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Household Budget Analysis for Pakistan under Varying the Parameter Approach

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ABSTRACT

Using micro-level household data for rural and urban Pakistan, this study estimates Engel equations for 22 commodity groups with quadratic spline specification, in which the number and locations of knots are determined through a search procedure. The study finds that the resulting flexibility produces many interesting patterns of changes in the classification of goods into necessities and luxuries across income ranges. This suggests that a uniform tax structure will have varying implications for budget allocation and welfare of households belonging to different income classes. This information can be gainfully utilised in preparing income transfer policies that could supplement uniform tax regimes.

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1. INTRODUCTION

The relationship between total expenditure and the expenditure devoted to purchase of a specific consumer good, called the Engel curve [following Engel (1857)], is considered as the starting point for the analysis of household budgets. Assuming that all the prices are constant, Engel curves are derived from utility maximisation. Since at a point in time consumers face the same set of prices, the differences in consumption pattern across households can be mainly attributed to differences in incomes or expenditures. In empirical analysis of consumer behaviour Engel curves have been used widely. Brown and Deaton (1972) and Blundell (1988) have provided international literature survey. In Pakistan a number of studies have analysed various aspects of household budget allocation behaviour.[1]

Although more recent studies tend to employ relatively flexible functional form for Engel equations, mostly derived on the basis of duality theory, yet the flexibility still remains confined to a turn or two in curvature. Almost all the well-known functional forms of Engel equations are characterised by few parameters and as such cannot pick up all type of changes in behaviour on the shape of Engel equations. Fortunately with a large number of observations available in survey data it is possible to carry out piece-wise estimation using dummy variables for shifts in the Engel curves. However, with this procedure, the Engel curves would become discontinuous at the points of shifts. If the shifts in Engel curves have to be smooth from one range of income to another, appropriate restrictions on parameters would need to be imposed. The use of shift dummies along with smoothing restriction results in the functions that are called Spline functions.[2] If Engel equations contain enough parameters, additional smoothing can also be obtained. Flexibility in the shape of Engel curves is the crucial benefit of Spline Engel equations that relegates the problem of the choice of functional form as a minor problem.

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[1]See for example, Bussink (1970), Khan (1970), Ali (1985), Malik (1982), Siddiqui (1982), Cheema and Malik (1984, 1985), Ahmad and Ludlow (1987), Malik, *et al*. (1987, 1988, 1993), Alderman (1988), Ahmed and Malik (1989), Arshad (1990), Burney and Akhtar (1990), Burney and Khan (1991), Bouis (1992), Aziz (1997), Burki (1997), Chaudhary, *et al*. (1999) and Shamim (1999).

[2]Poirier (1976) defines Spline functions as "In a simplest sense a Spline function is a piece-wise function in which the pieces are joined together in a suitably smooth fashion".

Spline functions have been used in economic modeling, e.g., to analyse the money demand elasticity [Barth, Kraft and Kraft (1976)] and to study the impact of money supply and inflation on interest rate [Suits (1973)]. Karunakaran and Ahmad (1996), and Ahmed and Karunakaran (1997) estimated Spline functions to analyse household budget data in Australia. Shamim and Ahmad (2007) performed similar analysis for Pakistan.

This study proposes a fairly comprehensive procedure for estimating Spline Engel equations. The Spline functions are derived for the *Quadratic Expenditure System* and an algorithm is proposed to select the number and position of the points of shifts, known as knots. The empirical analysis is carried out separately for rural and urban micro level household data of HIES (*Household Integrated Economic Survey*) data for the years 2000-01 compiled by *Federal Bureau of Statistics*, Government of Pakistan, Islamabad. The study analyses the pattern of consumption for 22 groups of commodities consisting of 12 food categories and 10 non-food categories.

2. SPLINE ENGEL EQUATIONS

Our analysis is based on QES (*Quadratic Expenditure System*) of Pollak and Wales (1979). This system does not involve mathematical complications associated with more flexible functional forms. In the present context flexibility is mainly achieved through Spline specification of a simple (quadratic) functional form, rather than from complex functional form. Denoting the expenditure on consumption category i and total consumption expenditure by E_i and TE respectively and the random error term in Engel equation of category i by U_i, the Engel equations under the QES can be written as

$$E_i = \alpha_i + \beta_i TE + \gamma_i TE^2 + U_i \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (1)$$

The QES is an extension of LES (*Linear Expenditure System*) and is based on the presumption that household consumption decision is made in two stages. In the first stage a household spends income on purchasing a subsistence amount of each commodity. The remaining income is then spent on buying the commodities in a variable proportion to yield supernumerary expenditures.

Like other well-known forms of Engel equations parameters of the above system are independent of the level of total expenditure. On the basis of Australian household expenditures data Ahmad and Karunakaran (1997) point out that the assumption of fixed parameters is not necessarily justifiable because changes in control variables may induce structural changes in the relationship under consideration. Spline functions can capture these changes. In order to derive Spline functions from the QES, we introduce structural shifts in the relationships at certain point, the number and location of which will be determined later. Thus consider the following shift dummies at m arbitrary shift points, known as knots, denoted by TE_i, where $i = 1,\ldots m$.

$D_i = 1$ for $TE \geq TE_i$ and $= 0$ otherwise. … … … (2)

Now the parameters of Equation (1) can be varied across knots as

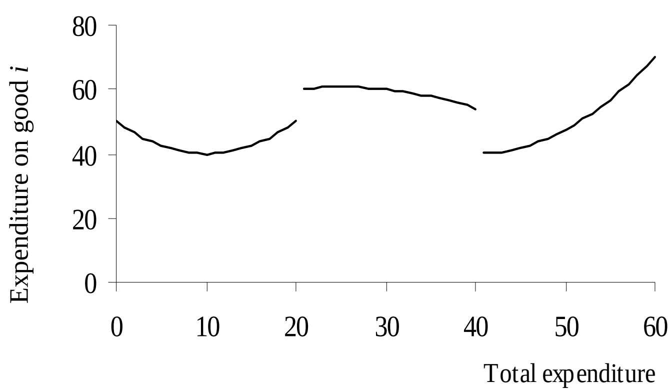
$$\alpha_i = \alpha_{i0} + \sum_{k=1}^{m} \alpha_{ik} D_k \ , \ \beta_i = \beta_{i0} + \sum_{k=1}^{m} \beta_{ik} D_k \ , \ \gamma_i = \gamma_{i0} + \sum_{k=1}^{m} \gamma_{ik} D_k \quad \ldots \quad (3)$$

Substitute the relationships in (3) into Equation (1) yields the following piece-wise equation.

$$E_i = \left(\alpha_{i0} + \sum_{k=1}^{m} \alpha_{ik} D_k \right) + \left(\beta_{i0} + \sum_{k=1}^{m} \beta_{ik} D_k \right) TE + \left(\gamma_{i0} + \sum_{k=1}^{m} \gamma_{ik} D_k \right) TE^2 + U_i \quad (4)$$

An example of this Engel equation with two knots is shown in Figure 1, which indicates that shifts in the function take place discretely and thus the function and its slop are discontinuous at knots.

Fig. 1. Piece-wise Engel Equation with Discontinuous Level and Discontinuous Slope



To make the function continuous we need to impose continuity conditions:

$$\underset{TE \to TE_k^-}{Limit} (E_k) = \underset{TE \to TE_k^+}{Limit} (E_k) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Imposing these limit conditions on the piece-wise Equation (4) will require after canceling out common terms from both sides of the equation that for all k.

