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THE ROTTERDAM DEMAND MODEL AND ITS APPLICATION TO MAJOR FOOD ITEMS IN PAKISTAN

Ayesha Anwar[1], Babar Aziz[2], Sadia Ali[1]

[1]Department of Economics, GC University, Faisalabad, Pakistan.
[2]Department of Economics, FC College (A Charted University), Lahore, Pakistan.

ABSTRACT

The study has used one of the most promising demand system i.e. Rotterdam Model for the calculation of elasticities for nine major commodities in Pakistan using recent household integrated survey (PIHS 2007-08). SUR Method was applied for the estimation of model parameters. All the elasticites were according to the theoretical expectations. All the expenditure elasticites were positive, reasonable in magnitude and less than one except for Mutton. The own-price elasticities for all food items were negative as per theoretical expectation and their absolute amounts were lower than unity.
According to the values of the cross-price elasticities substitution and complementary relationships were observed. The described elasticities examined the structure of food consumption and expenditure patterns in Pakistan.
KEYWORDS: Demand systems, Rotterdam Model, Price Elasticity, Pakistan,

1. INTRODUCTION

In economics the study of consumer behavior has always been of prime concern because consumer is one the most important pillar of market based system. The preferences and choices of consumers determine the organizational and economical behavior. Consumer decisions are comprised of taste, income, price of commodities, selection between the available alternatives etc. Economists are always concerned in providing the theoretical and statistically formulation of consumer behavior and demand analysis.

Economists and policy makers have attracted towards consumer analysis from the past many decades and it is proved from the long and rich history of economics and econometrics. The analysis of consumer demand has gone through various transitions, starting from the orthodox approach that concentrated on the demand of a single commodity with special characteristics (Stone, 1954) and then transformed into the estimation of simultaneous equations of demand system for every commodity group purchased by consumers. Now a day consumer demand analysis has stirred toward system-wide approaches. The majority of the presently available influential papers have appeared following the adoption of flexible functional forms, which depends greatly on duality theory. The expansion of demand related studies advocate that system-wide approaches provide more natural and realistic results both on theoretical and practical grounds. Rotterdam demand Model is one of the leading examples of System-wide approach.

In this study is aimed to apply the Rotterdam Model on the set of nine major commodities (wheat, rice, chicken, mutton, milk, apple, mango, potato, onion) of Pakistan. Both the models will provide the compensated and uncompensated own-price elasticities, cross price elasticites and income elasticities. The Model parameters are calculated by employing Seemingly Unrelated Regression (SUR) estimation method.

2. Methodological Framework:

This demand model was formulated by Theil (1965) and Barten (1966). The name of the model "Rotterdam" originated from situate of Barten and Theil in the 1960s. It has executed commendable links with the economic theory of the consumer and its simplicity has played a very important to its popularity and influential role in the development of the system-wide approach [Clement, Selvanathan (1988)]. The Rotterdam model has come up as turning point because it offered many features not presented in previous modeling efforts. The Rotterdam model can aptitude the whole substitution matrix. Econometrically the model is linear in parameters and could easily be related to the theoretical restrictions.[1]

[1] For details, see Mountain (1988)

***Corresponding Author:** Ayesha Anwar, Department of Economics, GC University, Faisalabad, Pakistan.
Email: rjayesha@yahoo.com

The demand functions $x_i^0 = x_i(p, m)$ arising from utility maximization subject to the budget constraint can be rewritten in terms of prices and a measure of real income *m*. The logarithmic differential of the resulting demand function can then be written as,

$$d(\log x_i) = n_{i0} d(\log \bar{m}) + \sum_j \beta_{ij} d(\log p_j) \quad (3.1)$$

Where

β_{ij} = the compensated cross price elasticity of good with respect to j^{th} price

n_{i0} = the income elasticity of the i^{th} good.

