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ESTIMATES OF GASOLINE DEMAND IN PAKISTAN

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A dynamic flow-adjustment model is used to estimate income and price elasticities of gasoline demand by OLS and GLS methods. The income elasticity is an important determinant of gasoline demand in Pakistan. The price elasticity is small and statistically not very significant. Several policy implications emerge for discussion.

Gasoline for automobiles accounted for one-quarter of total petroleum products used in the transportation sector of Pakistan in 1981.[1] Gasoline used by automobiles increased at an annual average rate of 9 per cent during 1960 to 1981 [Government of Pakistan (1982)]. The rapid growth in the use of gasoline was due to growth in income, population, urbanization and number of automobiles. Demand management and conservation appear as necessary policies in order to economise on the use of gasoline in Pakistan.

This study attempts to analyze the pattern of gasoline consumption in accordance with the standard theory of demand. It estimates elasticites and tests the statistical significance of determinants of gasoline demand in Pakistan. This study is divided into four sections. In section I, model for gasoline

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[1] (1) Gasoline refers to both regular and premium varieties of petroleum (Motor Spirit) used in Pakistan for automobiles. Automobiles stand for cars and motor bicycles owned by private individuals in the country. (2) Although the model discusses gasoline use by private owners of automobiles only, total gasoline demand by both private and public owners of automobiles is estimated. This is due to the absence of disaggregated data for the two groups of consumers separately.

use by private and public automobiles is formulated. In section II, sources of data and their estimation are described. In section III, estimates of income and price elasticities of gasoline use are examined. In the concluding section, usefulness of the study and some policy implications are discussed.

I. Model

Gasoline is demanded by the private automobiles (such as cars and motor cycles) and public automobiles (such as taxis, three wheelers or motor rickshaws) in Pakistan. The demand for gasoline by both private and public users of automobiles depends upon the stock, fuel-efficiency and the rate of utilization of automobiles. The stock of automobiles is determined by the investment in new vehicles and the rate of depreciation.[2] The rate of utilization of automobiles depends on income and price of gasoline. Fuel efficiency of automobiles responds to changes in price of gasoline, but only with a long lag [Pindyck (1979)].

The breakdown of the stock of automobiles into private and public uses is available for Pakistan. Data on automobile vintage, models, fuel-efficiency, price and rate of utilization of each use are absent. Segregated data on gasoline demand by private and public automobile owners are also not available. Therefore, gasoline demand in Pakistan will be estimated jointly for the two users using an aggregate dynamic flow-adjustment model, commonly used in the developed countries.

The dynamic flow adjustment model is appropriate for estimating gasoline use in Pakistan, because, first, models derived for estimating demand for gasoline in developed countries are based on the standard neo-classical assumptions of elastic supply and absence of government interference in quantity and price determination. In Pakistan, the price of gasoline is fixed by the government. However, the quantity is bought and sold freely at the determined price. The supply of gasoline is responsive to demand. Therefore, the paradigm of neo-classical economics is appropriate for deriving the gasoline demand model for Pakistan. Second, although gasoline is consumed by a small segment of the population – the middle and upper income groups in urban areas, the pattern of consumption is similar to consumers in the industrial countries.

Assume that the desired demand for gasoline by an individual in period t, G_t^*, is a function of his income, Y_t, and price of gasoline, P_t [Houthakker et. al. (1974), McGillivray (1976), and Verleger et. al. (1976)].[3]

[2] Stock is not sensitive in the short-run to changes in prices of automobiles, the price of gasoline or income, [Government of Pakistan (1981)].

[3] (1) Per capita consumption and per capita income are used as proxies for gasoline demand and

$$G_t^* = f(Y_t, P_t) \tag{1}$$

Assume that f( ) is log-linear,[4]

$$\log G_t^* = \log a + b \log Y_t + c \log P_t + u_t \tag{2}$$

Where u_t is the error term in logarithmic form.