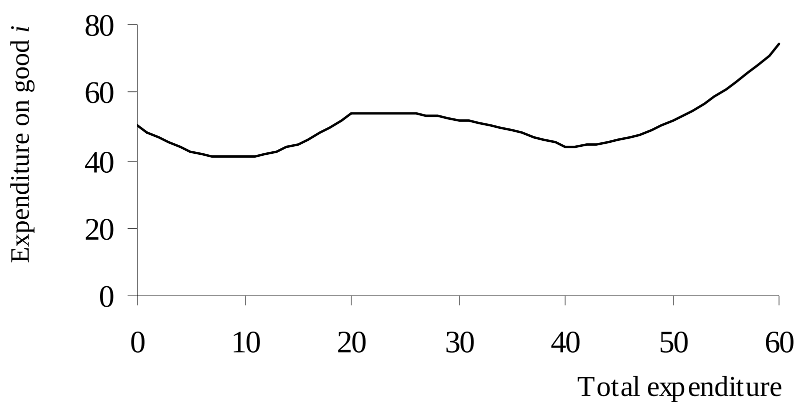
$$\alpha_{ik} = -\beta_{ik} TE_k - \gamma_{ik} TE_k^{\,2}, \quad k = 1, \ldots, m \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

Imposing the above restrictions on Equation (4) yields

$$E_i = \left[\alpha_{i0} + \sum_{k=1}^{m}\left(-\beta_{ik}TE_k - \gamma_{ik}TE_k{}^2\right)D_k\right] + \left(\beta_{i0} + \sum_{k=1}^{m}\beta_{ik}D_k\right)TE + \left(\gamma_{i0} + \sum_{k=1}^{m}\gamma_{ik}D_k\right)TE^2 + U_i = \alpha_{i0} + \beta_{i0}TE + \gamma_{i0}TE^2 + \sum_{k=1}^{m}\beta_{ik}\left(TE - TE_k\right)D_k + \sum_{k=1}^{m}\gamma_{ik}\left(TE^2 - TE_k{}^2\right)D_k + U_i \quad \ldots \quad (7)$$

The above equation shows that we still have two parameters associated with each knot at which the structural change takes place. The following graphic representation of this equation shows that function is continuous but its slope is discontinuous at knots.

Fig. 2. Engel Equation with Continuous Level but Discontinuous Slope



For many economic applications such as computation of income elasticities, continuity of slope is also required. For this purpose first of all we derive expression for slope of the function in (7).

$$\frac{\partial E_i}{\partial TE} = \beta_{i0} + 2\gamma_{i0}TE + \sum_{k=1}^{m}\beta_{ik}D_k + \sum_{k=1}^{m}2\gamma_{ik}TE\,D_k \quad \ldots \quad \ldots \quad (8)$$

Now continuity of the slopes at various knots requires:

$$\underset{TE \to TE_k^-}{Limit}\left(\frac{\partial Ei}{\partial TE}\right) = \underset{TE \to TE_k^+}{Limit}\left(\frac{\partial Ei}{\partial TE}\right) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (9)$$

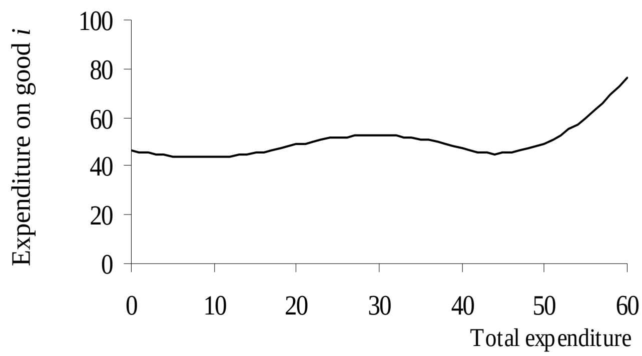
Evaluating slopes from Equation (8), substituting in (9) and simplifying yields:

$$\beta_{ik} = -2\gamma_{ik} TE_k, \quad k = 1,...,m \quad \dots \quad \dots \quad \dots \quad \dots \quad \dots \quad (10)$$

Now substituting these restrictions into (7) produces the following Spline function, which is not only continuous but also has continuous slope at each point including the knots as shown in Figure 3.

$$E_i = \alpha_{i0} + \beta_{i0} TE + \gamma_{i0} TE^2 + \sum_{k=1}^{m} \gamma_{ik} \left(TE - TE_k\right)^2 D_k + U_i \quad \dots \quad (11)$$

Fig. 3. Piece-wise Engel Equation with Continuous Level and Continuous Slope



3. DATA AND ESTIMATION PROCEDURE

The study is based on micro level household budget data from *Household Integrated Economic Survey (HIES) 2000-01*, compiled by the Federal Bureau of Statistics, Islamabad. The survey includes a nationwide sample of 14536 households with 9090 households from rural sector and the remaining 5446 from the urban sector. Following the established practice, the analysis is conducted separately for rural and urban sectors. Total expenditure is divided into 22 broad commodity groups consisting of 12 food and 10 non-food groups. To control for demographic differences across households, the household members are divided into seven categories with respect to age and sex as shown in the Table 1. The numbers of household members belonging to various categories are included directly into the Spline functions as additional variables.

Table 1

Households' Demographic Categories

Variable Name	Age Limit (Years)	Notation
Number of Babies	Age < 2	BAB
Number of Toddlers	2 ≤ Age ≤ 5	TOD
Number of Female Children	5 ≤ Age ≤ 15	FCH
Number of Male Children	5 ≤ Age ≤ 15	MCH
Number of Female Adults	15 ≤ Age ≤ 60	FAD
Number of Male Adults	15 ≤ Age ≤ 60	MAD
Number of Elderly	Aged > 60	ELD

Following the usual practice of estimating Engel equations in expenditure share form to avoid heteroscedasticity, we divide both sides of Equation (11) by total expenditure, which after including the demographic variables becomes:

$$\begin{aligned} E_i / TE_i &= \alpha_{i0} TE^{-1} + \beta_{i0} + \gamma_{i0} TE + \sum_{k=1}^{m} \gamma_{ik} \left[(TE - TE_k)^2 / TE \right] D_k \\ &+ \phi_{i1} BAB + \phi_{i2} TOD + \phi_{i3} FCH + \phi_{i4} MCH + \phi_{i5} FAD \\ &+ \phi_{i6} MAD + \phi_{i7} ELD + V_i \end{aligned} \quad \ldots \quad (12)$$

An important issue that needs to be settled is the determination of the number of knots and their locations. The exact location of the knots is not very important because the general shape of the Spline function remains quite flexible and it adjusts in the light of the location. However, the number of knots chosen can matter in determining the shapes of the Engel curves obtained. The earlier studies [e.g. Ahmad and Karunakaran (1997) and Karunakaran and Ahmad (1996)] chose arbitrary number of knots and base the location of the knots on qualitative assessment e.g. poverty line, average per capita income, etc. One of the reasons for bypassing the issue was the huge amount of computation required. However, significant improvements in computation facilities in recent years have made it possible to apply detailed algorithm. We shall use the following procedure for the determination of the number of knots and their location.

First note that due to adding-up property of Engel equation, the shift in the Engel equation for one commodity must imply shift in the Engel equation for at least one other commodity. Furthermore our interest is on the shift in allocation behaviour rather than shifts in consumption of individual commodity groups. Therefore the location of various knots for all the Engel equations must be the same. Assuming that the data are sorted in ascending order with respect to total expenditure, and the number of sample points is *n*, the algorithm for the choice of number and location of knots is based on the following steps.

Step 1

Estimate n–2 systems, allowing a single shift alternatively at the observations 2 to n–1.[3] Choose the system with the maximum value of log-likelihood. If the shift at the chosen point is statistically insignificant then there is no shift in the system and algorithm ends. If the shift is significant the search yields one knot. Suppose the knot chosen at step 1 take place at the observation n_1.

Step 2

Repeat the step 1 to search for a knot from observations 2 to n_1–1 and another one from n_1+1 to n–1. Suppose the likelihood function attains maximum value with the shifts at the observations n_a and n_b, where $n_a < n_1 < n_b$. If both the shifts are insignificant, the algorithm ends and there is only one knot at the observation n_1. If the shift at n_a (n_b) is insignificant and the one at n_b (n_a) is significant then there is no knot in the range of observations from 1 to n_1 (n_1 to n) while the point n_b (n_a) represents a knot and the search continues over the ranges of observations n_1 to n_b and n_b to n (1 to n_a and n_a to n_1). In case both the shift at n_a and n_b are significant, both are considered at the knots and the search is continued in the ranges 1 to n_a, n_a to n_1, n_1 to n_b and n_b to n.

