ISSUES IN THE METHODOLOGY OF MULTIMARKET ANALYSIS OF AGRICULTURAL PRICING POLICIES

by

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In three recent papers, Braverman, Hammer and Levinsohn (1983), Braverman, Hammer and Ahn (1983), and Braverman, Hammer and Jorgensen (1984), a multi-market analysis of agricultural pricing policies has been applied to Senegal, Korea and Cyprus. This paper is concerned with a number of methodological issues which have arisen in this work; in Section 1 I deal with six areas that seem to be of particular importance, either in theory or in practice. In Section 2, I discuss in a preliminary way an alternative approach to the simulation strategy that has so far been adopted. This is an approach based on reform where, instead of analysing the consequences of alternative policies often far removed from the status quo, the emphasis is on the impact of small changes from current policies and on finding a good direction for policy change.

Section 1 Six methodological issues

(i) A quadratic form of AIDS (QAIDS)

Given the sort of data typically used in the analysis, particularly data on the consumption of very disaggregated commodities, I doubt whether the standard AIDS of Deaton and Muellbauer (1980a) is likely to be sufficiently flexible, at least for modelling income responses. It incorporates probably more price flexibility than is typically useful, but the variation allowed in its income responses will often be insufficient to match some of the Engel curve shapes that sometimes appear in the survey data. Although AIDS has non-linear Engel curves, they are non-linear in a heavily prescribed way. For example, necessities always become inferior goods ultimately, and marginal propensities to spend are always monotone in total outlay. For some foodstuffs, marginal propensities to spend may first rise then fall, and other more complex patterns are occasionally observed.
One possible system that preserves much of the flavor of AIDS is QAIDS.

Consider a cost function of the form

\[
\log c(u, p) = a(p) - b(p) (u - d(p))^{-1}
\]  
(1)

for functions \( a(p) \), \( b(p) \). This is the logarithmic form of Howe, Pollak and Wales' (1981) quadratic expenditure system. Note that with \( d(p) = \text{constant} - d_0 \) say, \(- (u - d_0)^{-1}\) is a monotone increasing transform of utility so that (1) reduces to PIGLOG, the general class underlying AIDS. On the analogy with AIDS, then, choose \( a, b \) and \( d \) to give

\[
\log c(u, p) = \alpha_0 + \Sigma \alpha_k \log p_k + \frac{1}{2} \Sigma \Sigma \gamma_{kj} \log p_k \log p_j - \frac{\beta_k}{u - \Pi_p p_k}
\]  
(2)

with the following required properties (for homogeneity and symmetry)

\[
\Sigma \alpha_k = 1, \quad \Sigma \gamma_{kj} = \Sigma \gamma_{ij}, \quad \Sigma \gamma_{kj} = 0 = \Sigma \beta_k = \Sigma \beta_k
\]

\( \gamma_{ij} = \gamma_{ji} \)

The budget shares are given, as usual, by

\[
w_i = \frac{a}{a} \log c(u, p)/a \log p_i
\]

So that, differentiating and substituting yields, after some algebra

\[
w_i = \alpha_i + \Sigma \gamma_{ij} \log p_j + \beta_i \log \left( \frac{X}{P} \right) - \beta_i \frac{1}{\Pi_p p_k} \left[ \log \frac{X}{P} \right]^2
\]  
(3)

with \( \log P = \alpha_j + \Sigma \alpha_k \log p_k + \frac{1}{2} \Sigma \Sigma \gamma_{kj} \log p_k \log p_j \)  
(4)
Note that QAIDS becomes AIDS if \( \delta_i = 0 \) for all \( i \); as it is, it is somewhat less elegant because of the \( \prod_0^k \) that is attached to the last term. I can't find any way of respecifying the model to get rid of it, but I can think of a couple of neat enough ways of fixing it. Either (i) approximate it by unity (remember it's a zero weight index), this is like approximating \( \log P \) by any arbitrary price index, or (ii) starting from (i), estimate some \( \delta_i \)'s, calculate a \( \prod_0^k \) series - rescale it to average unity so that the \( \delta_i \)'s are altered as little as possible - and re-estimate.

This is all easy enough to do, and should greatly help in picking up the shapes of Engel curves without sacrificing theoretical consistency.

