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An Engel Curve Analysis of Household Expenditure in Taiwan: 1996-98

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Abstract

Seven systems of Engel curves for expenditures on ten commodity groups were estimated using Taiwanese household expenditure data for the period from 1996 through 1998. Results show that the estimated expenditure elasticities are insensitive to the choice of functional forms.

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Introduction

Since the pioneering work of Engel in 1857, the estimation of Engel curves and total expenditure elasticities has been an important part in family budget studies. An Engel curve describes the relationship between a household's expenditure on a particular good and the total household expenditure; while the total expenditure elasticity of a good measures the percentage change in expenditure of the good of interest relative to a percentage change in total household expenditure.

The traditional approach of estimating the total expenditure elasticities is to select an appropriate functional form for each good, estimate it and use the estimated parameters to obtain the elasticity at any level of total expenditure. Early studies (Allen and Bowley, 1935; Prais and Houthakker, 1955) used the functional specifications that are inconsistent with the adding-up constraint. As a consequence, there is a theoretical bias in the estimates. In recent studies, there has been a considerable amount of emphasis on utility-based approaches that consider the Engel curve as a system of equations. Such a system not only satisfies the adding-up conditions but also predicts non-negative component expenditures, and does not preclude saturation. These models include the Working's model (Working, 1943; Leser, 1963), the addilog model (Houthakker, 1960a, 1960b; Theil, 1965; Bewley, 1982), the almost ideal demand system or AIDS (Deaton and Muellbauer, 1980), and the generalized addilog model (Bewley, 1986).

A third approach is to derive expenditure elasticities from the estimated parameters of the Lorenz curve for total expenditure and concentration curves for individual items of expenditure (Iyengar, 1960; Kakwani, 1977, 1978; Tran-Nam & Podder, 1992; Podder & Tran-Nam, 1994). This approach has been shown to be not only better than the traditional approach in terms of goodness of fit and adding-up criteria but also more flexible in allowing Engel elasticities to vary non-monotonically with income or total expenditure.

Model Specifications

Numerous functional forms have been suggested and used as the basis for estimating Engel curves. This study attempts to estimate expenditure elasticities based upon the last two approaches discussed in the introduction, and then a comparison of derived corresponding expenditure elasticity estimates from different models can be made. We wish the estimated expenditure elasticities for Taiwan's data could be used to facilitate policy decision-making processes.

In general terms, for *m* households with similar characteristics and facing the same price for *n* consumer goods, the empirical Engel curves are

(1) $$x_{ij} = f_i(x_j), \qquad i = 1, 2, \ldots, n; \text{ and } j = 1, 2, \ldots, m.$$

where x_{ij} is the expenditure by household *j* on the *i*th good, x_j is the total expenditure by the *j*th household. If the *n* consumer goods are mutually exclusive and exhaustive, then the adding-up condition implies

(2) $$x_j = \Sigma_i\, x_{ij}, \qquad j = 1, 2, \ldots, m.$$

The set of Engel curves may be obtained from the linear expenditure system (Stone, 1954) or the Rotterdam model (Theil, 1965) is

(3) $$x_{ij} = \alpha_i + \beta_i x_j + \varepsilon_{ij},$$

where α_i and β_i are parameters to be estimated, and ε_{ij} is the disturbance term. Adding-up is assumed by imposing the restrictions $\Sigma_i\alpha_i = 0$ and $\Sigma_i\beta_i = 1$. The total expenditure elasticity for the *i*th good's expenditure is $\eta_{ij} = \beta_i/w_{ij}$, and $w_{ij} = x_{ij}/x_j$, the *j*th household's average budget share for the *i*th good.

Multiplying equation (3) by $(1/x_j)$, a set of Engel curves can also be derived:

(4) $$w_{ij} = \alpha_i + \beta_i/x_j + \varepsilon_{ij},$$

note that the parameters and disturbance terms are redefined. Adding-up is assured if $\Sigma_i\alpha_i = 1$ and $\Sigma_i\beta_i = 0$. In (4), the total expenditure elasticity is $\eta_{ij} = \alpha_i/w_{ij}$.

