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The Econometric Analysis of the Change on Meat Consumption Behavior

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Abstract

The estimate on meat consumption by M.Nerlove-type dynamic model which parameters are constant over a long term period(1964-1997), was hard to suit. Because the consumption behavior have gradually changed among those period. In this paper, M. Nerlove-type dynamic model was improved so that parameter itself was set as the function of the time variable. The problem of multicollinearity was arisen in this case. Therefore the best model avoided multicollinearity was found by calculating the Pearson correlation coefficient for variables.

The results estimated by this model are following. Income and price elasticities of meat were decreasing tendency every year. The habit formation effect increased every year little by little. These are theoretically suitable results, so the change of meat consumption behavior was able to be shown clearly.

Introduction

Japanese food consumption has changed greatly under improvement in the income level by high economic growth in or after 1960. In terms of nutrition, carbohydrate decreased sharply and protein and lipid increased. In terms of food composition, while rice and potato which had played the important role in traditional eating habits decreased, animal food, such as meat and dairy products, increased remarkably. However, since the economy in Japan turned to be in the stage of the stable growth after the first oil crisis in 1973, the change in food consumption has also got stabilized. That is, it is thought that it already reached the saturation level quantitatively. However, in recent years, exteriorizing, simplifying, diversification, upgrading, leisure

orientation, etc. are progressing in the contents of eating habits in connection with change of a life style and food consciousness.

In the econometric analysis of conventional food consumption behavior, the M.Nerlove-type dynamic model was applied in many cases. This model has the characteristic in that not only the economic factor of income and price but the habit formation effect was taken in. However, in the analysis over a long period of time, the consumer's reaction to income and price would change during the measurement term and the change of the consumption custom would also be seen. In the analysis which covers various economic affairs in the long period of time such as high economic growth, stable economic growth and economic depression in recent years, there's a limit to the conventional method which set parameters in the measurement term as constant.

In this study, by using the M.Nerlove-type dynamic model, it is examined to take in the change of consumption behavior to the model, and the change of consumption behavior of meat which is typical modernization food after the 1960' s is shown.

Estimate by the Conventional M.Nerlove-type Dynamic Model

First, estimates will be made by the conventional M. Nerlove-type dynamic model shown in ① formula and it will be proved that the model does not suit well to analysis over a long period of time. The data used for analysis are yearly average of monthly receipts and disbursements per household reported in "Annual Report on the Family Income and Expenditure Survey " (all households nationwide, annual version from 1963 to 1997) by Statistics Bureau Management and Coordination Agency. The measurement term will be for 34 years from 1964 to 1997.

q_t is the amount of meat consumption for a year, t, and the expenditure per person for a month in real term is used. Deflator for realizing the expenditure is the consumer price index of the concerned item. y_t is the income for the year, t, and the aggregate amount of the living expenditure per person for a month in real term is used. Deflator for realizing the expenditure is the consumer price index (general). p_t is the price of the year, t, and the relative price index is used, which is gained from dividing the consumer price index of the concerned item by the consumer price index (general). β_0~ β_3 are the parameter which should be estimated.

$$\log q_t = \beta_0 + \beta_1 \log yt + \beta_2 \log p_t + \beta_3 \log q_{t-1} \quad \cdots ①$$

The result estimated in the use of the formula ① is shown as follows. A value inside parentheses shows a standard error. In addition, by *t* test, ** shows the level of 1% and * shows the level of 5% with significant result. $\bar{R}^2$ is coefficient of determination with adjusted for degrees of freedom.

$$\log q_t = 0.5333 + 0.0011\log y_t + 0.0850\log p_t + 0.9280^{**}\log q_{t-1}$$
$$(0.4286)\quad (0.0561)\qquad (0.0455)\qquad (0.0497)$$
$$\bar{R}^2 = 0.9927$$

Although the result estimated was good as to the coefficient of determination with adjusted for degrees of freedom, the result of *t* test was not. Only the parameter β_3 showed a significant result with the very high habit formation effect. Generally, although it was recognized that the income elasticity of meat was larger than 1 and meat was superior goods as good characteristic, it has come to be gradually recognized as normal goods in the 1960's as eating habits has been westernized. Considering this point, the estimate result of income elasticity is beyond comprehension. Moreover, price elasticity shows positive value and signature conditions do not suit. The estimate result cannot be trusted from the above result.