The above procedure is continued till no more knots are obtained. In this procedure locations of the knots are determined sequentially rather than together. In particular, the search of knots at each step assumes that the knots already chosen are at the right location. This introduces some degree of arbitrariness and there is a need for fine-tuning. Thus further search is carried out in the neighbourhood of each knot following the above procedure. If two knots come very close to each other or very close to the beginning or end of the data, attempt is made to choose one knot and more rigorously search is carried out involving the location of more than one knot together in a single sequence.

Since all the equations have common set of explanatory variables, OLS yields unbiased and minimum-variance estimates despite the possibility of contemporaneous correlation. However, as mentioned above, the Engel equations are still estimated together as a system in order to apply the algorithm for the search of knots.

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[3]Since only one parameter (representing curvature) is subject to change, the shift point must leave at least one observation on each side. If there are k parameters that are subject to change the algorithm will start at observation number k+1 and end at the observation number n–k.

4. RESULTS AND DISCUSSION

The parameter estimates of the Spline functions are shown in Table A1 and A2 of the Appendix. These estimates are used to compute estimated expenditures on each of the 22 commodity groups at varying levels of total expenditure but at the sample average of the demographic variables in order to construct Spline Engel curves representing the relationships between total expenditure and expenditures on the individual commodity groups. In order to avoid repetition we shall discuss expenditure pattern on the basis of Spline curves only. However, before analysing the Spline curves it is important to note the following pints.

The points lying below the minimum household expenditure observed in the survey data will just be the extension of our Spline Engel curves and not based on actual data. The projected consumption pattern of household at very low level of total expenditure is likely to differ substantially from the actual pattern, which is not necessarily driven by rational choice. At very low levels of total expenditure households are likely to sustain their livelihood through other means such as charity, gifts, etc. and their consumption behaviour is determined more by non-economic factors than by the budget consideration. Due to these reasons, a contradiction with Engel's law and normal expected consumer behaviour may be found at very low levels of total expenditure/income.

The Spline Engel curves are drawn separately for urban and rural households and are shown in various panels of Figures 4 and 5.

4.1. Spline Engel Curves for Urban Sector

The Spline curves show that with just one exception all the goods are treated as normal goods at all levels of total expenditure. However, the slopes and curvatures of the curves indicate more complex expenditure patterns than would be revealed by even flexible Engel curves systems. By and large Engel's law seems to have been validated, as most of the curves for non-food items get steeper, while most of the curves for food items flatten out as the level of total expenditure increases. At zero total expenditure the estimated expenditures on wheat, housing and health are positive, indicating that the three goods are treated as absolute necessities, with the expenditure on wheat substantially high. On the other hand, at zero total expenditure the estimated expenditures on rice, dairy, edible oil, meat, poultry and fish, sugar, tobacco, tea and drinks, durables and miscellaneous non-food are negative. For the other goods the estimated expenditures at the zero total expenditure are almost equal to zero.

Coming now to the shape of various Spline curves, we observe that the Spline curve of wheat slopes downwards between total expenditures of Rs 13000 and Rs 20000, implying that in this range wheat is treated as an inferior good. At higher levels of total expenditure the expenditure elasticity of wheat again becomes positive, though it remains less than one. This apparently unexpected change of behaviour can be explained by the observation that household expenditure includes expenditure on servants and beggars, which is expected to rise with the increase in income. Apart from this pattern, the Spline curves for wheat, pulses and other cereals and edible oil show similar consumption behaviour. These expenditure categories are treated as necessity items among poor as well as rich households.

In the case of rice, dairy, sugar, fruit and vegetables, tea and drinks, tobacco, fuel and lighting and clothing and footwear the graphs show that the expenditure elasticities are around unity for poor households. This shows a stability in their budget shares when there is a moderate change in overall budget size. In other words, these commodities are considered equally important compared to the consumption of other goods. The curves show a decline in the elasticities of these items, when we consider the range of middle to higher total expenditure levels, but elasticities remain positive. Thus the expenditures on these categories of goods increase with the increase in total expenditure, but at diminishing rates. This pattern is most prominent for sugar. On the other hand, the expenditure on tobacco again starts increasing faster as the total expenditure increases further. This indicates that households switch to more expensive brands of cigarettes as their incomes increase beyond certain benchmarks. The Spline curve for fuel and lighting follows almost the same trend as of tobacco. In this case the expenditure elasticity increases at very high income level because at this level the expenditure on electricity starts increasing faster when the expenditure on household appliances increases faster than total expenditure as is indicated by the Spline curve of durables.

Meat, poultry and fish,—the two expensive sources of protein,—miscellaneous food, entertainment, health, and durables are considered as luxuries by the poor households, because for them the expenditure elasticity is greater than one, while in the case of rich households these items are classified as necessities because the expenditure elasticity in their case is less than one at higher income levels. For entertainment and durables, income elasticities are greater than one for poor and then approach to one in middle-income range. For rich households the elasticities decline below one and in the case of very high income i.e. in the case of very rich households, elasticities again rise to unity. The possible explanation is that as income level increases, the affordability of these items for poor to middle-income households becomes possible. When the income level increases further, households become used to such commodities and consider these items as necessities. Finally, when the income level increases even further, there is a further improvement in the living standards and households seek improved quality of these goods, so these commodities become luxuries for them.

The expenditure on personal care increases with total expenditure almost in a fixed proportion. Thus this consumption category is considered equally important by all the income classes. The graphs of transport, housing, education, and miscellaneous non-food depict that the expenditures on these items increase at an increasing rates with the increase in total expenditure and therefore these are luxuries at every level of total expenditure/income.

4.2. Spline Engel Curves for Rural Sector

The Spline curves for rural households show that each of the 22 consumption categories is considered as normal good at all levels of total expenditure. As in the case of urban sector results, Engel's law is supported for rural sector as well. With an increase in total expenditure, consumption of most of the food categories increases at diminishing rate, while the consumption of most non-food categories increases with increasing rate. When the total expenditure is zero, the estimated expenditures on wheat, tobacco, clothing and footwear and housing are positive, while the expenditures on edible oil, meat, fruit and vegetables, sugar, tea and drinks, miscellaneous food, fuel and lighting and health are negative. Like in urban case the estimated expenditure on wheat at the zero level of total expenditure is quite substantial.

The shapes of various Spline curves show that wheat, rice, pulses and other cereals, edible oil, fruit and vegetables, sugar, tea and drink, tobacco, fuel and lighting and clothing and footwear are necessity items for poor as well as rich households, though in case of rice, sugar, tea and drink, fuel and lighting the expenditure elasticities are greater than one at very low levels of total expenditure.

The consumption categories entertainment, transport and miscellaneous non-food can be classified into luxuries for rich as well as poor households as the marginal budget shares of these categories remain greater than the average budget shares in the entire range of total expenditure. The expensive sources of protein namely meat and poultry and fish fall into the category of luxuries for poor households, but they turn into necessities for rich households.

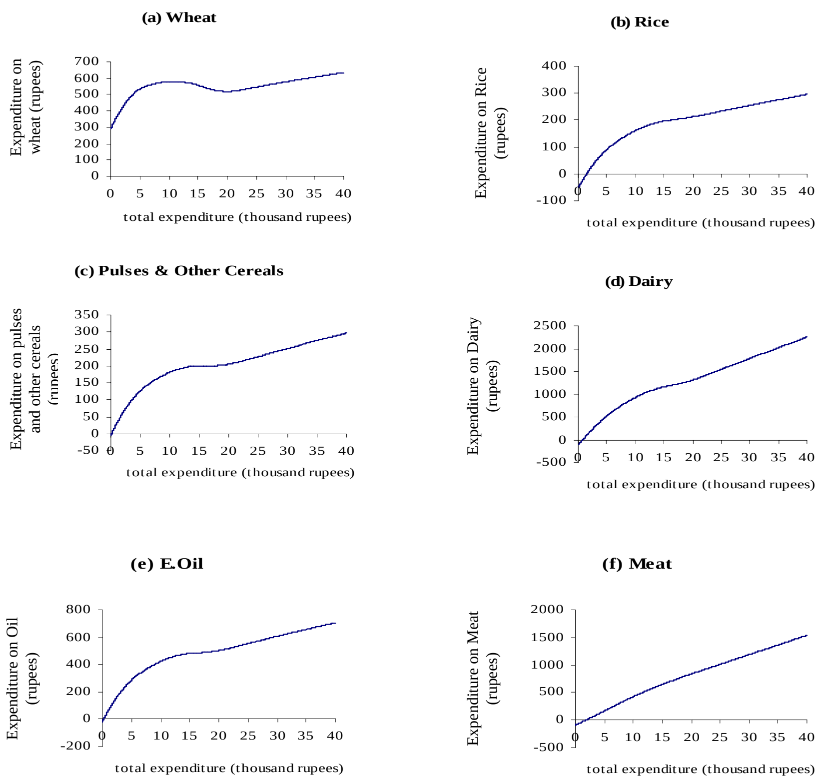
The expenditure on dairy initially increases at a faster rate than the increases in total expenditure, placing this important food item into the category of luxuries among poor households. However, as the total expenditure further rises, the rate of increase in dairy expenditure starts increasing at a somewhat reduced rate, implying that the dairy products are treated as necessities among middle-income households. As the total expenditure increases even further, dairy again turns into a luxury item. This is most likely due to the shift in the composition of goods within the dairy basket. Although upper-middle income and rich households can afford to consume expensive dairy products like imported cheese, they are still constrained to regard these products as luxury.

