638.9	231.9	339.2	-16.0	15.1
2004	-798.2	754.5	17.9	-9.4	-8.3
2005	-1150.4	752.2	323.1	-7.3	-5.3
2004	-1287.2	722.7	490.0	-5.9	9.3
total	-6103.9	3567.6	2339.1	-95.5	-0.1

	Yakitori	Hamburger meat	Hamburger	total
2001	-9.6	-41.8	60.2	-92.9
2002	64.9	-62.0	121.3	204.2
2003	-11.1	-51.0	198.8	67.8
2004	-140.2	-58.9	320.0	77.4
2005	-27.9	-6.2	455.6	333.9
2004	-27.7	-29.6	393.2	264.7
total	-151.6	-249.5	1548.9	

Note: 2001 contains days after 14th September

Table 10: Estimated economic impact of the events (BSE and bird flu) $(\mathbf{I}-\mathbf{A})^{-1}\Delta\mathbf{f}$: LES

unit million yen

	Beef	Pork	Chicken	Ground meat	Other fresh meat
2001	-2452.4	1042.6	1266.4	-51.4	-24.3
2002	-3026.2	1680.7	1670.2	-85.1	-1.7
2003	-1570.4	570.9	852.1	-38.5	36.1
2004	-1961.9	1857.4	45.1	-22.6	-19.9
2005	-2827.3	1851.9	811.7	-17.4	-12.8
2004	-3163.8	1779.2	1230.9	-14.1	22.3
total	-15002.1	8782.7	5876.3	-229.1	-0.2

	Yakitori	Hamburger meat	Hamburger	total
2001	-18.9	-82.6	117.7	-202.9
2002	128.1	-122.5	237.1	480.5
2003	-21.9	-100.7	388.6	116.2
2004	-276.9	-116.3	625.6	130.4
2005	-55.0	-12.2	890.8	629.5
2004	-54.8	-58.5	768.8	510.0
total	-299.5	-492.9	3028.5	

Note: 2001 contains days after 14th September

Table 11: Estimated changes of meat consumption: AIDS

						unit million yen
	Beef	Pork	Chicken	Ground meat	Other fresh meat	Total
2001	-851.2	459.2	344.0	-56.4	104.4	0
2002	517.0	-576.4	-452.3	-19.0	530.8	0
2003	1477.3	-1320.7	-879.3	103.5	619.2	0
2004	846.6	-137.5	-1271.1	165.7	396.3	0
2005	788.6	-497.9	-918.5	181.0	446.9	0
2006	402.4	-405.1	-692.2	169.4	525.5	0
Total	3180.6	-2478.3	-3869.5	544.1	2623.0	0

Note: 2001 contains days after 14th September

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