Comparing the period from the 1960's to the first half of the 1970's in which eating habits was westernized greatly, the period after the second half of the 1970's in which gradual change continued and, finally, the period of recent years, it is difficult to consider that consumer's reaction to income and price among those periods are the same. Then, it is hard to suit the estimates over such a long period of time for the conventional model such as ① formula which set parameters constant within the measurement term, and improvement of the model which took in the trend effect is needed.

Estimate of M. Nerlove - type Dynamic Model Containing Change of Consumption Behavior

1) The model formulization

As to analysis of change in economic phenomenon so far, although the time variant parameter model by the Kalman filter is often used, since habit - forming of food consumption behavior is high, it is considered to change gently with progress of time. Then, the parameter of formula ① itself was set as the function of the time variable[1]. It is shown in the formula from ② to ④ . t is a time variable (1964 =1 and 1965 year =2 --), and in order to avoid multicollinearity, u is introduced as power exponent. In the estimate of the least squares method, the most important premise conditions is that strong correlation must not exist in independent variables[2]. If high correlation exists in the specific two variables, the concerned variables should be treated as a variable, and there is no need to make it divided into two variables. In the measurement result, the parameter becomes unstable. This is the problem of multicollinearity. When the formulas from ② to ④ are substituted in the formula ① , the section concerned to income elasticity is divided in two, $a_1\log y_t$ and $b_1 t^u \log y_t$, the section concerned to price elasticity, $a_2\log p_t$ and $b_2 t^u \log p_t$ the section concerned to habit formation effect, $a_3\log q_{t-1}$ and $b_3 t^u \log q_{t-1}$, respectively.

Therefore, the problem of multicollinearity depends on the strength of the correlation of these variable quantities divided in two.

$$\beta_1=a_1+b_1t^u \ldots ②$$
$$\beta_2=a_2+b_2t^u \ldots ③$$
$$\beta_3=a_3+b_3t^u \ldots ④$$

Then, the value of u was changed one by one from 0 to 1, and the Pearson correlation coefficient for two variable ($logy_t$ and $t^u logy_t$, $logp_t$ and $t^u logp_t$, $logq_{t-1}$ and $t^u logq_{t-1}$) was calculated. The result is shown in Table 1. In each variable concerned to income elasticity, price elasticity and the habit formation effect, the Pearson correlation coefficient fell as the value of u became large. This is because, when the value of power exponent u becomes large, the influence of time variable t becomes stronger in connection with it and the influence of the original variable becomes weaker relatively. Moreover, the degree of the fall of the Pearson correlation coefficient is dependent on the contents of each variable quantities. Therefore, in this limitation, it seems to be more desirable as power exponent u is larger and larger. However, shown in Table 2 as the value of u becomes larger, the correlation of $t^u logy_t$ and $t^u logq_{t-1}$ becomes higher. That is, the correlation of the original variable, logyt and $logq_{t-1}$, becomes weaker relatively in order that the influence of t^u may come out strongly.

Table 1. Influence of power exponent on Pearson correlation coefficient for variable and its multiplied by t^u

power exponent u	Pearson correlation coefficient		
	$logy_t$ and $t^u logy_t$	$logp_t$ and $t^u logp_t$	$logq_{t-1}$ and $t^u logq_{t-1}$
0.00	1.0000	1.0000	1.0000
0.02	0.9975	0.9997	0.9959
0.04	0.9957	0.9988	0.9905
0.06	0.9948	0.9974	0.9860
0.08	0.9945	0.9954	0.9823
0.1	0.9944	0.9928	0.9791
0.2	0.9946	0.9725	0.9668
0.3	0.9938	0.9414	0.9556
0.4	0.9912	0.9017	0.9437
0.5	0.9869	0.8556	0.9306
0.6	0.9813	0.8047	0.9165
0.7	0.9745	0.7505	0.9016
0.8	0.9669	0.6938	0.8861
0.9	0.9586	0.6355	0.8702
1.0	0.9498	0.5760	0.8542

Thus, the problem arises in the way that, as time variable t and power exponent become larger, the Pearson correlation coefficient($logy_t$ and $t^u logy_t$, $logp_t$ and $t^u logp_t$, $logq_{t-1}$ and $t^u logq_{t-1}$) of one side becomes lower although the Pearson correlation coefficient of the other side ($t^u logy_t$ and $t^u logq_{t-1}$) becomes higher. Then, multicollinearity must be avoided to keep balance of both sides. In this research, in order to determine power exponent so that the coefficient of determination with adjusted for degrees of freedom is kept high, t value of each parameter becomes good and multicollinearity is avoided, the model was set up like ⑤ formula. In addition, since it was effective to include dummy variable D in the model when change in consumption behavior arises clearly, oil shock dummy variable D (1964 - 1973 =0, 1974 - 1997 =1) was also introduced. U and V are power exponent from 0 to 1.