The above pattern is more prominently observed in case of durables and, especially, education. Poor households regard education as a luxury because of the high opportunity cost of acquiring poor-quality education in terms of lost earnings and the risk of falling below the poverty line. Rich households, on the other hand, regard education as a luxury because of the high explicit cost of good quality education. Only the middle-income households take education as a necessity item because they can afford to forgo small earnings to acquire even poor-quality education that can at least sustain their living standards in the long run.

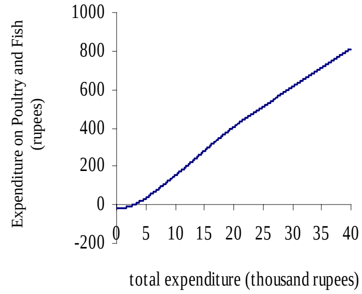
The Spline curves for health and personal care show that the two consumption items have almost unitary expenditure income elasticities, indicating that in response to changes in total expenditure, both these personal level expenditure categories are considered almost as important as the basket of the rest of the goods.

Miscellaneous food is considered luxury among the middle-income households and necessity among poor and rich households. Housing expenditure increases at increasing rate up to a certain level and then grows at almost a constant rate, indicating that housing falls into the category of luxury for poor households but it turns into necessity for the rich households.

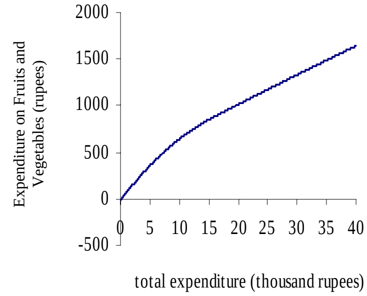
Fig. 4. Spline Curves for Urban Pakistan



