



VERIFICATION OF SEASONAL FLUCTUATION EFFECTS OF FRUITS IN THE INVERSE DEMAND SYSTEM: THE EVIDENCE FROM TAIWAN



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ABSTRACT

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This study is focused on establishing the inverse demand system estimation model of Taiwanese fruits taking into account seasonal fluctuation effects. The settings of the model will be adjusted according to the verification obtained from documentary evidence. The seasonal fluctuation effects lead to an inverse demand function and inverse demand system restrictions. Taiwanese fruits are divided into five categories, such as bananas, pineapples, citrus, melons, and others. The data of volumes and prices were obtained from The Statistics of Food Supply & Utilization in Taiwan from 2006 to 2016. The results show that the scale flexibility and uncompensated own-price flexibility of each fruit category was negative, which were consistent with the theoretical requirement. The signs of uncompensated cross-price flexibility were mixed, which revealed that there existed complementary and substitute relationships between different categories of fruit. The seasonal fluctuation effects of fruits existed in the inverse demand system.

Contribution/ Originality: The paper's primary contribution is finding that Taiwanese fruits taking into account seasonal fluctuation effects. The seasonal fluctuation effects of fruits existed in the inverse demand system. The signs of uncompensated cross-price flexibility were mixed, which revealed that there existed complementary and substitute relationships between different categories of fruit.

1. INTRODUCTION

With rapid economic development comes improved purchasing power and standard of living, causing a subsequent change in the consumption patterns of people. The traditional demand for rice is sliding drastically, whereas demand for vegetables, fruits, and other subsidiary food items has begun to increase significantly. This may be attributed to the growing number of fruits in recent years. In terms of fruits made available for consumption for each person annually, the amount increased from 105.13 kg in 1986 to 121.63kg in 2015, accounting for a 15.69% increase. This clearly shows that fruit consumption plays an important role in food consumption among the people in Taiwan.

Price is assumed as an exogenous variable in consumption theory of classical economics. This means that the price is fixed and consumers can decide on their most suitable consumption pattern based on their income limitation and on known prices. However, with many agricultural products, production is characterized by time lags and product perishability. The quantities depend on previous production decisions, and the quantities available to consumers in the current period cannot be changed. Hence, these two conditions can be balanced through the market price mechanism. Many scholars have conducted research on agricultural product consumption based on the Inverse Demand System. In this particular system, prices are regarded as endogenous variables, whereas quantities are exogenous variables (Anderson, 1980; Chambers and McConnell, 1983; Huang, 1988;1989; Barten and Bettendorf, 1989; Eales and Unnevehr, 1994; Rickersten, 1998; Chiang and Lee, 2000; Robert and Matthew, 2001; Matthew, 2002; Matthew and Richard, 2002; Wong and McLaren, 2005; Grant *et al.*, 2010; Krishnapillai, 2012; Thong, 2012; Asche and Zhang, 2013; Huang, 2015). If the fruits Inverse Demand System of Taiwan can be established with a theoretical basis, and then suited to the reality, the impact of fruit quantities on their prices and the prices of other substitutes may be determined.

The extreme fluctuation of agricultural products market in Taiwan is currently the focus of both the government and the public. This is because the agricultural products market in Taiwan is characterized by time lags and frequent price fluctuations. The quantities of agricultural products produced in Taiwan are characterized by seasonal fluctuations. Thus, the impact of available consumption of farm products in different seasons can be determined based on their prices and the prices of other substitutes. Specifically, this can be done by studying the inverse demand structures and characteristics of agricultural products with their seasonal fluctuations. Previous studies on demand and on the inverse demand system have based their evaluations and analyses using annual data. This study period may be too long because it involves looking at the structural transition of consumption to lower the reliability and practicability of estimated coefficients of each item without considering seasonal differences caused by different periods of agricultural product production. Huang and Hahn (1995) have estimated inverse demand based on seasonal data to prove the seasonal fluctuation effects on meat demand in the US. After adding seasonal dummy variables to the empirical econometric model, their results showed that there were significant differences in intercept terms of different seasons. However, in their paper, the seasonal fluctuation effects were not guided by price flexibility.

The general aim of this study is to establish an inverse demand system in which own and cross-price flexibilities change in different seasons, as led by seasonal fluctuation effects in Constant Flexibility Inverse Demand System, in order to estimate the flexibility of the seasonal fluctuation effects of Taiwan fruits. In turn, this can contribute to the improvement of economic meaning and practicability, as represented by estimated flexibility.

