Household Demand for Natural Gas in Pakistan

ANEES JAVED*

The roles which energy plays in the life of a nation as well as between nations have increased manifold in the twentieth century. Countries which are generously endowed with energy resources are considered stronger, both economically and politically. The only source of energy which is significantly available in Pakistan *vis-a-vis* her requirements is natural gas. Its use in industrial, commercial and domestic spheres of the economy is gaining increasing popularity. Its demand is rising day by day because of its low price, continuous flow and other advantages which it has over other types of fuels. This paper attempts to look at demand characteristics in the domestic sector of the gas market. This analysis pertains to the Punjab and the NWFP provinces where the Sui Northern Gas Pipelines Ltd. is the sole distributor of gas to domestic consumers.

This study uses time series data for analysis. The figures for gas consumption and income are expressed in per capita terms. This is necessary partly because the underlying theory of consumer choice refers primarily to individuals, and partly because per capita relationships are likely to be more meaningful and stable than relationships between aggregates [6, p. 29]. There are two parts of the study: one is the analysis of yearly data and the other is the analysis of monthly data.

METHODOLOGY AND DATA

In a general demand analysis, one normally looks at the utility which a particular commodity yields. Gas does not yield utility in itself but rather is desired as an input for other processes (or activities). These processes

---

*The author is a Staff Economist at the Pakistan Institute of Development Economics (PIDE) Islamabad. He is grateful to Aly Ercelawn of Quaid-i-Azam University for suggesting this study and for his advice at various stages which he was always willing to give, and to Dennis DeTray, Research Adviser to the PIDE, for his constant guidance and supervision. Thanks are also due to Khalil Hamdani, S.H.H. Naqavi and S.J. Malik, all of PIDE, for their valuable comments on an earlier draft. However, the author alone is responsible for any remaining errors.

utilize a certain capital stock (stoves, water heaters, etc.) and gas provides the energy input. The demand for gas is thus a demand derived from the demand for the output of the process in question [21]. For a fixed stock of appliances, variation in the demand for gas takes place owing to a variation in the intensity of the use of those appliances. The intensity of the use depends upon, among other things, income, price of gas and the price of substitute fuels available. But once an appliance is installed in a house, the household has a smaller degree of choice between fuels. The consumer in such cases cannot generally switch to alternative fuels without undertaking an additional investment. Hence in the case of gas its own price is the only relevant price [2, p. 36].

Apart from these "economic" variables, there are many other variables which can influence the consumer's demand but cannot be quantified. The influence of these variables is taken into account by introducing a trend variable, T, in the model [7, p. 271]. Our demand function is, therefore, of the form:

$$\frac{G}{N} = \frac{G}{N}\,(Y, P, T)$$

where

G = Total amount of gas consumed,
N = Total number of gas connections,
Y = Per capita income,
P = Price of gas, and
T = Time trend.

But the phenomenon of pricing gas, unlike that of other consumer goods, is not a simple one. The consumer does not face a single price but rather a minimum charge for gas plus a running charge. The pricing structure is like a two-part tariff [22, p. 89]. Every consumer who pays the minimum charge is entitled to consume the gas up to g^*. When his consumption increases beyond g^*, he is charged a certain price, P, per additional cubic foot.

Once a consumer pays the minimum of fixed charge, he is left with Y of his income to be spent on gas and other commodities.

The consumer's budget line [4, p. 14; 22, p. 78] is given by:

$$(\bar{g}).\ P+\bar{Y} = M-F \qquad (\text{if } g>g^*, \text{ i.e. } \bar{g}>0)$$
$$\text{and} \quad Y = M-F \qquad (\text{if } g=g^*)$$

where

p = Price of gas per cubic foot,

g = Amount of gas consumed,

g^* = Level of gas consumption after which running charge is payable,

$\bar{g}$ = $(g\text{-}g^*)$,

M = Money income of consumer,

F = Minimum charge for gas consumption,

Y = Income left after the payment of minimum charge, and

$\bar{Y}$ = Income spent on goods other than gas.