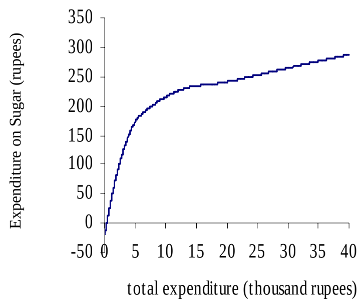
(g) Poultry & Fish



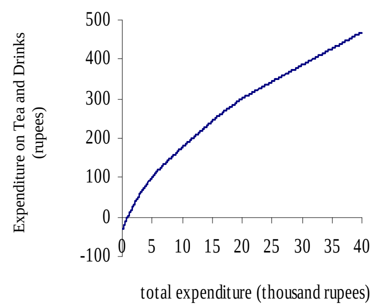
(h) Fruit & Vegetables



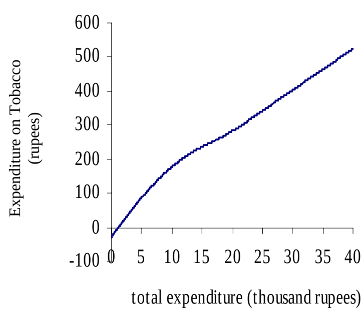
(i) Sugar



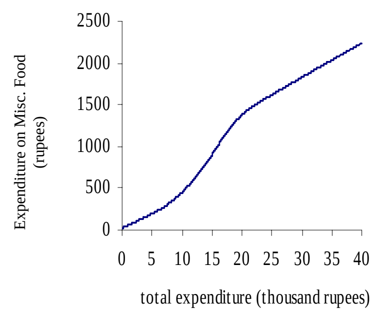
(j) Tea & Drinks



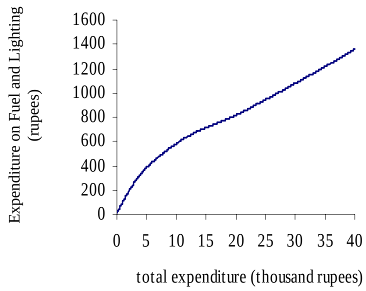
(k) Tobacco



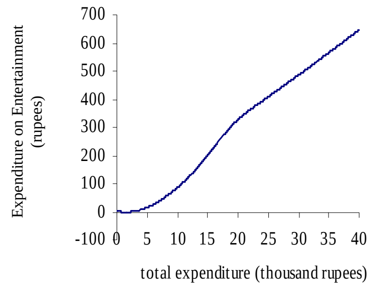
(l) Misc. Food



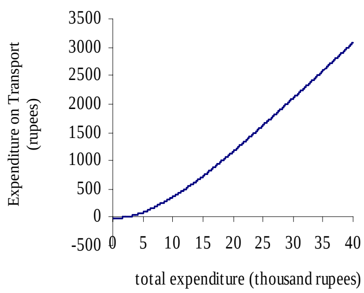
(m) Fuel & Lighting



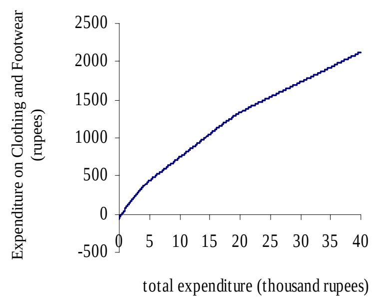
(n) Entertainment



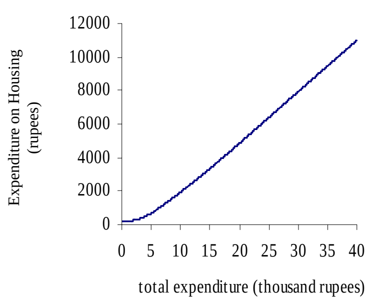
(o) Transport



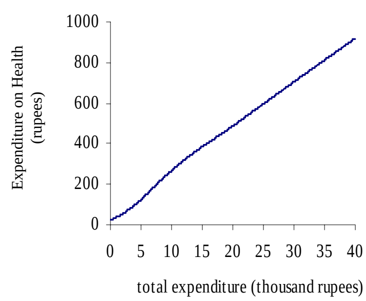
(p) Clothing & Footwear



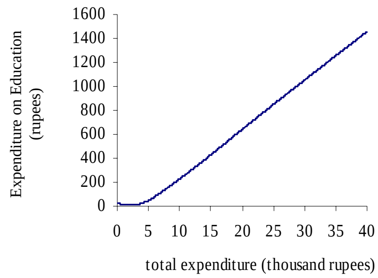
(q) Housing



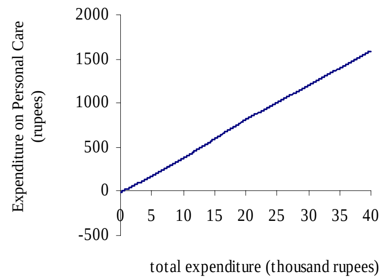
(r) Health



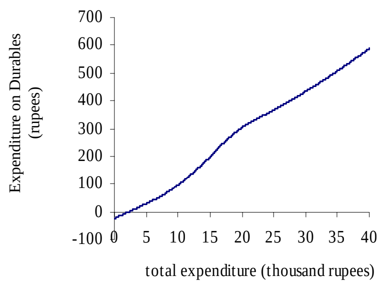
(s) Education



(t) Personal Care



(u) Durables



(v) Misc.Non-food

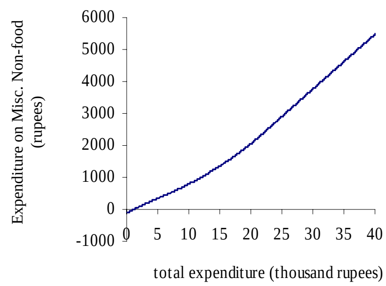
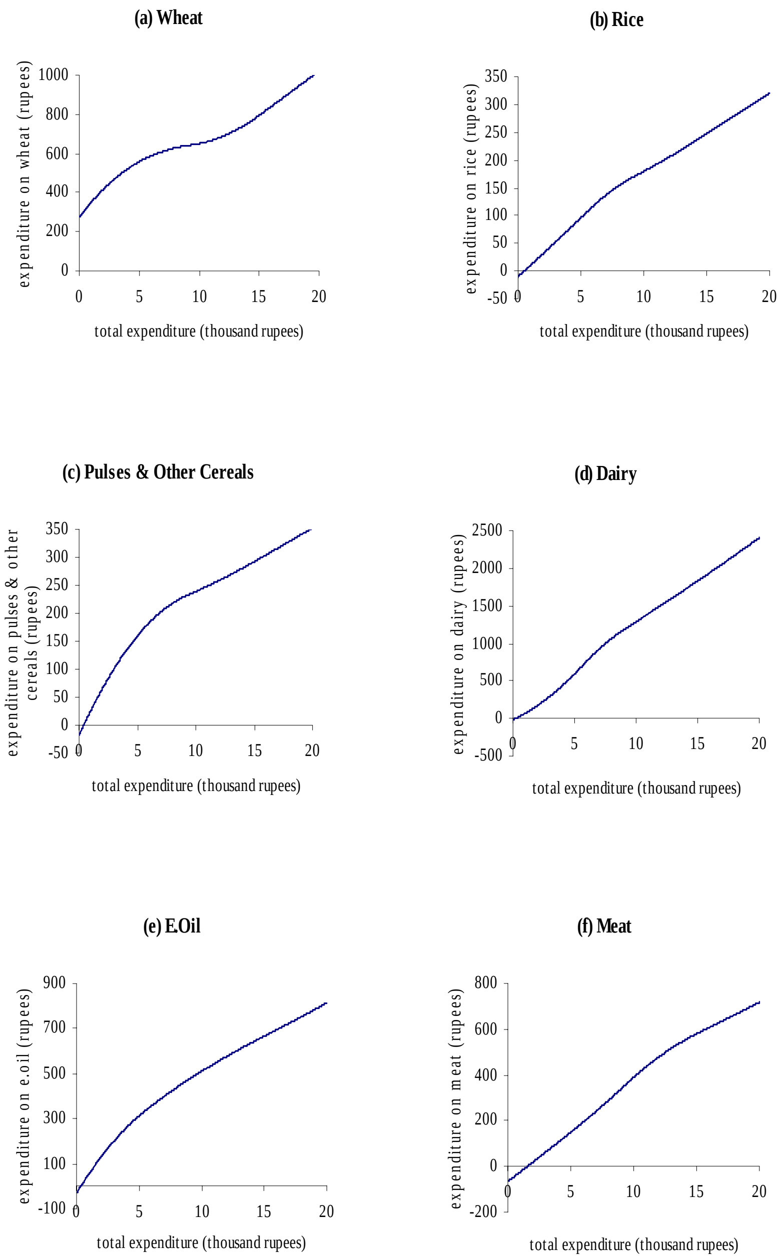
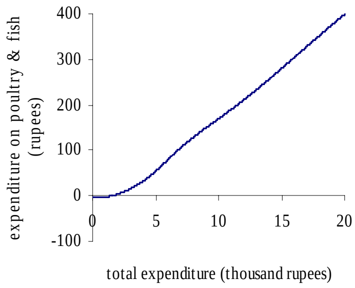


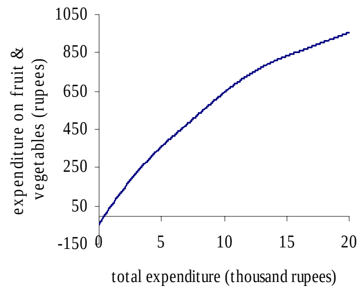
Fig. 5. Spline Curves for Rural Pakistan