(ii) AIDS and labor supply

AIDS was primarily and originally designed to serve as a model for the allocation of total expenditure between the various commodities. However, labor supply can readily be incorporated, either by treating it as another commodity, or by adding a leisure branch to a weakly separable utility function, in which the goods branch is represented by AIDS. Although the latter is usually better, I deal with both in turn.

(a) AIDS including labor supply. We simply redefine \( x \) as full expenditure, i.e.

\[
x^F = \omega T + b
\]

or, in an intertemporal context with intertemporal separability

\[
x^F = \omega T + b - \Delta A
\]

where \( b \) is transfer income, \( T \) is available hours, and \( \Delta A \) is the net increase in assets. We then have the leisure augmented AIDS written as
\[ w_i = a_i + \sum_{j=0}^{n} \gamma_{ij} \log p_j + \beta_i \log \left( \frac{X^F}{P} \right) \]  

\( i = 0, 1, \ldots, n \)

where 0 refers to leisure, so that

\[ w_0 = \frac{w(T-h)}{X^F} \]  

for hours h, and \( p_0 = \omega \), the wage rate, and P also includes \( p_0 \), the wage rate. It is straightforward (but tedious) to work out the elasticity of labor supply for this model, but it's not at all restrictive.

The problem here is that with T unobserved, the shares are hard to compute because T enters on both numerator and denominator for leisure and in the denominator for goods; shares are of full income. One can't get away without assuming some, essentially arbitrary, value for T, and the value one assumes is going to have a non-trivial effect on the answer.

(b) Separable AIDS with labor supply. The easiest course is to combine AIDS for goods with any conventional labor supply function. To do this requires that goods be separable from leisure, i.e. that the marginal rate of substitution between any pair of goods be independent of the amount of leisure, or equivalently, that the allocation of goods out of total expenditure is independent of leisure once total expenditure is given. If so, direct utility can be written

\[ u = u(q_0, \phi(q)) \]  

where \( q_0 \) is leisure and q is the vector of other goods. Maximization of \( u(\xi) \) implies maximization of \( \phi(q) \) subject to whatever is spent on q, say x, total outlay on goods. Hence \( \phi(q) \) can be rewritten as
\[ u = \psi(q_0, \psi(x, p)) \]  

where \( \psi(x, p) \) is the indirect utility function for goods, \( (10) \) is to be maximized subject to

\[ p_0 q_0 + x = x^F \]  

where \( p_0 = \omega \) is the wage as before. If we take the AIDS form for \( \psi(x, p) \), i.e.

\[ \psi(x, p) = F\left( \log x - a_0 - \Sigma_k \log p_k - \frac{1}{2} \Sigma_j \Sigma_k \gamma_{kj} \log p_k \log p_j / \Pi p_k \right)^{\xi_k} \]  

where \( F \) is any monotone increasing function, then, conditional on \( x \), the AIDS demand functions hold for commodities. The determination of labor supply then determines \( x \) given the budget constraint.

Labor supply/leisure behavior is determined by choice of \( F \) and of \( \psi \) in \( (10) \). To simplify the notation, write

\[ \psi(x, p) = F\{ \log (x/P) \cdot b(p) \} \]  

where \( P \) is the usual AIDS price index and \( b(p) \) is the zero degree homogenous product \( \Pi p_k^{-\xi_k} \). The labor supply problem can be written neatly by defining a commodity composite \( Q \equiv x/P \) and writing the problem as to maximize

\[ u = \psi(q_0, Q^b(p)) \]  

subject to \( p_0 q_0 + PQ = x^F \)

The presence of \( b(p) \) in \( (14) \) stops this from being an absolutely standard utility maximization procedure. Note, however, that \( b(p) \) is zero homogeneous and therefore will be close to a constant with trending time series data. In cross-section data, \( b(p) \) is constant over individuals, so that \( (14) \) does become a standard problem. Hence, either approximately, or exactly, it is
possible to proceed simply by writing down a convenient labor supply function, e.g. one that is linear in the wage and full income. If time-series data are used, then the commodity price deflator should be the same as that used in the AIDS, i.e. P. In cross-sections, the problem doesn't arise.

For reference, the direct utility function that generates a linear labor supply function is, see Deaton and Muellbauer (1980b, p. 96) or Hausman (1981).

\[ u = \log(q_C - r) + \frac{Q-\delta}{s(q_0 - r)} \]  

(16)

for goods composite Q and parameters s, r and δ. However, this would only be required for welfare analysis that involves the valuation of leisure, and I doubt whether it is wise to make such imputations. I shall take up this point again in (v) below, but I believe that the simplest, most comprehensible, [as well as defensible] welfare measure is that based on goods alone, i.e. the indirect utility function of the AIDS ignoring leisure.