Equation (2) cannot be estimated because the desired quantity of gasoline demand is not observable. To replace it we assume that the 'actual' change in gasoline demand in any one period is only a fraction of the 'desired' change. In logarithmic form, the adjustment process between the actual and the desired gasoline demand can be written as:

$$\log G_t - \log G_{t-1} = \lambda (\log G_t^* - \log G_{t-1}) + e_t \tag{3}$$

where $0 < \lambda \leqslant 1$ and e_t is the error term in logarithmic form.

Or
$$\log G_t = \log G_t^* + (1-\lambda) \log G_{t-1} + e_t \tag{4}$$

Substituting equation (2) into equation (4):

$$\log G_t = \lambda \log a + \lambda b \log Y_t + \lambda c \log P_t + (1-\lambda) \log G_{t-1} + v_t \tag{5}$$

where
$$v_t = u_t + e_t$$

The estimation of equation (5) would yield short-run income and price elasticities in terms of the coefficients of income, λb and the price, λc. The long-run demand elasticities can be derived by removing the adjustment lag from the equation. To do this, we first solve for the coefficient of the lagged consumption term $(1-\lambda)$. Then we remove the adjustment rate from the short-run elasticities as:

$$\eta_{\log y} = \lambda b/\lambda \tag{6}$$

income of a representative individual. (2) Population and income are major determinants of mileage travelled or the gasoline used by automobiles. As population increases, vehicle miles tend to increase proportionately. As income increases, so do vehicle miles: people tend to engage in more activities requiring additional mobility. Fuel cost is another important variable determining the vehicle miles travelled. Fuel cost per mile of driving depends on the price of gasoline and the fuel efficiency of automobiles. The price of gasoline is the major element of variable cost in the short run. In the long run, fuel efficiency of engines increases due to technological advancement. This reduces the cost of fuel per mile travelled and increases vehicle miles driven, [Verleger and Sheehan (1976)].

[4] The logarithmic specification yields better results in terms of significance of the estimated parameters. It has the added advantage that the coefficients are interpreted as demand elasticities, [Houthakker et. al. (1974)].

$$\eta_{\log p} = \lambda c/\lambda \qquad (7)$$

$\eta_{\log y}$ is the long run income elasticity of gasoline and $\eta_{\log p}$ is the long run price elasticity of gasoline demand [Beaton et. al. (1982); and Bohi (1981)].

Gasoline is a superior good for a developing country like Pakistan. Therefore, the income elasticity is expected to be greater than unity. The value of the price elasticity is difficult to determine *a priori*. It depends on how the price of gasoline is regulated in Pakistan and how it responds to pricing policy of OPEC.

II. Data

In this study gasoline demand is estimated with annual data from 1960 to 1981. The gasoline demand is measured in per capita BTU per year for the national and urban sector of the economy. National per capita consumption of gasoline is calculated by dividing total consumption of gasoline by total population. Urban per capita consumption of gasoline is estimated by dividing total consumption of gasoline by total urban population.[5] Figures for urban population for 1961, 1972 and 1981 are obtained from the Censuses. For the inter-censal periods, figures are estimated by multiplying the population of urban sector of Pakistan by its annual average compound growth rate of 5 per cent for 1961 to 1972 and 4 per cent for 1972 to 1981. For further explanation see Government of Pakistan (1982). Income is expressed in real per capita rupees per year and is measured for the urban sector and the total economy. Urban per capita income is estimated by dividing total urban GNP by total urban population. Urban GNP is computed by subtracting agricultural income from total GNP (1959-60 = 100). Real national per capita income (1959-60 = 100) is taken from Government of Pakistan (1982). The price of gasoline is measured in rupees per mm BTU. It is converted into real terms by deflating the price of gasoline by the consumer price index based on 1959-60 = 100. Price of gasoline refers to prices paid by the consumer at the gas station. Data for prices and total consumption of gasoline are obtained from the Government of Pakistan (1979); and (1981). Data for population, GNP and wholesale consumer price index are taken from Government of Pakistan (1982).