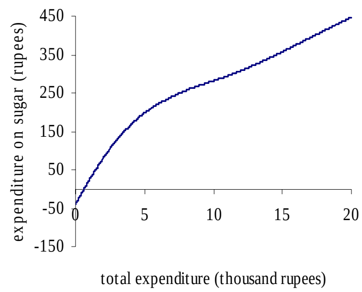
(g) Poultry & Fish



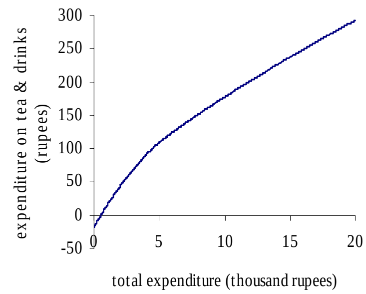
(h) Fruit & Vegetables



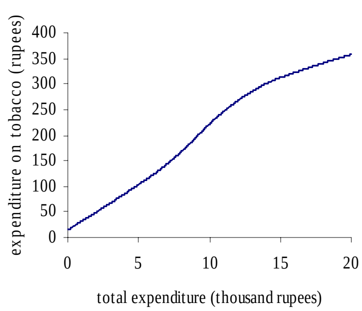
(i) Sugar



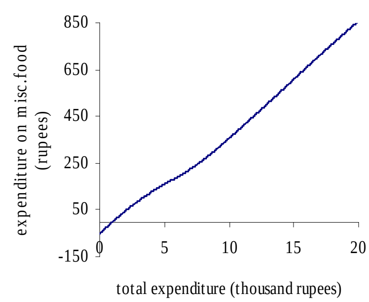
(j) Tea & Drinks



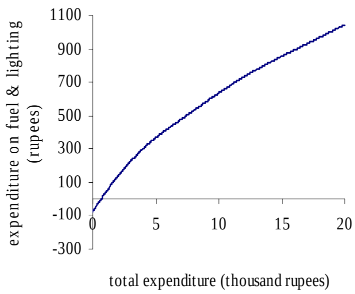
(k) Tobacco



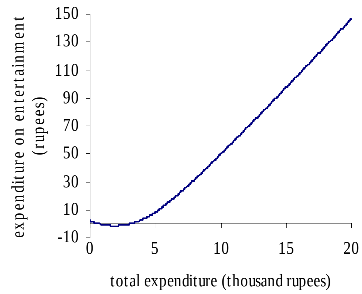
(l) Misc. food



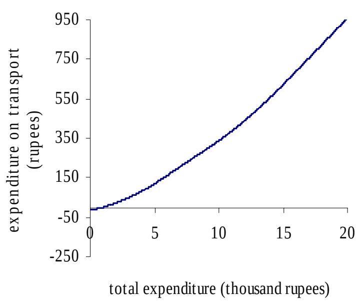
(m) Fuel & Lighting



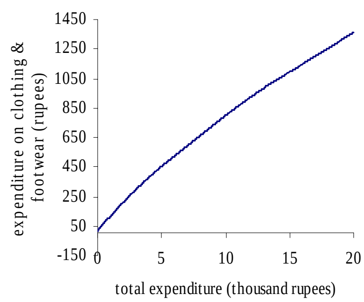
(n) Entertainment



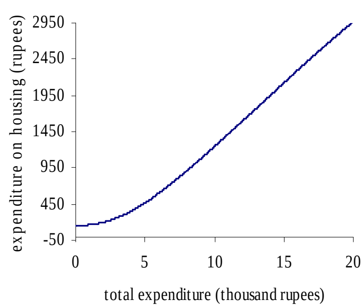
(o) Transport



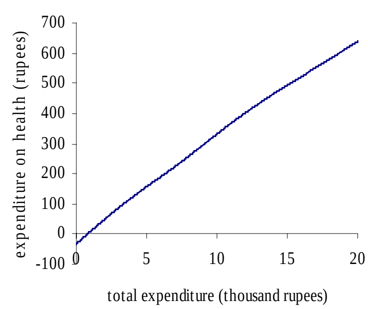
(p) Clothing & Footwear

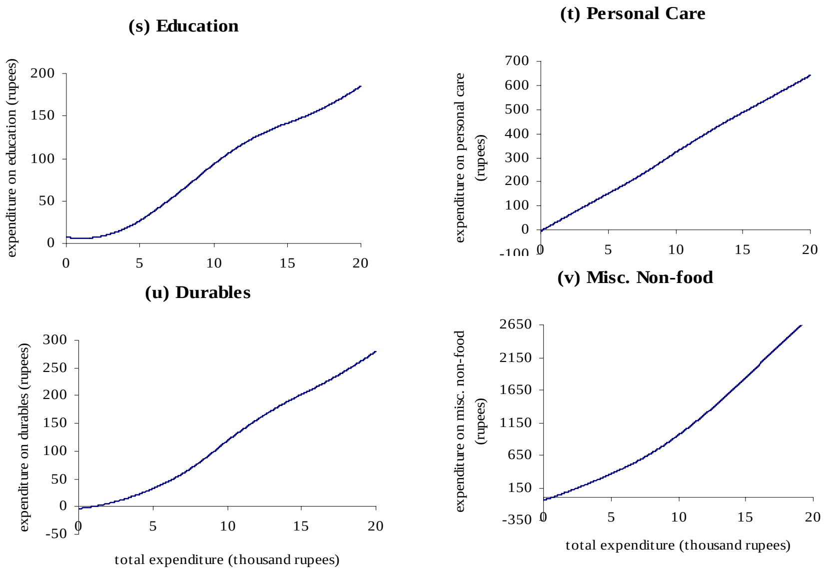


(q) Housing



(r) Health





5. CONCLUSION

The first important result of the study is that among rural households total expenditure elasticities of all the 22 commodity groups are positive at all levels of income. The same result holds for urban households except that wheat is considered 'inferior good' among the middle-income class. By and large Engel's law is validated by the data as most of the Engel curves for non-food items get steeper, while most of the curves for food items flatten out as the level of total expenditure increases.

Although in most cases urban and rural households are observed to have similar consumption pattern, there is a clear contrast of preferences when it comes to the matter of health. While urban households regard wheat, housing and *health* as absolute necessities, rural households consider wheat, housing and *tobacco*, besides clothing and footwear, as absolute necessities. Likewise dairy products, which are expected to be more abundantly available is rural areas than in urban areas, are considered a luxury consumption item for poor to middle income rural households, while in the urban sample this pattern holds for poor households only. The Engel curves for high protein and high-energy foods like sugar, edible oils, meats, poultry and fish and dairy products are by-and-large steeper, indicated higher total expenditure elasticities, for rural sample as compared to the urban sample. These results show that urban households tend to have stronger preferences for the goods that have higher health value like health care, dairy, sugar, edible oils, meats, poultry and fish. With the average income levels of urban households also better than those of rural households, this preference structure has undesirable implications for health of the poor.

The flexibility of Engel curves obtained through Spline specification unveils many interesting patterns. For example, while wheat is treated as ‘inferior’ among middle-income urban households, it again turns into ‘normal’ among the rich households, though its expenditure elasticities remains quite low. Some of the consumption items that uncharacteristically turn from necessities into luxuries at very high levels of total expenditure include entertainment, personal care and durables among urban households and dairy among the rural households.

The changing slopes and curvatures of Engel curves suggest that even a uniform tax structure, e.g. in the form of GST will have varying implications for budget allocation and welfare of households belonging to different income classes. Although practically it may be difficult to design a tax structure with varying tax rates, one may at least be informed of the distributional implications of a given tax system in order to propose supplementary transfer measures. A detailed analysis of taxation structure on these lines is our future research agenda.

Table A1

Parameter Estimates of Spline Function for Urban Pakistan

Commodities→	Wheat	Rice	Cereals and Pulses	Dairy	Edible Oil	Meat	Fish and Poultry	Fruit and Vegetable	Sugar	Tea and Drink	Tobacco
Intercept	0.0857	0.0361	0.0397	0.1562	0.0873	0.0388	–0.0039	0.0910	0.0652	0.0374	0.0264
	(5.14)*	(4.75)*	(5.42)*	(6.49)*	(8.96)*	(2.64)*	(–0.41)	(6.85)*	(10.25)*	(6.64)*	(1.91)**
Number of Babies	–0.0044	–0.0008	–0.0018	0.0002	–0.0027	0.0044	0.0015	–0.0014	–0.0010	0.0000	–0.0019
	(–2.29)*	(–0.92)	(–2.20)*	(0.08)	(–2.43)*	(2.64)*	(1.36)	(–0.91)	(–1.32)	(0.01)	(–1.20)
Number of Toddlers	–0.0051	0.00118	–0.0001	0.0012	0.0001	0.0007	0.0018	0.0013	0.0000	–0.0006	0.0016
	(–2.87)*	(1.44)	(–0.18)	(0.47)	(0.10)	(0.47)	(1.75)*	(0.89)	(0.06)	(–1.03)	(1.02)
Number of Male Children	–0.0005	–0.0009	–0.0008	–0.0021	–0.0010	0.0017	0.0003	–0.0020	–0.0009	–0.0002	–0.0003
	(–0.42)	(–1.58)	(–1.54)	(–1.18)	(–1.38)	(1.57)	(0.38)	(–2.01)*	(–1.86)**	(–0.46)	(–0.28)
Number of Female Children	–0.0014	0.0004	–0.0003	–0.0065	–0.0013	0.0026	0.0013	–0.0003	–0.0012	–0.0006	–0.0004
	(–1.12)	(0.75)	(–0.56)	(–3.59)*	(–1.78)**	(2.32)*	(1.84)**	(–0.26)	(–2.46)*	(–1.30)	(–0.39)
Number of Male Adults	–0.0025	0.0006	–0.0006	–0.0002	0.0005	0.0011	0.0005	–0.0015	–0.0008	–0.0002	0.0015
	(–1.95)*	(1.02)	(–1.02)	(–0.13)	(0.71)	(0.93)	(0.63)	(–1.49)	(–1.69)**	(–0.35)	(1.38)
Number of Female Adults	0.0011	0.0002	0.0001	0.0019	–0.0013	–0.0001	0.0016	–0.002	–0.0004	–0.0001	–0.0018
	(0.79)	(0.41)	(0.07)	(0.95)	(–1.55)	(–0.09)	(2.04)*	(–1.80)**	(–0.79)	(–0.12)	(–1.57)

Continued—

Table A1—(*Continued*)

Number of Elderly	–0.0019	0.0015	–0.0032	0.0003	–0.0016	–0.0020	–0.0021	–0.0025	–0.0011	–0.0012	–0.0000
	(–0.72)	(1.28)	(–2.77)*	(0.07)	(–1.07)	(–0.85)	(–1.42)	(–1.22)	(–1.13)	(–1.40)	(–0.01)
Inverse of Total Expenditure	291.31	–50.67	–4.212	–115.87	–17.478	–87.428	–21.372	–14.468	–19.952	–31.937	–28.338
	(7.65)*	(–2.91)*	(–0.25)	(–2.11)*	(–0.784)	(–2.60)*	(–0.99)	(–0.48)	(–1.37)	(–2.48)*	(–0.90)
Total Expenditure	–0.0540	–0.0188	–0.0197	–0.0495	–0.0434	0.0073	0.0179	–0.017	–0.0439	–0.0178	–0.0045
	(–3.39)*	(–2.58)*	(–2.82)*	(–2.15)*	(–4.66)*	(0.52)	(1.98)*	(–1.37)	(–7.22)*	(–3.31)*	(–0.34)
D1(TE-5800)^2/TE	0.0411	0.0122	0.0128	0.0138	0.0283	–0.0155	–0.0161	0.0023	0.0396	0.0165	–0.0015
	(2.25)*	(1.47)	(1.60)	(0.53)	(2.65)*	(–0.96)	(–1.56)	(0.16)	(5.69)*	(2.68)*	(–0.10)
D2(TE-15900)^2/TE	0.0289	0.0080	0.0115	0.0569	0.0225	0.0051	–0.0067	0.0153	0.0056	–0.0019	0.0096
	(3.29)*	(1.98)*	(2.96)*	(4.48)*	(4.38)*	(0.66)	(–1.34)	(2.18)*	(1.66)**	(–0.64)	(1.31)
D3(TE-22200)^2/TE	–0.0165	–0.0014	–0.0048	–0.0220	–0.0077	0.0032	0.0047	–0.0008	–0.0014	0.0032	–0.0036
	(–2.72)*	(–0.51)	(–1.78)**	(–2.50)*	(–2.18)*	(0.60)	(1.35)	(–0.16)	(–0.59)	(1.55)	(–0.71)

Note: The parameters in the last four rows are multiplies by 10000. The t-statistics significant at 5 percent and 10 percent level are indicated by * and ** respectively.