(iii) Concavity and AIDS

Standard flexible functional forms like the AIDS and translog are probably not the best vehicles for imposing global concavity when there are really plentiful data. Local concavity can readily be imposed, but if policies that move the economy a long way are to be evaluated, global concavity is required. (I'm skeptical, however, that we shall ever be in a position to characterize price and income elasticities at points far distant from previous experience; even third and fourth-order flexible functional forms may not be sufficient, and concavity is not even the worst problem). If data really are abundant, some of the new Fourier or Laurent flexible forms might work well since they have larger regular regions than traditional flexible functional forms like the AIDS or translog, but experience with these is lacking (as are
the abundant data, particularly in LDC's). Typically price responses, unlike income responses, are not easily estimated because we rarely have many genuinely distinct price situations. Instead, we have partial information, often on own-price elasticities, sometimes on the odd cross-price elasticity. If this is the situation, then something can probably be done, even within AIDS.

Start from the situation of little or no information on price elasticities and with imposing local concavity. A useful matrix to work with is $C$ with typical element $c_{ij}$ defined by

$$c_{ij} = p_i s_{ij} p_j x^{-1}$$

(17)

Where $s_{ij}$ is the Slutsky matrix. For the AIDS, $c$ is given by

$$c_{ij} = \gamma_{ij} + \beta_i \delta_{ij} \ln \left(\frac{x}{p}\right) - w_i \delta_{ij} + w_i w_j$$

(18)

for Kronecker delta $\delta_{ij}$. Since $S$ has to be negative semi-definite, so does $C$. At any given point, sample mean or, better, the point from which reform is to be considered, evaluate the actual (or predicted) $w_i$ and $w_j$, $\ln (x/p)$ and $\beta_i$ and $\beta_j$, the latter readily obtained from a household survey. Rewrite (18) as

$$c_{ij} = \gamma_{ij} + \delta_{ij}$$

(19)

where $\delta_{ij}$ is now known. Now, if there were no information on elasticities, it would be necessary to use something like direct additivity to link price elasticities to income elasticities. Under direct additivity,

$$c_{ij} = \phi (\delta_{ij} b_i - b_i b_j)$$

(20)

where $\phi$ is a scalar to be chosen (usually around - 0.5) and $b_i$ is the marginal propensity to spend on $i$, in the AIDS given by $(\beta_i + w_i)$. With no
knowledge, or only one price elasticity, choose \( \phi \) to get that one right, and set \( \gamma_{ij} \), given \( z_{ij} \) to satisfy (20). One then has a locally concave cost function, though it would be a moot point whether this is better than, say, the linear expenditure system though it has better Engel curves. If one has more information, say on each price elasticity, \( c_{ij} \) could be set to

\[
c_{ij} = \theta (\delta_{ij} c_i - c_i c_j), \quad c_i > 0,
\]

for a scalar \( \theta < 0 \) and \( \Sigma c_i = 1 \). (21) is always negative semi-definite, the \( c_i \)'s are each set to let the own-price elasticities match our priors, leaving the cross-price elasticities to look after themselves in a concavity consistent manner.

Going beyond this would require some new flexible functional form that allows imposition of global concavity. I only know one such, the (direct) quadratic utility function. But conic sections, especially concentric circles or ellipses, are not good indifference curves; there are satiation points and other embarrassments. Maybe there are other forms, but it's not easy to know how to look. One could be found tomorrow, or in twenty years. But I'm not convinced that the search is even worthwhile. Second-order flexible functional forms are only flexible around a point and their concavity can be guaranteed at that point. Elsewhere, I don't see the point of imposing concavity when there are no grounds for believing that the model bears any relation to reality in other respects. Concavity may avoid logical inconsistency in optimal tax or in "large" price change analysis. But logical consistency is not much comfort if there is little confidence in the actual numbers produced! In terra incognita it hardly matters what is up and what is down.
(iv) Short-cut welfare measures

In some respects the whole general equilibrium apparatus is not always necessary in order to evaluate welfare changes, especially in view of the sort of issues discussed in (iii) above. Consider the following example for a consumer (it would require some modification for a producer).