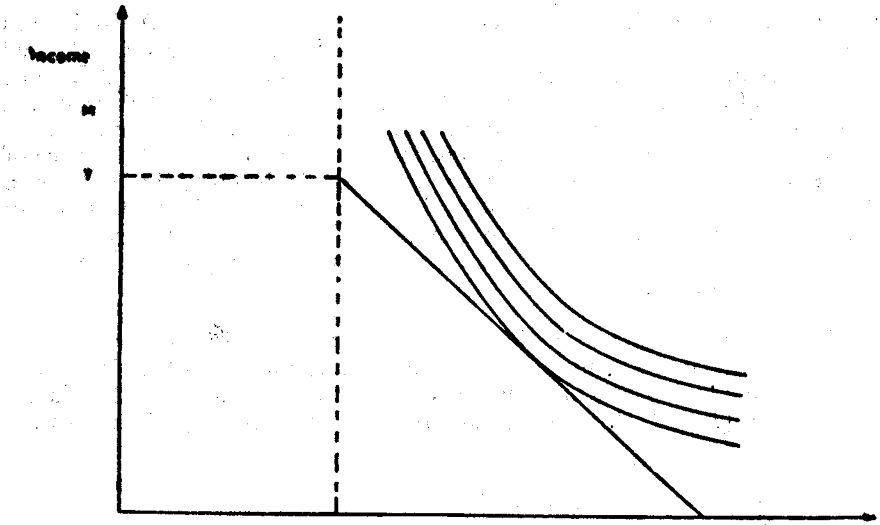

Figure 1
Consumers' Equilibrium

Any change in these charges has different effects on the consumers' welfare. An increase in the fixed charge, F, forces the consumer to move to the lower indifference curve and *vice versa*, thus having an income effect (Fig. 2); and a change in the running charge has both income and substitution effects (Fig. 3); [21].

