FOOD DEMAND PATTERN AND PRICING POLICY IN MAHARASHTRA : AN ANALYSIS USING HOUSEHOLD LEVEL SURVEY DATA

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0. Introduction

This paper uses data from the 38th round (1983) of the National Sample Survey to explore issues of food demand and food pricing in Maharashtra. The NSS collects data, not only on food expenditures, but also on *quantities* purchased, so that the survey can be used to measure prices, and to examine how prices vary across space and time. Doing so, and comparing the results with other information on prices is the first task of the paper. Our second task is to use the price variation to examine how food demands respond to price. The methodology here is that first discussed in Deaton (1988), but incorporates the advances described in Deaton (1994). Although many previous studies have estimated demand systems for India, the present exercise takes advantage of the household level data and of spatial variation in prices to estimate a flexible functional form, so that the matrix of own and cross-price elasticities is not restricted by additivity or other separability assumptions, as would be the case, for example, if the linear expenditure system were used. In the Maharashtran case, the generality turns out to be important. There are well-defined patterns of substitutability between different foods, particularly among the major cereals. The third and final task of the paper is to use the estimates of the demand respones to say something about policy issues, in particular about the consequences of possible price reforms. Price changes have efficiency effects, on the allocation of resources, and equity effects, on the distribution of real income across different households. At least for small changes in price, the survey data can be used directly to measure the latter without the need to specify any parametric model of demand. By contrast, calculation of efficiency effects requires knowledge of the own and cross-price responses, and the empirical results of the paper have very different implications for policy than would be obtained using a more restrictive methodology.

1. Prices and demand patterns in Maharashtra

The structure of the sample of Maharashtran households from the 38th round of the National Sample Survey is presented in Table 1. There are 5630 rural and 5500 urban households, distributed over the six regions and 28 disticts as shown. The sample design calls for the selection of ten households from each rural village, or urban block, so that, for example, the 240 rural households in Usmanabad district come from 24 different randomly selected villages. Prices of foods vary both seasoally and spatially over from one village to another, and it is this variation that we shall use to estimate the demand system. Further more, since all the households in the same village are interviewed at the same time during the year, it is reasonable to assume that they all faced the same prices during the (previous) month for which they report their consumption. More than a third of the urban households are located in Greater Bombay, and although these households are scattered over the city, it is probably not safe to assume that they all face the same prices. People travel around the city to work, and, at least to some extent, can change where they shop in response to price differences. As a result, and although we have carried out the same analysis for the urban sample, we focus on the behaviour of the rural households in the remainder of the paper.

Table 2 shows discriptive statistics for the composition of the budget and for the prices that households report paying for various categories of foods. Respondents are asked to recall how much they have consumed of each of more than three hundred items over the last thirty days, and, when appropriate, to report

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expenditures in rupees as well as physical quantities. There are 149 food items in the list. In those cases where physical quantities are available, and this is so for most foods, it is possible to calculate a price, or more accurately a unit value, by dividing the expenditure by the quantity. While it is to be expected that these unit values will give a good indicatin of price, this can only be guaranteed for perfectly homogenous goods. In practice, better-off households will typically buy higher qualities within any food category, so that unit values will be higher for richer households, even if the prices they face are the same.

We note also that the NSS collects data, not only on food purchased, but also on consumption of home grown food. For each household, we have not only the quantity purchased and its cost, but also the quantity consumed from home production (if any) and an estimate of its value at harvest prices, a value that typically is less than the market price by the amount of distribution and marketing costs. In the analysis here, we use data from both sources in an attempt to measure the marginal cost of consumption for each household. For households who report market purchases, we use the unit value of these puchases only and ignore the information on own produciton. For households who do not purchase in the market, but consume from own production, we use the harvest price as imputed by the NSS. When there is no purchase and no home consumption, the unit value is recorded as missing.

In most cases, this procedure should lead to good estimates of the cost of additional consumption at the margin. However, we note two issues. First, for households who consume all that they produce but buy nothing in the market, the shodow price of consumption is neither the harvest nor the market price, but something in between. Second, for households who have both home production and market purchases, we should ideally credit to their income the implicit distribution and marketing profit that they 'earn' from the difference between the value of their production at harvest prices and its value at market prices. In principle, the first problem can be addressed using econometric techniques that allow for non-linear budget sets, such as those reviewed by Hausman (1984). But these techniques typically make heavy use of distributional assumptions so that the price of the 'correct' treatment in terms of lost robustness may be higher than the benefits of the 'correct' specification if the assumptions happen to be correct. The imputation of marketing profits to income is not an issue given our method of demand analysis in which we condition, not on income, but on total expenditure. Such conditioning is forced by the lack of income data in the NSS consumption surveys, and is justified by the separability of consumption. Given the validity of the assumption, the precise definition of income is not important.

We distinguish 12 food categories in the analysis; these are listed on the left hand side of Table 2. The categories are largely the standard ones, and as usual we distinguish the coarse grains, jowar and other cereals, from rice and wheat. The Table shows the fractio of households who report that they consumed the good in the last thirty days, the average over all households (including those who do not buy) of the share of total expenditure (excluding durables) that is devoted to the good, and the average unit value over those households who bought the good. The left hand panel of the table shows weighted averages, using inverse sampling probabilities as weights, so that given the validity of the sampling, the estimates should be representative of rural households in the state of Maharashtra as a whole. The right hand panel shows simple unweighted means. The two sets of numbers are very close to one another, and since using the weights in more complex analyses poses a number of econometric problems we shall not make further use of them.

The average value of total monthly consumption excluding durables is 538 rupees per household, or 536 rupees from the weighted data. Slightly more than two thirds of the average budget is allocated to food, the sort of figure that characterizes only very poor societies. Nearly half of all food expenditure is on cereals, with more spent on jowar than on the combination of the more expensive rice and wheat. All of these commodities are consumed over the 30-day reporting period by 55 percent or more of the households, and apart from meat, wheat, and other cereals, all groups are consumed by more than 80% of households over a thirty day period. The unit values show that, in 1983, households paid nearly 16 rupees per kilo for oils and fats and for meat, while cereals cost from 1.72 rupees per kilo for jowar through to nearly double that amount for the much more expensive wheat.

To the extent that they can be compared, these figures are close to direct measurements of prices from other sources. For example, Government of India (1987) reports agricultural prices in India for each month at selected sites in the major states. The 1983 average wholesale price of coarse rice is listed as 3.00 in Kalyan, 3.05 rupees in Nagpur, and 2.86 rupees in Gondia. Jowar is priced at between 1.40 and 2.07 rupees per kilo wholesale and wheat at 21.3 to 2.93 rupees per kilo. Gur is 2.60 to 3.68 rupees and sugar

3.72 to 4.92 rupees. Groundnut oil is reported as fetching 15.64 rupees per kilo. All of these figures, although applying only to specific markets, are close to the averages from the NSS data as reported in Table 2.

Given these encouraging results, we explore further the geographical and temporal variation in the unit values, on the temporary supposition that differences in unit values correspond largely to variations in prices rather than to variations in quality. As we shall see later in this section the variation in unit value with income, although real, plays a minor role. Figures 1 and 2 provide graphical illustrations of the behaviour of two important prices, those of rice and jowar. (Other prices are not so displayed, for reasons of space, but will be analyzed numerically). For each household, we know in which subround of the survey it was interviewed, and these subrounds correspond to the four quarters of 1983, January through March, April through June, July through September, and October through December. We can then average by district and by subround to obtain the figures shown in the graphs. There are 27 districts (there are no rural households in Greater Bombay), and each is represented on the Figures by the first eight digits of its name. Although these labels are typically too small to be read, the districts appear in the order given by the numbers in brackets in Table 1. The point to note is the very substantial variation in these prices, both over seasons, and over districts. For rice, there is a pronounced seasonal pattern over the year; on average the log unit values rose by 15% from the first to the third quarter, and by a further 2% between the third and fourth quarters. However, there is substantial variation between districts, both in the level of prices, and in the seasonal pattern. For example in Dhule and Jalgaon districts, the price of rice peaked in the second quarter, at which point the price in Jalgaon was nearly 30% higher than in, for example, Chandrapur district. The price of jowar is also subject to seasonal variation, and rises 13% from the first to third quarter, falling by 2% to the last quarter. But the variation across districts is very much larger than for rice. Jowar prices in the Inland Eastern Districts where jowar production is heaviest, Buldana, Akola, Amravati, Yevatmal, Wardha, and Nagpur, are lower throughout the year, by 50% or 60 paise per kilogram, than in the Coastal Districts where no jowar is produced. These seasonal price patterns in 1983 appear to be typical for both crops, whose prices rise from one harvest to the next, with the jowar harvest a few months earlier than the year end harvest for rice.

Tables 3 and 4 provide a more comprehensive numerical picture of the extent and significance of spatial and seasonal price variation. Table 3 documents variability and its sources. The first column shows (100 times) the standard deviation of the logarithms of the unit values, so that the figures can be interpreted as percentage variability. The results are influenced both by the genuine variability of prices, and by the heterogeneity of the group. Fruits and nuts, and other cereals are the most heterogeneous groupings, with heats and dairy produce not far behind. The major cereals and edible oils have very similar measures of variability. The second and third columns show the decomposition of variance over the 563 villages, with F-statistics for village effects in column 2, and the corresponding R^2 statistics in column 3. The latter can be thought of as the R^2 statistic of a regression of the unit values on dummy variables, one for each of the villages where there is at least one purchaser of the good. Given that we shall be using the intervillage variation of prices to identify the demand model, and given that we want the unit values to behave like prices, the fact that these statistics are so large provides reassurance both that there is a great deal of intervillage variability in the data, and that the variability is much stroger between villages that it is within villages, as should be the case if the unit values are closely related to prices. The F-statistics are significant at any standard level of significance. A more stringent test is provided by Schwarz's Bayesian posterior odds ratio, where the F-statistic must be larger than the logarithm of the sample size, here 8.6. Even by this criterion, most prices show significant village effects.