Table A1—(*Continued*)

Commodities→	Miscellan-eous Food	Fuels and Energy	Entertain-ment	Transport	Clothing and Footwear	Housing	Health	Education	Personal Care	Durables	Miscellan-eous Non-food
Intercept	0.0439	0.1168	–0.0063	–0.0243	0.1274	–0.0162	0.0092	–0.0361	0.0342	0.0087	0.0827
	(1.46)	(7.28)*	(–0.58)	(–1.34)	(7.95)*	(–0.33)	(0.57)	(–2.57)*	(3.32)*	(0.74)	(2.57)*
Number of Babies	–0.0014	–0.0018	0.0006	0.0037	–0.0028	0.0049	–0.0000	0.0009	0.0000	–0.0013	0.0047
	(–0.40)	(–0.97)	(0.48)	(1.80)**	(–1.51)	(0.88)	(–0.00)	(0.59)	(0.03)	(–0.94)	(1.29)
Number of Toddlers	–0.0023	–0.0045	–0.0001	0.0017	–0.0019	0.0042	0.0003	0.0002	–0.0010	0.0017	–0.0001
	(–0.73)	(–2.62)*	(–0.11)	(0.86)	(–1.08)	(0.79)	(0.18)	(0.14)	(–0.93)	(1.37)	(–0.04)
Number of Male Children	–0.0024	–0.0039	0.0001	0.0048	–0.0014	–0.0017	0.0003	0.0068	–0.0007	0.0006	0.0041
	(–1.06)	(–3.26)*	(0.07)	(3.54)*	(–1.15)	(–0.45)	(0.24)	(6.54)*	(–0.91)	(0.74)	(1.74)**
Number of Female Children	–0.0001	–0.0029	0.0008	0.0019	–0.0000	–0.0021	0.0009	0.0043	0.0007	–0.0001	0.0044
	(–0.06)	(–2.42)*	(0.94)	(1.38)	(–0.03)	(–0.55)	(0.74)	(4.05)*	(0.87)	(–0.14)	(1.81)**
Number of Male Adults	0.0023	–0.0028	0.0008	0.0062	0.0021	–0.0120	0.0009	0.0027	0.0009	–0.0013	0.0019
	(1.00)	(–2.27)*	(0.94)	(4.42)*	(1.70)**	(–3.17)*	(0.74)	(2.53)*	(1.13)	(–1.39)	(0.77)
Number of Female Adults	–0.0071	–0.0020	0.0001	–0.0007	0.0009	0.0056	–0.0009	0.0003	–0.0002	0.0019	0.0030
	(–2.83)*	(–1.47)	(0.08)	(–0.47)	(0.64)	(1.36)	(–0.66)	(0.26)	(–0.28)	(1.90)**	(1.10)

Continued—

Table A1—(*Continued*)

Number of Elderly	–0.0012	–0.0004	0.0002	0.0020	–0.0002	0.0093	0.0063	0.0028	–0.0007	–0.0016	–0.0028
	(–0.23)	(–0.14)	(0.07)	(0.72)	(–0.09)	(1.22)	(2.51)*	(1.26)	(–0.46)	(–0.86)	(–0.55)
Inverse of Total Expenditure	25.209	13.164	1.8568	–7.0228	–55.025	217.60	24.384	27.031	–10.201	–23.84	–112.74
	(0.37)	(0.36)	(0.08)	(–0.17)	(–1.50)	(1.93)*	(0.66)	(0.84)	(–0.43)	(–0.89)	(–1.54)
Total Expenditure	0.0051	–0.0476	0.0129	0.0470	–0.0594	0.235	0.0160	0.0465	0.0043	0.0010	–0.0174
	(0.18)	(–3.10)*	(1.26)	(2.72)*	(–3.88)*	(5.00)*	(1.04)	(3.46)*	(0.44)	(0.09)	(–0.57)
D1(TE-5800)^2/TE	0.0336	0.0351	–0.0040	–0.0297	0.0609	–0.211	–0.0213	–0.0426	–0.0014	0.0056	0.0414
	(1.02)	(2.00)*	(–0.34)	(–1.50)	(3.472)*	(–3.92)*	(–1.21)	(–2.77)*	(–0.123)	(0.44)	(1.18)
D2(TE–15900)^2/TE	–0.0967	0.0189	–0.0200	–0.0101	–0.0206	–0.0140	0.0069	–0.0050	–0.0082	–0.0168	0.0109
	(–6.09)*	(2.23)*	(–3.50)*	(–1.06)	(–2.44)*	(–0.54)	(0.81)	(–0.68)	(–1.51)	(–2.73)*	(0.64)
D3(TE–22200)^2/TE	0.0572	–0.0057	0.0115	–0.0053	0.0196	–0.0111	–0.0018	0.0072	0.0055	0.0117	–0.0355
	(5.22)*	(–0.96)	(2.93)*	(–0.80)	(3.353)*	(–0.62)	(–0.30)	(0.14)	(1.47)	(2.75)*	(–3.03)*

Note: The parameters in the last four rows are multiplies by 10000. The t-statistics significant at 5 percent and 10 percent level are indicated by * and ** respectively.

Table A2

Parameter Estimates of Spline Function for Rural Pakistan

Commodities→	Wheat	Rice	Cereals and Pulses	Dairy	Edible Oil	Meat	Fish and Poultry	Fruit and Vegetable	Sugar	Tea and Drink	Tobacco
Intercept	0.0901	0.0169	0.0454	0.0652	0.0983	0.0377	–0.0048	0.1133	0.0690	0.0372	0.0196
	(6.94)*	(3.00)*	(7.59)*	(3.09)*	(13.48)*	(4.86)*	(–1.03)	(14.65)*	(13.84)*	(10.83)*	(2.46)*
Number of Babies	–0.0093	0.0027	–0.0001	0.0019	–0.0033	0.0016	0.0019	0.0000	–0.0011	–0.0016	–0.0003
	(–3.72)*	(2.50)*	(–0.05)	(0.47)	(–2.37)*	(1.08)	(2.12)*	(0.00)	(–1.17)	(–2.48)*	(–0.18)
Number of Toddlers	–0.0029	0.0009	0.0013	–0.0022	–0.0022	0.0001	0.0024	–0.0039	–0.0006	–0.0002	–0.0019
	(–1.32)	(0.98)	(1.31)	(–0.64)	(–1.79)**	(0.05)	(3.07)*	(–3.03)*	(–0.69)	(–0.41)	(–1.44)
Number of Male Children	0.0001	–0.0006	–0.0007	–0.0005	–0.0017	0.0009	0.0004	–0.0021	–0.0000	–0.0008	–0.0015
	(0.09)	(–0.91)	(–1.02)	(–0.19)	(–2.02)*	(1.06)	(0.79)	(–2.35)*	(–0.05)	(–2.14)*	(–1.68)**
Number of Female Children	–.0003	–0.0004	–0.0005	0.0026	–0.0005	0.0036	0.0008	–0.0003	0.0008	0.0003	–0.0021
	(–0.16)	(–0.53)	(–0.67)	(0.95)	(–0.49)	(3.66)*	(1.37)	(–0.29)	(1.20)	(0.69)	(–2.02)*
Number of Male Adults	–0.0011	0.00091	–0.0003	0.0006	–0.0007	0.0018	0.0005	–0.0025	–0.0009	–0.0010	0.0046
	(–0.61)	(1.18)	(–0.36)	(0.20)	(–0.67)	(1.68)**	(0.81)	(–2.33)*	(–1.24)	(–2.08)*	(4.17)*
Number of Female Adults	–0.0004	0.0006	0.0007	0.0071	–0.0018	–0.0021	–0.0007	–0.0021	0.0004	0.0002	–0.0031
	(–0.21)	(0.64)	(0.68)	(2.07)*	(–1.54)	(–1.69)**	(–0.89)	(–1.64)**	(0.52)	(0.35)	(–2.40)*

