The Impact of Foot-and-Mouth Disease Epidemic on the Consumption of Meat in Taiwan

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The paper addresses the important impact of the outbreak of Foot-and-Mouth Disease (FMD) on the meat consumption pattern in Taiwan. A linear almost ideal demand system model is employed to estimate the consumption for pork, beef, and chicken in Taiwan. Research results reveal that the consumption pattern for pork, beef, and chicken tends to favor chicken over pork. The outbreak of FMD caused a sharp reduction in pork consumption lasting for two months. Accordingly, the beef price and expenditure increased significantly. Such fact implies that consumers preferred the substitute of beef for pork right after the outbreak of FMD.

Keywords: Foot-and-Mouth Disease, LA/AIDS model

1. Introduction

The hog industry had been the major agricultural industry in Taiwan for 20 years,

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accounting for 21.09 % of agricultural production value in 1996 and the dominant import source for Japan before Taiwan's outbreak of Foot-and-Mouth Disease (FMD) in 1997. This paper applies the demand system equations to investigate the impact of the 1997 FMD outbreak on meat consumption in Taiwan. The demand for pork, beef, and chicken are put together forming the meat consumption structure. It takes into consideration the fact that most previous time-series analysis of the demand for meat have utilized single-equation analysis involving standard economic variables and have concentrated on estimating price and income elasticities for demand (Blake and Nied, 1997). These studies consider the relationships between demand for pork, beef, and chicken. Some have extended the single-equation framework to analyze the specified effects of advertising, the formation of consumer habits, or licensing. Since 1980, a system-wide approach of demand has been employed to incorporate relative economic variables in consumption (Deaton and Muellbauer, 1980). Yet others have extended the demand system approach to investigate the effects of policy changes, structural changes, and other external factors (Pollak and Wales, 1978). Thus, this paper adopts the linear almost ideal demand system (LA/AIDS) model considered as the most flexible and effective approach.

Pork is the traditional meat for consumption as well as chicken. Recently, the increase of beef consumption must be considered. The pattern of consumer meat consumption has therefore been noted by researchers. Lin and Chen (1991) used AIDS model to investigate the interrelationship between pork, poultry, beef, and fish expenditures by an exogeneous policy shock. The results show that a structural change is induced after the specified policy shock. Chen and Hsiao (1995) employ an AIDS-like model to investigate the impacts of government policy on imported beef, distinguished quality of beef, and imported beef price on meat demand. In order to incorporate the above policy impact on meat demand, domestic beef, US-beef, pork, poultry, seafood and other food are included in the AIDS-like model. The result shows that US-beef is "luxury" meat to be consumed more when its price is decreased, i.e. a trade liberalization of Taiwan market will consume more beef.

This paper considers the impact of the FMD epidemic on the quantity of meat consumption. It is found that the inclusion of the FMD variable greatly proved useful in explaining the shifts on meat consumption in Taiwan. In the next section, the changing pattern of meat consumption in Taiwan between 1990 and 1997 is reviewed. Section III considers the data set and theoretical specification of the demand system. Section IV discusses the empirical results and the final section summaries the conclusions.

2. The Pattern of Meat Consumption in Taiwan

Table 1 shows that the dominant share of pork consumption while total quantity of the meat consumption continuously increased during 1991-1997 period in Taiwan. Prior to 1996, pork consumption exhibited a gradually decreasing share while chicken consumption earned the substitution effects. The lower than 4 % beef consumption share resulted from significantly higher unit price in the market. However, the dominance of pork consumption was hurt significantly in 1997. As a result, chicken consumption and its chare increased significantly in 1997.

Table 1. Annual Per Capita Meat Consumption in Taiwan

Unit: kg, %

Year	Pork		Beef		Chicken		Total
	Quantity	Share	Quantity	Share	Quantity	Share	Quantity
1991	43.96	63.70	2.19	3.17	22.86	33.13	69.01
1992	44.28	61.88	2.32	3.25	24.95	34.87	71.55
1993	45.05	60.08	2.27	3.03	27.66	36.89	74.98
1994	46.00	59.74	2.44	3.17	28.56	37.09	77.00
1995	45.66	58.32	2.57	3.28	30.07	38.41	78.30
1996	46.54	57.44	2.26	3.79	32.23	39.77	81.03
1997	45.38	53.88	2.83	3.36	36.02	42.77	84.23

Source: Taiwan Agriculture Yearbook, Department of Agriculture and Forestry, Provincial Government of Taiwan, 1992-1998.