There is a price change, from vector $p^0$ to vector $p^1$ and we want to know the CV/EV or, equivalently, the true cost-of-living index number. Say we measure this by

$$\log c(u, p^1) - \log c(u, p^0)$$

(22)

i.e. by the log price index number, using $u = u^0$ (CV) or $u = u^1$ (EV) for example. Take a homothetic case first and write down a general homothetic cost function, i.e.

$$\log c(u, p) = \alpha_0 + \sum_k \log p_k + \frac{1}{2} \sum_{k,j} \gamma_{kj} \log p_k \log p_j + \log u$$

(23)

which is essentially the homothetic form of AIDS. Now one might proceed by estimating the $\alpha$'s and $\gamma$'s, and then evaluating welfare changes. However, there is a simpler way. In particular.

$$\log c(u, p^1) - \log c(u, p^0) = \frac{1}{2} (w^0_k + w^1_k) \log \left( \frac{p^1_k}{p^0_k} \right)$$

(24)

for all $u$. The expression on the right-hand-side is the Tornqvist index and this theory (essentially an extension of the Buschguennc-Komüs theorems on Fisher's Ideal Index) was worked out by Erwin Diwect (1981). Of course, we're not quite home since we still have to predict $w^1$, the budget shares after the policy change. But that is something that is much less formidable than estimating a whole set of concavity-consistent parameters in a flexible functional form.
Of course, homotheticity is not a sensible assumption, particularly if one is interested in the distributional effects of price changes. Modify (23) to the non-homothetic flexible functional form.

$$\log c(u, p) = \alpha_0 + \sum k \log p_k + \frac{1}{2} \sum_{kj} k_j \log p_k \log p_j + u \sum e_k \log p_k$$ (25)

(This looks a lot like AIDS but is not: John Muellbauer and I thought of it before AIDS but it is not as convenient for our original purposes). The corresponding equation to (24) is then

$$\log c(u^*, p^1) - \log c(u^*, p^0) = \frac{1}{2} (w_k^0 + w_k^1) \log (p_k^1/p_k^0)$$ (26)

where $$u^* = \sqrt{u^0 u^1}.$$ (27)

This makes the Tornqvist index not very useful as an aggregate index. However, we should be working with expenditure patterns for individuals or for groups of individuals that are homogenous with respect to total outlay, so that the Tornqvist should work well for them ($u^0$ will not be too far from $u^*$) and differences in the index between such groups will show up very well the distributional impacts of the policy.

(v) Real income and full income

There is a small point here that deserves some care. We usually think of real incomes, i.e. income divided by a price index, as being practical proxies to indirect utilities, so that e.g.

$$\psi(x^h, p) = x^h/P(p)$$ (28)

where $x^h$ is $h$'s income (outlay) and $p$ is a vector of prices. $P(p)$ is some price index. Note that (28) only works exactly with homotheticity, but it is
standard practice, we know what we're doing and it's all well understood. But what happens with **full** income?

Think of the budget à la Becker (1965) as being written

\[ p_0 q + p_0^h q_0 - p_0^T + b^h \]  \hspace{1cm} (29)

where \( p_0 \) is the price of leisure (wage), \( q_0 \) is leisure, \( T \) is the time-endowment, and \( b^h \) is transfer income together with any sales of assets. Indirect utility is then given by

\[ u^h = \psi(p_0^h, b, p) = \psi(x_F^h, p_0^h, p) \]  \hspace{1cm} (50)

for full income \( x_F^h \). Now the situation is different because, in (28), households with a higher \( x^h \) are always better-off because all face the same prices, while in (30), a high \( x_F^h \) could arise from a high \( b^h \) or a high \( p_0^h \); the second one of which is offset (partially) by the second argument of (30). A real income figure corresponding to full income must include the price of leisure in the price-index, i.e. real (full) income takes the form

\[ \psi(x_F^h, p_0^h, p) = x_F^h / P(p_0^h, p) \]  \hspace{1cm} (31)

The issue is important in practice when income distribution is assessed with allowance made for family members' time. Since \( T \) is essentially arbitrary, it turns out that different values of \( T \) can give us any conclusion we like if the real income correction is not done correctly, i.e. according to (31). Figure 1 illustrates for two individuals 1 and 2; 1 has a lower \( b_1 \) and a higher wage \( \omega_1(p_0) \) while 2 has a higher \( b_2 \) and lower wage rate. They are chosen so that they have the same utility level illustrated by the common indifference curve. Full income, or full income deflated by a common price in-
dex, is measured by taking the intersections of the two budget lines with various parallel verticals, those further to the left having a higher value of T. With values of T less than that at B, individual 2 is the better-off, while to the left of B, individual 1 is the more fortunate. Clearly, a suitable choice of T can produce any results we like, for welfare rankings, income distribution, ginis, or whatever.