Continued—

Table A2—(*Continued*)

Number of Elderly	–0.0052	0.0009	–0.0003	0.0081	–0.0003	–0.0028	–0.0014	–0.0021	0.0012	–0.0003	0.0006
	(–1.67)**	(0.63)	(–0.19)	(1.59)	(–0.17)	(–1.52)	(–1.24)	(–1.14)	(0.99)	(–0.40)	(0.34)
Inverse of Total Expenditure	276.18	–10.064	–17.899	–19.050	–29.543	–64.971	–3.9017	–44.853	–40.112	–18.071	14.923
	(11.90)*	(–1.00)	(–1.68)**	(–0.51)	(–2.27)*	(–4.69)*	(–0.47)	(–3.24)*	(–4.50)*	(–2.94)*	(1.05)
Total Expenditure	–0.0451	0.0013	–0.0202	0.0862	–0.0407	0.0025	0.0257	–0.0397	–0.0413	–0.0177	0.0016
	(–3.08)*	(0.21)	(–3.00)*	(3.63)*	(–4.96)*	(0.29)	(4.91)*	(–4.55)*	(–7.35)*	(–4.57)*	(0.17)
D1(TE–5600)/TE	0.0162	–0.0154	0.0008	–0.1840	0.0297	0.0079	–0.0373	0.0401	0.0263	0.0152	0.0123
	(0.62)	(–1.36)	(0.07)	(–4.32)*	(2.03)*	(0.51)	(–3.99)*	(2.58)*	(2.62)*	(2.20)*	(0.77)
D2$(TE–9200)^2$/TE	0.0610	0.0166	0.0221	0.1010	0.0048	–0.0314	0.0160	–0.0285	0.0210	0.0015	–0.0300
	(2.53)*	(1.59)	(1.99)*	(2.58)*	(0.36)	(–2.18)*	(1.85)**	(–1.99)*	(2.27)*	(0.23)	(–2.03)*
D3$(TE–15000)^2$/TE	–0.0308	–0.0029	–0.0024	0.0047	0.0092	0.0213	–0.0052	0.0299	–0.0062	0.0002	0.0140
	(–2.31)*	(–0.50)	(–0.40)	(0.22)	(1.23)	(2.67)*	(–1.10)	(3.76)*	(–1.22)	(0.04)	(1.71)**

Note: The parameters in the last four rows are multiplies by 10000. The t-statistics significant at 5 percent and 10 percent level are indicated by * and ** respectively.

Table A2—(*Continued*)

Commodities→	Miscella-neous Food	Fuels and Energy	Entertain-ment	Transport	Clothing and Footwear	Housing	Health	Education	Personal Care	Durables	Miscella-neous Non–food
Intercept	0.0552	0.1281	–0.0071	0.0039	0.1019	0.0095	0.0414	–0.0101	0.031588	0.00133	0.0564
	(5.85)*	(12.56)*	(–2.09)*	(0.479)	(11.53)*	(0.52)	(4.49)*	(–2.98)*	(6.99)*	(0.25)	(3.40)*
Number of Babies	0.0001	0.0016	0.00113	0.0024	–0.0011	–0.0009	0.0032	–0.0009	0.000736	–0.0002	0.0014
	(0.06)	(0.84)	(1.74)**	(1.551)	(–0.63)	(–0.24)	(1.81)**	(–1.36)	(0.85)	(–0.24)	(0.44)
Number of Toddlers	–0.0022	–0.0038	0.0006	0.0041	–0.0022	0.0051	0.0019	–0.0005	–0.00015	–0.0006	0.0069
	(–1.37)	(–2.21)*	(1.00)	(3.021)*	(–1.49)	(1.65)**	(1.24)	(–0.91)	(–0.20)	(–0.65)	(2.50)*
Number of Male Children	0.0018	–0.0011	0.0002	0.0010	0.0001	–0.0013	–0.0005	0.0028	–0.00073	0.0009	0.0033
	(1.65)**	(–0.97)	(0.43)	(1.062)	(0.09)	(–0.61)	(–0.47)	(7.28)*	(–1.42)	(1.44)	(1.76)**
Number of Female Children	–0.0004	0.0006	0.0006	–0.0001	–0.0016	–0.0055	–0.0010	0.0024	0.000213	–0.0006	0.0012
	(–0.31)	(0.48)	(1.39)	(–0.134)	(–1.40)	(–2.36)*	(–0.80)	(5.55)*	(0.37)	(–0.93)	(0.59)
Number of Male Adults	–0.0001	–0.0066	0.0011	0.0035	0.0012	–0.0057	–0.0004	0.0019	0.000716	–0.0005	0.0029
	(–0.04)	(–4.70)*	(2.33)*	(3.111)*	(0.98)	(–2.25)*	(–0.33)	(3.97)*	(1.15)	(–0.69)	(1.28)
Number of Female Adults	–0.0012	–0.0003	–0.0001	–0.0002	0.0012	0.0004	–0.0008	0.0004	0.0001	0.0018	–0.0002
	(–0.76)	(–0.16)	(–0.22)	(–0.125)	(0.86)	(0.14)	(–0.53)	(0.69)	(0.13)	(2.19)*	(–0.06)

Continued—

Table A2—(*Continued*)

Number of Elderly	–0.0016	0.0041	0.0003	–0.0024	0.0018	–0.0025	0.0031	–0.0000	–0.0023	–0.0002	0.0014
	(–0.69)	(1.67)**	(0.42)	(–1.234)	(0.84)	(–0.57)	(1.38)	(–0.04)	(–2.06)*	(–0.13)	(0.34)
Inverse of Total Expenditure	–51.349	–72.632	2.199	–15.737	17.929	153.936	–32.907	7.454	–4.032	–3.529	–43.95
	(–3.04)*	(–3.98)*	(0.36)	(–1.078)	(1.14)	(4.70)*	(–1.99)*	(1.23)	(–0.50)	(–0.38)	(–1.48)
Total Expenditure	–0.0213	–0.0566	0.0100	0.0269	–0.0299	0.1280	–0.0090	0.0134	–0.0016	0.0084	0.0195
	(–2.01)*	(–4.93)*	(2.63)*	(2.93)*	(–3.01)*	(6.18)*	(–0.86)	(3.50)*	(–0.32)	(1.43)	(1.04)
D1(TE–5600)/TE	0.0481	0.0565	–0.0074	–0.0274	0.0306	–0.0858	0.0159	–0.0099	0.0120	0.0047	0.0503
	(2.54)*	(2.76)*	(–1.09)	(–1.67)**	(1.72)**	(–2.33)*	(0.86)	(–1.46)	(1.32)	(0.45)	(1.51)
D2$(TE-9200)^2$/TE	–0.0237	–0.0137	–0.0022	0.0208	–0.0157	–0.0366	–0.0147	–0.0109	–0.0167	–0.0209	–0.0196
	(–1.35)	(–0.72)	(–0.35)	(1.37)	(–0.96)	(–1.08)	(–0.86)	(–1.74)**	(–1.99)*	(–2.16)*	(–0.64)
D3$(TE-15000)^2$/TE	–0.0070	0.0155	–0.0002	–0.0192	0.0192	–0.0216	0.0088	0.0129	0.0074	0.0131	–0.0606
	(–0.72)	(1.48)	(–0.05)	(–2.29)*	(2.11)*	(–1.15)	(0.93)	(3.71)*	(1.59)	(2.44)*	(–3.56)*

Note: The parameters in the last four rows are multiplies by 10000. The t-statistics significant at 5 percent and 10 percent level are indicated by * and ** respectively.

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