2. MODEL SPECIFICATIONS

The inverse demand function can be indicated using the quantity vector under the original utility level, as shown in Eq. (1) :

$$r_i = r_i(s \cdot q^*) \quad i = 1, 2, \dots, n \quad (1)$$

where, r_i : standardized price of the i -th product; $r_i = \frac{p_i}{m}$, retail price is divided by per capita expenditure.

The inverse demand function property derived from distance function of Anderson (1980) can be used for establishing compensated and uncompensated inverse demand function. The equation is indicated in the price flexibility pattern, the relationship between compensated flexibility and uncompensated flexibility can be obtained, as shown in Eq. (2) .

$$f_{ij}^* = f_{ij} - g_i w_j \tag{2}$$

where f_{ij}^* and f_{ij} separately the compensated and uncompensated price flexibility, respectively; w_j represents expenditure rate of product j ; and g_i represents the scale flexibility of product i . This equation indicates the degree of its impact on the rice of product i when all product quantities are changed with same proportion and under the consumer's budget.

The conditional restriction of uncompensated price flexibility can be deduced, as shown in Eq. (3), (4), (5) and (6)

1. Homogeneity :

$$\sum_{j=1}^n f_{ij} = g_i \tag{3}$$

2. Symmetry :

$$\frac{f_{ij}}{w_j} - g_i = \frac{f_{ji}}{w_i} - g_j \tag{4}$$

3. Negativity :

$$f_{ii} - g_i w_i < 0 \tag{5}$$

4. Scale Adding-up :

$$\sum_{i=1}^n w_i g_i = -1 \tag{6}$$

The above restriction is added into the inverse demand system for the estimation. This ensures that estimated results conform to theory and will also reduce the parameters awaiting estimation, thereby improving the validity of the statistics. Based on the inverse demand theory, this study aims to establish an empirical model by way of the first derivative for inverse demand function. Specifically, the research method of Huang (1991) is introduced. There are several advantages for using this method. First, setting the inverse demand function form in order to avoid the argument caused by setting function is unnecessary. Second, the empirical equation exported from the model is linear, enabling easy estimation. Finally, using the proposed model with the first derivative, problems of multi collinearity among independent variables can be lowered.

This kind of setting method mainly divides the price fluctuation of products into two effects: (1) the scale effect, which is the price fluctuation caused by equal proportional fluctuation of all kinds of products quantities, and (2) the Antonelli substitution effect, which indicates the price fluctuation caused by consuming a substitute for another product in order to keep original utility level unchanged. This can be obtained by making first derivative to Eq. (1) .

$$dr_i = \sum_{j=1}^n \left(\frac{\partial r_i}{\partial q_j^*} \right) dq_j + \left(\frac{\partial r_i}{\partial s} \right) ds \quad i = 1, 2, \dots, n \tag{7}$$

The empirical model in this study applies the inverse demand system with fixed flexibility; thus, Eq. (7) can be changed into compensated flexibility form, as shown in Eq. (8). Equation (8) indicates the inverse demand system of the n-th kind of product.

$$\frac{dr_i}{r_i} = \sum_{j=1}^n f_{ij}^* \left(\frac{dq_j^*}{q_j} \right) + g_i \left(\frac{ds}{s} \right) \quad i = 1, 2, \dots, n \quad (8)$$

where $\frac{dr_i}{r_i}$: ROC of standardized price of the i -th product; f_{ij}^* : the price flexibility of the i -th product as

the j -th product is changed; $\frac{dq_j^*}{q_j}$: ROC of relative quantity of the j -th product; g_i : scale flexibility of the i

th product; $\frac{ds}{s}$: scale ROC; δ_i : intercept term of the i -th product; f_{idj}^* : in the d -th season, the price

flexibility of the i -th product when quantity of the j -th product is changed; and D_d : Seasonal Dummies.

The following restrictive conditions exported from compensated inverse demand theory are added in this study in terms of making empirical estimation. This was done in order to make the meat inverse demand system conform to the theoretical requirements, as well as to coordinate the seasonal characteristics of the empirical model:

1. Homogeneity:

$$\sum_{j=1}^n f_{ij}^* = 0 \quad i = 1, 2, \dots, n \quad (9)$$

2. Homogeneity of seasonal adjustments:

$$\sum_{j=1}^n \sum_{d=1}^{s-1} f_{idj}^* = 0 \quad \begin{matrix} i = 1, 2, \dots, n \\ d = 1, 2, \dots, e-1 \end{matrix} \quad (10)$$

3. Symmetry:

$$\frac{f_{ji}^*}{w_i} = \frac{f_{ij}^*}{w_j} \quad i, j = 1, 2, \dots, n \quad (11)$$