Figure 1

There's a good deal to be said for keeping to standard real income concepts in this sort of situation and the separable "goods only" part of total utility, e.g. $\psi$ in (10) is a theoretically satisfactory measure, see Deaton (1980) for a fuller discussion.
(vi) Buying and selling prices

Models like the translog, and the AIDS require that the budget constraints facing producers and consumers be straight lines. This is a reasonable first approximation in most circumstances, but there must be some doubt whether buying and selling prices are likely to be the same for small farmers close to subsistence. In many LDC's, the smallest farmers are net consumers of basic foodstuffs (e.g. rice), though in good years there may be surpluses. With the selling price lower than the buying price, the response of net supply to price is not the same qualitatively, as it would be with a single price for both transactions. In particular, a substantial mass of farmers are likely to be self-sufficient, producing only for their own needs, even though in principle they could sell some of their crop, if only in good years. A similar phenomenon occurs for consumers in the presence of rationing or dual price systems; once again there is an incentive to consume exactly the allocation and changes in allocation will not have the same effects as changes in income, contrary to the usual presumption. These effects are not hard to model, but the models that result are not of the standard form. For some issues of policy at least, getting these things right may be important.

Section II An approach to policy reform

A computable market-clearing general equilibrium model would be a perfect tool for policy analysis if we could persuade ourselves (and others) that the model was an accurate description of reality. The "if" is a particularly severe stumbling block when policies are considered that are very different from those that are, or have been, in effect. An exactly analogous problem arises in
optimal tax analysis where calculation of optimal tax rates requires very
detailed and specific information about preferences and technology. Even
in the simplest model with constant returns to scale and the non-substitu-
tion theory in operation, such fundamental questions as to whether luxuries
should be taxed more heavily than necessities depend on third derivatives
of consumer expenditure functions at the optimum, see e.g. Atkinson and
Stiglitz (1980) or Deaton (1981). Measuring second derivatives (i.e. price
elasticities) at the status quo is hard enough; third derivatives at some
far removed optimum are essentially unknowable. In the empirical tax
literature, as well as in the theory, emphasis has recently moved to the
analysis of tax reform, see in particular Ahmad and Stern's (1983) work on
India. In this, the relatively ambitious questions of optimal tax rates
are set aside and attention is focussed on the welfare and efficiency conse-
quences of small changes in existing taxes. Specific changes can be assessed
as improving or worsening social welfare, and an optimal direction of tax
reform can be located. All this requires only local information on
preferences and technology; consumption and output levels are required
together with their price elasticities. In the context of multimarket
analysis of agricultural pricing, exactly the same procedures can be followed.
The loss is the ability to predict the consequences of major policy changes,
but that is a loss only to the extent that the predictions are credible.
What remains is a policy prescription for policy change, for example, that
a price decrease would be welfare improving, together with a detailed
quantification of the associated gains and losses. It seems to me that
persuading a government to change a policy in a given direction is in itself
a considerable achievement, even if we don't know how far the reform should
be pushed. This disadvantage is likely to be more than offset by the increased convincingness of a case based on local, credible information.

I illustrate the general procedure here using the case of grain in Korea. I show in outline how the model in Braverman, Hammer, and Ahn (1983) can be modified to analyse reform. I make the following modifications to the original model:

(i) The models can be generalized since specific functional forms are not required, except for estimation, and even there play a relatively small role. As in the original, I use profit functions to represent production technology and cost/expenditure functions to represent consumer preferences. However, no specialization to the translog or to AIDS is made.

(ii) I simplify the original model by omitting several inessential exogenous variables. They are inessential in that changes in them are not simulated in the original and they are not modelled to the point where their interactions with policy can be taken into account. On the production side, the price of "other" agricultural inputs is an example; on the consumption side, the price of "other" consumer goods.

(iii) In the original paper, there are three alternative treatments of the rural labor market. I take only one of these here for the illustration. Arbitrarily, I have chosen Case II, where the rural wage adjusts to clear the market.

