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Estimation of Price and Income Elasticities of Demand for Food Grains in an Economy with Public Distribution Schemes

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I. INTRODUCTION

Agricultural production in India depends upon weather to a great extent and is bound to be so for a long time. According to the National Commission on Agriculture, it will be feasible to irrigate only half of the gross sown area even ultimately. Thus the supply of agricultural commodities, and hence their prices, will be subject to wide fluctuations in the absence of public policies to stabilize consumption and prices.

Prices of agricultural commodities exercise a dominant influence on the behaviour of the overall general price level. For economic and political reasons, stable prices are desirable. Public distribution schemes, procurement prices and buffer-stocks are meant to achieve this goal. To operate these schemes successfully, summary measures of consumers' and producers' behaviour like the price elasticities of demand and supply, income elasticities of demand etc. are necessary.

Estimation of price and income elasticities is a simple exercise under conditions of perfect competetion. Numerous estimates of such parameters exist for the market economies in the West. However, the exercise becomes a little more complicated in the presence of public policies. For instance, if there is total rationing of a commodity, at a fixed price, as was the case for cement until recently, it is impossible to estimate the price elasticity of demand directly. Partial rationing also poses some problems in this respect. With more than one price for a commodity, what is the precise meaning of the terms like 'price elasticity of demand'?

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More than thirty years ago, Tobin and Houthakker (1951) remarked "For better or for worse, controls such as rationing can no longer be regarded as unusual and temporary. If we regard experience under controls as distorted and discard it as irrelevant to our science, we cut ourselves off from a major source of modern empirical material". Later developments in applied econometrics do not appear to have been influenced by this remark. Our knowledge in this direction seems to be almost the same as it was thirty years ago (except for some interesting developments in the general equilibrium theory of rationing).

The purpose of this note is to develop some methods to estimate price and income elasticities of demand for some agricultural commodities when there is partial rationing.

II. CONSUMER DEMAND IN THE PRESENCE OF PUBLIC DISTRIBUTION SCHEMES

In this section, we will study the consumer demend for commodities when some of the commodities are covered by the public distribution schemes. Assume that there are $(k + l)$ commodities, of which 'k' are covered by the public distribution schemes. Consumers are given quotas for commodities available through the public distribution scheme. Wheat, rice and sugar are some of the commodities covered by such schemes. Thus, for example, a consumer can purchase maximum of two kilos of sugar per month at a fixed price in a ration shop. We assume that all commodities can be bought and sold in the open market. However, to begin with, we rule out the possibility of resales of commodities bought in the ration shops. In general there will be two prices for every commodity which is available in the market as well as the ration shop. The open market price of a commodity must be at least as high as its price in the ration shop. The consumer's problem is to choose a bundle to maximise his preference subject to the budget and quota constraints.

We can state this problem formally as follows*. Suppose a consumer has a fixed money income of m Rs., of which $m_0 < m$ is his expenditure on all goods. Let his preferences be given by a utility function 'u'. Let $q = (q_1, q_2, \ldots, q_k, q_{k+1}, \ldots, q_{k+t})$ be the vector of prices in the open market. Prices of commodities sold in the ration shops are given by $p = (p_1, \ldots, p_k)$. For $j = 1, \ldots, k$ let D_j denote the maximum quantity of the jth good which a consumer can buy in the ratioh shop**. Then the

*Consumer behaviour under dual pricing is studied in greater detail in the forthcoming paper by Chetty and Jha (1984).

**If 'y' is a vector, we denote its ith component by y_i.

budget constraint is given by

$$\sum_{i=1}^{k} p_i x_i + \left(\sum_{i=1}^{l} q_{k+i} x_{k+i} \right) + \sum_{i=1}^{k} (q_i - p_i) (\max[\, x_i - D_i, 0]) = m_0. \tag{1}$$

Consider a consumer who does not buy any commodity in the open market, when it is available in the ration shop. Then $x_i \leqslant D_i$ for $i = 1, \ldots, k$. In this case, the constraint (1) reduces to the ordinary budget constraint

$$\sum_{i=1}^{k} p_i x_i + \sum_{i=1}^{l} q_{k+i}\, x_{k+i} = m_0.$$

Otherwise, the budget constraint is non-linear in quantities. Similarly, for a consumer who consumes more than the respective quotas of goods $1, \ldots, k$, the budget constraint (1) can be written as

$$\sum_{i=1}^{k} \{p_i D_i + q_i(x_i - D_i)\} + \sum_{i=1}^{l} q_{k+i}\, x_{k+i} = m_0$$

where D_i and $(x_i - D_i)$ are respectively the rationed demand and the free market demand for good $i = 1, \ldots, k$.

Suppose there are only two goods, say, cloth and wheat, and that wheat is available in the ration shop. The feasible set *abc* of consumer is shown in Figure 1.