By Table 2, total meat expenditure has been increasing steadily since 1991. One of the major contributing factors was the expenditure for chicken which increased from 1,687 NT dollars in 1991 to 2,623 NT dollars in 1997. The share for chicken within the total meat expenditure increased from 26.69 % to 37.43 % during that period. The expenditure for pork increased from 3,498 NT dollars in 1991 to 3,767 NT dollars in 1997. However, the share of meat expenditure for pork decreased from 63.05 % to 53.75 % during that period. The *real* dollar expenditure for beef increased while the share for beef within the total expenditure decreased. Therefore, the growth of the expenditure for chicken is the greatest among all meat categories.

Table 2. Annual Per Capita Meat Expenditure in Taiwan

Unit: NT, %

	Pork		Beef		Chicken		Total Meat
	Expenditure	Share	Expenditure	Share	Expenditure	Share	Expenditure
1991	3,498	63.05	569	10.25	1,481	26.69	5,548
1992	3,485	61.90	578	10.26	1,567	27.84	5,629
1993	3,599	60.76	549	9.26	1,776	29.98	5,924
1994	3,686	59.44	551	8.88	1,965	31.69	6,202
1995	3,728	58.72	567	8.93	2,054	32.35	6,348
1997	3,767	53.75	618	8.82	2,623	37.43	7,008

Source: Taiwan Agriculture Yearbook, Department of Agriculture and Forestry, Provincial Government of Taiwan, 1992-1998.

3. Model Specifications

The general single-equation demand is used to specify the maximization of a utility function subject to budget constraints. The equation, however, fails to integrate the feedback effects of goods concerned. The main alternative models to incorporate the interactive effects of the substitutes and complements are the log-linear model proposed by of Stone (Stone, 1954) and the Rotterdom model proposed by Theil (Theil, 1965). The log-linear model can be used to test homogeneity property. However, the model cannot satisfy with adding-up property if all equations are in log-linear forms. When the budget shares are not constant over time, it is difficult to test the symmetry property. The Rotterdom model is very similar to Stone's method and can be employed to test the restrictions of demand theory. Instead of working on the level of logarithms, it works on the level of differentials. In this paper, the demand equations are estimated using the almost ideal demand system (AIDS) proposed by Deaton and Muellbauer (1980). The model embodies the advantages of both the Stone model and the Rotterdom model. While applied, the LA/AIDS is convenient for making empirical estimations and all restricted properties of the demand system are satisfied simultaneously. Therefore, the LA/AIDS model is considered and employed to estimate the interrelation among different meat categories.

Assuming all consumers operate under price independently generalized logarithmic (PIGLOG) preferences, the quantity of the market demand is equal to the summation of these consumers' demand (Deaton and Muellbauer, 1980). The expenditure function of the representative consumer is defined as

$$\log E(u,p) = (1-u)\log a(p) + u\log b(p),\ 0 \le u \le 1 \qquad \text{...(1)}$$

where $a(p)$ and $b(p)$ define the costs of subsistence and bliss, respectively. Therefore, $E(u,p)$ defines the minimum expenditure necessary for a specified utility level, u. For example, in this paper, $E(u,p)$ is the expenditure on meat and u is the sub-utility corresponding to the entire meat group of pork, beef, and chicken.

The logarithms of the functions $a(p)$ and $b(p)$ are defined as

$$\log a(p) = \alpha_0 + \sum_j \beta_j \log p_j + \frac{1}{2}\sum_j\sum_k \gamma^*_{jk} \log p_j \log p_k \qquad \text{...(2)}$$

$$\log b(p) = \log a(p) + \delta_0 \prod_j p_j^{\delta_j} \qquad \text{...(3)}$$

where α, β , γ , and δ are parameters to be estimated.

