Targeted Policies for Poverty Alleviation Under Imperfect Information: Algorithms and Applications

Martin Ravallion, *The World Bank*
Kalvin Chao, *The Australian National University*

A methodology is proposed for solving the targeting problem of poverty alleviation with imperfect information on recipients' incomes. A measure of the gain from targeting is also proposed. The problem of allocating a fixed budget for poverty relief among sectors and regions of an LDC is used as an example, and calculations of the poverty minimizing allocations are presented for Bangladesh, Indonesia, the Philippines, and Sri Lanka. The gains from optimal targeting can be considerable, although they vary widely according to the distributional circumstances of particular countries and the amount of targeting information available to the policymaker.

1. INTRODUCTION

The problem of targeting a limited budget for poverty relief without full information on individual incomes is of considerable policy relevance; see, for example, the discussion in the World Bank's (1986) recent policy study. Kanbur (1987a) has recently formalized the theoretical problem of policy design under imperfect information, using the Foster et al. (1984) class of poverty measures.[1] This article demonstrates how the general targeting problem can be solved in a computationally feasible way, thus permitting potentially wide applications.

The methods of analysis are illustrated using a longstanding development policy problem, that of choosing sectoral and regional priorities for poverty alleviation. Results are presented for Bangladesh, the Philippines, and Sri Lanka, with the use of published aggregate distributional data, and for Indonesia, with the use of distributions constructed

[1]For other applications of the FGT class of poverty measures, see Greer and Thorbecke (1986), Besley and Kanbur (1988), and Ravallion (1988b).

Address correspondence to Martin Ravallion, The World Bank, 1818 H Street N.W., Washington D.C. 20433.

The World Bank does not accept responsibility for the views expressed here.

Received June 1988; accepted February 1989.

0161-8938/89/$3.50

for this purpose from household level data. Potential gains from optimal targeting are found to vary widely according to circumstances of particular countries, although the general case in favor of targeting policies toward rural sectors is supported.

The following section describes the targeting problem facing a poverty alleviation agency with imperfect information on individual incomes. Section 3 outlines a computationally feasible method for solving that problem in general, while section 4 offers a simple money metric of the gains in terms of poverty relief from optimal targeting. Sections 5 and 6 give the article's empirical results for hypothetical poverty alleviation budgets for a number of countries. Section 7 offers some conclusions and points out possible directions for developing our approach further.

2. POVERTY ALLEVIATION POLICIES UNDER IMPERFECT INFORMATION

Suppose an agency has a fixed budget available for poverty alleviation in a population of n individuals. The population can be classified into k mutually exclusive groups. For concreteness, we shall call these "sectors," although noting that this is only one of the possible categorizations of interest; other examples include region, industry of employment, and (in a rural setting) landholding class.[2] The poverty alleviation agency can estimate the distribution of income within each sector from survey data, but it does not know who has which income within the population, and the cost of obtaining that information is prohibitively high. Thus, the agency faces a problem of targeting under imperfect information; the "first best" solution based on full information about each individual's income is not feasible. The agency is also constrained in its policy instruments. The only instrument considered here is a sectorally specific lump-sum payment of x_j made to each individual domiciled in sector j. However, the problem and algorithm can be readily adapted to the case of multiplicative changes in incomes. Note that informational constraints entail that an individual in a given sector receives the same amount whether poor or not. There are n_j individuals in sector j, and this is fixed. Aggregate population

[2] Specific policy examples include the problem of where to locate food ration shops (discussed by Besley and Kanbur 1987a), and that of how to allocate land released by a land reform. Ravallion (1988a) uses the methods presented in this paper to assess the potential for using landholding class as a targeting variable in designing policies for alleviating rural poverty in Bangladesh.

size is normalized at unity. The total budget available to the allocating agency is

$$\sum_{j=1}^{k} n_j x_j = \bar{x} \tag{1}$$

which is the (fixed) mean transfer payment under the poverty alleviation program. This need not be positive. For example, the agency may be aiming to redistribute a fixed aggregate income across sectors so that $\bar{x} = 0$. Or it may be interested in the effects on poverty of alternative sectoral allocations of a short-term *reduction* in aggregate income, as required by a macroeconomic adjustment program.[3] Then $\bar{x} < 0$.