$w_i = \frac{p_i x_i}{m}$ = expenditure share (Weighting each demand equation by the expenditure share)

We obtain a re-parameterization as:

$$w_i d(\log x_i) = \mu_i d(\log \bar{m}) + \sum_j \pi_{ij} d(\log p_j) \quad (3.2)$$

The price coefficient, $\pi_{ij} = \left(\frac{p_i p_j}{m}\right)\left(\frac{\partial q_i}{\partial p_i}\right)$ is the cross price elasticity e_{ij}, weighted by the *i*th expenditure proportion, and the coefficient $\mu_i = p_i\left(\frac{\partial q_i}{\partial m}\right)$ is again marginal budget share of the *i*th commodity. Restriction implied by the neoclassical formulation of the consumer optimization problem can be shown to hold for the parameters in the set of equations specified in equation (3.2). Homogeneity requires for all *i*'s; the Slutsky symmetry condition implies the symmetry of the matrix $[\pi_{ij}]$. The adding up property implies that $\sum \mu_i = 1$; and finally the classical second order condition requires that the matrix $[\pi_{ij}]$ be negative semi definite. The first three sets of restrictions can be imposed on the estimation procedure in a straightforward manner. The inequality constraints implied by the last condition are more difficult to impose (they would require the use of programming techniques), but they can be used as a check on the validity of the numerical results.

The equation in (3.2) uses absolute prices while the model used in the recent work emphasizes deflated or relative prices. The differential model, with constant parameters, is consistent with individual optimizing behaviours only under strong additional restrictions on these parameters [McFadden (1964)].

3. RESULTS AND DISCUSSION

In the countries like Pakistan, there is typically rather few time-series data from which price elasticities can be attained. As a result of this restraint and with the availability of cross-sectional data resulting from extensive surveys on household expenditures, most studies in Pakistan concentrated on the estimation of expenditure elasticities (Engel relationship) and overlooked the price elasticities.

Here we are intend to provide the own price elasticities, cross price elasticities (compensated & uncompensated for both) and expenditure elasticities using Rotterdam model. Complete demand function is computed by estimating a system of share equation subject to the restriction with the help of Seemingly Unrelated Regression (SUR) by Zellner. The estimation is carried out for nine major commodities of Pakistan (Wheat, Rice, Milk, Mutton, Chicken, Apples, Mango, Potato, and Onion).

3.1 Price Elasticities from HIES Data: How?

Considering the limitation of lack of prices data availability, Theil (1965), Barten (1966), Deaton (1987) developed a methodology for using household survey data to detect the spatial variation in prices and to estimate the price elasticities by comparing spatial price variation to spatial demand patterns. . They stated that household surveys contain information on the spatial distribution of prices, and thus, by recovering this information in a useful form, there is a potential for estimating the impact of prices on quantity demanded. Since prices for food products are not provided by the survey, the ratio of expenditure to purchased quantity can be used as a proxy for prices. These prices should be corrected before being incorporated into the demand system according to the causes of cross-sectional price variations.

3.2 System Assumptions:

The demand system works under the following assumptions:

- Each household has the same utility function. This is an assumption of most demand studies, and without this assumption, we should model for each household separately.
- The economic variables - income and prices - are the only variables that determine food demand.
- It is assumed that income distribution is the same for all regions.

Finally, the household is assumed to have the same demographic characteristics, because of the absence of complete data about demographic variables for each Province.

3.3 Model results of Rotterdam Model:

The Rotterdam model is estimated for the nine commodities (Wheat, Rice, Milk Mutton, Chicken, Apples, Mango, Potato and Onion). The experimental results of specified model for Rotterdam show that all the estimated results are according to our theoretical expectations. The results of the Model are discussed under four segments. First section deals with the results of estimated parameters (Section 3.3.1). Second section analyses the expenditure elasticities (Section 3.3.2). Third section is comprised of own-price elasticities (Section 3.3.3) and last section examines the cross price relation of the nine commodities (Section 3.3.4).

3.3.1 Parameter Estimates of Rotterdam Model:

Parameters of the Rotterdam model with their associated T-vales are calculated under the system of equations and the value of R^2 of each equation is mentioned corresponding to that equation (see Table 3.1). The results show that twenty-five parameters are statistically significant out of Eight-one parameters.