4. Symmetry of Seasonal Adjustments:

$$\frac{f_{jdi}^*}{w_i} = \frac{f_{idj}^*}{w_j} \quad \begin{matrix} i, j = 1, 2, \dots, n \\ d = 1, 2, \dots, e-1 \end{matrix} \quad (12)$$

5. Scale Adding-up:

$$\sum_{i=1}^n w_i g_i = -1 \quad i = 1, 2, \dots, n \quad (13)$$

By virtue of adding restrictions, this study has made an estimation of all items of flexibility factors in Eq. (8) using Iterative Seemingly Unrelated Regression (ISUR). ISUR was utilized to verify whether or not the fruit inverse demand system in Taiwan with seasonal fluctuation effects can improve predictive ability of the model.

Regarding the goodness of fit of the demand system, the root mean square (RMS) percentage errors to sample means of actual observations are calculated to represent the goodness of fit for each demand equation as the following:

$$RMS = \frac{\left[\sum_t \frac{(r_t - r_t^*)^2}{T} \right]^{\frac{1}{2}}}{r^{**}} \times 100 \quad (14)$$

where r_t , r_t^* and r^{**} are respectively, the level of actual, projected and sample mean of normalized prices for a sample period T years.

3. DATA

In this study, fruits in Taiwan were divided into five categories: bananas, pineapples, citrus, melons, and others. Data used in the analysis are from The Statistics of Food Supply & Utilization in Taiwan from 2006 to 2016. The first season was from January to March of each year, with each year divided into four seasons. Overall, the study utilized 44 information sources. The fruits prices are converted to real terms using the consumer price index (CPI) with the base CPI equal to 100 in 2006.

Data processing proved challenging because collecting information on fruit consumption was difficult. In addition, the differences between consumption and supply volume depend on goods in stock. In Taiwan, the agricultural products mainly focus on fresh products, most of which are bought and consumed by consumers. Importers are not inclined to keep imported products in stock because of the added cost. Hence, the trading volume of fruits market in Taiwan was considered as the empirical information in this study.

4. EMPIRICAL RESULTS

Table 1 presents the seasonally adjusted coefficients estimated in first quarter period of each year in comparison with the base period. Compensated price flexibility of all kinds of fruits during four seasons is shown in table 2. The uncompensated price flexibility shown in table 3 can be obtained from table 2 and Eq. (2).

The estimated scale flexibilities in table 1 show the potential response of a fruit price to a proportionate increase in the quantities of all fruits. For example, the scale flexibility for bananas is -0.8427, which indicates that a proportionate increase in the quantities of all fruits by 1% would decrease the price of bananas by 0.8427%. The scale flexibility for pineapples, citrus, melons, and others are -1.9146, -0.6090, -0.0639, and -0.5306, respectively. All estimated scale flexibilities are negative, which conform to the negativity constraints. According to the implications of scale flexibility, the results in pineapples appear to be luxuries, while the bananas, citrus, melons, and others are necessities.

These data obtained after totaling seasonally adjusted coefficients and base period factors, show as table 2. The estimated flexibilities vary across seasons, implying evident seasonality in demand. I notice that the standard errors for pineapples and melons in the fourth quarter are much greater than other seasons. This may be due to very small harvests in October to December. The results in table 3 show that the uncompensated own-price flexibilities for bananas in four seasons are less than -1, indicating flexible demand for fruits. The own-price flexibilities for pineapples, citrus, melons, and others in four seasons are greater than -1, indicating inflexible demand for fruits. In first quarter, the uncompensated own-price flexibilities for bananas, pineapples, citrus, melons, and others are -1.3286, -0.3980, -0.0232, -0.3381, and -0.8850, respectively. These measures indicate that, for a given utility level, a marginal 1% increase in the quantity of bananas, pineapples, citrus, melons, and others would require a price decrease of 1.3286%, 0.3980%, 0.0232%, 0.3381%, and 0.8850%, respectively.

The cross-price flexibilities show relationships between two fruits. The uncompensated cross-price flexibilities in the table 3 reflect substitution if the sign is negative and complementary if the sign is positive. The uncompensated cross-price flexibility between the price of bananas and the quantity of citrus is -0.1596, which implies that the two fruits are substitutes. A marginal 1% increase in the quantity of citrus is associated with a

0.1596% decrease in the price of bananas to induce consumers to purchase the same quantity of bananas instead of substituting citrus in first quarter. On the contrary, the uncompensated cross-price flexibility between the price of pineapples and the quantity of bananas is 0.1629, indicating a complementary relationship between these two fruits in first quarter.