Following Kanbur (1987a), we consider the allocation $x^* = (x^*_1, \ldots, x^*_k)$, which minimizes aggregate poverty under the above conditions, subject to the available budget. Aggregate poverty is measured by:

$$\phi(x) = \sum_{j=1}^{k} n_j P_{\alpha j} \tag{2}$$

where $P_{\alpha j}$ is the Foster et al. (1984) poverty measure:

$$P_{\alpha j} = \int_{0}^{z - x_j} \left(\frac{z - y - x_j}{z} \right)^{\alpha} dF_j(y) \qquad (\alpha \geq 0) \tag{3}$$

in which z denotes the (fixed) poverty line, and $F_j(y)$ is the distribution function of income y in sector j. The objective function ϕ is strictly decreasing in x_j for all j and is also strictly quasi-convex in x for $\alpha > 1$. The parameter α is interpreted as the decisionmaker's aversion to inequality among the poor; the larger α, the more sensitive P_α is to inequality (Foster et al. 1984). One may also wish to derive poverty minimizing allocations subject to the additional constraint that $x_j \geq 0$ for all j. This applies when the poverty alleviation agency does not have the power to tax. "Political economy" considerations (interpreted as political restrictions on the agency's redistributive powers) can also be readily incorporated as inequality constraints on x. For example, although the government has the power to tax, it may be politically infeasible to levy taxes on certain groups beyond some point.

As an aside, it should be clear that a poverty focused welfare function such as equation (2) does not attach positive weights to persons above

[3]See Kanbur (1987b) for further discussion.

the poverty line. Nonetheless, the informational constraints built into the policy problem can easily produce transfer allocations that induce changes in the distribution of income among the nonpoor; this happens when two or more target groups with different distributions of income contain nonpoor persons (and, of course, the agency cannot identify those persons—otherwise they should be reclassified as new groups in the detailed formulation of the policy problem).

3. CONDITIONS FOR AN OPTIMUM AND AN ALGORITHM

The solution method presented here assumes that $\alpha = 2$. The resulting measure can be shown to satisfy the main axioms found in the poverty measurement literature, including Sen's (1976) Monotonicity and Transfer Axioms and also a weak form of Kakwani's (1980) Transfer Sensitivity Axiom (the "strong form" requires $\alpha > 2$). The P_2 proverty measure has been preferred in past empirical applications; see, for example, Foster et al. (1984), Greer and Thorbecke (1986), and Ravallion (1988a).

The problem is first solved permitting negative values of x_j for some j. Then the first order conditions for an optimum imply that (in addition to equation (1)), $P_{\alpha-1j}$ is constant across all j (Kanbur 1987a). (The second order conditions hold for all $\alpha > 1$ since ϕ is then strictly quasi-convex). Thus, for $\alpha = 2$, x^* satisfies (in addition to equation (1)):

$$\int_{o}^{z - x_j^*} \left(\frac{z - y - x_j^*}{z} \right) dF_j(y) = \lambda \qquad (j = 1, \ldots, k) \tag{4}$$

On expanding the expression on the LHS and rearranging, this equation can be conveniently written in the following equivalent form:

$$\left(\frac{z - \bar{y}_j^p - x_j^*}{z} \right) P_{oj} = \lambda \qquad (j = 1, \ldots, k) \tag{5}$$

where

$$\bar{y}_j^p = \int^{z - x_j^*} y dF_j(y)/P_{oj} \tag{6}$$

is the mean (posttransfer) income of those individuals below the poverty line.