The illustration of each equation separately shows that if the price of a particular commodity (out of nine commodities) increases the budget allocated to that commodity also increases and leads to the reduction in the allocated budget to other commodities. For instance, the equation corresponding to Wheat shows that as the price of wheat increases (δ_{i1} =0.044) people allocate more share of their budget to wheat as being a necessity to the inhabitants of Pakistan. But increase in the prices of Chicken (-0.147), Mango (-0.075), Potato (-0.046) and Onion (-0.022) reduces their share in budget and consumer prefer to spend that budget on Wheat. Further more, the equation of Mango demonstrates that though increase in the price of Mango (δ_{i7} =0.016) increase its share in Budget but it does not lead to reduce the budget share of Wheat (δ_{i1} =0.026), Rice (δ_{i2} =0.027) and Potato (δ_{i8} =0.119).

Table: 3.1 Parameter Estimates of Rotterdam Model

Commodities	α_i	β_i	δ_{i1}	δ_{i2}	δ_{i3}	δ_{i4}	δ_{i5}	δ_{i6}	δ_{i7}	δ_{i8}	δ_{i9}	R^2
Wheat	0.309	-0.057	0.044	0.076	-0.130	0.142	-0.147	0.064	-0.075	-0.046	-0.022	0.702
	1.034	-1.246	0.093	0.895	-1.556*	1.239	-2.157**	0.776	-1.986*	-0.422	-0.763	
Rice	0.035	-0.011	0.002	0.061	0.016	0.004	-0.050	0.004	-0.008	0.075	0.005	0.752
	0.370	-0.729	0.186	2.284**	0.640	0.111	-2.356**	0.174	0.657	1.979*	0.551	
Milk	-0.029	0.007	-0.003	-0.014	0.006	0.048	-0.014	-0.011	0.001	0.004	0.009	0.723
	-0.719	1.168	-0.541	-1.264	0.510	3.103***	-1.646*	-1.031	0.034	0.304	2.228**	
Mutton	-0.048	-0.005	0.014	0.009	-0.014	0.021	-0.005	-0.002	0.001	0.051	0.003	0.767
	-0.926	-0.652	1.780*	0.588	-0.991	1.077	0.412	-0.119	0.021	2.463**	0.629	
Chicken	0.171	-0.016	-0.012	0.016	-0.002	-0.023	0.014	-0.002	0.009	-0.048	0.004	0.710
	2.473**	-1.290	-1.087	0.764	-0.138	-0.799	0.795	-0.104	0.918	-1.546*	0.583	
Apples	0.128	0.072	-0.033	-0.050	0.063	-0.016	0.030	0.011	0.021	-0.065	0.006	0.702
	0.427	1.582*	-0.707	-0.584	0.750	-0.151	0.436	0.129	0.555	-0.541	0.208	
Mango	0.066	-0.009	0.026	0.027	-0.031	-0.112	0.087	-0.044	0.016	0.119	-0.016	0.698
	0.349	-0.281	0.865	0.501	-0.583	-1.526*	1.987*	-0.835	0.666	1.539*	-0.880	
Potato	0.097	-0.006	0.002	0.004	0.033	0.026	-0.020	-0.023	-0.001	0.005	-0.007	0.668
	1.814*	0.668	0.205	0.300	2.180**	1.239	-1.599*	-1.609*	-0.046	0.238	-1.368	
Onion	0.109	0.024	-0.041	-0.124	0.054	-0.088	0.103	-0.002	0.044	-0.094	0.016	0.677
	0.686	1.020	-1.688*	-2.752**	1.211	-1.448	2.852**	-0.042	2.198**	-1.473	1.009	

Note: 2nd line of each group describes the t-values, in smaller font size. * * * Indicates significant at one percent level of significance, * * Indicates significant at five percent level of significance and * Indicates significant at ten percent level of significance.