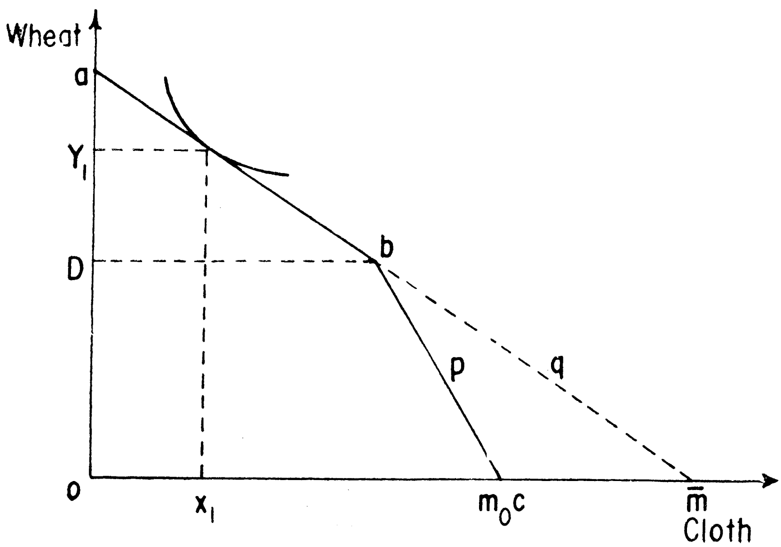

Fig. 1

Consider a consumer buying the bundle (x_1, y_1). The diagram suggests that, if the consumer is given an additional income of $\overline{m} - m_0$ units of cloth and if he is asked to make all his purchases in the open market, he will buy exactly the same bundle (x_1, y_1) which he was demanding under the dual pricing scheme. It is also easily seen from the diagram that this amount is equal to $D(q - p)$. This shows that the ration card is worth exactly $D(q - p)$ units of cloth. It is important to notice that this compensation in income for withdrawing the ration card leaves the consumer in exactly the same equilibrium position as earlier; i.e. his demand for goods remaining unaltered. We can obtain similar compensatory schemes for consumers at other points of the budget boundary. (In standard price theory, when the price of a good changes, we compensate the consumer's income to derive the compensated demand. In this case, the consumer remains on the same indifference curve, but usually demands of different basket of goods). For the sake of simplicity we shall now concentrate on the more interesting case of a consumer buying more than the quotas of goods $1, \ldots, k$.

When many goods are distributed through ration shops, what is the compensation required, if the ration card is to be withdrawn ? Intuition suggests that this amount should be $\sum_{i=1}^{k} D_i(q_i - p_i)$, if the consumer buys some positive amount in all open markets. It turns out that this is exactly the additional income required. (See Appendix I for proof).

Let us define the compensated income $\overline{m}$ as

$$\overline{m}(x, D, p, q) = m_0 + \sum_{i=1}^{k} D_i(q_i - p_i)\, c(x_i, D_i)$$

where

$$c(x_i, D_i) = 1 \qquad \text{if } x_i - D_i > 0, \qquad i = 1, \ldots, k,$$
$$= 0 \qquad \text{otherwise.}$$

Then the following consumer's choice problems have the same solution :

(A) Maximize $u(x)$

subject to
$$\sum_{i=1}^{k} p_i x_i + \sum_{i=1}^{l} q_{i+k}\, x_{i+k} + \sum_{i=1}^{k} (q_i - p_i) \operatorname{Max}(x_i - D_i, 0) \leqslant m_0$$

(B) Maximize $u(x)$

subject to
$$\sum_{i=1}^{k+l} q_i\, x_i \leqslant \overline{m}$$

The second is the standard consumer's choice problem. Let $\phi(p, q, D, m)$ and $\psi(q, \bar{m})$ denote the solutions to problems (A) and (B), respectively. (We assume that the problems have a unique solution). We can make use of the equivalence of the two problems to compute various elasticities. For example, suppose we want to find out the effect of a change in the price q_i on the demand for the jth good. That is, we want to compute the derivative $\partial\phi_j/\partial q_i$ where ϕ_j denotes the jth component of ϕ. Notice that $\phi(p, q, D, m) = \psi(q, \bar{m})$ where $\bar{m}$ is a function of p, q, D and m.
Hence

$$\frac{\partial\phi_j}{\partial q_i} = \frac{\partial\psi_j}{\partial q_i} + \frac{\partial\psi_j}{\partial\bar{m}} D_i, \quad i = 1, \ldots, k \tag{2}$$

Similarly, the effect of changing the quota D_i on ϕ_j is given by

$$\frac{\partial\phi_j}{\partial D_i} = \frac{\partial\psi_i}{\partial\bar{m}} (q_i - p_i), \quad i = 1, \ldots, k \tag{3}$$