The last three columns of Table 3 repeat in numerical form the results for rice and jowar in Figures 1 and 2. The first column gives the F-statistics or broad regional effects, all of which are very large, while the second and third columns give the F's for the seasonals, and for the interactions between regions and seasonals. The seasonals are as important as might be expected, while the interactions are a good deal less so. Again, conventional tests would adjudge all of the interactions important, but the much lower figures here support the idea that arbitrage would set limits on the magnitude of long-standing regional differences in seasonal *patterns* for homogeneous goods.

The final column in Table 3 represents something of a puzzle, It reports the F-statistics for a dummy variable associated with the subsample to which the household belongs. The NSS survey generates two interpenetrating subsamples, a design that is used to help calculate standard errors, but the two samples should each have identical properties. The fact that for a few of these commodities, the F-tests are so large is not something for which have a ready explanation.

Table 4 lists the regression coefficients for regional and seasonal variables obtained from regressions of each unit value on the regional, seasonal, and subsample dummies, but without interaction terms. For rice and jowar, we see the same patterns as were revealed in Figures 1 and 2; prices are lower at the beginning of the year, rice is cheapest in the (omitted) Eastern Region, and coarse cereals in Inland Eastern Region, where there is a good deal of production. The seasonal pattern of prices is simialr across all of the foods apart from meat, eggs, and fish, and it is generally the case that food is cheaper in the dry winter months, after the harvest, and when there is a plentiful supply of winter vegetables. Note too the very strong and significant regional price differences; once again, these results confirm that there is adequate regional and temporal price variation to support the estimation of demand functions.

To carry the analysis of prices and of demand patterns further, it is useful to estimate a simple econometric model, and this is turn, provides a bridge to the more formal demand analysis in the next section. Consider in particular, the following two equations linking budget shares and unit values to household total expenditures, other household characteristics, and the underlying prices of commodities.

$$W_{Gic} = \alpha_G^0 + \beta_G^0 \ ln x_{ic} + \gamma_G^0 . z_{ic} + \sum_{H=1}^{N} \theta_{GH} ln p_{Hc} + (f_{Gc} + u_{Gic}^0) \qquad (1)$$

$$ln v_{Gic} = \alpha_G^1 + \beta_G^1 \ ln x_{ic} + \gamma_G^1 . z_{ic} + \sum_{H=1}^{N} \psi_{GH} ln p_{Hc} + u_{Gic}^1 \qquad (2)$$

In equation (1), w_{Gic} is the budget share of good G in he budget of household i, living in village (or cluster) c. The share is taken to be a linear function of the ogarithm of total household expenditure, x, and the ogarithms of the N prices, as well as of a vector of ousehold characteristics z. The first component of the esidual, f_{Go} is a village fixed effect for good G, ssumed to be orthogonal to the prices, while the diosyncratic term u_{Gic}^0 represents not only taste ariations, but also any measurement error in the udget share. From an econometric point of view, the on-standard feature of equation (1) is that the prices re not observed. Instead, we have data on the unit alues v, which are not identical to the prices, but are elated to them by equation (2). The logarithm of unit alue is a function of Inx, so that β_G^1 is the elasticity of uality with respect to total expenditure, and of the haracteristics z, since household featues may affect uality choice. The unobservable prices appear hrough the matix Ψ. In the simplest case, where prices re unit values, this matrix would be the identity atrix and the other variables would be absent. The xtra generality allows for quality 'shading' in response to price change, so that the might expect $1 1 C_{GG} < 1$, with some non-zero off-diagonal terms. Not surprisingly the Ψ matrix is not identified without further assumptions, and in Deaton (1988, 1994) a theoretical model is developed that provides suitable prior information. For the moment, the nature of this matrix need not concern us.

The difficult problems in estimating (1) and (2) are concerned with estimating the effects of prices, the matrices Θ and Ψ, and these will be the topic of the next section. However, if we are prepared to accept the assumption that the unobservable prices are the same for all households in the same village, it is straightforward to estimate the α, β, and γ parameters in the two equations (1) and (2). If we include a dummy variable for each village in the regressions, we shall not be able to estimate the effects of prices, but the dummies will control for prices and for the village fixed effects in (1), and we shall obtain consistent estimates of all the other parameters. A selection of the results from this first stage of the estimation is given in Table 5. Household composition effects, the z's in equaitons (1) and (2), are modelled by entering, together with the logarithm of total household expenditure, the logarithm of total household size, and the thirteen *ratios*, n_j/n, where n_j is the number of people in age and sex group j, and n is total household size. There are seven age groups for each sex, making fourteen in all; the ratios sum to unity, so only thirteen need be included in the regression. For the budget shares, the Table shows only the coefficients on total expenditure and household size even though the demographic ratios and the other variables are often also important, see Subramanian and Deaton (1991) for further details. For the unit value regressions, the demographic ratios are typically not important; the Table shows the other coefficients, for total expenditure, household size, labor type, and religious and caste variables.

Start with the budget share equations in the first two columns. If the coefficient on In x is positive, as is the case for wheat, dairy products, meat, and fruit, the share of the budget spent on the good rises with total expenditure, so that the good is classed as a luxury. The other goods, rice, jowar, other cereals, pulses, edible oils, vegetables, and sugar, have shares that decline as we move from poor to rich, and these goods are therefore classed as necessities. Note however, that the current analysis is somewhat different from the standard one because expenditures on a group can increase at fixed prices either because quantity increases, as in the standard case, or because unit values increase. Since expenditure is the product of quantity and unit value, the elasticity of expenditure with respect to total expenditure is the sum of the elasticity of quantity and the elasticity of quality, the latter being given by β_G^1 in equation (2), and the third column of Table 5. To derive the usual quantity elasticity, note that budge share w_G is quantity multiplied by unit value divided by total expenditure x, so that

$$\frac{\partial \ln w_G}{\partial \ln x} = e_G + \beta_G^1 - 1 = \frac{\beta_G^1}{w_G} \qquad (3)$$

where e_G is the total expenditure elasticity of quantity, and the last equality comes from differentiating equation (1). Hence, given estimates of β_G^0 and β_G^1, we can calculate the conventional elasticity, at least for any given value of the budget share. The first column of Table 6 reports the results calculated at the mean values of the shares, and these are very much as expected. Jowar has a very low quantity elasticity of 0.3, other cereals, rice and pulses are next in the cereals hierarchy, with wheat at the top.

The effects of household size on the budget shares are listed in the second column of Table 5. Looking across the goods, it is frequently the case that the coefficient of log household size is of similar magnitude but of the opposite sign to the coefficient on the logarithm of total expenditure x. When this is the case, as for rice, jowar, other cereals, pulses, or edible oils, the budget share depends on *per capita* total household expenditure *(PCE)*. The exceptions to the rule conform to the pattern that would occur in the presence of positive returns to scale to household size, so that doubling total expenditure and doubling household size effectively makes the household better off. For example, if *PEC* is held constant, and household size is increased, the budget shares of wheat, dariy products, fruit, and meat would rise, and those of coarse cereals, pulses, vegetables, and sugar would fall; this is much the same pattern that would be induced by a pure increase in total outlay.

The third column of Table 5 shows the elasticities of unit values with respect to total expenditure, or 'quality elasticities' in the terminology of Prais and Houthakker (1955). The point to note is that these estimates, although all positive, and mostly significantly so, are small. The largest, for meat, eggs, and fish, is 18 percent, followed by other cereals and dairy with 12 and 11 percent respectively. For the important cereal categories, jowar, rice, and wheat, even a doubling of total outlay would not raise the average price paid by more than about 5 percent Better-off households buy better quality bundles of goods, but the effect is modest. Note also that if quality is relatively inelastic to income, it is also unlikely that there is a great deal of quality shading in response to price changes. As is the case for the budget shares, an increase in household size affects quality much as does a reduction in income; the coefficients on the logarithm of household size are approximately equal in size and opposite in sign to the coefficients on the logarithm of total expenditure. The other variables exert a modest, if occasionally ineteresitng effect on unit values. Agriculturalists, (Types 2 and 4) tend to pay less per kilo, presumably substituting cheaper qualities to get the additional calories that they need, see also Subramanian and Deaton (1992). Perhaps most interesting are the large coefficients on the Hindu and Buddhist dummies on the unit values of other cereals, of meat, eggs, and fish, and (negatively) on fruit. For the meat group, this looks like a classic selection story. Many Hindus (an all Jains) are vegetarians, and although some will eat chicken or fish—which are the most expensive items in the group—they do not eat mutton or beaf which cost much less.

2. *The estimation of price elasticities*

2.1 *Econometric procedures*

The straightforward analysis of 'within-village' regression has provided estimates of the toal expenditure and quality elasticities, as well as of the effects of a range of demographic and other variables. To obtain price elasticities we use the price variation *between* the villages. There are a number of details in the calculations that make the formula look complex, but the basic idea is very straightforward. At its simplest, we regress village demad patterns as represented by the budget shares, on the average village prices, as represented by unit values. To allow for the quality effects, we use the firt stage results to 'purge' the budget shares and unit values of the effects of total outlay, household composition, and the other socio-demographic variables. We also make allowance for the possibility that, even after averaging over each village, there is measurement error both in the shares and in the unit values, and again we use the first stage estimates to make a correction . Finaly, it is possible to make an allowance for quality shading, the Ψ matrix in equation (2), although in the Maharashtran case, as in most other cases, the allowance has only a small effect because the quality effects are small. The discussion of the econometrics given below comes, with minor modifications, from Deaton (1994).