3.3.2 Expenditure Elasticities:

The expenditure (income) elasticities of the entire household sample are shown in Table 3.2, calculated using Rotterdam Model. The results portray that all the nine commodities are normal goods[2]. These commodities can further be classified into necessities[3] and luxuries[4]. Eight commodities are recorded as necessities out of nine commodities. Mutton is the only commodity that has come up as luxury with the expenditure elasticity of 1.074. It is categorized as most income affected commodity. A small change in income will leads to a larger share change in its demand.

Wheat is the least affected item by the change in income. The expenditure elasticity of Wheat is 0.346, followed by Rice and Potato having 0.392 and 0.398 income elasticities respectively. These results make it evident that these commodities already occupy an elite position in the diet of Pakistani inhabitants. The expenditure elasticities of Onion, Milk, Mango, Apples and Chicken are 0.445, 0.682, 0.760, 0.881 and 0.888 respectively. Results are showing that change in the income of inhabitants of Pakistan is not causing some major changes in their food habits.

3.3.3. Compensated and Uncompensated Own-Price Elasticities:

The compensated and uncompensated own-price elasticities are demonstrated in Table 3.2. These elasticities are satisfying the a priori expectation, displaying negative relationship between the price of one commodity and its quantity demanded. The absolute calculation of own-price elasticities (uncompensated and compensated) of all commodities is less than unity indicating that no good is too much price responsive. The uncompensated price elasticity of Onion (-0.391) and potato indicates that these two goods are least price responsive. Apples and Mutton have uncompensated price elasticity closer to unity (-0.904 and -0.928) suggesting that change in price leads to almost same change (increase or decrease) in the quantity demanded.

The results of compensated elasticity are also fulfilling the negativity relation condition. The compensated elasticities are less in absolute terms as compared to the uncompensated elasticities revealing

[2] All the commodities have positive values.

[3] For necessity goods expenditure elasticity should be greater then zero but less than unity ($0 < \varepsilon_i < 1$).

[4] For luxury goods expenditure elasticity is positive and greater than unity ($\varepsilon_i > 1$).

the off setting effect of changes in real income in compensated approach. Here Onion, Potato and wheat are listed as least price responsive with -0.213, -0.279 and -0.392 own price elasticities respectively. Under the compensated elasticity no commodity has own-price elasticity even closer to zero. Rice, Mango, Milk, Chicken, Apples and Mutton attained -0.432, -0.598, -0.648, -0.745, -0.858 and -0.880 of compensated own-price elasticities respectively.

3.3.4. Cross-price Elasticities:

Table 3.3 and 3.4 shows the cross price relationship among the commodities estimated with the help of Rotterdam Model. We have quantified both compensated and uncompensated cross price elasticities presented in the form of matrix tables. The main diagonals of both the tables are showing the own- price elasticities.

Firstly we take a look to the compensated elasticities. Wheat has a strong substitute in the form of Rice (0.656) whereas Chicken (-0.476) and Onion (-0.365) are complements of wheat but are not exhibiting very strong relation. Following the same track Rice can be substituted with wheat (0.653). Mutton and Chicken has strong Substitutable relation with 0.780 and 0.741 compensated own- price elasticity. Chicken is by far complemented with Wheat (-0.469), Rice (-0.627) and Potato (-0.561).

Milk has a very weak complementary with fruits [Apples (-210) and Mango (-0.264)]. Apples and mangoes can easily be substitute with each other indicting that the people of Pakistan consume all type of fruits and can easily replace one fruit with the other because thing that matter to them is the price of a fruit but not the nutritional value that it contains. Onion has feebly complemented with Wheat (-0.366), Rice (-0.459), Mutton (-0.279), Chicken (-0.297) and Potato (-0.453). Onion is independent of Milk, Mango and Apples.

By looking at the results of uncompensated cross price elasticities the nature of relationship among commodities is same as depicted in the compensated cross price elasticities. The only difference is that the uncompensated cross price elasticities are greater than the compensated cross-price elasticities in absolute terms.