These derivatives are easily interpreted. Consider a small increase Δq_i in the price of the good 'i'. For a consumer, who is buying some amount of this good in the open market, this increases the value of the ration card by $D_i\Delta q_i$. The effect of this on the demand for the good 'i' is given by $(\partial\psi_i/\partial\bar{m}) \cdot D_i\Delta q_i$. This term is in general positive. The direct effect of the increase in the own price on the demand for the good is approximately. $(\partial\psi_i/\partial q_i)\,\Delta q_i$. In general, this term is negative. Hence the total change in the demand for good 'i' is given by

$$\Delta\phi_i \simeq \frac{\partial\psi_i}{\partial q_i} \Delta q_i + \frac{\partial\psi_i}{\partial\bar{m}} D_i\Delta q_i$$

i.e.

$$\frac{\Delta\phi_i}{\Delta q_i} \simeq \frac{\partial\psi_i}{\partial q_i} + \frac{\partial\psi_i}{\partial\bar{m}} D_i.$$

Taking limits, we have

$$\frac{\partial\phi_i}{\partial q_i} = \frac{\partial\psi_i}{\partial q_i} + \frac{\partial\psi_i}{\partial\bar{m}} D_i$$

which is equation (2). Since the terms on the right hand side are of opposite signs, the sign of $\partial\phi_i/\partial q_i$ is indeterminate, *even if the good is* normal (i.e. positive income elasticity for the compensated demand ψ_i). Hence the free market demand for a good, which is also distributed through the public distribution scheme, may increase with the increase in its free market price. However, this is quite unlikely. For converting the above equation into elasticities, we have,

$$\frac{q_i}{\phi_i}\frac{\partial \phi_i}{\partial q_i} = \frac{q_i}{\phi_i}\frac{\partial \psi_i}{\partial q_i} + \frac{\overline{m}}{\phi_i}\frac{\partial \psi_i}{\partial \overline{m}}\frac{q_i D_i}{\overline{m}}.$$

Suppose the price elasticity of compensated demand is —.4 and the income elasticity is around .5. The term $q_i D_i/\overline{m}$ represented the fraction of compensated consumption expenditure needed to buy the ration quota at open market prices. A rough estimate of this for foodgrains will be around 5% (15 million × 3000 Rs/84000 crores). Hence the price elasticity will be around —.375.

Similarly, if the quota for the ith good is increased by ΔD_i, then the compensated income increases by $\Delta D_i(q_i - p_i)$. The effect of this on good 'j' is approximately given by

$$\Delta\phi_j = \frac{\partial \psi_j}{\partial \overline{m}} \Delta D_i(q_i - p_i).$$

Hence

$$\frac{\Delta\phi_j}{\Delta D_i} = \frac{\partial \psi_j}{\partial \overline{m}} (q_i - p_i)$$

which again agrees with (2). Converting it into elasticities, we have,

$$\frac{D_i}{\phi_j}\frac{\Delta\phi_j}{\Delta D_i} = \frac{\overline{m}}{\phi_j}\frac{\partial \psi_j}{\partial \overline{m}} D_i \frac{(q_i - p_i)}{\overline{m}}.$$

The term $D_i(q_i - p_i)/\overline{m}$ represents the share of subsidy for the ith good in the total expenditure and is very small.

From our analysis, it is clear that the change in the usual specification of the demand functions due to the presence of public distribution schemes is to use the compensated income instead of the actual income. But this compensation is a very small fraction of the expenditure. One may be tempted to argue that this change will not have any significant effect on the estimates of the parameters. This will indeed be the case, if all the assumptions we have made to calculate the partial derivatives are true.

We will now examine this in some detail. Let the total demand by the consumer for the ith good $\phi_i(p, q, D, m)$ be written as

$$\phi_i(\cdot) = F_i(\cdot) + D_i$$

where $F_i(p, q, D, m)$ is the demand for the ith good in the open market. Then,

$$\frac{\partial \phi_i}{\partial q_i} = \frac{\partial F_i}{\partial q_i}$$

This means that we can use either the total demand or the free market demand to study the effect of a change in the open market price. In other words, in a multiple linear regression model of demand, the partial regression coefficient of the open market price is the same, whether we use the total or free market demand. However this conclusion is crucially dependent on the assumption that the variations in D_i are independent of the variations in q_i. In practice, at times of drought, the open market price rises. To keep this rise under control, greater quantity of this good is released through the ration shop. Of course, the increase in such release is generally not adequate to compensate for the draught. Thus one would expect D_i to increase when q_i increases. Then,

$$\frac{\partial \phi_j}{\partial q_i} = \frac{\partial F_i}{\partial q_i} + \left(\frac{\partial F_i}{\partial D_i} + 1 \right) \frac{\partial D_i}{\partial q_i} .$$