III. Regression Results

Per capita gasoline consumption is estimated by the Ordinary Least

[5] Data on seperate consumption of gasoline between the urban and rural sector is absent. It should not affect the estimates, for all gasoline is consumed in urban areas where networks of roads and highways are developed.

Squares (OLS) technique.[6] The regression results show that signs of income and price coefficients (elasticities) are consistent with economic theory. The long-run income elasticity is greater than unity (2.21) as expected.[7] Its value is relatively higher than that found in similar studies for developed

TABLE 1

Regression results of gasoline demand in Pakistan, 1961-81

Independent Variable	Coefficient	t-value*	R^* and F-ratio	h-stat and DW	Long-run Elasticity
OLS:					
Constant	−1.11	0.63	$R^2 = 0.86$	h-stat = 2.05	Income = 2.13
Income	0.27	1.93	F (3/17) = 38.0		
Price	−0.10	−1.42			Price = − 0.77
Lag. Var.	0.87	5.55			
GLS:					
Constant	0.48	0.22	$R^2 = 0.77$	DW = 2.0 (p = 0.13)	Income = 2.21
Income	0.33	2.00	F (3/17) = 19.0		
Price	−0.11	−1.14			Price = − 0.73
Lag. Var.	0.85	3.74			

* The t-value is significant at 0.05 level for income, 0.10 level for price in OLS and 0.15 level for price in GLS. The t-value for lagged variable is highly significant.

[6] It is generally considered that private autos are common features of cities. This is because roads and highways are well developed in cities, maintenance and service stations are at hand, residential and working areas are generally located at travelling distances, and the level of income is sufficiently high to maintain private autos and hire taxi services. Therefore, we also estimated the urban per capita gasoline demand with urban per capita income and price of gasoline as explanatory variables. The results are not very different from the estimates obtained from national per capita gasoline demand. The regression results are given below:

$$\text{OLS:}\quad \underset{\text{(t-value)}}{\log G_t} = \underset{(0.65)}{-1.10} + \underset{(2.31)}{0.28 \log Y_t} - \underset{(1.55)}{0.11 \log P_t} + \underset{(5.54)}{0.89 \log G_{t-1}}$$

$$R^2 = 0.88 \qquad F\,(3/17) = 42 \qquad \text{h-stat.} = 2.07$$

$$\text{GLS:}\quad \underset{\text{(t-value)}}{\log G_t} = \underset{(0.29)}{0.63} + \underset{(2.43)}{0.34 \log Y_t} - \underset{(1.27)}{0.21 \log P_t} + \underset{(3.60)}{0.77 \log G_{t-1}}$$

$$R^2 = 0.77 \qquad F\,(3/17) = 20 \qquad DW = 1.99 \quad (\hat{\rho} = 0.12)$$

Since the choice of measures to calculate urban per capita demand and urban per capita income were arbitrary, we preferred to use national per capita consumption of gasoline for the analysis.

[7] Unfortunately, studies on gasoline demand of developing countries are not available for comparison. Using the translog cost function, Uri (1979) has estimated the own- and cross-price elasticities of energy demand for five different sectors of India. The own-price elasticity of demand for the total petroleum products in the transport sector is reported as −0.10.

countries [Bohi (1981)].[8] This difference can be explained from the theory of consumer preference. Due to the wider choice of goods and services, including automobiles, in rich countries, the services of automobiles may be considered a necessity. For a developing country like Pakistan, automobiles are luxury items. Therefore, we would expect that the income elasticity would be relatively higher in Pakistan than in developed countries [Pindyck (1979)].