4. Conclusion:

The main focus of the study is to investigate consumer demand and responsiveness of households regarding prices and income for nine[5] most extensively and commonly used commodities by employing Rotterdam Model. The PIHS data set for the year 2007-08 is utilized. The expenditure and own-price (Marshallian and Hicksian) elasticities of these major food items are quite elevating in Pakistan. The expenditure elasticities are reasonable in magnitude and positive in respect of signs, indicating that selected commodities are normal goods. Mutton is the only commodity that is regarded as luxury. The absolute amount of compensated and uncompensated own-price elasticities is less than unity. So the demand to selected commodities reacts in-elastically due to change in own-price. The cross price elasticities have defined the relation among commodities whether complementary or substitutable. It has also elaborated the level of relationship (strong or weak) among goods. The cross price substitution effect is noted between wheat and rice, chicken and mutton, rice and mutton, apple and mango. The cross price complementary relation is eminent between wheat and chicken, rice and chicken. Milk is complemented with fruits only. Onion has complementary relation with all meat and vegetables and almost same in the case of potatoes.

Table: 3.2 Expenditure and Own-price Elasticities for Rotterdam Model:

Commodities	Expenditure Elasticity	Uncompensated Own-price Elasticity	Compensated Own-price Elasticity
Wheat	0.346	-0.414	-0.392
Rice	0.392	-0.456	-0.432
Milk	0.682	-0.683	-0.648
Mutton	1.074	-0.928	-0.880
Chicken	0.888	-0.785	-0.745
Apples	0.881	-0.904	-0.858
Mango	0.760	-0.630	-0.598
Potato	0.398	-0.399	-0.279
Onion	0.445	-0.391	-0.213

[5] Wheat, Rice, Chicken, Mutton, Milk, Apple, Mango, Potato and Onion.

Table: 3.3 Compensated (Hicksian) Price Elasticities for Rotterdam Model:

Commodities	Wheat	Rice	Milk	Mutton	Chicken	Apples	Mango	Potato	Onion
Wheat	**-0.392**	0.656	0.511	0.511	-0.476	0.445	0.334	0.472	-0.365
Rice	0.653	**-0.432**	0.300	0.453	-0.569	0.185	0.090	-0.376	-0.469
Milk	0.569	0.345	**-0.648**	0.366	0.453	-0.210	-0.264	0.090	0.010
Mutton	0.477	0.446	0.405	**-0.880**	0.780	0.201	0.282	-0.366	-0.282
Chicken	-0.469	-0.627	0.472	0.741	**-0.745**	0.384	0.204	-0.561	-0.311
Apples	0.477	0.279	-0.273	0.218	0.279	**-0.858**	0.572	0.117	0.018
Mango	0.308	0.104	-0.181	0.259	0.297	0.656	**-0.598**	0.108	0.094
Potato	0.564	-0.323	0.138	-0.400	-0.478	0.047	0.134	**-0.378**	-0.472
Onion	-0.366	-0.459	0.017	-0.279	-0.297	0.030	0.103	-0.453	**-0.371**

Table: 3.4 Uncompensated (Marshallian) Price Elasticities for Rotterdam Model:

Commodities	Wheat	Rice	Milk	Mutton	Chicken	Apples	Mango	Potato	Onion
Wheat	**-0.414**	0.691	0.538	0.538	-0.502	0.469	0.352	0.497	-0.384
Rice	0.689	**-0.456**	0.316	0.478	-0.600	0.195	0.094	-0.396	-0.494
Milk	0.600	0.364	**-0.683**	0.386	0.478	-0.221	-0.278	0.095	0.011
Mutton	0.503	0.470	0.426	**-0.928**	0.823	0.212	0.297	-0.386	-0.297
Chicken	-0.494	-0.661	0.497	0.781	**-0.785**	0.404	0.215	-0.591	-0.327
Apples	0.503	0.294	-0.288	0.230	0.294	**-0.904**	0.602	0.123	0.019
Mango	0.325	0.109	-0.191	0.273	0.313	0.691	**-0.630**	0.114	0.099
Potato	0.594	-0.340	0.146	-0.422	-0.503	0.050	0.141	**-0.399**	-0.497
Onion	-0.386	-0.484	0.017	-0.294	-0.313	0.031	0.108	-0.478	**-0.391**

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