Start from the village averages, 'purged' of the effects estimated at the first stage Define :

$$\tilde{y}^0_{Gc} = \frac{1}{n_c}\sum_{i\in c}(w_{Gic} - \tilde{\beta}^0_G \ln x_{ic} - \tilde{\gamma}^0_G z_{ic}) \quad (4)$$

$$\tilde{y}^1_{Gc} = \frac{1}{n^+_{Gc}}\sum_{i\in c}(\ln v_{Gic} - \tilde{\beta}^1_G \ln x_{ic} - \tilde{\gamma}^1_G z_{ic}) \quad (5)$$

where n_c is the number of households in village 02c, n^+_{Gc} is the number of households who purchase good G (and thus provide data on the unit values) and superimposed tildes indicate estimates from the first, within-village stage. As the number of observations in the first-stage regression increases, the first-stage estimates will tend to their true values, so that y^0_{Gc} and y^1_{Gc} will tend to the true cluster means, which, by (1) and (2) can be written :

$$y^0_{Gc} = \alpha^0_G + \sum \theta_{GH} \ln p_{Hc} + f_{Gc} + u^0_{Gc} \quad (6)$$

$$y^1_{Gc} = \alpha^1_G + \sum \psi_{GH} \ln p_{Hc} + u^1_{Gc} \quad (7)$$

where u^0_{Gc} and u^1_{Gc} and the cluster means of the errors in (1) and (2). Note that in the construction of (4) and (5), the right hand side variables *do not* have the means excluded; the cluster means contain the information about the prices that must be excluded from the first stage regressions, but must be included in the between cluster regressions if the price effects are to be identified. If we knew the first-stage parameters, the correction would leave us with the effects of prices, the village fixed effects, and any measurement error that survives? the averaging over the households in the village.

If the matrix Ψ were the identity matrix, and if the cluster means u^0_{Gc} and u^1_{Gc}*01 were zero, the columns of the matrix* Θ of price effects could be estimated by regressing each y^0_{Gc} on the matrix of corrected prices y^1_{Gc}. This is in fact very close to what we do. Given that the quality effects are not large, the correction for the Ψ matrix is not as important as is the correction for the fact that the sample clusters are not large enough to allow us to ignore the averages of the measurement errors. The procedure is a standard errors in varibles one, which allows both for the measurement error in the prices, and any possible correlation between the measurement errors in the price and share equations.

Define the typical elements of the variance and covariance matrices corresponding to (6) and (7):

$$q_{GH} = \text{cov}(y^0_{Gc}, y^0_{Hc}), \quad s_{GH} = \text{cov}(y^1_{Gc}, y^1_{Hc}), \quad r_{GH} = \text{cov}(y^0_{Gc}, y^1_{Hc}). \quad (8)$$

By the definition of ordinary least squares, the OLS estimator would be $S^{-1}R$, a feasible version of which is $\tilde{S}^{-1}\tilde{R}$, where the tildes show that the covariances in (8) are evaluated using the estimates in (4) and (5) rather than (6) and (7). The problem with these estimators is that the variance covariance matrix S overestimates the variance covariance matrix of the true prices, because it includes the effects of the measurement error in (7); similarly R is contaminated by any covarinces in the measurement error between the two equations. But the variances and covariances of the errors can be esimated from the first stage regressions, and the estimates used to make the correction. Let $e^j_{Gic}, j=1,2$ be the residual for household i cluste c good G, from the first stage share regression (j = 1) or unit value regression (j = 1). We can use these to estimate variances and covariances from the own and cross products in the usual way Define :

$$\tilde{\sigma}_{GH} = (n-C-k)^{-1}\sum_c\sum_i e^0_{Gic}\, e^0_{Hic},$$

$$\tilde{\omega}_{GH} = (n^+_G-C-k)^{-1}\sum_c\sum_i (e^1_{Gic})^2, \quad (9)$$

$$\tilde{\gamma}_{GH} = (n^+_G-C-k)^{-1}\sum_c\sum_i e^1_{Gic}\, e^0_{Hic}$$

where n^+_G is the total number of households in the survey who report purchases of good G. Denote the matrices defined in (9) by $\tilde{\Sigma}, \tilde{\Omega}, \tilde{\Gamma}$, and their limits Σ, Ω, Γ. Then, from (6) and (7), if M is the unobservable variance covariance matrix of the true price vector,

$$S = \Psi M \Psi' + \Omega N^{-1}, \; R = \Psi M \Theta' + \Gamma N^{-1}. \quad (10)$$

where $N^{-1} = \text{plim}\, C^{-1}\sum_c D(n^+_c)^{-1}$, $D(n^+_c)$ is a diagonal matrix formed from the elements of n^+_{Gc}, and N^{-1} is the corresponding matrix formed from the n_c's. To eliminate the effects of the measurement error, we need to correct OLS by removing the second terms on the right hand side of (10). This leads to the estimator:

$$\tilde{B} = (\tilde{S}-\tilde{\Omega}\tilde{N}^{-1})^{-1}(\tilde{R}-\tilde{\Gamma}\tilde{N}^{-1}) \quad (11)$$

where $\tilde{N}^{-1}$ and $\tilde{N}^{-1}$ correspond to the sample averages instead of the probability limits. From (10), it is immediate that, taking probability limits as the sample size goes to infinity but with the cluster sizes remaining fixed :

$$\text{plim } \tilde{B} = B = (\Psi')^{-1}\Theta \qquad (12)$$

To interpret these results, start with equation (12). If Ψ is the identity matrix, $\tilde{B}$ converges to the transpose of the matrix of price responses Θ, which is what we want. If $\Psi \neq I$, then B is all that can be identified without further theory, and we cannot go further with the data alone. From (11) we see that, in the absence of measurement error, in which case the matrices Ω and G would be zero, the estimator reduces to the ordinary least squares estimtor, as it should. Even if these matrices are enot zero, large cluster sizes will make the post-multiplying diagonal matrices small, so that, once again, we approach the OLS estimator. In this case, averaging over clusters is enough to remove the measurement error and the price response matrix can simply be estimated by least squares once the expenditure and demographic effects have been removed at the first stage. The present procedure is more general and allows for the possibility that measurement error is sufficiently severe, or cluster size small enough, so that even the averages are contaminated. This seems wise, since cluster sizes are often in single figures, and the number of purchasers of a good in each cluster will often be only two or three.

The variance covariance matrix of B is given in the Appendix of Deaton (1990, equation A.12). We use

$$V\{\text{vec}(\tilde{B})\} = C^{-1}(P'HP \otimes S^{-1}JHJ'A^{-1}) + C^{-1}(P'HJ'A^{-1} \otimes A^{-1}J\Lambda J'A^{-1})K \qquad (13)$$

where $A = (S - \Omega N^{-1})$, $J = (O_N | I_N)$, and $P' = (I_N | -B')$. The matrices H and Λ are formed from the variance covariance matrices of the measurement errors and the data according to :

$$H = \begin{pmatrix} Q & R' \\ R & S \end{pmatrix} \quad \Lambda = \begin{pmatrix} \Sigma & \Gamma' \\ \Gamma & \Omega \end{pmatrix} \qquad (14)$$

K is the $2N^2 \times 2N^2$ commutation matrix; it is the matrix of ones and zeros with the property that K vec(A) = vec)A') for an arbitrary conformable matrix A, see Magnus and Neudecker (1988) for a full discussion. Equation (13) is a simplified version of the full asymptotic variance covariance matrix given in Deaton (1990) and is obtained by ignoring the sampling variability of the first-stage estimates; it has proven accurate in other applications, and the additional terms make to noticeable difference in the current case.

We shall follow standard practice in demand analysis and present our results as elasticities, rather than as the underlying parameters of the econometric model. The apropriate formulae are derived in Deaton (1994), who also explains how to disentangle the quantity effects from the quality effects. The matrix of own and cross-price elasticities E, is given by

$$E = \{D(w)^{-1}B' - I\}\{I - D(\xi)B' + D(\xi)D(w)\}^{-1} \qquad (15)$$

where w is the vector of budget shares, the elements of ξ are given by

$$\xi_G = \{(1 - \beta^1_G)w_G + \beta^0_G\}^{-1}\beta^1_G \qquad (16)$$

and, as before, the operator $D(.)$ diagonalizes its vector argument. The variance covariance matrix of the elasticities can be derived from the variance-covariance matrix of B, (13), using the formula :

$$V\{\text{vec}(E')\} = \{(D(w)^{-1} + ED(\xi)) \otimes G\} V\{\text{vec}(B)\} \{(D(w)^{-1} + D(\xi)E') \otimes G'\}$$
$$G = \{I - D(\xi) + D(\xi)D(w)\}^{-1} \qquad (17)$$

2.2 *Completing the system, and imposing symmetry*

It is possible to use the theory of consumer choice, not only to provide restrictions on the elasticities, essentially 'symmetry restrictions,' but also to complement the food analysis by adding at twelfth 'other food and non-food' category, and to construct a complete system of demand equations that accounts for the allocation of all expenditure. Although we do not have quantities, and thus unit values, for the final category, the system can be completed with only minimal additional assumptions. In particular, since we have expenditure data on the category, we have a budget share, and the effects of outlay, of demographics, and of the prices of the other foods can be analyzed in the usual way. While we cannot measure the effects of the price of the new category on the demand for foods, the homogeneity restriction of demand analysis allows us to derive one cross price elasticity from knowledge of the outlay elasticity and all the other price elasticities. As we shall see, this calculation requires one piece of information that we do not have, and cannot estimate, which is the quality elasticity of the final category. Since all of the estimated quality elasticities have been small, the plausible range for this elasticity is not very large, and its arbitrary specification (here at 0.1) does not have a major effect on the results.

Start from the original equations (1) and (2), ignore the error terms and the demographics, and rewrite them in matrix form to give.

$$w = \alpha^0 + \beta^0 \ln x + \Theta \ln p \tag{18}$$

$$\ln v = \alpha^1 + \beta^1 \ln x + \Psi \ln p \tag{19}$$

Suppose also that we have 'completed' the system, so that the budget shares exhaust the budget x, and there are a corresponding number of unit values. As compared with the previous empirical estimates, the vectors β^0 and β^1 will have one more element. Use (19) to obtain an expression for $\ln p$ and substitute the result into (18) to give

$$w = (\alpha^0 - B'\alpha^1) + (\beta^0 - B'\beta^1)\ln x + B'\ln v \tag{20}$$

and $B' = \Theta\Psi^{-1}$, is the same B as before, cf. equation (12); although by completing the system, we have added an additional row and column to the matrix.