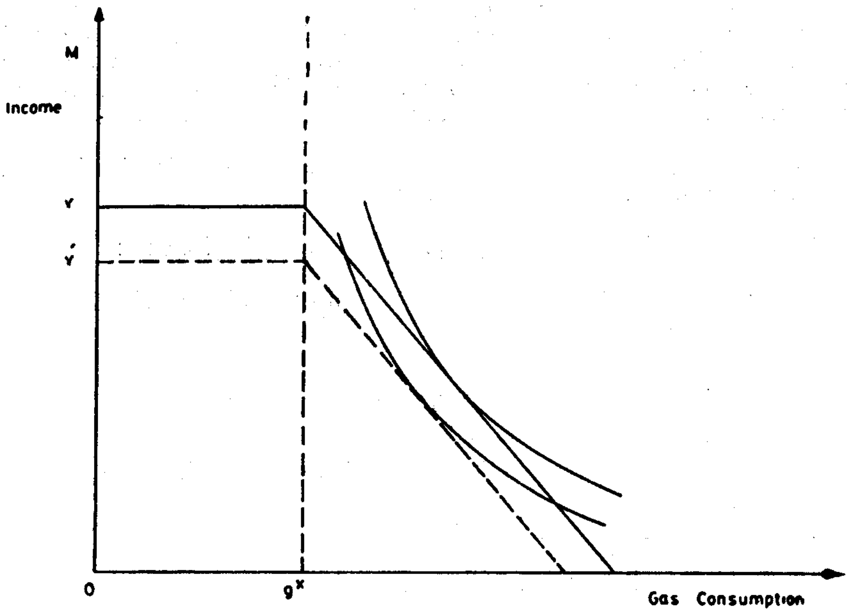

Figure 2
Income Effect Caused by the Change in Fixed Charge

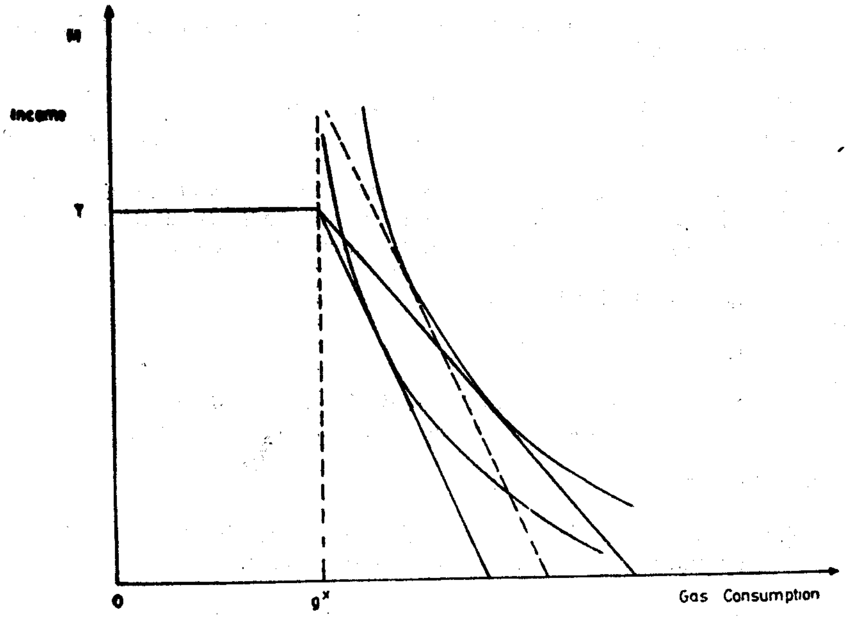

Figure 3

Income and Substitution Effects Caused by Change in Running Charges

The presence of such a price schedule, which is like a two-part tariff, has important economic implications for the gas consumer and for the demand function itself. It is easy to collect average prices and sales per consumer for a number of undertakings, draw a curve through the scatter diagram thus obtained, and call the result a demand curve. But this procedure has no economic significance. The average price under a two-part tariff depends not only on the running charge and the fixed charge, but also on the amount consumed itself, and is, therefore, not an independent variable in the economic or statistical sense [5 p. 360]. Therefore marginal price is used, which determines the amount consumed by making a comparison between the utility of an additional unit of gas and the utility of alternative ways of spending its cost.

Another point of investigation is the effect of temperature on the amount of gas consumed and the effect of room heating on gas demand in the winter season. Gas is used for water heating also. But that is not affected as severely by changes in temperature as room heating. Usually people use gas for water heating throughout the year for dish washing, laundry, etc. Moreover, people who are used to taking baths with hot water use it irrespective of the temperature prevailing. Thus water heating can be taken to be almost as regular a phenomenon as cooking. Its intensity of use might be changing with the change in temperature but its use will not stop when the temperature becomes very high, as room heating does. In the region selected for the study people usually start room heating (for this purpose gas heaters are used) in the month of November and continue doing so till March.

We are thus dividing the whole year into two periods according to the weather conditions, i.e.

(1) Summer: from April to October, and
(2) Winter : from November to March (when room heating starts).

The temperature during November-March period usually remains below 20°C [10]. We are defining another variable to separate the effect of room heating on gas consumption from its other domestic uses.

$$t_r = t \quad \text{for } t \leqslant 20°C$$

and

$$tr = 0 \text{ for } t > 20°C$$

where

t = Average temperature during the month, and
tr = Temperature when room heating commences.

We have two hypotheses to test:

(1) The difference in amount used for room heating between winter and summer is significantly different from zero.

(2) The effect of change in price of gas in winter is significantly different from zero.

To look at the effect of price in winter we define another variable, P. (tr). Thus our demand function is of the following form:

$$g^m = g^m \ [Y, P, t, P. (tr)]$$

As mentioned earlier, this analysis is done for the NWFP and Punjab provinces where Sui Northern Gas Pipelines Ltd. is supplying gas for household consumption and for other uses. The time period covered is 1965-1977, inclusive. The data were obtained from the Directorate of Natural Gas, Government of Pakistan. This was in the form of monthly consumption of the households. The number of consumers in each month was also available. The average per capita consumption for each month was calculated; later the average per capita consumption for the whole year was calculated. The figures for per capita income were taken from the Government of Pakistan publications [9, p. 8; 11, p. 296; 12, p. 178; 13, p. 152]. The figures for the price of gas during different time periods were taken from the official gazettes of the Government of Pakistan [14, p. 547; 15, p. 1739; 16, p. 943; 17, p. 158; 18, p. 645; 19]. The figures for temperature were taken from the publications of the Ministry of Agriculture [10]. The minimum and maximum temperatures during the month for the big cities were available. An average for the month for all these cities was calculated. Price of the gas and the per capita income have been converted into constant prices.[1]