$$logq_t = \beta_0 + (a_1 + b_1 t^u) logy_t + (a_2 + b_2 t^u) logp_t + (a_3 + b_3 t^v) logq_{t-1} + a_4 D \quad \cdots ⑤$$

Table 2. Influence of power exponent on Pearson correlation coefficient for another variables

power exponent u	Pearson correlation coefficient		
	$t^u logy_t$ and $t^u logp_t$	$t_u logy_t$ and $t^u logq_{t-1}$	$t^u logp_t$ and $t^u logq_{t-1}$
0.00	-0.8213	0.9550	-0.7318
0.02	-0.7965	0.9806	-0.7440
0.04	-0.7802	0.9891	-0.7433
0.06	-0.7669	0.9929	-0.7384
0.08	-0.7551	0.9950	-0.7318
0.1	-0.7441	0.9962	-0.7242
0.2	-0.6935	0.9986	-0.6814
0.3	-0.6462	0.9992	-0.6368
0.4	-0.6011	0.9995	-0.5930
0.5	-0.5581	0.9996	-0.5507
0.6	-0.5172	0.9997	-0.5103
0.7	-0.4782	0.9998	-0.4716
0.8	-0.4408	0.9998	-0.4344
0.9	-0.4049	0.9998	-0.3986
1.0	-0.3699	0.9999	-0.3638

2) The result of estimate and consideration

Considering what is described above, as a result, it became clear that in the case of u= 0.6 and v= 0.4, it suits the model shown in ⑤ formula the best. The estimation result is shown below.

$$\log q_t = -2.4974^{*} + \{0.7267^{**} - 0.0130^{**} t^{0.6}\}\log y_t - \{1.3410^{**} - 0.2105^{**} t^{0.6}\}\log p_t$$
$$(1.0166)\quad (0.1076)\quad (0.0031)\qquad (0.2024)\quad (0.0367)$$

$$+\{0.2915^{**} + 0.0248^{*} t^{0.4}\}\log_{t-1} - 0.0066D$$
$$(0.1063)\quad (0.0118)\qquad (0.0134)$$

$$\bar{R}^2 = 0.9976$$

The coefficient of determination adjusted for degrees of freedom was high and the result of *t* test for the parameter was significant except the oil shock dummy. Asking for annual transition of income elasticity from this result estimated, which is shown in Fig.1, although it was 0.7136 in 1964, which was the value of the range of normal goods, it can be said that it was quite high. It fell every year and was set to 0.6185 at 1997. Annual transition of price elasticity, which is shown in Fig.2, was flexible with the value of 1.1306 in 1964. This also showed decreasing tendency every year. Although negative value has been shown in or after 1985, it is thought to have been under the influence of price decline by import liberalization of beef. Improvement of the model is needed by introducing the dummy variable about liberalization, etc. It is regarded as a future task. Although the habit formation effect was 0.3163 in 1964, it increased every year little by little and was set to 0.3930 in 1997, which is shown in Fig.3.

Usually, in the process that new food spreads through consumers' eating habits and is firmly fixed finally, it is known that the reaction of consumers to economic factors becomes dull and the habit will become strong. Meat has also become the existence which is indispensable in eating habits by westernizing the eating habits, although it had been the food of which the frequency to eat was very small. When the parameter itself is estimated by using the model set up, with the function of time variable, income elasticity and price elasticity fell while the habit formation effect is increasing , and the change of meat consumption behavior was able to be shown clearly.