Equation (20) is useful, not only because it provides another way of seeing where the matrix B comes from, but also because, as shown in Deaton (1994), this system, with budget shares a function of outlay and unit values, can be regarded as a standrd form demand system when we come to look at adding up, homogeneity, and symmetry. In particular, adding up requires that

$$\iota' B' = 0, \iota' \beta^0 = 0, \tag{21}$$

where ι is the vector of units. Homogeneity requires that

$$B'(\iota - \beta^1) + \beta^0 = 0, \tag{22}$$

while the symmetry restriction is that

$$B(I - \beta^1 \bar{w}') + \beta^0 \bar{w}' = (I - \bar{w}\beta^{1\prime}) B' + \bar{w}\beta^{0\prime} \tag{23}$$

The homogeneity and adding-up restrictions are used to complete the system, given the missing quality elasticity of the final goods. As usual, adding up provides no new information, since the budget shares add up by construction, and the regression analysis using the budget share for the last good, will yield estimates for the last element of β^0 and the last row of B′ that are the same as would be obtained by direct calculation. Homogeneity, by contrast, gives us something that cannot be obtained without it, since by (22) it allows us to fill in the last column of B', which are the effects of the unobservable price of other goods on each of the foods. Symmetry, unlike either adding-up or homogeneity, provides testable restrictions on the matrix B.

The calculations are carried out exactly as detailed in Deaton (1994). The B matrix is calculated without restrictions, as in the previous section, and the final rows and columns filled in using homogeneity and adding-up. The symmetry test can be written as a set of linear restrictions on the elements of this matrix, and we use these restrictions both to calculate a Wald test statistic for the symmetry restrictions and to calculate restricted estimates that satisfy the symmetry restrictions.

2.3 *Results*

Table 6 shows the estimates of own and cross-price elasticities of quantity without symmetry imposed. These results come from a version of the model in which the demand functions include dummy variables for quarters (subrounds) and for (five of the) six broad regions. We discuss below the justification for including these effects, and the consequences of doing so. Elasticities that are absolutely larger than twice their standard errors are printed in bold face. The first column contains the total expenditure elasticities of quantity, calculated from the first-stage estimates in Table 5.

All of the diagonal terms in the matrix are negative, and all are significantly different from zero. Note that the higher quality cereals, rice and wheat, are much more price elastic than is the basic coarse cereal jowar, or even pulses. Sugar is also a good for which it is hard to find substitutes, and this may account for its small price elasticity. It should also be noted that the Table shows no universal link between the sizes of the expenditure elasticity and of the own price elasticity. While it is true that wheat and fruit have among the highest expenditure elasticities and also have (absolutely) high price elasticities, meat is outlay but not price elastic, and while other cereals are less expenditure elastic than are either rice or pulses, the price elastictiy of other cereals is much-higher than those of either rice or pulses. These patterns are important because demand systems with additive preferences, such as the linear expenditure system, impose an approximate proportionality between outlay and price elasticities. This proportionality has the effect of balancing the efficiency and equity effects of price distortions, so that optimal tax rates are the same at the second best welfare optimum, and, furthermore, all movements towards uniform taxes are welfare improving. Since there is no reason to suppose that additive preferences are correct, especially for a set of food demand equations, its imposition is likely to give the wrong answer to questions about pricing policies. The results in Table 6, and especially the non-proportionalities between the elasticities, are very different from what would be obtained from a model that embodied additive preferences.

Table 7 deals with another issue, which is the effects of including in the demand equation dummies for quarters and regions. The issue is whether there are broad regional taste differences that we do not wish to attribute to regional price differences, and whether we wish to impose that seasonal differences in price should have the same effect on demand as spatial differences. Rice may usually be ten percent cheaper at the beginning of the year than in the summer, and it may generally be ten percent cheaper in one district than another. But seasonal and regional differences in tastes may mean that the differences in demands are not the same as between the two situations, even when we have controlled for incomes, demographics, and other observable features. Of course, if we imposed no structure on tastes, and allowed demands to vary arbitrarily from village to village, it would be impossible to estimate any parameters. Our preferred procedure is to allow quarterly and regional dummies, and the results from this specification were those that were reported in Table 6. Table 7 repeats the diagonal elements of the price matrix in its first column, together with aggregate elasticities for cereals and the sum of the foods, calculated on the assumption that prices change proportionally for all components of the aggregate. Columns two through four show the effects on these own price elasticities of excluding both sets of dummies, of including only quarter dummies, and of including only regional dummies. The important issue turns out to be whether or not regional dummies are included. The estimates in the first and last columns, where regions are included, are close to one another, as are the estimates in the second and third columns, where regions are excluded. In most but not all cases, the estimates in the central columns are absolutely larger than those in the outer columns. One interpretation of these results runs in terms of the long-run effects of prices. Some interregional price differences are of very long-standing, and it is plausible on general Le Chatelier grounds that long-run price elasticities are absolutely larger than short term elasticities. In consequence, regional dummies may capture some of the long-run price effects, and estimated price elasticities will be lower when regional dummies are included. When we consider price reform proposals, we are probably not greatly interested in effects that take many years, perhaps centuries, to be established, and we prefer the generally lower estimates that come from including the dummies. A somewhat different perspective comes from considering the last row of the Table, which reports Wald test statistics for symmetry and where the lowest numbers are obtained when regional dummies are included. If conformity with the theory is an objective, regional dummies ought to be included.

Table 8 gives the final set of results, obtained by completing the system and by imposing the symmetry restriction. Given the inclusion of the regional and seasonal dummies, the Wald test for symmetry takes the value of 147.1, which, if symmetry were true, would be a random drawing from a χ^2-distribution with 55 degrees of freedom. Such a value is highly significant using conventional criteria, but is much less so when we take into account the size of the sample. There are 403 villages that have at least one unit value on all the foods, so that the Schwartz critical level for the test would be 55 times. ln(403) or 330, which is very much larger than the calculated figure. The credibility of symmetry is further reinforced by the fact that the important and well-determined elasticities in Table 6, particularly the own-price elasticities, are changed very little by the imposition of the restriction. Yet we also get the advantage, not only of more precise estimates, but also of a more theoretically satisfactory structure, so that, for example, cross-price effects are consistent whether calculated via the effects of *i* on *j*, or of *j* on *i*.

As before, the results show a number of important patterns, particularly of substitutability between the various foods. Wheat and other cereals are substitutes for one another, as are wheat and dairy products, with people switching from one to the other in response to relative prices. Jowar and other cereals are also substitutes, as are rice and sugar, an important link given the role that each commodity could potentially play in pricing and subsidy policy. Somewhat less clear is a pattern of complementarity between jowar, pulses, dairy products, and sugar, although note that since coarse cereals account for about 20% of the budget, the income effect is occasionally large enough to worry about, as for example in the effect of the coarse cereals price on the demand for all other goods. (Because coarse cereals are used to feed cows, there are also important supply-side links between coarse cereals and dairy products.)

It is instructive to compare these estimates with those for rural Pakistan reported in Deaton and Grimard (1992). In Pakistan, the staple food is wheat, rather than coarse cereals, and as incomes rise, the movement is towards rice, as opposed to towards rice and ultimately wheat in Maharashtra. With allowance for the different roles of the different foods, the elasticities are remarkably similar. The own price elasticity for wheat in rural Pakistan is estimated to be −0.51, while that for the 'superior' rice is −1.53. In Table 8, jowar has a price elasticity of −0.36, while the estimates for rice and wheat (in that order) are −0.55 and −1.32. In both Indian and Pakistani samples, sugar is price in elastic, and the elasticity of non-food is −0.66 and −0.69 respectively. Of course, there are also differences. Both edible oils and dairy products are much more price elastic (−1.59 and −0.89) in the Pakistani results than in the Indian ones.

3. *The analysis of price reform*

In this section we show how the estimates of the previous sections can be used, together with appropriate assumptions about shadow prices, to measure the costs and benefits of raising government revenue by means of a hypothetical increase in the consumer price of each of the twelve goods in our demand system. At this point, we are not concerned with whether or not these various price changes are practical, and some are a good deal more so than others. For traded goods, like wheat and rice, there are obvious instruments for affecting prices, while for a commodity like jowar, most of which is consumed close to where it is grown, it is far from clear that it is even possible for the government to affect the consumer price independently of the producer price. Even so, the calculaltions illustrate the interplay of equity and efficiency that would accompany each of the hypothetical price changes, and would be necessary information for an informed consideration of any proposed price reform. As in previous sections, the exposition follows closely that in Deaton and Grimard (1992).

The theory of price and tax reform in developing countries is well-developed in the literature, see for example the introductory chapters in Newbery and Stern (1987), the survey paper by Dreze and Stern (1987), and the monograph by Ahmad and Stern (1991). In the standard case, where there are no quality effects, and everyone faces the same price, the analysis runs as follows. Suppose that there is a proposal to increase the consumer tax on goods i. The (local) consequences of this change can be assessed by looking at the derivatives of consumer welfare with respect to the change, together with the effects on government revenue. The compensation required by agent h for price change Δp_i is $q_i^h \Delta p_i$. But we are typically not indifferent as between different gainers and losers, particularly in LDC's where there are very limited instruments for redistribution, so these individual compensations must be weighted according to weights Θ^h that are proportional to the social marginal values of income to each agent. The social cost of the tax increase is therefore given by the derivative

$$\frac{\partial W}{\partial t_i} - \Sigma_h \Theta^h q_i^h \tag{24}$$

The tax change will also have an effect on government revenue, directly through the additional taxes raised on the goods, and indirectly through the own-and cross-price substitution effects that are induced by the price increase. If R is total government revenue, then the derivative is

$$\frac{\partial R}{\partial t_i} = \Sigma_h q_i^h + \Sigma_h \Sigma_k t_k \frac{\partial q_k^h}{\partial t_i} \tag{25}$$

The ratio of (24) to (25), typically denoted λ_i, measures the social costliness of raising additional revenue through goods i. If λ_i is large, additional units of revenue are obtained at high social cost, as would happen, for example, if the good is heavily taxed, is highly price elastic, and most heavily consumed by the poor. By contrast, goods with low λ_i values are attractive candidates for raising revenue.