[1]The problem was to find a consumer price index to convert these current figures into constant figures. But, for the whole series a single consumer price index was not available. Different price indices with different base years were available. These were converted into a single base (1961=100) and then the prices and income were deflated by this index.

To define the price variable for the yearly analysis was not simple. The price of gas is regulated by the Government; it does not change in the beginning of the year.[2] It is changed whenever the Government wants to change it. Thus during some months of the year one price is charged from consumers and during the rest of the year another price is charged. The problem was which price to use for which year. This problem was tackled by using the weighted prices[3] for the yearly analysis, which is defined as follows.

$$P = \frac{\sum_{i=1}^{12} G_i^m \; P_i^m}{\sum_{i=1}^{12} G_i^m}$$

where P = Weighted marginal prices,
G_i^m = Marginal quantity consumed by all the households during a month, and
P_i^m = Marginal price during the month.

The weighted price was calculated as follows:

$$g^t = g^f = g^m$$
$$G^m = N \; g^m$$
$$G^m = N \; (g^t - g^f)$$
$$G^m = G^t - N \; g^f$$

where g^t = Total quantity consumed by an average household during a month,
g^f = The quantity for which the average household pays the fixed charge during a month,[4]
g^m = The marginal quantity, or the quantity for which the average household pays marginal charge during a month,

N = The number of households during a month,
G^t = The total quantity consumed by all the households during a month,
G^m = The marginal quantity consumed by all the households during a month.

FACTORS AFFECTING THE GAS CONSUMPTION BEHAVIOUR

For yearly and monthly data different forms of the model have been estimated, using ordinary least-squares method.

For the yearly analysis these forms are:

I $\quad g_y^m = \alpha_0 + \alpha_1 Y + \alpha_2 P + u$

II $\quad g_y^m = \alpha_0 + \alpha_1 Y + \alpha_2 P + \alpha_3 T + u$

---

[2]The year is defined as July-June.

[3]Price means the marginal price.

[4]For some periods a minimum charge and the price per cubic foot of gas were given. For them the fixed quantity was calculated by dividing the minimum charge by the price per cubic foot of gas.

where g_y^m = Marginal quantity consumed by all the household during a year.

The regression results for the two models based on the analysis of yearly data are presented in Table 1, with the standard errors in parentheses. In both the models the consumption of gas rises with an increase in income and falls with a decrease in income. With the price gas consumption has inverse relationship, i.e. it rises with a decrease in price and falls with an increase in price. In the first model the results for income and price are significant at the 95 percent and the 90 percent levels of confidence respectively. In the second model income and price are significant at the 90 percent level of confidence, and the time variable is significant at the 95 percent level of confidence. Based on F-ratio, R^2 and DW, we conclude that most satisfactory results are given by the second model.

Table 1

Income, Price and Time and Household Consumption (Based on Yearly Data)

Coefficient	I	II
Intercept	−7.827 (9.93)	0.224 (5.96)
Income (Y)	0.076* (0.023)	0.0064* (0.0208)
Price (P)	−5.266** (2.345)	−0.633* (1.7)
Time (T)		1.516** (0.343)
R^2	0.54	0.86
F-Ratio	5.396	17.528
D.W	0.86	1 79

*Significant at 90% level of confidence.
**Significant at 95% level of confidence.

For the analysis of monthly data the following forms of the functions have been estimated.