Given this, there are essentially three "segments" of the Korean model, and these segments would be expected to recur in other contexts. The first segment consists of the welfare equations. These link profits, technology, incomes and preferences on the one hand with prices and price policy on the
other hand. The welfare equations translate price changes into money measures of welfare change for producers and consumers and they permit as disaggregated an analysis of gains and losses as is required for the problem at hand. The second segment of the model consists of market clearing equations. The role of these equations is to translate policy changes into price changes through the market clearing mechanism. The price changes can then be assessed for welfare changes using the welfare equations. The third and final segment of the model are the government budget equations. These determine the effects of policy changes, through market clearing, on government surpluses and deficits. In some applications, these equations will act as constraints, in others they simply detail effects that have to be taken into account.

I start with the Korean welfare equations. For a producer in class \( r \) (\( r = 1, \ldots, 4 \) depending on size of landholding), profits from production are given by the profit function

\[
\pi^r = \pi^T\left(p^R_H, p^T, p^R_B, w_L, w_F\right)
\]

(32)

where \( p^R_H \) and \( p^R_B \) are prices of high-yielding variety rice and barley respectively (H and B) in the rural areas (R), \( p_T \) is the price of traditional rice (the same in urban and rural areas), and \( w_L \) and \( w_F \) are the prices of labor (rural wage) and fertilizer respectively. For such a producer and his family, welfare, \( u^r \), is determined by

\[
E_T w_L + \pi^r + \theta^r = c^r(u^r, w_L, p^R_H, p_T, p^R_B)
\]

(33)

where \( E_T \) is the number of members in the family, \( T \) is their time endowment, \( \theta^r \) is transfer income, and \( c^r \) is the cost function for a type \( r \) household. Equations (32) and (33) together determine welfare of a type
rural farming household. For an urban household of type \( u \), there is no production, so that welfare \( u^u \) is given by the counterpart to (33) i.e.

\[
E \frac{TW^u}{L} + \theta^u = c^u(u^u, \bar{w}_L, P^z_H, P^z_T, P^z_B)
\]

(34)

for urban prices of high-yielding variety rice and barley, \( P^z_H \) and \( P^z_B \).

Equations (32), (33) and (34) are essentially the same as those in the original paper though there are a number of minor changes. The profit function (32) is expressed in money and is optimized over crop choice (HYV rice, traditional rice, and barley) and over land allocation between HYV and traditional. It is therefore conditional on \( K_T \), total paddy land available.

I have also dropped the price of other inputs from the profit function and the prices of other consumer goods in the cost functions. They play no essential role in what follows, but note that their omission means that the \( \pi^r \), \( c^T \) and \( c^u \) functions are no longer linearly homogenous.

Equations (32), (33) and (34) are used in the reform analysis to evaluate local changes in welfare consequent on price changes. For example, if only \( P^R_H \) changes, the change in \( \theta^r \) necessary to keep \( u^R \) constant is given by

\[
\frac{\partial \theta^r}{\partial P^R_H} = (q^s_H - q^d_H)
\]

(35)

for quantities supplied \( q^s_H \) and demanded \( q^d_H \). This expression is, of course, the equivalent or compensating variation (locally they are the same) for the price change. For some purposes, one wants only the quantities (35), i.e. to compare gains and losses over different \( r \)'s or as between urban and rural consumers. If an overall assessment is required, each equivalent variation can be multiplied by \( \phi^h \), the social marginal utility of money to the relevant group (h), so that the weighted sum gives the local derivative of social welfare.
The second segment of equations are those that determine market clearing. There are four commodities, traditional rice, HYV rice, barley, and rural labor. For traditional rice, with \(n^r\) and \(n^u\) the numbers of families of type \(r\) and \(u\),

\[
\sum_{r} n^r \left\{ \frac{\partial H}{\partial P^r_T} (P^r_H, P^r_T, P^R_B, W_L, W_F) - \frac{3c^r}{2P^r_T} (u^r, W_L, P^R_H, P^T_T, P^R_B) \right\} = \sum_{u} n^u \left\{ \frac{3c^u}{2P^u_T} (u^u, W_L, P^u_H, P^T_T, P^u_B) \right\}
\]