When the *i*th good is normal, $\partial \phi_i / \partial D_i$ will be positive. This means that $(\partial F_i / \partial D_i) + 1 > 0$. What can be say about the sign of $\partial F_i / \partial D_i$? Suppose the ration quota of wheat is increased by a kilo per month per person. This is equivalent to an increase in income of the consumer. Hence, if wheat is a normal good, the total demand for wheat will increase. But the question is whether it will increase by more than a kilo. With an increase income of one kilo of wheat, if the total demand for wheat goes up by more than a kilo, the demand for one or more goods must decrease. That is, there must be one or more inferior goods. In that case, $\partial F_i / \partial D_i$ will be positive. Otherwise, it will be non-positive. It is generally observed that consumers do switch from inferior cereals to wheat and rice as income increases. Hence, it is quite possible that $\partial F_i / \partial D_i$ is positive. Also, $\partial D_i / \partial q_i$ will be usually positive, while $\partial F_i / \partial q_i$ will be negative. Thus, the use of total demand in place of the free market demand will result in an under estimate of the magnitude of the price elasticity. The price elasticity will be an over estimate and may turn out to be zero or even positive. But this really depends upon the magnitudes of the income elasticity and the response of quotas to change in the open market price, which are empirical questions. We cannot argue on theoretical grounds that $(\partial F_i / \partial D_i)$ $(\partial D_i / \partial q_i)$ will be small.

By similar reasoning, we can determine the effect of a change in income on the total demand for a commodity. We have,

$$\frac{\partial \phi_i}{\partial m} = \frac{\partial F_i}{\partial m} + \sum_{j=1}^{k} \frac{\partial F_i}{\partial D_j} \frac{\partial D_j}{\partial m} + \frac{\partial D_i}{\partial m} .$$

At the aggregate level, when the income decreases, as at the time of a drought, the releases through public distribution schemes must, and often do, increase. This suggests that the partial derivative $\partial D_i/\partial m$ must be negative for all i. Hence, the income elasticities may be under estimates, when the total demand is used as a dependent variable.

The commodities distributed through the public distribution schemes are in general not substitutable. One may question this assumption with respect to some commodities like wheat and rice, but, even in this case, we are not sure whether they are really substitutes. (A Tamil or a Bengali may not substitute rice by wheat under most circumstances). Thus one would expect $\partial D_j/\partial q_i = 0$ for $j \neq i$. This means that the estimates of cross-price effects are not affected by using the total demand instead of the free market demand, i.e., $\partial \phi_i/\partial q_j = \partial F_i/\partial q_j$.

III. SOME EMPIRICAL RESULTS AND THEIR INTERPRETATIONS

In the previous section, we analysed some of the behavioural implications of a consumer when there are public distribution schemes for some commodities. By using micro-data, we can test the validity of these implications. Since such data are not readily available, we have to make use of the aggregate data for our analysis. We assume that the demand functions studied relate to a representative consumer and that the same results hold for the aggregate demand functions.

(a) *Wheat*

Suppose the demand functions are linear. Let

$$y_t = a + b\, q_t + c\, m_t$$

where

y_t = aggregate (total) demand for wheat in thousand tonnes
q_t = retail price of wheat in Rs./Quintal
m_t = personal disposable income at current prices in crores of rupees.

The subscript 't' refers to the time period.

Using the data for the period 1961-62 to 1978-79, (see Appendix 2 for the exact sources of the data), the following demand function was estimated by the method of least squares* :

$$y_t = 15917.29 + \underset{(.84)}{31.15}\, q_t + \underset{(3.3)}{.213}\, m_t \qquad R^2 = .73$$

$$D.W. = 1.52$$
$$D.F. = 15$$

*Figures within parenthesis are 't'-values.

The elasticities at the mean are :

$e_q = .13$ and $e_m = .29$.

A positive price elasticity of demand for wheat seems quite unreasonable. Earlier we argued that the use of total demand instead of free market demand can lead to over estimates of price elasticities and under-estimates of income elasticities. When the aggregate free market demand is used as the dependent variable, we have the following demand functions :

$$F_t = 13502.64 - \underset{(-.26)}{7.92\, q_t} + \underset{(4.52)}{.241\, m_t} \qquad \bar{R}^2 = .76$$

$$D.W. = 1.3$$
$$D.F. = 15$$

The elasticities at the mean are

$e_q = -.04$ and $e_m = .42$

The price elasticity has the right sign, though not statistically significantly different from zero. The income elasticity has increased considerably. Thus, ignoring the existence of a public distribution scheme appears to effect the elasticity estimates even to the extent of reversing the sign. It should be noted that the wheat distributed through the ration shops is approximately 21% of total consumption (average for the period). This is certainly not an insignificant amount to be ignored.