Moreover, a set of Engel curves can be derived from the Almost Ideal Demand System (Deaton and Muellbauer, 1980) or sometimes called the Working model (Working, 1943; Leser, 1963) as

(5) $$w_{ij} = \alpha_i + \beta_i \ln x_j + \varepsilon_{ij}.$$

The adding-up restrictions are $\Sigma_i\alpha_i = 1$ and $\Sigma_i\beta_i = 0$; and $\eta_{ij} = [\alpha_i + \beta_i(1 + \ln x_j)]/w_{ij}$.

The specification "generalized addilog demand system" proposed by Bewley (1982) is derived from (5) and has the advantages of allowing for saturation levels as well as ensuring adding-up and non-negativity:

(6) $$\ln(w_{ij}/w_j^*) = \alpha_i + \beta_i \ln x_j + \varepsilon_{ij},$$

where $ln w_j^* = \Sigma_i \, ln w_{ij}/n$, the adding-up restrictions are $\Sigma_i\alpha_i = \Sigma_i\beta_i = 0$, and $\eta_{ij} = (\beta_i + 1) - \Sigma_i w_{ij}/\beta_i$. In addition, there are two variants of the Addilog model (Bewley, 1982), they are

(7) $$ln(w_{ij}/w_j^*) = \alpha_i + \beta_i x_j + \varepsilon_{ij}; \text{ and}$$

(8) $$ln(w_{ij}/w_j^*) = \alpha_i + \beta_i/x_j + \varepsilon_{ij};$$

the adding-up restrictions are similar to (6), and the total expenditure elasticities are $\eta_{ij} = 1 + x_j(\beta_i - \Sigma_i \, \beta_i w_{ij})$ and $\eta_{ij} = 1 - (\beta_i - \Sigma_i\beta_i w_{ij})/x_j$, respectively, for (7) and (8).

An alternative to the direct estimation approach is to derive expenditure elasticities from concentration curves (Iyengar, 1960; Kakwani, 1977, 1978; Podder and Tran-Nam, 1994; Tran-Nam and Podder, 1992). In this approach, it is assumed that the per capita household expenditure, *X*, is a continuous, non-negative random number. Let *f(X)* be the probability density function of *X*, then one can define the following variables:

$p = F(x) = \int_0^x f(X)dX$ is the proportion of households having per capita total expenditure up to *x*;

$q = (1/\mu)\int_0^x Xf(X)dX$ is cumulative proportion of *X* of those households, where μ (=E(*X*)) is the mean value of *X*;

$q = L(p)$ represents the Lorenz function of *X*. The Lorenz curve relates the proportion of total expenditure to the proportion of persons spending up to a given level of per capita total expenditure.

Let X_i (=$g_i(X)$) denote per capita household expenditure on the *i*th good and $\Sigma_i X_i$ = X. Then $q_i = (1/\mu_i)\int_0^x g_i(X) f(X)dX$ represents the cumulative proportion of X_i by those households with per capita total expenditure up to x, where μ_i (= $E(X_i)$) is the mean value of X_i; and $q_i = C_i(p)$ represents the concentration function of X_i. That is, the concentration curve relates the proportion of total consumption of a specific good to the proportion of persons spending up to a given level of per capita total expenditure.

The first and second-order derivatives of the Lorenz and concentration functions are

(9) $L'(p) = \partial L(p)/\partial p = x/\mu$,

(10) $C_i(p) = \partial C_i(p)/\partial p = g_i(x)/\mu_i$,

(11) $L''(p) = \partial^2 L(p)/\partial p \partial p = 1/[\mu_i f(x)]$,

(12) $C_i''(p) = \partial^2 C_i / \partial p \partial p = (\partial g_i / \partial x)/[\mu_i f(x)]$.

Using (10) one can represent the Engel function of the *i*th good as

(13) $g_i(x) = \mu_i C_i'(p)$.

Therefore, (13) is the implicit form of the Engel function expressed in terms of the concentration function of the *i*th good. The following functional forms (Tran-Nam and Podder, 1992) was used to estimate the respective individual commodity concentration curves and Lorenz curve in the current study:

(14) $C_i(p) = p^{\alpha_i} e^{\beta_i(p-1)} e^{u_i}$; and $L(p) = p^{\alpha} e^{\beta(p-1)} e^{u}$,

where u_i and u are the disturbance terms. In general, the above functional form (10) satisfies $C_i(0) = 0$, $C_i(1) = 1$, and $C_i(p) > 0$. With these particular functional forms in (14), the total expenditure elasticity of the *i*th commodity can be expressed as

$$(15) \qquad \eta_i(x) = \frac{[(\alpha_i + \beta_i p)^2 - \alpha_i](\alpha + \beta \ p)}{(\alpha_i + \beta_i p)[(\alpha + \beta \ p)^2 - \alpha]} .$$

Note that by the construction of the model (14), adding-up condition may not be satisfied under the concentration curve approach.