The problem can be solved numerically. First, note that equations (1) and (5) would be a system of $k + 1$ *linear* equations in the $k + 1$ unknowns (x^* and λ) except for the fact that $\bar{y}^p$ and P_o are functions of x^*. This suggests an algorithm that solves the problem iteratively by linearizing at each step around the previous estimate of x^* and λ. The algorithm estimates these variables at each iteration t by solving the system of linear equations:

$$\begin{bmatrix} (P_{ot-1}) & zi' \\ n & 0 \end{bmatrix} \begin{bmatrix} \hat{x}_t^{*\prime} \\ \hat{\lambda}_t \end{bmatrix} = \begin{bmatrix} w_{t-1} \\ \bar{x} \end{bmatrix} \qquad (7)$$

where (P_{ot-1}) is the k^2 diagonal matrix with diagonal elements given by the values of P_{oj} ($j = 1, \ldots, k$) implied by the values of x^* obtained at iteration $t-1$, while w_{t-1} is the column vector of k elements formed by $(z - \bar{y}_{jt-1}^{p})P_{ojt-1}$ for $j = 1, \ldots, k$, as obtained at $t-1$, and $n = (n_1, \ldots, n_k)$. Having solved for x^* to the desired degree of accuracy, the problem can be repeated, constraining the solution to (for example) nonnegative values of x_j^* for all j if this does not already hold.

It should be noted that one usually only obtains data for *discrete* points on the income distribution functions $F_j(y)$. Thus, further approximations will generally be required at each iteration. The simplest procedure is to interpolate linearly between the discrete points available. Consideration may also be given to plausible nonlinear interpolations. Naturally, the greater the number of observed points on the income distribution function, the more accurate will be any interpolation method. Household level data is, of course, preferable in terms of accuracy, but it will be computationally more expensive than grouped data. We present examples of both, below.

A general purpose Fortran program is available from the authors to find poverty minimizing allocations for any number of sectors and any given poverty line and budget. The program assumes that only discrete points on the distribution function of income are available for each sector, and it uses linear interpolation between those points. The inputs are the values of $F_j(y)$ and $\bar{y}_j^p$ or all j at each point, and the outputs are estimates of x_j^* for all j and λ to any desired accuracy.

3. EVALUATING THE GAINS FROM TARGETING

Once the poverty minimizing allocation across sectors is calculated, it is of interest to also measure the gains in terms of poverty reduction obtained by optimal targeting. The untargeted allocation gives $\bar{x}$ to each sector, and since x^* minimizes poverty for the given budget, it must be the case that $\phi(x^*) \leq \phi(\bar{x})$ where $\bar{x}$ denotes the k vector with $\bar{x}$ as each element. An obvious measure of the gains from targeting is $1-\phi(x^*)/\phi(\bar{x})$, being the maximum proportionate reduction in poverty achievable by targeting. However, in policy discussions, it is likely to be more useful to have a monetary measure of the gains from targeting. Such a measure is the number $\eta \geq 0$ such that

$$\phi(x_1^*, \ldots, x_k^*) = \phi(\bar{x} + \eta, \ldots, \bar{x} + \eta) \tag{8}$$

We term η the *equivalent gain from targeting*, i.e., the amount by which an untargeted budget would have to be increased in order to achieve the targeted poverty level. From equation (8), it is clear that η is strictly decreasing in $\phi(x^*)$; the greater the reduction in poverty attainable by optimal targeting of a given budget, the greater the value of η.

The equivalent gain from targeting can be readily estimated numerically for the poverty measures discussed above. A general purpose Fortran program for calculating η using the interval-halving method is also available from the authors.

4. SECTORAL PRIORITIES FOR POVERTY ALLEVIATION IN THREE ASIAN COUNTRIES

The allocation of public investments and other policy interventions between the modern (primarily urban) and traditional (rural) sectors of a dualistic economy has been a long-standing issue in development policy discussions. The effects on poverty of alternative growth strategies and policy interventions have been a major concern. Thus, it is of interest to apply the methods of analysis outlined in previous sections to the problem of allocating a poverty alleviation budget between urban and rural sectors of an LDC.