We argued in the previous section that the total demand for wheat is a function of the free market price of wheat, the compensated income and the price of substitutes, say rice. A linear approximation to this function is

$$y_t = F_t = D_t = \alpha + \beta q_t + \gamma ma_t + \delta r_t$$

where y_t and F_t are as defined before and

GW_t = public distribution of wheat in thousand tonnes

GR_t = public distribution of rice in thousand tonnes

r_t = retail price of rice in rupees per quintal

p_t = ration price of wheat in rupees per quintal

s_t = ration price of rice in rupees per quintal

ma_t = compensated imcome

$$= m_t + GW_t(q_t - p_t) + GR_t(r_t - s_t).$$

Hence, we have,

$$F_t = \alpha + \beta q_t + \gamma ma_t + \delta r_t + \mu^*$$

The estimated demand function is :

$$F_t = 9899.7 - \underset{(-2.48)}{116.684\, q_t} + \underset{(2.86)}{.173\, m_t} + \underset{(2.35)}{108.34\, r_t} + \underset{(2.2)}{.54\, GW_t} \quad \bar{R}^2 = .83$$

$$D.W. = 1.8$$
$$D.F. = 13$$

The elasticities at the mean are :

$$e_q = -.609$$
$$e_m = .302$$
$$e_r = .538$$
$$e_D = .314$$

All the coefficients are significantly different from zero at the 5% level. The coefficients of price and income variables have the right signs. Wheat and rice are substitutes and hence we would expect the cross-price elasticity to be positive. It is indeed the case. The income elasticity is slightly larger with the inclusion of '*I*' and '*D*' than our initial estimate of .29 for the total demand, In the previous section, we argued that the estimated price elasticities for the total demand will have a positive bias, if $\partial y/\partial GW$ and $\partial GW/\partial q$ are both positive. We notice that $\partial y/\partial GW = .54$ and significantly different from zero. Also the simple correlation coefficient between GW_t and q_t for the period 1961-78 is .64. This is significantly different from zero ($t = \sqrt{n-2}\, r/\sqrt{1-r^2} = 3.33$). Thus the results are consistent.

Our estimate of the income elasticity is smaller than th estimates available in the literature. This could be due to two reasons : 1. Neglecting the impact of the public distribution schemes ; 2. Use of real income instead of money income. With respect to the first reason, there is no doubt that the right dependent variable is the free market demand. As regards the income variable, first we notice that an 1% increase in real income will lead to a larger increase in the quantity demanded than that associated with an 1% increase in nominal income. Thus the elasticity of demand with respect to nominal income will be smaller. But the question is : what is the correct income variable to be used in the demand functions ? One of the reasons for using real income is related to the proposition that

*We also estimated the demand functions using the per capita consumption and income and also a log-linear model. The results for the per capita variables were not satisfactory while the results for the log-linear model were similar to the linear model.

demand is homogeneous of degree zero in prices and money income. But this proposition is not quite true. The homogeneity postulate implies the absence of money illusion. Naturally, the standard theory of the consumer must relate to a monotary economy. Each consumer is assumed to have a fixed money income. Once we recognize the existence of a fiat money, it is difficult to avoid the complications due to expectations of prices in future. Thus it is not possible to prove the homogeneity proposition in a monetary economy without serious restrictions on expectation formation or savings behaviour (like zero elasticity of savings with respect to commodity prices). This has been very well brought out in the literature on Temporary General Equilibrium Theory (See e.g. Grandmont (1974)). Thus we do not see any reason why we should use necessarily the real income. The effects of prices are taken into account when the relevant prices are included. Moreover, empirical evidence is also not in favour of the homogeneity hypothesis (See e.g. Barten (1977), Deaton (1979)).

We conclude our discussion of the demand for wheat with a brief review of the literature. The National Council of Applied Economic Research conducted an all India expenditure survey in 1964-65 and used this data to estimate the income elasticities for various commodities. They found that the income elasticity of demand for wheat ranges from .25 to .48. These estimates are derived from a linear regression of the per capita consumption of the commodity on the average monthly income of the consumption unit and other characteristic of the family like the level of education attained by the head of the family. Iyengar (1967) used the N. S. S. data relating to the period December 1955 to May 1956 and found the income elasticity for urban areas to be .737 and rural areas to be 1.576. These estimates certainly appear to be rather high. It is difficult to believe that wheat is a luxury.

(*b*) *Rice*

The average distribution of rice during the period 1961-78 is 40.5 million tonnes, of which approximately 3 million tonnes (7.5% of total demand) were distributed through the fair price shops. Thus the impact of public distribution schemes is likely to be much less for rice than for wheat.