Data and Results

The above model specification (14) and six other models (3)-(8) by Stone (1954), Working (1943), Houthakker (1960), and Bewley (1986) were estimated using Taiwanese household expenditure survey data for the period from 1996 through 1998 (Executive Yuan, ROC). The survey involved 1,920 households over the study period. These households kept records of their expenditures and incomes for the entire year. The daily expenditures were compiled into annual expenditures and the expenditures of ten commodity groups were calculated in this study. These commodity groups are food, clothing, housing and rent, fuel and utilities, furniture and equipment, housekeeping, health and medicines, transportation and communication, education and recreation, and miscellaneous. Among the 1,920 households, 11 households had zero expenditure on one or more of these ten commodity groups. Therefore, the expenditure information for these 11 households was not included in the analysis (Wales and Woodland, 1983; Bewley, 1986).

Table 1 shows the sample's average expenditure shares and the average household annual expenditures. As shown in Table 1, with the average annual per household total expenditure of NT$218,589, housing expenditure accounted for 26% of total expenditure and is the highest among the ten commodity groups studied. Food expenditure ranked the second and accounted for 23% of total expenditure, which is followed by education, 15%; health and medicine and transportation, 8% each, and clothing, 5%. Fuel and furniture accounted for 3%, individually. Housekeeping expenditure accounted for only 2% of total expenditure.

Since household composition information was not available, per capita total expenditure and expenditures for the ten commodity groups were used in the estimation. The ordinary least squares method was used to estimate the parameters in (3) through (8) and (14). All parameter estimates are statistically different from zero at $\alpha = 0.01$ level. Table 2 shows the estimated expenditure elasticities calculated at sample means.

Generally, the estimated expenditure elasticities are insensitive to the choice of functional form. For example, regardless to the functional form used, the expenditure elasticities for food, housing and rent, fuel and utilities, and health and medicines are less than unity, while the expenditure elasticities for the rest commodity groups are greater than unity. The broad conclusion from Table 2 are that “food”, “housing”, “fuel and utilities”, and “health and medicine” emerge as necessities; “clothing”, “transportation”, “education and recreation”, “furniture”, and “housekeeping” emerge as luxury expenditure groups.

It is interesting to compare our estimated expenditure elasticities in Table 2 with those obtained by previous studies in other countries. A comparison is made for four expenditure groups in Table 3. Although it should be stressed that with the different time periods and countries (an Engel curve is usually deduced from a complete demand system by aggregating the (fixed) price effects into the constant terms, however, the prices are not constant across different time periods and countries), estimation methods, and types of data involved, there are limits to how much may be drawn from such a comparison. In addition, it should be noted that the estimates reported by Lluch and Powell (1975) and by Deaton and Muellbauer (1980) are based on complete demand systems, using time-series data rather than on Engel curves.

In general, our elasticity estimates are of magnitudes similar to those estimated from Deaton and Muellbauer (1980) using the AIDS on UK data, i.e., “food” and “housing” are necessities, while “clothing” and “transportation” are luxuries. Our estimates are also similar to those obtained by Giles and Hampton (1985) using New Zealand data; those estimated by Bewley (1982) using the Addilog model on Australian data; and the ones obtained by Lluch and Powell (1975) using the US data. However, in these three previous studies, ‘housing” was found to have close to unity expenditure elasticities while the current study found “housing” to be a necessity.

Concluding Remarks

In this study we have attempted to analyze some aspects of household expenditure behavior in Taiwan by estimating Engel curves on the basis of the 1996-98 household expenditure survey conducted by the Executive Yuan of the Taiwanese government. In this study, we find that seven functional specifications each lead to very similar estimates of the expenditure elasticities for any given commodity group, at least at the sample mean.