I $g^m = b_0 + b_1y + b_2P$

II $g^m = b_0 + b_1y + b_2P + b_3t$

III $g^m = b_0 + b_1y + b_2P + b_4 t_r + b_5P (t_r)$

The results obtained from an analysis of monthly data are presented in Table 2. In the first model both income and price are having inverse relationship with gas consumption. Income is significant at the 90 percent level of confidence and price is insignificant. In the second model the gas consumption is related positively to income and negatively to the price of gas. Both income and price are significant at the 90 percent level of confidence. Gas consumption increases with a rise in temperature and decreases with a fall in it. The coefficient of temperature is significant at the 99.99 percent level of confidence. In the third form of the model gas consumption increases with a rise in income and decreases with a fall in it. It is related inversely to the price of gas. Both income and price are significant at the 90 percent level of confidence.

Table 2

Income, Price and Temperature and Household Consumption of Gas (Based on Monthly Data)

	I	II	III
Intercept	2.353 (0.792)	2.796 (0.6101)	1.7885 (0.8407)
Income (Y)	−0.00693** (0.0196)	0.0282** (0.0156)	0.00582** (0.0176)
Price (P)	−0.2391* (0.1462)	−0.235** (0.112)	−0.3586** (0.1598)
Temperature (t)		−0.0875*** (0.01)	
Temperature when room heating starts (t_r)			0.0256 (0.0568)
(P) (t_r)			0.01166 (0.0152)
R^2	0.03	0.43	0.29
Ratio	1.952	27.447	10.984
D.W.	0.55	0.69	0.906

*Significant

**Significant at 90% level of confidence.

***Significant at 99.99% level of confidence.

To test our two hypotheses established initially we take the third model which is

$$g^m = b_0+b_2y+b_4P+ b_4t_r+b_5P\ (t_r)$$

Our first hypothesis to be tested is that the difference in the gas consumption during summer and winter is significantly different from zero. The increase in gas consumption due to low winter temperatures gives us this difference and it is denoted by

$$\frac{\partial g^m}{\partial t_r} = b_4+b_5(P)$$

Our hypothesis, thus, becomes

$$H_0 = b_4 + b_5\ (P) = 0$$
$$H_1 = b_4 + b_5\ (P) \neq 0$$

by nothing that

$$\left[\frac{\hat{b}_4 + \hat{b}_5(P)}{S_{b_4} + b_5(P)}\right] \backsim t_{n-k}$$

where

$$S_{b_4} + b_5\ (P) = \sqrt{S^2_{b_4} + S^2_{b_5}\ (P)^2 + 2\ \text{ESt COV}\ (b_4 + b_5)\ (P)}$$

See [8, p. 37]. The hypothesis was tested by applying 't' test. It was noted that $b_4+b_5(P)$, at the 99 percent level of confidence, is significantly different from zero, which implies that the increase in consumption during winter is significantly different from zero, which proves our first hypothesis.

Our second hypothesis is that the effect of price in winter is significantly different from zero. The effect of price in winter is given by

$$\frac{\partial g^m}{\partial P} = b_3+b_5\ (t_r)$$

Our hypothesis is

$$H_0 = b_3+b_5\ (t_r) = 0$$
$$H_1 = b_3+b_5\ (t_r) \neq 0$$

This hypothesis was tested by applying 't' test and it was found that at the 90 percent level of confidence the null hypothesis is true. Therefore we reject the alternate hypothesis and accept the null hypothesis which says that the effect of price on gas consumption in winter is not significantly different from zero.

Price elasticities of gas in the second and third models are −0.7 and −1.0 respectively.

CONCLUSIONS

The foregoing analysis has confirmed that gas consumption, based on both yearly and monthly data, is not affected by the income or price changes. It has, however, been found that gas consumption is very sensitive to changes in temperature—decreases in the latter bring about substantive increases in the former. Price and income, however, remained insignificant in all seasons.

It has also been observed that the average amount of gas consumed per household is rising continuously.

The effect of price on gas in winter, being insignificant, eliminates the possibility of using price as a policy instrument in controlling gas supply.

There are many other factors whose effect on gas consumption needs to be studied; for example, the effect of growing urbanization, intra-regional disparities in living styles, and the size and composition of the family structure.[5]

There is also a need to study in depth the method and level of price fixation, keeping in view the present average consumption per household and the initial investment in order to redetermine the fixed and running charges of gas on a more scientific basis.