The least squares estimates of the log-linear relations are the following:

$$\log R_t = 7.63 - \underset{(-2.6)}{.3886} \log r_t + \underset{(4.3)}{.4579} \log m_t \qquad \bar{R}^2 = .74$$

$$D.W. = 1.93$$
$$D.F. = 15$$

where

R_t = total demand for rice in thousand tonnes at time t and r_t and m_t are as defined earlier. The price and income elasticities have the correct sign and are significantly different from zero, even when we ignore the effect of public distribution schemes. When the dependent variable is replaced by the free market demand for rice, we have the following :

$$\log FR_t = 7.47 - \underset{(-2.73)}{.5023} \log r_t + \underset{(3.96)}{.5167}\, m_t \qquad \bar{R}^2 = .63$$

$$D.W. = 1.72$$
$$D.F. = 15$$

where

FR_t = free market demand for rice in thousand tonnes at time 't'. Again, as expected the estimate of the own price elasticity is smaller and the income elasticity larger. But $\bar{R}^2$ is lower and the Durbin-Watson statistic lies in the indecisive region, indicating possibly some misspecification or auto-correlation. Inclusion of the quantity distributed through the ration shops, GR_t, measured in thousand tonnes, results in the following equation :

$$\log FR_t = 8.19 - \underset{(-1.78)}{.3234} \log r_t + \underset{(4.1)}{.480} \log m_t - \underset{(-2.25)}{.147} \log GR_t$$

$$\bar{R}^2 = .76$$
$$D.W. = 1.9$$
$$D.F. = 14$$

While there is some effect on the estimates of elasticities due to the omission of public distribution of rice, it is not as serious as in the case of wheat. This is understandable in view of the smaller fraction of rice distributed through the ration shops. The coefficient of the retail price of wheat is negative but not statistically significantly different from zero, suggesting that wheat is not a substitute for rice.* Our results for wheat suggest the contrary. This may appear to be contradictory at first sight. But then it should be kept in mind that wheat is mainly consumed in the north, and rice in the south. The demand functions refer to different groups of consumer. It is not surprising that consumers of wheat substitute it to some extent by rice, while the consumers of rice do not.

In the N.C.A.E.R. (1962) study, the income elasticity of rice was found to range from .19 to .28. Iyengar (1967) estimated this elasticity to be .631 for rural consumer and .227 for the urban. The weighted

*The results of this regression are not reported here.

average of these estimates; with weights proportional to population, will be around .5, which is close to our estimated.

As in the case of wheat, the regressions involving per capita variables give very low $\bar{R}^2$.

(c) Cereals

Linear and log-linear demand functions for cereals were estimated using personal disposable income and retail price index of cereals as explanatory variables. The estimated demand function is :

$$\log C_t = 5.72 - \underset{(-2.1)}{.255} \log PC_t + \underset{(5.0)}{.428} \log m_t \qquad \bar{R}^2 = .89$$

$$D.W. = 1.57$$
$$D.F. = 15$$

where

C_t = Expenditure on cereals and substitutes in 1970-71 prices in Rs. Crores.

PC_t = Retail Price index of cereal.

For the linear demand function, the coefficient of price is negative but not significantly different from zero ($t = -1.6$) while the income coefficient is positive and significant ($t = 2.35$). Similarly, the use of per capita variables resulted in low R^2 and insignificant coefficient for price.

One may like to compare these elasticities with the elasticities of individual commodities like wheat and rice. What can we say in general about the relation between the elasticities for individual commodities and the elasticity for a group ? Consider, for example, the price elasticity. For a commodity like wheat, there are good substitutes and hence if the price of wheat increases, its demand will go down due to the substitution effect. For broad commodity groups like food, clothing, such substitutions are not possible. Hence one would expect the price elasticity for the group to be smaller in magnitude than those of individual commodities. But this will depend very much upon the type of aggregation of commodities and prices. It is not easy to derive a simple relation between these elasticities.

In the case of cereals, the price elasticity, −.255, is smaller in magnitude than those of wheat and rice, −.609 and −.3234. The N. C. A. E. R. study has estimated the price elasticity as −.37 and the income elasticity as .616. The same study has also estimated the range for income elasticity to be .11 to 19 using cross-section data. Iyengar (1967) found the estimate of income elasticity to be .595 for the rural consumers and .319 for the urban.

(d) *Major Commodities and Services*

Using the time series data on private final consumption expenditure in the domestic markets for major goods and services reported in the National Accounts Statistics for the years 1961-78, several demand functions have been estimated. The dependent variable is taken as the consumption expenditure in 1970-71 prices. The implicit retail price index is derived by dividing the expenditure in current prices by the expenditure in constant prices and multiplying by 100. The price index for 1970-71 is taken to be 100. Linear and log-linear regressions were estimated using the own price index and personal disposable income as explanatory variables. The best of the two in terms of, signs of coefficients, *t*-values and $\bar{R}^2$ are reported in Table 1.