In many LDCs, one finds that the incidence of poverty (P_o) is higher (often very much higher) in rural areas than urban areas. However, the relevant shadow price for minimizing P_2 is directly proportional to P_1 rather than P_0. Thus, a low (although positive) incidence of urban poverty does not mean that the poverty minimizing allocation of aid between urban and rural areas will give a higher per capita transfer to the latter. Similarly, although the incidence of poverty may be many times greater in rural areas, it does not follow that the poverty alleviation budget should ignore urban areas. The average *depth* of poverty may be greater in urban areas, even if the incidence is lower.

Table 1 gives the results obtained applying the above methods to three countries. These calculations have had to be based on readily available published sources. These have given household distributions of money incomes or expenditures for each sector. Thus, it has not been possible to make allowance for household composition effects

Table 1: Sectorally Targeted Poverty Alleviation Budgets for Three Countries

	Budget ($\bar{x}$)	Optimal Sectoral Allocation (x^*)			Post-transfer Poverty ($P_2 \times 10$)		Gain from targeting (η)	
		Urban	Rural	Estate	Untargeted	Targeted	Budget	Percent
Bangladesh (78/79)	1.00	0	1.11	—	0.575	0.566	0.023	2.34
(Taka 100/mn)	1.64	0.582	1.76	—	0.369	0.361	0.032	1.95
(z = 7.5; n_r = 0.90)	2.00	0.962	2.12	—	0.281	0.272	0.039	1.95
Philippines (85)	0.400	0	0.645	—	0.154	0.143	0.150	37.5
(₱ 1000/mn)	0.450	0	0.726	—	0.150	0.138	0.165	36.7
(z = 10; n_r = 0.62)	0.500	0	0.806	—	0.146	0.133	0.182	36.3
Sri Lanka (81/82)	1.00	0	1.04	2.44	0.780	0.727	0.117	11.7
(Rp100/mn)	1.58	0.559	1.66	2.81	0.547	0.511	0.105	6.65
(z = 7; n_r = 0.69; n_u = .19)	2.00	1.03	2.09	3.06	0.411	0.386	0.090	4.49

Note: Bangladesh calculations use the household income distributions given in Tables 15.24 and 15.25 of *Statistical Yearbook of Bangladesh, 1983–84* (Bangladesh Bureau of Statistics 1984). Philippines calculations use the household expenditure distributions given in Table 2.9 of *Philippines Statistical Yearbook 1986* (National Econonic and Development Authority 1986). The data for Sri Lanka are the distributions of income given in Table 5.17 of *Report on Consumer Finances and Socio Economic Survey 1981–82 Sri Lanka* (Central Bank of Ceylon 1984).

and/or spatial price variability. In the case of Sri Lanka, the rural population is also divided into "rural" and "estate" sectors (the latter are plantations for tea, rubber, and/or coconut production). Results for each country are given for three budgets: The second of these is the budget that would be sufficient to eliminate poverty with perfect information on each person's income (thus bringing every person up to the poverty line). This is given by $P_1 z$. Results are also given for budgets slightly above and below this amount. The solutions were constrained to be nonnegative, and the method used linear interpolation, which appeared satisfactory. Quite rapid convergence to within 0.1 percent was usually achieved.

The following observations on the results in Table 1 can be made:

1. The lowest allocation is to the urban sector in all cases considered, although positive allocations to that sector are still desirable in some situations. Targeting toward the rural sector is strongly indicated for all countries, with a particular bias toward the estate sector being desirable in Sri Lanka.

2. The equivalent gains from optimal targeting vary considerably between countries. The comparison between Bangladesh and the Philippines is the most striking; while optimal sectoral targeting is equivalent to a seemingly modest 2 percent of the untargeted budget for Bangladesh, the equivalent gain from targeting for the Philippines represents almost 40 percent of the budget. This reflects the greater difference between sectors in the depth of poverty in the Philippines.