The price elasticity is small in magnitude and is statistically not very significant. This may be due to the fact that the price of gasoline is con-

TABLE 2

Consumption, income and price of gasoline in Pakistan, 1960-81

Years	Per Capita (National) Consumption of Gasoline in BTU	Per Capita (Urban) Consumption of Gasoline in BTU	Per Capita Real (National) Income in Rs. (1959-60 = 100)	Per Capita Real (Urban) Income in Rs. (1959-60 = 100)	Real Price of Gasoline in Rs./mm BTU (1959-60 = 100)
1960	16271	74008	373.15	918.38	0.194
1961	17057	76359	381.47	962.11	0.186
1962	17190	75933	393.08	976.95	0.189
1963	17334	75614	409.16	1017.93	0.189
1964	18528	79806	423.81	1070.98	0.180
1965	19842	84389	450.13	1152.75	0.172
1966	20198	84838	470.88	1242.98	0.168
1967	20873	86704	471.85	1214.86	0.197
1968	19541	80286	490.26	1213.85	0.206
1969	19965	81147	507.32	1257.67	0.205
1970	21031	84548	541.67	1330.91	0.203
1971	22354	88910	526.29	1304.92	0.210
1972	22213	87389	519.15	1259.13	0.241
1973	21591	84045	542.00	1344.81	0.249
1974	20604	79300	566.74	1416.27	0.255
1975	21663	82514	572.91	1462.69	0.257
1976	22155	83479	580.86	1466.75	0.254
1977	22790	84990	585.89	1474.05	0.262
1978	26330	97138	627.79	1615.41	0.249
1979	29039	106104	642.72	1651.36	0.248
1980	30247	109459	667.77	1701.22	0.288
1981	32663	116997	681.85	1727.15	0.310

Source: Government of Pakistan (1979); (1981); and (1982).

[8] The long-run income elasticities vary from 0.72 in studies done by Adams and others (1974), on the pooled data (1955-1969) of OECD countries to 1.74 in a study done by Kouris (1978), on the pooled data (1956-1973) of EEC countries.

trolled in Pakistan. This limits the movement of the price variable in the regression equation. Secondly, the price of gasoline for most of the estimation period remained constant or declined slightly in real terms. This reduces the effectiveness of regression estimation in producing significant parameter estimates. The price elasticity is generally close to the values reported for developed countries, though its value is expected to be relatively small for Pakistan, because at low levels of income most energy is consumed as a necessity and as income grows, the additional use of energy becomes more discretionary.[9] Therefore, at a high level of income, there would be greater substitution from one form of energy to another due to changes in relative prices. This would produce a high price elasticity of demand for energy. But with the present state of technology, there is little room for substitution away from gasoline in either the developed or under developed countries. Therefore, the price elasticities are not expected to be different [Burright and Enns (1975)].

The value of the adjustment coefficient, λ is low (about 0.15).[10] This implies that there is large difference between the actual and the desired quantity of gasoline demand in Pakistan. In other words, the rate of addition of automobiles is very slow and owners of automobiles like to hold on to the existing stock. This can be explained by the following facts. The income in Pakistan has not increased to the level that the owners of the old stock can switch easily to new automobiles. There are restrictions on imports of automobiles and about 150 per cent duty is levied on the value of each import. Adequate repair facilities are available in urban areas and spare parts are locally manufactured. The discounted value of total cost of repairs and maintenance of vehicles usually appears less than the cost of new automobiles. Therefore, it is economical for automobile owners to hold on to the existing stock.

The use of OLS for estimating the gasoline demand model may be criticised on the following grounds: first, the presence of a lagged dependent variable on the right hand side of the equation results in interdependence of the lagged variable with the error term. As a result estimates produced

[9] The price elasticity varies considerably for studies of gasoline demand in the United States. The long-run price elasticity ranges from −0.24, estimated by Houthakker et. al. (1974), to −1.50, estimated by Griffin (1979). The long-run price elasticity is reported as −0.40 in the study done by Adams et. al. (1974), on OECD countries and −0.76 in the study done by Kouris (1978), on the EEC countries.