As written, equations (24) and (25) take no account of distortions elsewhere in the economy, nor of the resource allocation effects of tax changes that will typically result if prices do not reflect opportunity costs. To take account of these effects, write the consumer price p_i as $s_i + t_i$, where, for the moment, s_i is interpreted as a base price that is unaffected by the tax change. Since the tax change does not alter the total amount spent by consumers, (25) can be rewritten as

$$\frac{\partial R}{\partial t_i} = \Sigma_h \Sigma_k s_k \frac{\partial q_k^h}{\partial t_i} \tag{26}$$

so that the tax cost ratios λ_i become

$$\lambda_i = \frac{\Sigma_h \theta^h q_i^h}{-\Sigma_h \Sigma_k s_k \dfrac{\partial q_k^h}{\partial t_i}} \tag{27}$$

Under appropriate (but non-trivial) assumptions, Dreze and Stern (1987) show that (27) has an attractive alternative interpretation that allows a substantial generalization over the pure revenue focus of (24) and (25). In particular, if *actual* taxes are ignored, the vector s is taken as a vector of *shadow* prices, *i.e.* prices that reflect the relative social opportunity costs of the goods, so that the vector t is a vector of shadow tax rates, then (27) captures all of the effects of the tax changes through the general equilibrium system, and is therefore of quite general applicability. Indeed, the denominator of (27) represents minus the resource costs, *i.e.* the resource benefits of the tax increase, while its numerator is, as before, the welfare cost, so that the λ_i's are simply cost-benefit ratios at the "right," *i.e.* shadow prices.

The implementation of (27) requires the consumption of the various commodities, which we have from the survey, the price derivatives, which have been estimated in Section 2, social income weights, which are discussed below, and shadow prices. In this paper, we focus only on the major distortions in Indian agricultural policy, and do not attempt to derive a full set of shadow prices; for an example of the latter for 1979/80 based on the data used in the Technical Note to the Sixth Indian Plan, see Ahmad, Coady and Stern (1986). The Indian domestic prices of rice and of wheat are held below their world prices by the Public Distribution System (PDS) which procures and stockpiles cereals, and which sells them to consumers through fair-price shops. While purchases in fair-price shops are rationed, so that above the ration, the marginal price is the free-market price—which is presumably higher than it would be in the absence of PDS—we simplify by treating the PDS as if it straightforwardly subsidized rice and wheat. The other important distortion that we incorporate is the effective taxation of edible oils. The government protects the domestic groundnut processing industry, and in consequence the prices of edible oils are above the world prices. Gulati, Hanson, and Pursell (1990) calculate that, on average from 1980 to 1987, the domestic price of rice was 67 percent of its world price, that of wheat was 80 percent of the world price, and that of groundnuts was 150 percent of the world price. These translate into tax factors, the tax share in the domestic price $\tau_i/(1+\tau_i)$ of −0.50, −0.25, and 0.33 for rice, wheat and groundnut oil. While these are somewhat stylized figures, and ignore other price distortions in food prices, they are based on the Indian reality of the 1980s, and will serve very well to illustrate the general points of the analysis.

Before calculating the results, we need to adapt the basic model of tax reform to a world where people pay different prices, and where quality as well as quantity is an object of choice. The simplest assumption, and that adopted here, is that taxes on each goods are *ad valorem*, so that the tax paid is a cons tant proportion of price, so that the tax per kilo is higher for higher priced varieties, as well as at locations where rice is more expensive. It is easy to think of cases where this is not true, where taxes are fixed at rates per quintal, and where transport margins are the same irrespective of the total value of the load. Nevertheless, the assumption yields substantial simplifications, as we shall see. If the tax rate on goods i is τ_i, then the tax paid by consumer h on goods i is $\tau_i \tilde{v}_i^h q_i^h$ where $\tilde{v}_i^h = v_i^h/(1+\tau_i)$ is the ex-tax unit value. Hence, the compensation payable for an increase $\Delta\tau_i$ is $\tilde{v}_i^h q_i^h \Delta\tau_i$ so that the numerator of the λ_i ratio (24) is replaced by

$$\frac{\partial W}{\partial \tau_i} - \sum_h \Theta^h \tilde{v}_i^h q_i^h = \sum_h (x^h/n^h)^{-\varepsilon} x^h w_i^h \qquad (28)$$

where we have adopted the standard (Atkinson) practice that the social weight given to additional income for h is proportional to the level of *per capita* household expenditure, x/n, *raised to the power of* $-\varepsilon > 0$. A value of ε of unity implies that additional income is twice as valuable to someone with half the income, with higher values implying a greater focus on the poor, and lower values less. Social welfare accounting is done for individuals, not households, but (28) is nevertheless correct under the inevitable assumption that household consumption levels are equally shared among household members.

To derive the revenue effects of changes in τ_i, it helps to decompose unit value into the product of p_i and quality, μ_i. Revenue raised from consumer h, R^h is then

$$R^h = \sum_k \tau_k \mu_k^h \bar{p}_k^h q_k^h \qquad (29)$$

where p_k^h is the ex-tax price faced by the consumer. We can then differentiate with respect to τ_i, remembering to take into account the shading of qualities in response to price, and using the facts that

$$\frac{\partial p_i^h}{\partial \tau_i} = \frac{p_i^h}{1+\tau_i} \qquad \frac{\partial \ln \mu_i}{\partial \ln p_j} = \psi_{ij} - \delta_{ij} \qquad (30)$$

it is possible to show that

$$\frac{\partial R^h}{\partial \tau_i} = \frac{1}{1+\tau_i} \sum_k \frac{\tau_k}{1+\tau_k} x^h (\theta_{ki} - \delta_{ki} w_i^h) \qquad (31)$$

which can be evaluated given actual or shadow tax rates, the data from the survey, and the estimates of the parameters. One final formula will be useful. Define the aggregate budget shares, the shares of each expenditure in aggregate consumers' expenditure, by

$$\tilde{w}_i = \frac{\sum_h x^h w_i^h}{\sum_h x_h} \qquad (32)$$

and the 'socially representative' budget shares by

$$w_i^E = \frac{\sum_h (x_h/n_h)^{-\varepsilon} x^h w_i^h}{\sum_h x^h} \qquad (33)$$

The cost-benefit ratios λ_i are the ratios of (28) to (31) and can be written

$$\lambda_i = w_i^{\varepsilon}/\bar{w}_i \div \left[1 + \frac{\tau_i}{1+\tau_i}\left(\frac{\theta_{ii}}{\tilde{w}_i} - 1\right) + \sum_{k \neq i} \frac{\tau_k}{1+\tau_k}\frac{\theta_{ki}}{\tilde{w}_i} \right] \quad (34)$$

The numerator of (34) is a pure distributional measure for good *i*; it can be interpreted as the relative shares of the market representative individual (the representative agent) and the socially representative individual, whose income is lower the higher is the inequality aversion parameter ε. This measure is modified by the action of the terms in the denominator. The first of these (apart from 1) is the tax factor multiplied by the elasticity of expenditure on good *i* with respect to its price, quality and quantity effects taken together. This term measures the own-price distortionary effect of the tax. If it is large and negative, as would be the case for a heavily taxed price elastic good, the term will contribute to a large λ_i-ratio and would indicate the costliness of raising further revenue by that route. The last term is the sum of the tax factors multiplied by the cross-price elasticities, and captures the effects on other goods of the change in the tax on good *i*, again with quantity and quality effects included. From a theoretical point of view, this decomposition is trivial, but when we look at the result, it is useful to separate the own-and cross-price effects since the former are likely to be more reliably measured than the latter.

Table 9 shows the calculated efficiency effects of raising taxes on each of the goods, distinguishing between the various terms in the denominator of (34). The first column shows the tax factors $t_i(1+\tau_i)$ calculated from the accounting ratios discussed above: these are the shadow taxes and subsidies discussed above. The second column shows the own-price elasticities of quality and quantity together: since the quality effects are small, these are very close to the own-price elasticities in Table 8. For the same reason, we do not elaborate on how the difference is calculated, see Deaton (1994) for full details. The product of the first and second columns, which is the third columns, gives the contribution of the own-price effects to the measure of the distortion that would be caused by a marginal increase in price. These are non-zero only for rice, wheat, and oil: note that because wheat is more price elastic than rice, its own-price distortion is larger than that for rice, even though its subsidy rate is half as much. However, as the next column shows, that distortion caused by the wheat subsidy is somewhat alleviated by the cross-price effects, because a lower wheat price draws some demand away from rice, which is even more heavily subsidized. The other important cross-price effect is for meat, which comes from the fact that rice demand decreases in response to increases in the meat price. Because of the heavy subsidy on rice, increases in the meat price would decrease distortion, so that it is meat, rice and wheat that attract the largest magnitudes in the final column, while oil gets the smallest. On efficiency grounds alone, the prices of wheat, rice, and meat should be increased, and that of oil decreased.

Table 10 brings in the equity effects, and computes the cost benefit ratios that trade-off both equity and efficiency. In the first pair of columns, the Atkinson inequality aversion parameter is zero, so that all individuals are treated alike, no matter how much their household has to spend. In this case, the λ ratios are simply the reciprocals of the last column in Tabe 9, and we get again the same ranking of relative tax costs. As we move to the right, and the ε parameter increases, the equity column gives larger values to the goods most heavily consumed by the poor, and relatively smaller values to those that are most heavily consumed by the those who live in households that are better-off. for ε=0.5, jowar receives the highest weight, with other cereals, pulses, vegetables, and sugar also receiving weights larger than unity. These are the goods most heavily consumed by the poor. At ε=1 or above, jowar and other cereals are even further emphasized as a 'poor' goods, and the ordering of the other goods is much the same as before. Of the two subsidized cereals, the equity case is stronger for rice than wheat—which is indeed why rice carries the larger subsidy—and the difference between them increases with the degree of inequality aversion. In Maharshtra neither cereal is consumed as heavily by the poor as is jowar, although there limitations on the extent to which the government could intervene in that market. Note that since we compute these equity effects from the raw data, without the assumption of any functional form for Engel curves, there is no reason why the rankings should change in any simple way with changes in the inequality aversion parameter.