We can make some general observations in these regressions. In most cases, there is some evidence of serial correlation, indicating possibly some specification error. The price and income elasticities have the expected signs and are mostly statistically significantly different from zero and the values of $\bar{R}^2$ are high:

The coefficients of price for fuel and power, salt, edible oils, and domestic services are not statistically significantly different from zero. That the demand for salt does not change with a change in its price is only to be expected. The inelasticity of domestic services with respect to price is also understandable, since the major cost of domestic services are in real terms like providing food, clothing and shelter. Also the consumers of these services belong to the supper income class and are not likely to be affected by such increases in prices. The case of fuel and power is somewhat puzzling. Neither the income nor the price elasticity is significantly different from zero. The variation in the dependent variable is somewhat limited (coefficient of variation around 11% compared to 25% for the free market demand for wheat). One may argue that the price of fuel is so high that any change in price has no effect on consumption. But such high prices are a recent phenomenon and can not explain the average behaviour for the period 1961-78. There appears to be some serious specification error.

The elasticities for edible oils reveal interesting information. The $\bar{R}^2$ is reasonably high and the Durbin-Watson statistic does not indicate any auto-correlation. The income elasticity is positive and significant. But the price elasticity is not significantly different from zero. One expects this elasticity to be low, but not zero. However, if this is true, it certainly

TABLE 1
DEMAND FUNCTIONS FOR VARIOUS GOODS AND SERVICES FOR THE PERIOD 1961-78*

Dependent Variable	*Coeff. of* *p*	*Coeff. of* *I*	*Elasticity*		$\bar{R}^2$	*D.W.*	*Type*	*Constant*
			Price	*Income*				
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Food, beverages and tobacco	−0.409 (−3.872)	0.528 (7.162)	−0.409	0.528	0.96	1.19	log-lin	6.257
Food	−0.414 (−3.890)	0.549 (7.386)	−0.414	0.549	0.959	1.23	log-lin	5.990
Cereals and cereal substitutes	−0.273 (−2.378)	0.461 (6.064)	−0.273	0.461	0.911	1.58	log-lin	5.439
Milk & Milk products	−0.459 (−1.360)	0.393 (2.335)	−0.459	0.593	0.927	0.63	log-lin	3.711
Edible oils	−0.192 (−0.982)	0.375 (2.193)	−0.192	0.375	0.677	1.81	log-lin	4.157
Meat egg & fish	−1.957 (−1.168)	0.011 (2.748)	−0.273	0.481	0.938	1.4	lin	635.251
Sugar	−0.225 (−2.708)	0.341 (6.038)	−0.225	0.341	0.804	0.94	log-lin	4.659
Salt	−0.155 (−0.963)	0.406 (4.527)	−0.155	0.406	0.849	1.48	log-lin	0.646

Table 1 (*contd. on page* 110)

Table 1 (*contd. from page* 109)

(*1*)	(*2*)	(*3*)	(*4*)	(*5*)	(*6*)	(*7*)	(*8*)	(*9*)
Other food	−0.616 (−3.408)	0.707 (5.356)	−0.616	0.707	0.886	1.07	log-lin	3.758
Other items excluding non-alcoholic beverages	−0.533 (−3.335)	0.607 (5.441)	−0.533	0,607	0.863	1.05	log-lin	4.357
Pan, tobacco & intoxicants	−0.751 (−2.715)	0.547 (2.696)	−0.751	0.347	0.315	1.43	log-lin	4.988
Alcoholic beverages, pan & other intoxicants	−1.901 (−3.386)	0.005 (6.435)	−0.315	0.330	0.842	1.41	lin	539.144
Tobacco	−1.010 (−2.760)	0.759 (2.464)	−1.010	0.759	0.338	1.56	log-lin	3.503
Clothing and Footwear	−17.374 (−3.380)	0.065 (7.003)	−0.885	1.070	0.979	1.99	lin	1803.484
Clothing	−16.765 (−2.998)	0.063 (5.815)	−0.859	1.092	0.974	1.71	lin	1622.370
Footwear	−0.391 (−6.046)	0.002 (15.698)	−0.607	0.595	0.941	1.78	lin	118.056
Fuel and power	−0.089 (−0.232)	0.225 (0.948)	−0.089	0.225	0.588	0.44	log-lin	5.049
Furniture, furnishing, household equipment and operation	−6.443 (−2.485)	0.026 (4.981)	−0.841	1.118	0.943	1.19	lin	616.413
Domestic services	−0.158 (−1.373)	0.172 (4.037)	−0.158	0.172	0.613	0.19	log-lin	4.028

Furniture, furnishings, household equipment etc.	−3.164 (−1.481)	0.020 (4.215)	−0.491	1.062	0.935	0.94	lin	295.848
Medical Care	−0.955 (−2.860)	1.045 (7.738)	−0.955	1 045	0.674	1.42	log lin	−0.038
Transport and communication	−0.157 (−2.076)	0.641 (14.287)	−0.157	0.641	0.992	1.29	log-lin	1.326
Personal transport equipment	−0.501 (−3.786)	1.170 (10.694)	−0.501	1.170	0.984	1.47	log-lin	−4.324
Others including purchased services	−2.573 (−2.139)	0.022 (9.188)	−0.257	0.672	0.979	0.80	lin	691.139
Recreation, entertainment, education & cultural services	−1.447 (−5.161)	1.249 (8.004)	−1.447	1.249	0.917	0.92	log-lin	0.562
Education	−1.462 (−4.903)	1.238 (7.216)	−1.462	1.238	0.885	0.93	log-lin	0.517
Others	−1.174 (−4.442)	1.194 (9.258)	−1.174	1.194	0.928	0.74	log-lin	−1.734
Miscellaneous goods & services	−7.815 (−5.024)	0.024 (7.161)	−0.777	0.788	0.927	1.66	lin	1104.183
Private final consumption exp. in the domestic market	−0.637 (−5.516)	0.715 (9.649)	−0.637	0.715	0.988	0.79	log-lin	5.773