[10] The per capita consumption of gasoline increased at a subtantially higher rate, 8.1 per cent per annum between 1976 and 1981 as compared to 1.9 per cent per annum between 1960 and 1976 – suggesting varying λ between the two periods. The varying value of λ was estimated by a dummy variable. The estimated value of the dummy variable was poor and statistically insignificant. Therefore, it was dropped from the present estimation.

by OLS may be biased and inconsistent. Generally for large samples, instrumental variable or error component methods are possible alternative techniques for estimation [Koutsoyiannis (1973)]. With cross-section and time series data of more than 100 observations, Balestra and Nerlove (1966) and Houthakker and others (1974) have estimated the demand for natural gas and gasoline with the error component method. The estimates obtained from the error component method were found to be statistically superior to the OLS estimates. We used the instrumental variable method to estimate the gasoline demand equation.[11] However, the parameters produced by this method were statistically less satisfactory than the OLS estimates.[12] This was due to the large standard errors of the parameter estimates, perhaps resulting from low correlations of the instrumental variables with the regressors. Moreover, the three lagged values of regressors, used as instrumental variables, were estimated with 19 observations. Thus there was a problem of lack of degrees of freedom [Koutsoyiannis (1973)].

The second problem with the OLS estimation technique is that the regressor lagged dependent variable makes the DW test for serial correlation invalid. Durbin has proposed an alternative test, known as the Durbin h-test. The value of the h-statistic obtained suggests the presence of first-order serial correlation at the 5 per cent level of significance.[13] To make the parameter estimates more reliable, equation (5) is estimated using the Generalised Least Squares (GLS) method.[14] The GLS estimation corrected the serial correlation and improved the t-value of the income elasticity estimates. However, it reduced the statistical significance of price elasticity, which is not unexpected in the presence of price regulation and reasons stated earlier.

IV. Conclusion

The income and price elasticities estimated in this study are general indicators rather than exact estimates, as these are based on a relatively

[11] The error component method has restricted application to pooled time series cross-section data, [Balestra and Nerlove (1966)].

[12] Lagged values of income and price were used as instruments to estimate the parameters under the instrumental variable method. The number of lags was decided on the basis of improvement in the fit as additional lagged values of the explanatory variables were introduced, [Koutsoyiannis (1973)].

[13] The values of h-statistic correspond to the standardized normally distributed Z-table. We accept the hypothesis that the disturbances are free of first-order correlation at the 5 per cent level of significance when the calculated value of h-statistic lies between ± 1.95, [Dutta (1975)].

[14] The residuals are modelled as an autoregressive process of order one.

simple model of demand. Nevertheless, these results coupled with the other considerations discussed earlier, seem to indicate that the market may be better able to deal with the allocation of gasoline on efficiency grounds.

The price of gasoline appears inelastic, even in the long run. Therefore, a substantial increase in price is necessary to have any marked effect on demand. Such policy may, however, lead to a redistribution of income without decreasing the consumption of gasoline. Generally there is limited substitution in gasoline use. But large price differentials between different fuels may lead to substitution in fuel use by making minor modifications in motor vehicle engines. For example, with slight modification, LPG can be substituted for gasoline in spark ignition engines and kerosene can be used to adulterate gasoline [such cases have been reported in Pakistan [World Bank (1980)]].

Income appears as an important determinant of gasoline use in Pakistan. The estimates show that quantity of gasoline increases at a rate of more than twice the rate of growth of GNP. The real per capita income is projected to rise at 3.2 per cent annually in the 1980s [Government of Pakistan (1978)]. Therefore, we would expect a substantial increase in the demand for gasoline during the decade. The government can help in fulfilling the growing demand of gasoline by raising its domestic production through tax rebate and other investment incentives.[15] To suppress the demand for gasoline in Pakistan, the government is already regulating the price of gasoline by imposing various taxes. The tax revenue collected from the gasoline sale are used to subsidise other commercial fuels, such as kerosene. The import of automobiles is also restrained by quotas and tariffs [World Bank (1980)]. Such restrictive measures may, however, lead to increased adulteration of gasoline and black markets in automobiles. These unintended consequences of price control are well documented in the rent-seeking and black-market literature [Tollison (1982)]. It may behove the policy planners to pay greater attention to market signals, given the results of this and similar studies.

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[15] According to a survey conducted in 1979, 77 per cent of recoverable oil reserves of Pakistan were sitting in ground to be recovered, [World Bank (1980)].

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