To derive the expenditure share for goods j , w_j , first, equation (2) and equation (3) are substituted into equation (1) to obtain equation (4). Secondly, the demand system can be obtained by applying Shephard Lemma in equation (4), and then multiplying by $p_j / E(u,p)$, the expenditure share of goods j is obtained. Since consumers try to maximize their utilities, their total expenditures equal to $E(u,p)$ which can be briefly expressed by *E*. Therefore, the expenditure share form of the AIDS model can be rewritten as equation (5).

$$\log E(u,p) = \alpha_0 + \sum_j \beta_j \log p_j + \frac{1}{2}\sum_j \sum_k \gamma^*_{jk} \log p_j \log p_k \quad \text{......(4)}$$

$$\omega_j = \beta_j + \sum_k \gamma_{jk} \log p_k + \delta_j \log(E/p) \quad \text{......(5)}$$

where $\gamma_{jk} = \frac{1}{2}(\gamma^*_{jk} + \gamma^*_{kj})$ and the price index is defined by equation (6).

$$\log p = \alpha_0 + \sum_j \beta_j \log p_j + \frac{1}{2}\sum_j \sum_k \gamma_{jk} \log p_j \log p_k \quad \text{......(6)}$$

The restrictions are defined by equations (7)-(9)

$$\sum_k \gamma_{jk} = 0 ; \quad \text{......(7)}$$

$$\sum_j \beta_j = 1 ; \ \sum_j \gamma_{jk} = 0 ; \ \sum_j \delta_j = 0 ; \quad \text{......(8)}$$

$$\gamma_{jk} = \gamma_{kj} ; \quad \text{......(9)}$$

where equation (7) follows from the homogeneity of the share equations, equation (8) is the adding-up condition, and equation (9) is the Slutsky symmetry condition.

The translog price index causes the demand system nonlinear. Deaton and Muellbauer proposed a Stone price index, $\log p = \sum_j w_j \log p_j$, as an approximation of the true demand system to avoid nonlinearity. However, the use of the Stone translog price index is inappropriate due to the inconsistent problem of the estimated parameters. Moschini suggests the corrected Stone price index, which is written as $\log p = \sum_j w_j \log\left(\frac{p_j}{p_j^o}\right)$, to keep the demand system linear (Moschini, 1995). The theoretical properties of homogeneity and symmetry on equation (6) can be applied directly to the parameter estimating processes.

The domestic meat demand can be categorized as pork, beef, and chicken by assuming weak separability between these meats and all other goods which are most concerned to incorporate relationships that allow for substitution. Any change in price for one group will affect the changes in quantity for the other two groups as well as for the meat consumption patterns. Therefore, the LA/AIDS model discussed previously is designed specifically for handling the incorporation of specific economic variables and FMD outbreak variable by the expenditure share form for pork, beef, and chicken. The expenditure function for this research is defined as equation (10).

$$\log E(u, p, FMD) = \alpha_0 + (\sum_j \beta_j + \beta_{jf} \cdot FMD + \lambda_x X + \sum_m \mu_{jm} D_m)\log p_j + \frac{1}{2}\sum_j \sum_k \gamma^*_{jk} \log p_j \log p_k + u\,\delta_0 \prod_j p_j^{\lambda_j} \quad \text{.............................(10)}$$

Under the assumption of no FMD impact and assuming the LA/AIDS model provides an approximation of the true demand system, the set of parameters in equation (10) gives a full representation of the utility maximization process. The FMD impact can be characterized by allowing this set of parameters to change over time. In addition to the FMD impact, the seasonal changes and holiday effect are incorporated in the demand system. The variables are embodied in the demand system according to the translating procedure used by Pollak and Wales (1978). Given the cross-equation restrictions in equations (12)-(14), the FMD impact will affect all equations simultaneously, so an alternative model incorporating the FMD impact in intercept term is represented.