Table-1. Estimates of the adjusted coefficients

price \ quantity		bananas	pineapples	citrus	melons	others
bananas	first quarter (the base period)	-1.2011* (0.1230)	0.2243* (0.0945)	-0.0277 (0.0315)	0.2402* (0.1031)	0.7643* (0.1223)
pineapples		0.2035* (0.0856)	-0.3533* (0.1015)	-0.0372 (0.0290)	0.0244 (0.0697)	0.1627* (0.0736)
citrus		-0.0267 (0.0300)	-0.0083 (0.0064)	-0.0188 (0.0293)	-0.0219 (0.0499)	0.0760 (0.0564)
melons		0.1061* (0.0453)	0.0119 (0.0329)	-0.0010 (0.0221)	-0.2581* (0.0870)	0.1501* (0.0748)
others		0.0795* (0.0119)	0.0187 (0.0124)	0.0081 (0.0070)	0.0354 (0.0264)	-0.1416* (0.0266)
bananas	second quarter	0.3145* (0.1290)	0.176887 (0.1305)	0.1255 (0.2469)	-0.0981 (0.1074)	-0.2180* (0.1247)
pineapples		-0.0890 (0.0976)	-0.1978 (0.1124)	0.0988 (0.2311)	-0.1754 (0.1200)	0.0994 (0.1993)
citrus		0.0456 (0.0320)	0.0657* (0.0341)	-0.0535 (0.1022)	-0.0836* (0.0342)	-0.0464 (0.0256)
melons		-0.1271* (0.0667)	-0.0066 (0.0728)	-0.0896 (0.1123)	0.1172* (0.0435)	0.0768 (0.1123)
others		0.0025 (0.0240)	-0.0012 (0.0212)	0.0025 (0.0195)	0.0083 (0.0071)	-0.0052 (0.0295)
bananas	third quarter	0.1089 (0.2551)	0.0472 (0.0351)	0.0679* (0.0322)	-0.0554 (0.1069)	-0.2878* (0.1525)
pineapples		-0.3599 (0.3158)	-0.0490* (0.0275)	-0.0141 (0.0318)	0.0302 (0.088)	0.2409* (0.0920)
citrus		0.0008 (0.0931)	0.0062 (0.0415)	0.0214 (0.0360)	-0.0896 (0.1074)	-0.0576 (0.0791)
melons		0.0019 (0.0808)	-0.0263 (0.0293)	-0.0010 (0.0281)	0.1331* (0.0743)	0.0260 (0.1312)
others		0.0260* (0.0095)	0.0096 (0.0110)	-0.0041 (0.0137)	-0.0160* (0.0050)	0.0024 (0.0318)
bananas	fourth quarter	-0.0149 (0.1677)	-0.2028 (0.2560)	0.0243 (0.0525)	-0.0120 (0.1644)	0.0239 (0.2108)
pineapples		0.1578 (0.2317)	0.0039 (0.1649)	0.0725 (0.059)	-0.0454 (0.2374)	0.2270 (0.1483)
citrus		-0.0022 (0.0800)	0.2913 (0.1611)	0.0893 (0.3079)	-0.0384 (0.2709)	-0.1489* (0.0358)
melons		0.5262* (0.2501)	0.0498 (0.2234)	0.0101 (0.0607)	-0.5954* (0.2598)	-0.0952 (0.1439)
others		-0.1402* (0.0597)	-0.0224 (0.0350)	-0.0228 (0.0483)	0.1508* (0.0783)	0.0099 (0.0010)
scale flexibility coefficient		-0.8427* (-10.17)	-1.9146* (0.2190)	-0.6090* (0.1996)	-0.0639* (0.1716)	-0.5306* (0.1515)

Notes: An asterisk (*) denotes statistical significance at the 10% level of high. Values in parentheses are standard errors.