The cost benefit ratios λ bring together the equity and efficiency effects. Rice, wheat, and when ε is large, meat and fruit, have the lowest ratios. Wheat is a more attractive candidate for price increases than is rice because it has a higher price elasticity, and because it is more of a luxury than rice, but working in the opposite direction are the facts that its existing subsidy is lower, which causes less distortion, and that subsidies on neither commodity are very effective at reaching the poorest. The best candidates for price reduction are edible oil, for which there is no good distributional argument for industrial protection, and jowar, a cheapening of which would help the poor but which is probably impractical.

In conclusion, we must again emphasize the illustrative nature of these calculations. It would be more interesting to evaluate realistic reform proposals, and to have more precise estimates of shadow prices. But given these, the application of the techniques of this paper, and of the estimated elasticities, is straightforward. It would also be desirable to be able to say something more precise about the operation of ration shops in urban areas, something that should be possible with later rounds of the NSS, where respondents are asked where they purchased their food.

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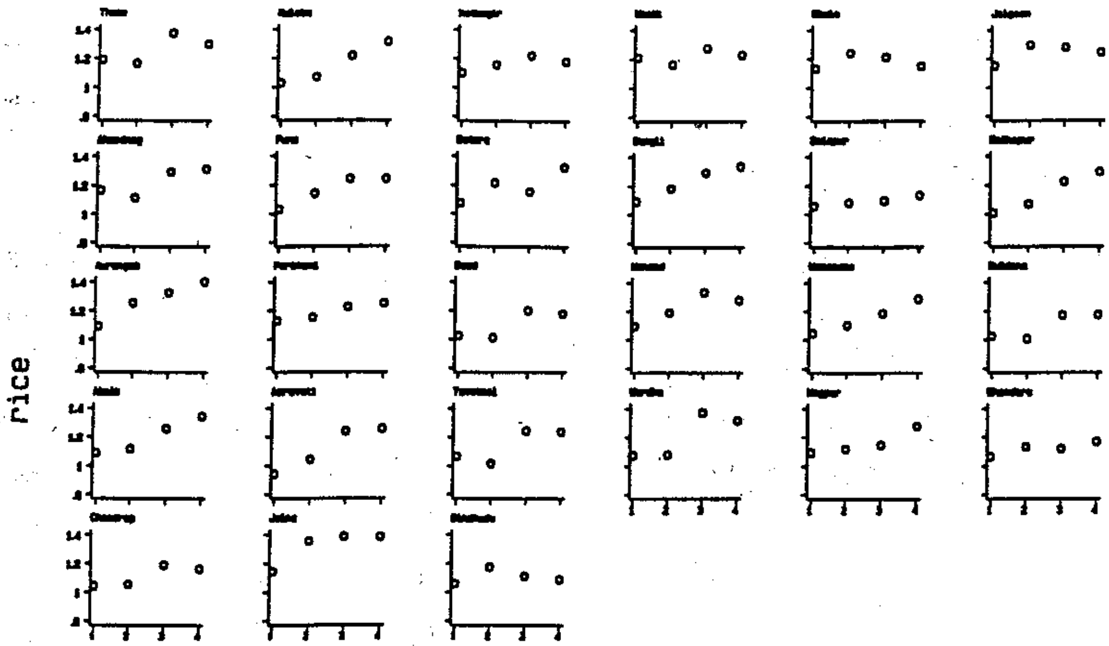

Figure 1: Log unit price of rice by district and subround, rural Maharashtra 1983

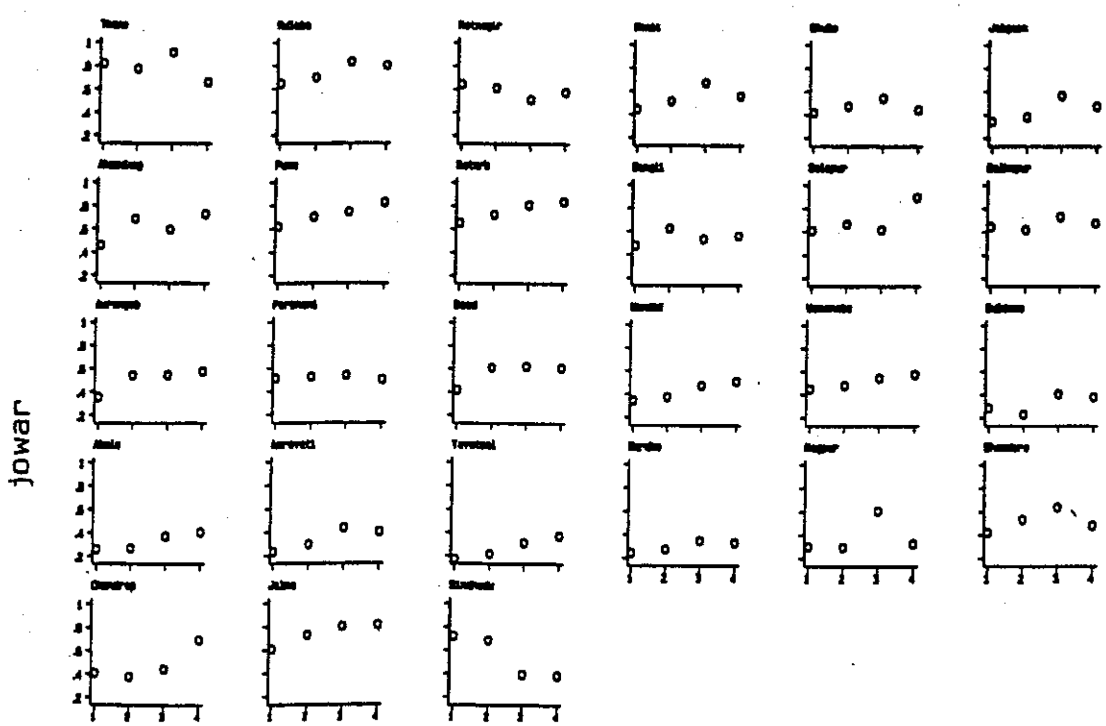

Figure 2: Log unit price of jowar by district and subround, rural Maharashtra, 1983

Table 1

Numbers of sample households by region and district
Urban and rural Maharashtra, NSS 38th round, 1983

	rural	urban		rural	urban
Region 1 Coastal			*Region 4 Inland Coastal*		
(01) Greater Bombay	0	1990	(14) Aurangabad	160	110
(02) Thane	240	290	(15) Parbhani	160	90
(03) Kulaba	160	30	(16) Beed	160	90
(04) Ratnagiri	160	20	(17) Nanded	160	60
(28) Sindhudurg	80	20	(18) Usmanabad	240	100
Region 2 Inland Western			(27) Jalna	80	70
(08) Ahmednagar	320	120	*Region 5 Inland Eastern*		
(09) Pune	320	460	(19) Buldana	160	60
(10) Satara	240	90	(20) Akola	230	100
(11) Sangli	240	80	(21) Amravati	240	130
(12) Solapur	240	240	(22) Yevatmal	240	70
(13) Kohlapur	240	160	(23) Wardha	70	40
Region 3 Inland North			(24) Nagpur	150	360
(05) Nasik	320	240	*Region 6 Eastern*		
(06) Dhule	240	80	(25) Bhandara	230	90
(07) Jalgaon	320	200	(26) Chandrapur	230	110

Note: The numbers in brackets are the NSS codes for the districts and define the order of the graphs in Figures 1 and 2.

Table 2

Budget shares, unit values and fractions buying various foods
Rural Maharashtra, NSS 38th Round, 1983

(Percentages or rupees per kilo)

	weighted			unweighted		
	% consuming	share	unit value	% consuming	share	unit value
rice	88.6	8.63	3.32	88.3	8.24	3.30
wheat	72.7	3.89	2.75	72.4	3.68	2.75
jowar	74.1	11.89	1.73	76.0	12.27	1.72
other cereals	53.3	3.24	6.34	55.2	3.54	6.32
pulses & gram	98.1	5.97	5.60	98.6	5.97	5.56
dairy produce	84.4	5.27	3.79	85.2	5.33	3.80
edible oils & fats	98.5	5.87	15.89	99.0	6.00	15.90
meat, fish, and eggs	61.4	3.54	15.68	60.5	3.45	15.88
vegetables	98.3	4.67	2.10	98.9	4.70	2.07
fruit	83.1	2.32	6.34	83.1	2.30	6.35
sugar and gur	98.3	4.26	4.06	98.3	4.34	4.03
other food	100.0	7.82		100.0	7.57	
All food	100.0	67.39		100.0	67.41	

Notes : Weighted means are calculated using the sampling multipliers so as to give estimates that are representative of the population as a whole; unweighted means are sample means. The means of budget shares are the means of the individual shares and are not the same as the ratio of average expenditure on the good to average total expenditure. Percetages consuming and budget shares are in percentages unit values in (1983) rupees per kilo.