*Dependent variable : Consumption expenditure at 1970-71 prices for the commodity groups listed.
p (Independenr variable) : Retail price index
I (Independent variable) : Personal disposable income at current prices
The best of log-lin vs. linear regressions are presented here.

explains the behaviour of the prices of edible oils in recent years. We notice that their prices have gone up almost by 300% during the last 10 years. Prices have risen even during the years when production of oil seeds went up by 25%.

The income elasticities for recreation and entertainment, education and furniture are greater than one indicating the luxurious nature of these goods and services. Medical care is highly sensitive to price and income. The income elasticity is unity. Given the low average income, it is also understandable to have such high elasticities, inspite of the essential nature of medical services.

It must be noted that we have not taken into account the various government welfare measures for distributing goods and services in our last set of calculations. It would certainly be desirable to take such information into account in the analysis. But this will involve much more work. We will conclude our discussion by citing one more example in this context. In a detailed study of the sugar industry (see Chetty (1981)) the price elasticity of the free market demand for sugar was found to be −1.65 while our estimate here is −.225. When 2/3 of the output of sugar is distributed through the ration shops, a serious under estimate of the price response is only to be expected.

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APPENDIX 1

Assume that a consumer has an initial money income m_0 of which $m > 0$ is for current expenditure. Let $q = (q_1, q_2, \ldots, q_2, q_{k+1}, \ldots, q_{k+2})$ be the vector of prices in the open market and $p = (p_1, p_2, \ldots, p_k, 0, 0, \ldots, 0)/l$ be the vector of prices in the ration shops for the first 'k' commodities. The 'l' zeros are added for convenience. The ration quotas are given by $D = (D_1, D_2\ D_k' \ 0, 0, \ldots, 0)$. Consider any consumption plan $x = (x_1, \ldots, x_k, x_{k+1}, \ldots, x_{k+l})$ with the following properties :

$$x_i > D_i, \qquad i = 1, \ldots, k \tag{1}$$

$$\sum_{i=1}^{k+l} q_i x_i = \overline{m}, \text{ where } \overline{m} = m + \sum_{i=1}^{k+l} (q_i - p_i) D_i. \tag{2}$$

We claim that*

$$p \cdot x + (q - p)(x - D \, V \, 0) = m \Leftrightarrow q \cdot x = m + (q - p) \cdot D$$

Proof: Note $q \cdot x = m + (q - p) \cdot D$

$\Leftrightarrow p \cdot x + (q - p) \cdot x = m + (q - p) \cdot D$

$\Leftrightarrow p \cdot x + (q - p)\,\underline{(x - D)} = m$

$\Leftrightarrow p \cdot x + (q - p)(x - D \, V \, 0) = m$ since $x_i > D_i \ \forall\ i = 1, \ldots, k$

Let x^* maximize u subject to $p \cdot x + (q - p)(x - D) = m$ and $\bar{x}$ maximize u subject to $q \cdot x = \overline{m}$.

Proposition : If u is strictly quasi-concave and $x_i^* > D_i$ for $i = 1, 2, \ldots, k$, then $x^* = \bar{x}$.

Proof: Suppose not. Let $\hat{x} = (1 - \lambda)\, x^* + \lambda \bar{x}$. For small λ, $\hat{x}_i > D_i$ for $i = 1, \ldots, k$. By our earlier arguments, $p \cdot \bar{x} + (q - p)(\bar{x} - D \, V \, 0) = m$. Hence $\bar{x}$ is feasible under the dual pricing scheme. This means that $u(x^*) > u(\bar{x})$, It is also easily verified that $\hat{x}$ is feasible under the dual pricing scheme. By strict quasi-concavity of u, we have $u(\hat{x}) > u(x^*)$, a contradiction.

*$x \cdot y = \sum_{i=1}^{l+k} x_i y_i$ and $(x \, V \, y) = (z_1, \ldots, z_i, \ldots)$ where $z_i = \max(x_i, y_i)$

APPENDIX 2

Sources of Data:

Production, internal procurement, imports, and public distribution of wheat and rice are taken from the Bulletins on Food Statistics. Data relating to prices and personal disposable income are from various issues of the National Accounts Statistics.