$$w_j = \beta_j + \beta_{jf} \cdot FMD + \lambda_{jx} X + \sum_m \mu_{jm} D_m + \sum_k \gamma_{jk} \cdot \log p_k$$

$$+\lambda_j \log(E/PI) \quad \text{...} (11)$$

The subscripts of i, j denote pork=1, beef=2, and chicken=3, respectively, and $m =$ denotes the seasonal orders of 2, 3, and 4. Where w_i is the per capita expenditure shares for pork, beef, and chicken, respectively. Furthermore, p_i defines the deflated *real* retail prices for pork, beef, and chicken, respectively. E defines the sum of minimum expenditures on meat products to reach a specified utility level and PI defines the corrected Stone price index of meat consumption (Moschini, 1995). The impacts of the FMD outbreak on pork, beef, and chicken consumptions are represented by the dummy variable, FMD. If there is an outbreak of FMD, the FMD dummy variable is equal to 1, otherwise, 0. In addition, X denotes the month when the Chinese new year is celebrated; D_2, D_3, and D_4 denote summer, autumn, and winter, respectively.

Before of FMD outbreak event, equation (11) can be estimated without the FMD variable for comparison. Then the FMD variable is incorporated to capture the FMD effect.

The theoretical conditions of homogeneity in price and income, adding-up restriction, and symmetry of the cross effects of demand functions are

$$\sum_k \gamma_{jk} = 0 \;; \qquad (12)$$

$$\sum_j \beta_j = 1,\ \sum_j \beta_{jf} = 0,\ \sum_j \lambda_{jx} = 0,\ \sum_j \mu_{jm} = 0,\ \sum_j \gamma_{jk} = 0,\ \sum_j \lambda_j = 0 \;; \qquad (13)$$

$$\gamma_{jk} = \gamma_{kj} \;; \qquad (14)$$

A formal test of the FMD variable is:

$$H_0 : \beta_{jf} = 0$$

$$H_a : \beta_{jf} \neq 0$$

When the estimated t-value exceed the critical t-value, the null hypothesis is rejected and the FMD variable is statistically significant.

4. Empirical Results

The data set consists of monthly quantities of meat statistics of import and export data from the Directorate-General of Customs, Ministry of Finance. For beef, chicken, and pork, quantities are per capita disappearance in real weight by the difference between domestic production and net export. The real retail prices of meat are deflated from the nominal prices in the Taiwan Agriculture Yearbook, Department of Agriculture and Forestry, Provincial Government of Taiwan. The deseasonalization of the data series is done by removing deterministic seasonality with quarterly dummy variables and dummy variable and a dummy variable capturing the effects Chinese new year.

The impacts of the 1997 FMD outbreak event on the shares of meat expenditures are evaluated by applying Zellner's interative seemingly unrelated regression estimate (ISURE) in the LA/AIDS model (Zellner, 1962). The estimation results involve model comparisons of that with and without the consideration of FMD variable. The restrictions of homogeneity and symmetry properties implied by demand theory are imposed in the estimating processes. However, the adding-up conditions imply that the covariance matrix is singular. To avoid this problem, one equation of the system is deleted. The system is invariant to which equation is deleted, therefore, the equation of beef expenditure share is omitted because of its relatively small share. The parameters in the omitted beef expenditure share equation are obtained by applying the adding-up conditions.

As shown in the Table 3, own and cross price effects on meat expenditure shares are statistically significant. The own price coefficients of the major meat categories are all positive and statistically significant at the 5 % level of confidence. The positive signs of all own price parameters indicate that the shares of expenditure for pork, beef, or chicken will increase when its own price rises. In other words, all categories of meat are price inelastic for demand. The signs for the prices of another meat category depend upon the relative changes in the share of expenditure for that category. For example, the negative sign of the beef price on the pork expenditure share equation implies that the change in the share of expenditure for pork due to the change in the price of beef has a negative effect.

The share of expenditures for pork is decreasing, on the contrast, the share of expenditure for chicken is increasing as well as the total expenditures for meat. The expenditure for meat is significantly negative while the parameter for the share for chicken is significantly positive. Based on these indications, changes in the meat consumption patterns have shown that more chicken and less pork is consumed. Furthermore, while the consumer's living standard improves and the consumer's health awareness expands, the growth rate in chicken expenditures would exceed the growth rate in pork expenditures. The tremendous growth in fast food chains might contribute to the successful promotion of fried chicken year round. The seasonal dummies fully reflect Taiwanese meat consumption customs. The traditional customs for pork consumption are usually be prepared in the ancient memorial ceremony. Chicken expenditures remain unchanged during the year except for a decrease during Chinese new year.