Table 3

Variability of unit values and ANOVA by villages, regions, subrounds and subsamples
Rural Maharashtra, NSS 38th round, 1983

	Village ANOVA			Region, quarter and subsample ANOVA			
	log sd	*F-v*	*R^2-v*	*F-reg*	*F-q*	*F-reg*q*	*f-subs*
rice	19.9	8.11	0.506	22.2	183.0	7.71	2.40
wheat	19.5	6.45	0.493	27.6	70.9	3.06	1.68
jowar	23.1	22.4	0.752	481.4	50.9	11.7	9.02
other cereals	59.4	10.5	0.649	176.4	19.2	5.55	4.67
pulses	20.1	12.9	0.591	228.1	157.7	5.29	3.88
dairy	37.9	4.08	0.346	76.3	17.1	2.89	0.41
oils	16.2	13.5	0.603	159.8	286.2	13.5	0.02
meat, eggs & fish	37.6	7.00	0.573	143.0	30.3	6.6	16.4
vegetables	28.7	52.5	0.855	262.2	2221	28.0	11.9
fruit & nuts	80.7	8.93	0.544	44.1	13.9	6.03	17.4
sugar & gur	16.5	10.2	0.534	23.3	273.7	4.84	0.00

Notes : The first column is 100 times the standard deviation of the logarithm of unit value, calculated over all households purchasing the good. Columns 2 and 3 show the *F*-test and R^2-statistic associated with the presence of dummy variables for each village in the survey. Columns 4, 5, 6 and 7 show the results of an analysis of variance of log unit values on dummies for the six regions, the four quarters of 1983, interactions between region and quarters and the two interpenetrating subsampes of the NSS.

TABLE 4 : REGIONAL AND SEASONAL DIFFERENCES IN UNIT VALUES RURAL MAHARASHTRA, NSS 38TH ROUND, 1983

	R1	R2	R3	R4	R5	Jan-Mar	Apr-Jun	Jul-Sep	R^2
rice	7.2	5.6	9.6	7.2	3.0	—17.1	—11.9	—2.0	0.143
	(6.3)	(5.7)	(8.6)	(6.7)	(2.8)	(23)	(16)	(2.7)	
wheat	8.8	9.3	2.9	11.6	5.4	—13.9	—9.8	—4.1	0.106
	(5.8)	(7.3)	(2.0)	(9.0)	(4.2)	(17)	(12.0)	(5.1)	
jowar	17.8	18.4	—1.7	3.9	—16.2	—12.5	—5.9	—0.1	0.387
	(11)	(15)	(1.2)	(3.1)	(13)	(16)	(7.4)	(0.1)	
other cereals	—81.5	—21.3	—79.2	—19.5	—13.2	—15.7	—7.9	19.0	0.255
	(9.7)	(2.8)	(10.2)	(2.5)	(1.6)	(6.0)	(3.0)	(7.4)	
pulses & gram	28.4	21.1	18.5	15.1	6.8	—13.2	—10.5	—0.1	0.240
	(26)	(23)	(18)	(15)	(6.9)	(20)	(16)	(0.9)	
dairy	14.5	—16.9	2.7	—13.3	3.2	—10.7	—5.6	6.3	0.089
	(5.1)	(7.9)	(1.2)	(5.9)	(1.4)	(7.3)	(3.8)	(0.4)	
oils	20.5	16.8	20.3	18.2	13.7	—12.3	—8.5	1.4	0.233
	(24)	(22)	(25)	(23)	(17)	(23)	(16)	(2.7)	
meat, eggs & fish	—27.6	12.5	14.6	17.6	11.6	0.8	—6.0	8.6	0.194
	(11)	(5.5)	(5.9)	(7.3)	(4.8)	(0.5)	(3.7)	(5.2)	
vegetables	25.6	2.7	3.9	3.6	—6.1	—47.4	—42.2	—10.3	0.589
	(23)	(2.8)	(3.6)	(3.5)	(5.9)	(68)	(61)	(15)	
fruit & nuts	79.6	70.5	86.0	66.0	49.1	—2.6	—16.7	—5.0	0.067
	(13)	(13)	(15)	(11)	(8.4)	(0.8)	(5.2)	(1.6)	
sugar & gur	0.8	—5.7	—4.0	—5.0	—4.9	—16.0	—9.8	—2.0	0.169
	(0.8)	(7.0)	(4.5)	(5.7)	(5.7)	(28)	(17)	(3.6)	

Notes : The estimates are obtained from regressing the logarithm of unit value against a constant (not shown), five regional dummies, three quarterly dummies, and a subsample dummy (also not shown). Absolute velues of *t*-values are shown in brackets. The figures shown are 100 times the estimates and can be interpreted (approximately) as percentage differences from the base region (Eastern) and the base season (Oct-Dec). The regions are R1, coastal, R2 Inland Western, R3 Inland Northern, R4 Inland Central, and R5 Inland Eastern.

TABLE 5: FIRST STAGE REGRESSIONS: BUDGET SHARES AND LOG UNIT VALUES ON HOUSEHOLD CHARACTERISTICS RURAL MAHARASHTRA, NSS 38TH ROUND, 1983

	budget share		long unit value								
	ln *x*	ln *n*	lnx	ln *n*	type 1	type 2	type 3	type 4	s/c	hindu	budd
rice	−2.27	2.05	5.8	−4.1	−1.3	−4.7	−3.1	−4.5	0.5	−0.7	−1.5
	(11)	(10)	(8.8)	(5.7)	(1.1)	(4.5)	(2.1)	(4.4)	(0.7)	(0.6)	(0.9)
wheat	0.60	0.32	4.7	−2.6	−2.8	−4.0	−3.5	−3.9	−1.9	−0.9	0.0
	(4.2)	(2.1)	(6.3)	(3.2)	(2.2)	(3.4)	(2.1)	(3.5)	(2.4)	(0.7)	(0.0)
jowar	−8.21	6.86	4.2	−4.2	−2.0	−3.4	−2.2	−4.2	−0.2	−1.1	−1.8
	(33)	(26)	(7.1)	(6.5)	(1.7)	(3.2)	(1.5)	(4.1)	(0.3)	(1.10)	(1.3)
other cereals	−1.49	1.66	12.3	1.1	−3.1	−10.8	4.3	−5.9	−16.5	55.6	55.0
	(9.3)	(9.6)	(5.6)	(0.5)	(0.8)	(3.0)	(0.9)	(1.7)	(6.9)	(9.2)	(7.3)
pulses + gram	−1.85	1.13	2.2	−2.6	−0.6	−0.3	−2.0	−3.9	−0.8	0.5	3.0
	(21)	(12)	(3.9)	(4.2)	(0.5)	(0.3)	(1.5)	(4.3)	(1.3)	(0.4)	(2.1)
dairy	1.19	−0.58	10.9	−3.4	−1.3	−3.6	−4.6	−4.6	−1.1	1.5	2.9
	(7.6)	(3.4)	(7.2)	(2.1)	(0.5)	(1.5)	(1.3)	(2.0)	(0.7)	(0.6)	(0.8)
oils	−1.08	0.77	3.4	−2.2	0.0	−1.7	−0.8	−0.7	−0.0	0.3	−1.4
	(13)	(8.3)	(7.6)	(4.4)	(0.0)	(2.2)	(0.8)	(1.0)	(0.0)	(0.4)	(1.3)
meat etc.	0.79	0.01	17.9	−8.5	−0.9	0.0	2.4	−0.0	−0.2	11.3	8.3
	(6.3)	(0.1)	(11)	(5.2)	(0.3)	(0.0)	(0.7)	(0.0)	(0.1)	(4.4)	(2.5)
vegetables	−1.75	0.73	3.7	−1.5	−0.5	−1.2	−1.6	−0.8	−1.0	−0.9	−0.8
	(27)	(10)	(7.6)	(2.9)	(0.5)	(1.5)	(1.4)	(1.0)	(1.9)	(1.0)	(0.6)
fruit & nuts	0.18	−0.06	9.7	−4.6	4.1	−2.1	−0.2	−1.8	−1.6	−23.0	−18.8
	(3.0)	(0.9)	(3.6)	(1.6)	(0.9)	(0.5)	(0.0)	(0.4)	(0.5)	(4.6)	(2.8)
sugar & gur	−1.30	0.82	5.2	−4.6	−2.6	−4.8	−4.3	−3.5	−1.2	−0.5	−0.4
	(20)	(12)	(11)	(8.7)	(2.9)	(6.0)	(3.8)	(4.5)	(2.3)	(0.5)	(0.4)

Notes: Each row shows the (partial) results of two regressions. In the first, columns 1 and 2, the budget share is regressed on lnx, the logarithm of total household expenditure, ln*n*, the logarithm of household size, nine ratios describing the age and sex structure of the households, dummies for household type (type 1 self-employed non-agriculture, type 2 agricultural labor, type 3 other labor, type 4 self employed in agriculture, and type 5, omitted here, other: type has the heighest living standard on average), a dummy (s/c) for scheduled caste or tribe, a dummy for hindu (including jain and parsi), a dummy for Buddhist, the omitted category being Christian or Muslim, and a constant. Dummies for each village are also included. Only the first two coefficients are shown. In the second regression, the dependent variable is the logarithm of unit value, and the right hand-side variables are the same. The expenditure, household size, and household type dummies are shown in the table. The sample size is 5630 with 563 villages for the share equations, but varies from good to good in the unit value equations with the numbers of households who purchase. All coefficients are shown as 100 times their value. Fuller details on the share equations are given in Subramanian and Deaton (1991).