Fig. 1 Change of .Income Elasticity

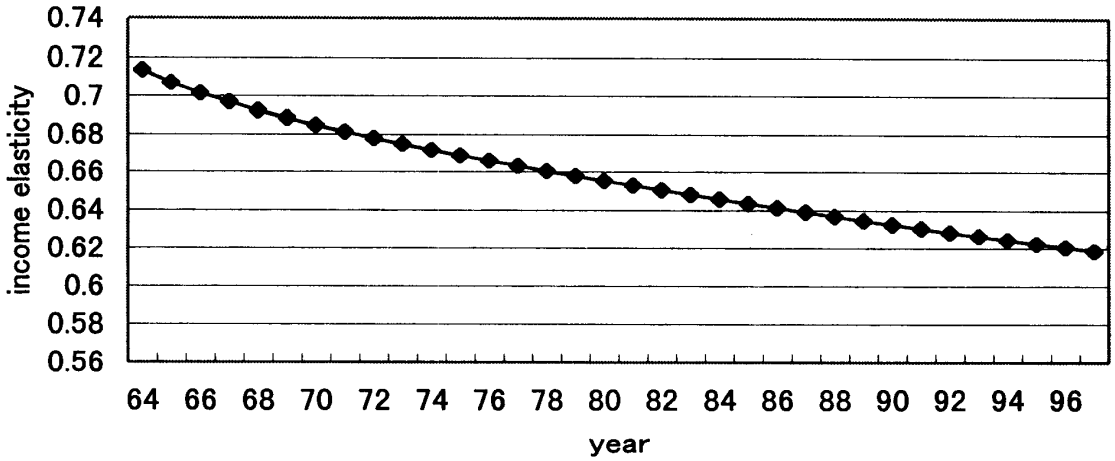


Fig. 2. Change of Price Elasticity

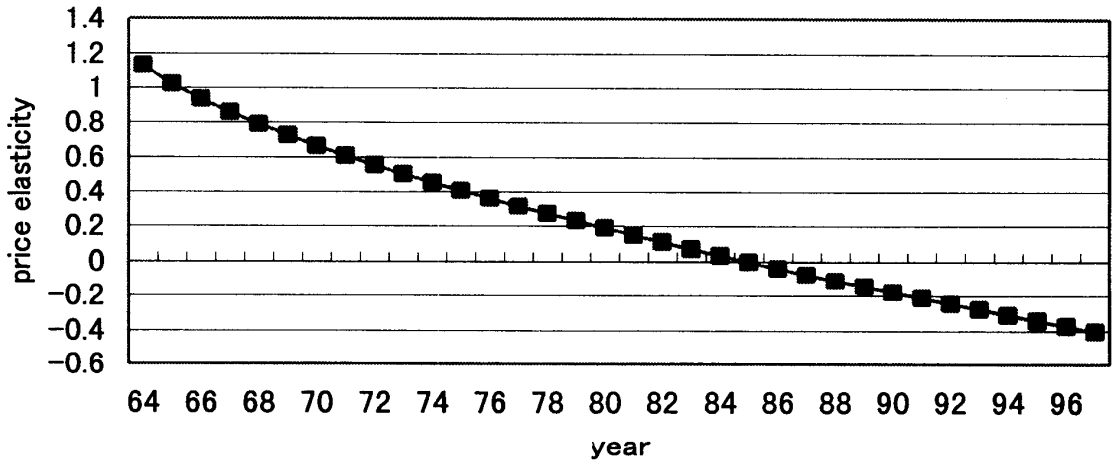
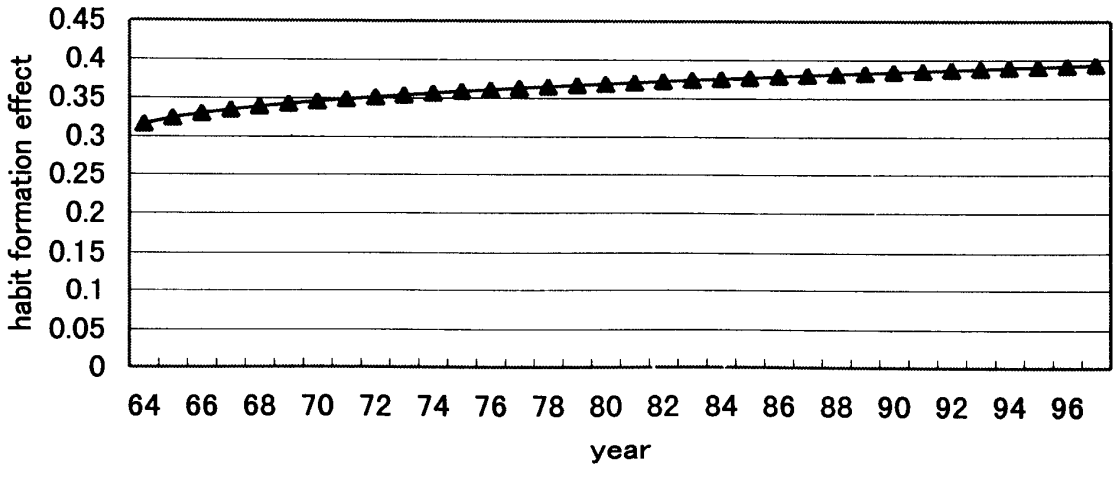


Fig. 3. Change of Habit Formation Effect



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