3. The equivalent gain from targeting may increase or decrease with size of the budget.[4] It may well be that the greater the budget available for poverty relief, the less it matters how that budget is targeted. For example, while the equivalent gain increases as the budget increases for the first two countries in Table 1, this is not so for Sri Lanka.

5. APPLICATION USING HOUSEHOLD LEVEL DATA FOR JAVA

We now consider the results obtained using a more detailed regional/sectoral partition for Java in Indonesia. For this purpose, access was obtained to the primary data tapes of the 1981 household expenditure survey (the *Susenas*) done by the Central Bureau of Statistics. A subsample of 5,218 households was drawn, comprising 20 randomly se-

[4]By standard comparative static methods it can be verified that (under the assumptions made in previous sections) the sign of the implicit derivative of η with respect to $\bar{x}$ in equation (8) is indeterminate.

lected local administrative units.[5] The use of household level data (rather than published summary distributions) has two main advantages here: First, the investigator can partition the data according to any desired set of variables (thus permitting the definition of more policy-relevant target groups), and, second, more behaviorally sound welfare measures can be constructed for measuring poverty.

For this application, a simple spatial division of Java was made into western areas (the provinces of West Java and Jakarta), the central areas (provinces of Central Java and Yogyakarta), and the east (the province of East Java), with each of these regions further divided into urban and rural sectors. This division is of particular interest, as it has been claimed that recent economic development in Java has been both spatially and sectorally uneven, with urban areas of western Java (such as Jakarta and Bandung) developing far more rapidly than many other areas, such as the island of Madura off eastern Java and the other dry rural areas in the east-central part of the main island. The household welfare measure used in this application is total consumption expenditure per person. This is undoubtedly a better welfare measure than household incomes and expenditures as used in Table 1. It does not, however, allow for any spatial variation in prices or for different demographic compositions of households.[6]

The second, third, and fourth columns of Table 2 give poverty profiles by region/sector, while the panels to the right give optimal budgetary allocations with and without a nonnegativity constraint. As in Table 1, the main budget assumed is the one that would be sufficient to eliminate poverty with perfect income information.

A number of points emerge clearly from the results in Table 2:

1. All three measures indicate that the highest levels of poverty are found in the eastern rural areas; for example, while about 11 percent of the whole sample is below the poverty line, this figure reaches 31 percent in rural east Java.

2. The optimal budgetary allocations allowing the power to tax only involves *positive* transfers to the central and eastern rural areas, with the highest tax burden (by a large margin) falling on urban areas of western Java. When only nonnegative transfers are possible, the budget should go entirely to rural areas in the east.

3. The equivalent gains from targeting in this example are very high,

---

[5]These data were kindly provided to us by Dominique van de Walle; further details on the sampling method and data can be found in van de Walle (1988a).

[6]A better approach is to construct money metrics of individual welfare from a demand model; see van de Walle (1988b).

Table 2: Regional/Sectoral Poverty Alleviation Budgets for Java

Region/sector		Population proportion (n_j)	Poverty measure (P_α)			Optimal allocations of $\bar{x} = 114$			
			$\alpha = 0$	$\alpha = 1$ ($\times 10$)	$\alpha = 2$ ($\times 100$)	x^* (Rp/hh/mn)	P_2 ($\times 100$)	$x^* \leq 0$ (Rp/hh/mn)	P_2 ($\times 100$)
West	Urban	0.130	0.003	0.003	0.005	−2,585	0.281	0	0.005
	Rural	0.167	0.030	0.033	0.054	−551	0.171	0	0.054
Central	Urban	0.177	0.050	0.065	0.124	−146	0.167	0	0.124
	Rural	0.322	0.136	0.217	0.525	696	0.139	0	0.525
East	Urban	0.027	0.063	0.079	0.231	−7	0.233	0	0.231
	Rural	0.176	0.306	0.792	2.91	1,963	0.134	652	0.133
Aggregate		1.0	0.114	0.229	0.719	114	0.169	114	0.441
Equivalent gain from targeting		—	—	—	—	881	—	256	—

Note: Based on a sample of 5,218 households drawn randomly from the data tapes of the 1981 household expenditure survey (*Susenas*) for Java. The poverty line is 5,000 Rupiah per person per month in 1981.

considerably exceeding the budget. This reflects the underlying variation in poverty gaps.