TABLE 6: TOTAL EXPENDITURE, OWN, AND CROSS-PRICE ELASTICITY ESTIMATES RURAL MAHARASHTRA, NSS 38TH ROUND, 1983

	ε1	price elasticities										
		ric	whe	jow	oce	pul	dai	oil	mea	veg	fru	sug
ric	0.67	**0.68**	0.11	0.14	—0.07	—0.10	0.00	**—0.75**	—0.02	—0.04	**—0.13**	—0.01
whe	1.12	—0.22	**—1.28**	—0.02	**0.19**	0.02	0.14	—0.35	—0.09	—0.06	—0.05	0.25
jow	0.29	0.19	0.04	—0.33	**0.20**	0.30	0.02	0.23	0.10	—0.11	**0.07**	—0.34
oce	0.46	0.21	0.27	0.37	**—1.24**	0.02	—0.34	0.11	**—0.52**	—0.11	—0.05	0.09
pul	0.67	—0.13	0.15	**—0.36**	—0.02	**—0.52**	**—0.15**	0.04	0.04	—0.11	**0.05**	**0.31**
dai	1.11	—0.23	0.25	—0.18	**0.12**	0.07	**—0.50**	0.05	0.12	0.15	—0.07	0.21
oil	0.79	0.17	—0.04	—0.09	0.03	—0.13	0.01	**0.54**	**0.11**	0.01	0.03	**0.36**
mea	1.05	—0.41	—0.07	0.03	—0.00	—0.43	**—0.25**	0.17	**—0.58**	—0.11	**0.09**	0.32
veg	0.59	0.10	0.15	**0.36**	0.06	**0.47**	**—0.20**	**—0.46**	0.06	**—0.89**	—0.04	—0.07
fru	0.98	**0.64**	0.12	—0.23	—0.03	0.01	—0.22	0.41	—0.08	—0.14	**—0.93**	**—0.84**
sug	0.65	**0.33**	—0.09	0.26	0.03	—0.01	0.01	0.04	—0.01	—0.10	—0.01	**—0.27**

Notes: The first column is the estimate of the total expenditure elasticity computed at the means of the budget shares using the estimate of β^0 from Table IV. Standard errors can be calculated by dividing the standard errors of β^0 in table IV by the average budget shares in Table I. The matrix of price elasticities is calculated after allowing for the effects of seasonal and regional dummies on the budget shares, see Table VII below for variants. Estimates printed in bold face are (absolutely) greater than twice their standard errors. The goods are identified by the first three letters of their names; see previous tables for fuller titles. The elasticity in row *i*. column *j* estimates the effect of a change in the price of good *j* on the quantity demanded of good *i*. The estimates imply that the own-price elasticity of cereals is —0.33 (0.10) and that of all foods shown is —0.32 (0.00). Estimates are based on averaged data for 410 villages.

TABLE 7: OWN-PRICE ELASTICITIES UNDER ALTERNATIVE SPECIFICATIONS RURAL MAHARASHTRA, NSS 38TH ROUND, 1983

	Dummy variables included :—			
	quarters regions	none	quarters	regions
rice	−0.68 (0.25)	−1.00 (0.41)	−0.87 (0.37)	−0.63 (0.25)
wheat	−1.28 (0.22)	−1.3 (0.22)	−1.18 (0.22)	−1.25 (0.22)
jowar	−0.33 (0.13)	−0.64 (0.12)	−0.61 (0.12)	−0.35 (0.13)
other cereals	−1.24 (0.08)	1.24 (0.07)	−1.28 (0.08)	−1.21 (0.08)
pulses & gram	0.52 (0.13)	−0.70 (0.14)	−0.80 (0.14)	−0.50 (0.13)
dairy	−0.50 (0.1)	−0.82 (0.10)	−0.73 (0.10)	−0.55 (0.10)
edible oils	−0.54 (0.13)	−0.47 (0.08)	−0.42 (0.15)	−0.57 (0.13)
meat, eggs & fish	−0.58 (0.11)	0.91 (0.09)	−0.93 (0.09)	−0.58 (0.10)
vegetables	−0.89 (0.11)	−1.07 (0.09)	−1.00 (0.10)	−0.75 (0.09)
fruit and nuts	−0.93 (0.05)	−0.95 (0.06)	−0.91 (0.05)	−0.97 (0.05)
sugar and gur	−0.27 (0.12)	−0.20 (0.12)	−0.32 (0.12)	−0.23 (0.12)
all cereals	−0.33 (0.10)	−0.42 (0.15)	−0.37 (0.12)	−0.29 (0.10)
all food	−0.32 (0.00)	0.11 (0.00)	−0.34 (0.00)	−0.27 (0.00)
Wald symmetry test	147.1	2137	284.8	149.9

Notes: The specification is the same as that in Table 6 above, but the columns show the effects of including different sets of dummy variables at the second stage of estimation. Column 1 corresponds to Table 6. Standard errors are shown in brackets.

TABLE 8 : OWN, AND CROSS-PRICE ELASTICITY ESTIMATES WITH SYMMETRY IMPOSED RURAL MAHARASHTRA, NSS 38TH ROUND, 1983

	ε_1	price elasticities											
		ric	whe	jow	oce	pul	dai	oil	mea	veg	fru	sug	other
ric	0.67	**−0.55**	0.01	0.07	0.07	−0.05	−0.04	0.12	−0.11	−0.06	−0.05	**0.13**	−0.07
whe	1.12	−0.02	**−1.32**	0.03	**0.20**	0.08	**0.26**	−0.19	−0.10	0.00	0.04	−0.14	0.03
jow	0.29	0.08	0.04	**−0.36**	**0.18**	**−0.10**	0.08	−0.05	0.02	**0.12**	**0.04**	**−0.10**	−0.09
oce	0.46	−0.15	**0.22**	**0.61**	**−1.17**	0.00	**0.12**	0.05	−0.00	0.05	−0.00	0.04	−0.24
pul	0.67	−0.07	0.07	**0.24**	−0.00	**−0.52**	−0.05	−0.02	0.01	0.11	**0.05**	0.04	−0.02
dai	1.11	−0.10	**0.18**	−0.29	0.07	−0.09	**−0.52**	0.03	−0.02	−0.11	**−0.08**	0.02	−0.19
oil	0.79	0.16	−0.11	−0.17	0.02	−0.03	0.04	**−0.40**	**0.09**	−0.06	−0.03	0.14	**−0.51**
mea	1.05	−0.29	−0.11	−0.03	−0.02	−0.00	−0.04	0.14	**−0.55**	0.05	0.06	0.02	−0.29
veg	0.59	−0.10	0.02	**0.28**	0.04	0.14	−0.09	−0.07	0.05	**−0.78**	**0.06**	−0.08	−0.06
fru	0.98	−0.21	0.0	0.15	−0.02	0.11	**−0.17**	0.07	0.10	0.09	**−0.93**	−0.01	−0.22
sug	0.65	**0.26**	−0.11	**−0.32**	0.03	0.05	0.05	**0.20**	0.03	−0.09	0.00	−0.31	**−0.45**
other	1.28	−0.06	−0.01	**−0.15**	**−0.04**	−0.04	−0.03	**−0.11**	−0.03	−0.04	**−0.02**	**−0.08**	**−0.66**

Notes : The matrix of price elasticities is calculated after allowing for the effects of seasonal and regional dummies on the budget shares, see Table 7 above for variants, and with the symmetry restrictions imposed, see the text. Estimates printed in bold face are (abolutely) greater than twice their standard errors. The goods are identified by the first three letters of their names; see previous tables for fuller titles. The elasticity in row *i*, column *j* estimates the effect of a change in the price of good *j* on the quantity demanded of good *i*. The X^2 test for symmetry has a value of 147.1 and has 55 degrees of freedom. The estimates imply an own-price elasticity for cereals of −0.41 (0.09) and for all foods shown of −0.33 (0.04). Estimates are based on averaged data from 403 villages.

TABLE 9: EFFICIENCY EFFECTS OF PRICE INCREASES: MAHARASHTRA

	tax factor	e_{ii}	own	cross	total
rice	—0.50	—0.60	0.30	0.05	1.35
wheat	—0.25	—1.32	0.33	—0.06	1.27
jowar	0	—0.27	0	—0.08	0.92
other cereals	0	—1.51	0	0.04	1.03
pulses	0	—0.53	0	0.04	1.04
dairy produce	0	—0.63	0	—0.02	0.98
edible oils	0.33	—0.41	—0.13	—0.07	0.80
meat, etc.	0	—0.63	0	0.22	1.22
vegetables	0	—0.62	0	0.08	1.08
fruit	0	—1.06	0	0.13	1.13
sugar	0	—0.22	0	—0.08	0.92
all other	0	—0.76	0	—0.02	0.09

Notes: The tax factor is the share of the shadow tax in the tax inclusive price, e_{ii} is the own-price elasticity of quality times quantity, and is approximately equal to the own price elasticity shown in Table 8. Own and cross refer to the second and third terms in the denominator of equation (34) in the text, and total is the denominator itself.

TABLE 10: EQUITY AND COST-BENEFIT RATIOS OF PRICE INCREASES: MAHARASHTRA 1983

	$\varepsilon = 0$		$\varepsilon = 0.5$		$\varepsilon = 1.0$		$\varepsilon = 2.0$	
	equity	λ	equity	λ	equity	λ	equity	λ
rice	1	0.74	1.00	0.75	1.00	0.74	0.98	0.72
wheat	1	0.78	0.96	0.76	0.93	0.73	0.87	0.68
jowar	1	1.08	1.09	1.18	1.17	1.27	1.33	1.44
other cereals	1	0.97	1.07	1.03	1.12	1.08	1.19	1.15
pulses	1	0.96	1.03	0.99	1.05	1.01	1.10	1.06
dairy produce	1	1.02	0.95	0.97	0.91	0.93	0.83	0.84
edible oils	1	1.25	1.00	1.25	1.01	1.26	1.03	1.28
meat	1	0.82	0.98	0.80	0.95	0.78	0.91	0.74
vegetables	1	0.93	1.02	0.94	1.03	0.95	1.05	0.97
fruit	1	0.88	0.95	0.84	0.90	0.79	0.81	0.71
sugar	1	1.09	1.02	1.10	1.03	1.12	1.07	1.17
all other	1	1.02	0.94	0.96	0.89	0.91	0.84	0.86

Notes: The parameter ε is the Atkinson parameter and controls the degree of inequality aversion: with $\varepsilon=0$ there is no equity weighting, and as ε increases, increasingly more weight is given to the effects on the poor. The column labelled equity is the (normalized) numerator of equation (34) and is the ratio of the budget shares of the socially representative and market representative individuals divided by its mean. The column labelled λ is the cost benefit ratio of raising one unit of government revenue by inceasing the consumer price of the commodity, taking both equity and efficiency effects into account.