Table-2. Seasonal Compensated Flexibilities

price \ quantity		bananas	pineapples	citrus	melons	others
first quarter	bananas	-1.2011	0.2243	-0.0277	0.2402	0.7643
	pineapples	0.2035	-0.3533	-0.0372	0.0244	0.1627
	citrus	-0.0267	-0.0083	-0.0188	-0.0219	0.076
	melons	0.1061	0.0119	-0.001	-0.2581	0.1501
	others	0.0795	0.0187	0.0081	0.0354	-0.1416
second quarter	bananas	-0.8866	0.4012	0.0978	0.1421	0.5463
	pineapples	0.1145	-0.5511	0.0616	-0.1510	0.2621
	citrus	0.0189	0.0574	-0.0723	-0.1055	0.0296
	melons	-0.0210	0.0053	-0.0906	-0.1409	0.2269
	others	0.0820	0.0175	0.0106	0.0437	-0.1468
third quarter	bananas	-1.0922	0.2715	0.0402	0.1848	0.4765
	pineapples	-0.1564	-0.4023	-0.0513	0.0546	0.4036
	citrus	-0.0259	-0.0021	0.0026	-0.1115	0.0184
	melons	0.1080	-0.0144	-0.0020	-0.1250	0.1761
	others	0.1055	0.0283	0.0040	0.0194	-0.1392
fourth quarter	bananas	-1.2160	0.0215	-0.0034	0.2282	0.7882
	pineapples	0.3613	-0.3494	0.0353	-0.0210	0.3897
	citrus	-0.0289	0.2830	0.0705	-0.0603	-0.0729
	melons	0.6323	0.0617	0.0091	-0.8535	0.0549
	others	-0.0607	-0.0037	-0.0147	0.1862	-0.1317

Table-3. Seasonal Uncompensated Flexibilities

price \ quantity		bananas	pineapples	citrus	melons	others
first quarter	bananas	-1.3286	0.0838	-0.1596	-0.0485	-0.4616
	pineapples	0.1629	-0.3980	-0.0792	-0.0674	-0.2272
	citrus	-0.0310	-0.0130	-0.0232	-0.0315	0.0351
	melons	0.0708	-0.0270	-0.0376	-0.3381	-0.1896
	others	0.0022	-0.0665	-0.0719	-0.1397	-0.8850
second quarter	bananas	-1.0141	0.2607	-0.0341	-0.1466	-0.6796
	pineapples	0.0739	-0.5958	0.0196	-0.2428	-0.1278
	citrus	0.0146	0.0527	-0.0767	-0.1151	-0.0113
	melons	-0.0563	-0.0336	-0.1272	-0.2209	-0.1128
	others	0.0047	-0.0677	-0.0694	-0.1314	-0.8902
third quarter	bananas	-1.2197	0.1310	-0.0917	-0.1039	-0.7494
	pineapples	-0.1970	-0.4470	-0.0933	-0.0372	0.0137
	citrus	-0.0302	-0.0068	-0.0018	-0.1211	-0.0225
	melons	0.0727	-0.0533	-0.0386	-0.2050	-0.1636
	others	0.0282	-0.0569	-0.0760	-0.1557	-0.8826
fourth quarter	bananas	-1.3435	-0.1190	-0.1353	-0.0605	-0.4377
	pineapples	0.3207	-0.3941	-0.0067	-0.1128	-0.0002
	citrus	-0.0332	0.2783	0.0661	-0.0699	-0.1138
	melons	0.5970	0.0228	-0.0275	-0.8535	-0.2848
	others	-0.1380	-0.0889	-0.0947	0.0111	-0.8751

In order to verify the seasonal fluctuation effects in inverse demand system, the study was verified by root mean square (RMS). As shown in the Table 4, most of estimated RMS errors are less than 7% for each demand equation. Therefore, the adaptability of the inverse demand system with seasonal fluctuation effects of fruits is excellent.

Table-4. The Simulation Ability

	Bananas	Pineapples	Citrus	Melons	Others
RMS	6.88	4.03	5.81	4.83	6.97

5. CONCLUSION

The study aims to prove the seasonal fluctuation effects of fruits in the inverse demand system in Taiwan. The seasonal fluctuation effect is guided by the constraints of inverse demand function and inverse demand system. These constraints were employed to establish an inverse demand system that varies with different seasonal fluctuations. Based on the inverse demand system with seasonal fluctuation effects, this study has described the scenario wherein the fluctuation degrees of standardized price of the produced fruit quantities are changed. Furthermore, information and results can be provided through seasonal fluctuation effects.

The results show that: the scale flexibilities of five fruits are negative, which conform to the negativity constraints. This implies that the standardized prices of all kinds of fruits will decrease if the total quantities of fruits increase 1%. The uncompensated own-price flexibilities of five fruits in four seasons are negative, which conform to the negativity constraints. The uncompensated cross-price flexibilities of fruits in four seasons are positive or negative, this implies that substitution or complementary relationship between two fruits in four seasons.

This model of fruits inverse demand system with seasonal fluctuation effects has excellent adaptability. Thus, the seasonal fluctuation factor should be considered in estimating inverse demand system of agricultural products. By adding the seasonal fluctuation effects, the predictive ability of the model can be improved. Also, the changed situation of own and cross-price flexibility of fruits in different seasons can be realized. Taken overall, this model provides a helpful means to plan production schemes, make consumption decisions, and establish government policies.

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