6. CONCLUSIONS

A general method has been offered for solving the targeting problem of poverty alleviation using contingent transfers with imperfect information on the incomes of recipients. A quantitative measure of the gain from targeting has also been proposed. A set of Fortran programs is available from the authors to perform these calculations.

The methodology has potential wide-ranging policy applications. It has been illustrated here using the problem of establishing sectoral and regional priorities for poverty alleviation in four countries in Asia. All of the results support the case for targeting policies toward rural sectors. And specific subsectors and regions can be readily identified when the data permits a finer stratification. The gains from optimal targeting vary widely, according to the distributional circumstances of particular countries, the size of the budget, and the number of potential target groups.

There are a number of possible directions for future enrichment of the methodological approach that we have outlined. In our view, the most interesting of these involve the incorporation of more elaborate (and realistic) specifications of the constraint set on the poverty alleviation problem. We have mentioned the possibilities for introducing "political economy" constraints. Better welfare measures allowing behavioral responses to the relative price effects of poverty alleviation policies would clearly be desirable, and market equilibrium conditions may then emerge as important constraints.[7] Finally, we would mention the potential importance of introducing intergroup mobility responses and, hence, location equilibrium conditions, as relevant constraints on regional and sectoral poverty alleviation policies.[8]

REFERENCES

Besley, T., and Kanbur, S.M.R. (1988) Food Subsidies and Poverty Alleviation, *The Economic Journal*, 98: 701–710.

Bigman, D. (1987) Targeted Subsidy Programs under Instability: A Simulation and an Illustration for Pakistan, *Journal of Policy Modeling* 9: 483–501.

---

[7]Thus, our approach may be combined fruitfully with market and policy simulation studies of targeted poverty alleviation programs, such as that of Bigman (1987).

[8]For an approach to introducing data consistent location equilibrium constraints (which do not *assume* free mobility), see Ravallion (1982).

Foster, J., Greer, J., and Thorbecke, E. (1984) A Class of Decomposable Poverty Measures, *Econometrica* 52: 761–765.
Greer, J., and Thorbecke, E. (1986) A Methodology for Measuring Food Poverty Applied to Kenya, *Journal of Development Economics* 24: 59–74.
Kakwani, N. (1980) On a Class of Poverty Measures, *Econometrica* 48: 437–446.
Kanbur, S.M.R. (1987a) Measurement and Alleviation of Poverty, *IMF Staff Papers* 34:60–85.
——— (1987b) Structural Adjustment, Macroeconomic Adjustment and Poverty: A Methodology for Analysis, *World Development* 15: 1515–1526.
Ravallion, M. (1988a) Land-Contingent Policies for Rural Poverty Alleviation mimeo, Department of Economics, Research School of Pacific Studies, The Australian National University.
——— (1988b) Expected Poverty under Risk Induced Welfare Variability, *The Economic Journal*, 98: 1171–1182.
——— (1982) The Welfare Economics of Local Public Spending: an Empirical Approach, *Economica* 49: 49–61.
Sen, A. (1976) Poverty: An Ordinal Approach to Measurement, *Econometrica* 44: 219–231.
van de Walle, D. (1988a) On the Use of the Susenas for Modelling Consumer Behaviour, *Bulletin of Indonesian Economic Studies*, 98: 107–122.
——— (1988b) *The Welfare Analysis of Food Pricing Policies*, Department of Economics. Research School of Pacific Studies, the Australian National University.
World Bank (1986) *Poverty and Hunger: Issues and Options for Food Security in Developing Countries*. World Bank Policy Study, Washington, D.C.: World Bank.