REFERENCES

1. Anderson, K.P. "Residential Energy Use: An Econometric Analysis." *The Rand Corporation* (*R*-1297-*NSF*). October 1973.

2. Ercelawn, Aly Alp. "Demand for Electricity." Unpublished Ph.D. dissertation, Vanderbilt University, Nashville (Tenn.) Dec. 1974.

3. Fisher, F.M. and C. Kaysen. *A Study in Econometrics: The Demand for Electricity in the United States.* Amsterdam: North Holland Publishing Co. 1962.

4. Henderson, James M. and Richard E. Quandt. *Micro Economic Theory: A Mathematical Approach.* New York: McGraw-Hill Book Co. Inc. 1958.

5. Houthaker, H.S. "Some Calculations of Electricity Consumption in Great Britain." *Journal of Royal Statistical Society.* Vol. 114, Part III. 1951. pp. 351-71.

6. ———— and Lester D. Taylor. *Consumer Demand in the United States: Analyses and Projections.* (Second and Enlarged Edition.) Cambridge (Mass.): Harvard University Press. 1970.

[5]The effects of these variables on electricity consumption have been studied by Fisher and Kaysen [3] and Anderson [1].

7. Koutsoyiannis, A. *Theory of Econometrics*. London: The MacMillan Press Ltd. 1973.

8. Kmenta, J. *Elements of Econometrics.* New York: The MacMillan Company. 1971.

9. Pakistan. Finance Division. Economic Adviser's Wing. *Pakistan Economic Survey*, 1976-1977. Islamabad.

10. ————. Ministry of Agriculture. *Weather and Crop Report.* (Various Issues).

11. ————. Ministry of Finance. Economic Affairs Division. Central Statistical Office. 25 *Years of Pakistan in Statistics*, 1947-1972. Karachi. 1972.

12. ———— Ministry of Finance, Planning and Economic Affairs. Statistical Division. *Statistical Year Book* 1974. Karachi. 1975.

13. ————. Ministry of Finance, Planning and Economic Affairs. Statistical Division. *Statistical Year Book* 1975. Karachi. 1976.

14. ————. Ministry of Fuel, Power and Natural Resources. (Directorate of Oil Operation). "S.R.O. 134(I)/69". *The Gazette of Pakistan* (*Extraordinary*). June 28, 1969.

15. ————. Ministry of Fuel, Power and Natural Resources. "S.R.O. 1198(I)/73." *The Gazette of Pakistan* (*Extraordinary*). August 15, 1973.

16. ————. Ministry of Fuel, Power and Natural Resources. (Directorate of Oil Operation). "S.R.O. 700(I)/74." *The Gazette of Pakistan* (*Extraordinary*). June 8, 1974.

17. ————. Ministry of Fuel, Power and Natural Resources. (Directorate of Oil Operation). "S.R.O. 146(I)/75." *The Gazette of Pakistan* (*Extraordinary*). Feb. 1, 1975.

18. ————. Ministry of Fuel, Power and Natural Resources. (Directorate of Oil Operation). "S.R.O. 277(I)/76." *The Gazette of Pakistan* (*Extraordinary*). March 25, 1976.

19. ————. Ministry of Industries and Natural Resources. (Natural Resource Division). "S.R.O. 17(R)/67." *The Gazette of Pakistan* (*Extraordinary*). Feb. 8, 1967.

20 ————. Ministry of Petroleum and Natural Resources (Directorate of Gas Operation). "Sale of Sui Nortern Gas Company". (Unpublished data.)

21 Taylor, Lester D. "The Demand for Electricity: A Survey." *The Bell Journal of Economics*. Vol. 6, No 1. Spring 1975. pp. 74-110.

22 Walter, Y.O.I. "A Disneyland Dilemma: Two Part Tariffs For A Mickey Mouse Monopoly." *Quarterly Journal of Economics*. Vol. 85. Feb. 1971. pp. 77-96.