Table 3. Parameter Estimates of Meat Expenditure Shares under the No FMD Event Scenario

Dependent Variables	Pork Estimate	Pork t-value	Chicken Estimate	Chicken t-value
Constant	1.2240	(4.88)[a]**	-0.3411	(-1.53)
$\log(P_1)$	0.2742	(4.49)**	-0.1948	(-3.84)**
$\log(P_2)$	-0.0783	(-2.86)**	-0.0054	(-0.26)
$\log(P_3)$	-0.1948	(-3.84)**	0.2000	(4.06)**
log(E/PI)	-0.0881	(-2.30)**	0.1071	(3.11)**
X[b]	0.0438	(2.75)**	-0.0324	(-2.19)**
D^b_2	-0.0503	(-4.30)**	0.0391	(3.59)**
D_3	-0.0487	(-4.17)**	0.0357	(3.27)**
D_4	-0.0327	(-2.76)**	0.0303	(2.74)**
R^2	0.4240		0.4280	

[a] Numbers in parentheses are t-values.

* indicates statistical significance at the 10% level of confidence.

** indicates statistical significance at the 5% level of confidence.

[b] Dummy variables, X=1denotes the month within the Chinese new year celebrated, D_2=1denotes the period from April to June, D_3 =1denotes the period from July to September, and D_4 =1denotes the period from October to December, otherwise are equal to 0.

To describe the meat consumption expenditure change, an alternative elasticity measure rather, than the price and expenditure elasticity's is employed. The market share elasticities define the relative change in the share of expenditures to the change in the own price. Table 4 shows the market share elasticities which refer to the relative change in the share of expenditures while the own price changes are presented. For example, when price increase by 1 %, the share of its expenditure will increase by 0.1672 %, 0.3132 %, and -0.4804 %, respectively. The positive relationships of market shares and own prices show that the meat category expenditures will increase when own prices increase. This indicates that each category of meat is price inelastic for demand. However, the changes in expenditures for pork, beef, and chicken are not known.

Table 4. Meat Market Share Elasticities under the No FMD Scenario

	P_1	P_2	P_3
Pork	0.1672	0.3132	-0.4804
(w_1)	(1.78) [a] *	(4.26)**	(-6.49)**
Beef	-1.519	0.9862	0.5328
(w_2)	(-4.52)*	(3.74)**	(2.01)*
Chicken	0.0563	-0.8600	0.8037
(w_3)	(0.31)	(-6.14)**	(5.71)**

[a]Numbers in parentheses are t-values.

* indicates statistical significance at the 10% level of confidence.

** indicates statistical significance at the 5% level of confidence.

By adding the FMD variable to the original model to incorporate the economic impact of the FMD event, the result is shown in Table 5. By Table 5, the t-values of FMD parameters in the expenditure equations for pork and chicken are –4.11 and 3.56, respectively. Therefore, the null hypothesis of no impact on the share of meat expenditures during the FMD event is rejected. That is to say, the FMD event has had a significant impact on the share of meat expenditures. Consumers have been buying chicken instead of pork since the outbreak of FMD. This is consistent with the sharp reductions of pork consumption in the two months following the outbreak of FMD. The positive relationships between the own price and the share of expenditures indicate that all meat categories are price inelastic for demand. The share of expenditures for chicken increases while per capita expenditure for meat increases. However, changes in the expenditures for beef and pork are not significant. When the seasonal effects are involved, the expenditure share for pork during Chinese new year is greater and the expenditure share for beef in summer and autumn are greater than other seasons. On the other hand, the expenditure share for chicken in the spring is less than the shares in other seasons.