In general, our estimated Engel curves appear to be quite well specified and the expenditure elasticities generally accord well with our prior expectations and with the results of similar studies for other countries. Expenditures on food, housing, fuel, and health emerge as necessities, while clothing, furniture, housekeeping, education and recreation, and transportation are luxury expenditure items.

Our work has been limited by the absence of detailed household composition and income information. Given the required survey data, an allowance for differences in household composition would be an obvious and interesting extension of this current work.

Table 1. Sample statistics

Variable	Mean	Maximum	Minimum
		Expenditure Share	
Food	0.2280	0.6818	0.0305
Clothing	0.0529	0.2923	0.0003
Housing	0.2642	0.7315	0.0552
Fuel	0.0303	0.1602	0.0057
Furniture	0.0302	0.3237	0.0005
Housekeeping	0.0221	0.3058	0.0007
Health	0.0763	0.4173	0.0003
Transportation	0.0759	0.5827	0.0061
Education	0.1500	0.5218	0.0001
Miscellaneous	0.0702	0.5268	0.0038
		Total Expenditures	
NT$/household	218,589	2,388,633	48,123

Table 2. Total expenditure elasticity estimates

	Total Expenditure Elasticity Estimates						
	(3) β_i/w_i	(4) α_i/w_i	(5) $[\alpha_i+\beta_i(1+\mathit{ln}x)]/w_i$	(6) $(\beta_i+1)-\Sigma_i\beta_i w_i$	(7) $1-(\beta_i-\Sigma_i\beta_i w_i)/x$	(8) $1+x(\beta_i-\Sigma_i\beta_i w_i)$	Concentration curve
Food	0.4215	0.6371	0.5825	0.5853	0.6571	0.6752	0.5815
Clothing	1.2002	1.3331	1.3737	1.4196	1.2107	1.1642	1.3227
Housing	0.8606	0.7885	0.7560	0.7544	0.7645	0.8089	0.7189
Fuel	0.3495	0.4420	0.3964	0.4246	0.4338	0.5025	0.4773
Furniture	2.5978	1.4673	1.5957	1.5401	1.2930	1.2972	1.6214
Housekeeping	3.2101	1.6973	1.8452	1.5614	1.2874	1.3399	1.9267
Health	0.6793	0.9097	0.8801	0.8779	0.8065	0.8068	0.8370
Transportation	1.5719	1.4249	1.5501	1.3903	1.1541	1.1660	1.5572
Education	1.2514	1.3598	1.3755	1.5049	1.2963	1.1771	1.1918
Miscellaneous	1.3436	1.4140	1.4642	1.4265	1.2081	1.1744	1.4927

Table 3. Comparison of estimated total expenditure elasticities

	Country				
	Taiwan	New Zealand[a]	Australia[b]	United Kingdom[c]	United States[d]
Food					
Linear (3)	0.42	0.73			0.32
Linear (4)	0.64	0.83			
W-L (5)	0.58	0.77		0.21	
Log-linear			0.42		
Addilog (6)	0.59	0.76			
Addilog (7)	0.66				
Addilog (8)	0.68				
(13)	0.58				
Clothing					
Linear (3)	1.20	1.16			1.12
Linear (4)	1.33	1.09			
W-L (5)	1.37	1.12		2.00	
Log-Linear			0.91		
Addilog (6)	1.42	1.11			
Addilog (7)	1.21				
Addilog (8)	1.16				
Conc. (13)	1.32				
Housing					
Linear (3)	0.86	1.05			1.02
Linear (4)	0.79	1.18			
W-L (5)	0.76	1.11		0.30	
Log-linear			1.16		
Addilog (6)	0.75	1.11			
Addilog (7)	0.76				
Addilog (8)	0.81				
Conc. (13)	0.72				
Transportation					
Linear (3)	1.57	1.29			1.37
Linear (4)	1.42	1.23			
W-L (5)	1.55	1.23		1.23	
Log-linear			1.22		
Addilog (6)	1.39	1.23			
Addilog (7)	1.15				
Addilog (8)	1.17				
Conc. (13)	1.56				

[a]Refers to Giles and Hampton (data period covers 1981-82)
[b]Refers to Bewley (1982, data period covers 1966-68)
[c]Refers to Deaton and Muellbauer (data period covers 1954-74)
[d]Refers to Lluch and Powell (data period covers 1955-68)

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