so that net rural supply equals total urban demand. Similarly, for HYV rice

\[
\sum_{r} n^r \left\{ \frac{\partial H}{\partial P^r_H} (P^r_H, P^r_T, P^R_B, W_L, W_F) - \frac{3c^r}{2P^r_H} (u^r, W_L, P^R_H, P^T_T, P^R_B) \right\} = \sum_{u} n^u \left\{ \frac{3c^u}{2P^u_H} (u^u, W_L, P^u_H, P^T_T, P^u_B) \right\} - M + A_H
\]

for rice imports \(M\) and wastage \(A_H\). For barley

\[
\sum_{r} n^r \left\{ \frac{\partial B}{\partial P^r_B} (P^r_H, P^r_T, P^R_B, W_L, W_F) - \frac{3c^r}{2P^r_B} (u^r, W_L, P^R_H, P^T_T, P^R_B) \right\} = \sum_{u} n^u \left\{ \frac{3c^u}{2P^u_B} (u^u, W_L, P^u_H, P^T_T, P^u_B) \right\} + I_B + A_B
\]

for inventory accumulation \(I_B\) and wastage \(A_B\). Finally, for the rural labor market to clear

\[
\sum_{r} n^r \left\{ \frac{\partial T}{\partial W_L} (u^r, W_L, P^R_H, P^T_T, P^R_B) \right\} = \sum n^r \left\{ \frac{3c^r}{2W_L} (P^R_H, P^T_T, P^R_B, W_L, W_F) \right\}
\]

These four equations can be used in a number of different ways. For example, given the urban wages \(W_L^u\) and the policy instruments \(M, W_F, (P^R_H - P^R_B)\),
and \((P^R_B - P^Z_B)\), (36) to (39) determine the rural wage \(W_L\), the price of traditional rice \(P_T\), and urban and rural prices of barley and HYV rice, \(P^R_H, P^R_B, P^Z_H, P^Z_B\). Since, for the analysis of tax reform, we are only interested in the consequences of changes, the four equations can be totally differentiated to yield a four by four matrix of net demand/supply elasticities the inversion of which converts policy changes into price changes. The empirical requirements are for the aggregate own and cross-price elasticities, the measurement of which is a difficult enough task but one that is immensely simpler than the specification, estimation, and testing of profit and cost functions for individual groups of farmers and consumers.

Policy changes in price wedges, in fertilizer prices or in imports also affect the surpluses and deficits of the various government agencies that handle the commodities. If \(G_H, G_B, \) and \(G_F\) are the deficits on HYV rice, barley, and fertilizer respectively, then

\[
G_H = (P^R_H - P^Z_H + h_H)(P^Z_H - M) + (P^W_H - P^Z_H)M \tag{40}
\]

\[
G_B = (P^R_B - P^Z_B + h_B) (P^Z_B + I_B) \tag{41}
\]

\[
G_F = (P^O_F - W_F + h_F) (X_F + X^O_F) + (P^O_F + h_F) I_F \tag{42}
\]

where the \(h\)'s are handling costs, \(P^Z_H\) and \(P^Z_B\) are urban demands (given by the derivatives of the cost functions as in the market-clearing equations), \(P^O_F\) is the purchase price of fertilizers, \(X_F\) is the demand by farmers (from the derivative of the profit function) and \(X^O_F\) is the demand for other purposes.

The three equations (40), (41) and (42) can be used to complete the social welfare analysis by assigning social welfare weights to changes in the deficits. The total effect of a policy change is then the weighted sum of producers', consumers' and government surpluses. Alternatively,
the government may only be prepared to consider policy changes that
leave individual (or the sum of) deficits unchanged. Equations (40)-(42)
then imply a linear relationship between the various instrument changes
which gets fed into the market clearing equations and thence to the
welfare equations.

The advantages of this approach seem to me to be as follows:

(i) The analysis is very simple and yet relatively general. There is
a minimum of special assumptions about functional form or structure.
(ii) The welfare equations yield extremely simple formulae for consumers'
and producers' surpluses. For local changes, all that needs to be known
are quantities bought and sold, and these can be measured with considerable
accuracy.
(iii) Empirical demands are minimized. Household surveys can yield much
of the information. However, aggregate net supply/demand elasticities are
required. There is no straightforward, uniformly reliable way to measure
these. However, knowledge of them is the minimum required to say anything
very useful.
(iv) the calculations are very straightforward, the most complex being
(in the Korean case) the inversion of a 4 X 4 matrix. This is important,
not only for the time and effort that is saved, but also because it
facilitates repetition under alternative assumptions. It is thus very
easy for the analyst to assess the robustness of policy recommendations.
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