Table 5. Parameter Estimates of Meat Expenditure Shares under the FMD Event Scenario

Dependent Variables	Pork Estimate	Pork t-value	Chicken Estimate e	Chicken t-value
Constant	1.0625	(4.18)[a]**	-0.1141	(-0.54)
log (P_1)	0.1965	(3.34)**	-0.1335	(-2.87)**
log(P_2)	-0.0622	(-2.37)**	-0.0376	(-1.91)*
log(P_3)	-0.1335	(-2.87)**	0.1711	(4.01)**
log(E/PI)	-0.0636	(-1.65)*	0.0761	(2.31)**
FMD	-0.0621	(-4.11)**	0.0465	(3.56)**
X[b]	0.0387	(-2.32)**	-0.0288	(-2.02)**
D^b_2	-0.0468	(-3.93)**	0.0335	(3.29)**
D_3	-0.0373	(-3.10)**	0.0245	(2.38)**
D_4	-0.0213	(-1.72)*	0.0215	(2.03)**
R^2	0.537		0.601	

[a] Numbers in parentheses are t-values.

* indicates statistical significance at the 10% level of confidence.

** indicates statistical significance at the 5% level of confidence.

[b] Dummy variables, X=1denotes the month within the Chinese new year celebrated, D_2=1denotes the period from April to June, D_3 =1 denotes the period from July to September, and D_4 =1denotes the period from October to December, otherwise are equal to 0.

The market share elasticities under the FMD event scenario are not significantly different from those without the FMD event scenario, though the parameter of retail pork prices in the pork expenditure share equation becomes statistically insignificant (Table 6). After the outbreak of FMD epidemic, the beef expenditure increased meaningfully while beef prices also increased. The phenomenon shows that consumers have been willing to eat more beef instead of pork since the outbreak of FMD. In addition, the chicken expenditure increased but the share of expenditures for pork decreased while chicken prices increased.

The share of expenditures for pork was decreased due to the relatively low retail price of pork after the outbreak of FMD. On the other hand, the impact of the retail price of pork on the share of expenditures for beef is negative. That is to say, the share of expenditures for beef has increased due to the relatively low retail price of pork. The impact of the retail price of beef on the share of expenditures for chicken is negative. This implies that the share of expenditures for chicken will increase if the retail price of beef decrease holding other things constant (Table 6).

Table 6. Meat Market Share Elasticities under the FMD Event Scenario

	P_1	P_2	P_3
Pork	0.1139	0.3709	-0.4708
(w_1)	(1.17)	(4.45)**	(-4.72)**
Beef	-1.3321	0.7190	-0.0639
(w_2)	(-4.16)**	(2.63)**	(-0.20)
Chicken	0.1468	-0.9299	0.8322
(w_3)	(0.9)	(-6.69)**	(5.00)**

[a] Numbers in parentheses are t-values.

* indicates statistical significance at the 10% level of confidence.

** indicates statistical significance at the 5% level of confidence.

5. Concluding Remarks

During the past few decades, the meat consumption pattern has been changing and consumers tended to consume more chicken and less pork before the outbreak event of FMD. That is to say, the growth rate of chicken expenditures fairly exceeds the growth rate of pork expenditures. Furthermore, that the demand elasticities of pork, beef, and chicken are all price inelastic would explain the positive relationships between the own price and the related share of expenditures. Pork export has been prohibited due to the outbreak of FMD which caused a 4.32 trillion NT dollar loss in export value. The Japanese market for exportation will not be available until FMD is eradicated. If government's policy in the hog industry has shifted to satisfy domestic needs, the impact of the FMD event on domestic meat consumption will be the major factor.

Although pork is still an important and traditional food for domestic consumers, the patterns of meat consumption have been shifting toward more consumption of chicken. Unfortunately, the outbreak of FMD harmed the hog industry. Furthermore, due to the greater awareness of food safety issues for consumers, the control and/or eradication programs of FMD need to be strengthened.

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毛豬口蹄疫爆發對臺灣肉類消費之影響

蔡建雄*

本文探討毛豬口蹄疫爆發對臺灣肉類消費型態之影響。研究中，利用一線型近似理想需求體系模型估測臺灣豬肉、牛肉與雞肉之消費。研究結果顯示口蹄疫爆發導致其爆發後兩個月之豬肉消費急劇地下降。消費者傾向以雞肉替代豬肉。且牛肉價格與牛肉購買支出均顯著地增加，亦顯示出口蹄疫爆發後，牛肉對豬肉的替代效果。

關鍵詞：口蹄疫、線型近似理想需求體系

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