INTERNATIONAL
FOOD
POLICY
RESEARCH
INSTITUTE

THE EFFECT OF FOOD PRICE AND INCOME CHANGES ON THE ACQUISITION OF FOOD BY LOW-INCOME HOUSEHOLDS

BY HAROLD ALDERMAN

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

THE EFFECT OF FOOD PRICE AND INCOME CHANGES ON THE ACQUISITION OF FOOD BY LOW-INCOME HOUSEHOLDS

BY HAROLD ALDERMAN

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
1776 MASSACHUSETTS AVENUE, N.W.
WASHINGTON, D.C. 20036 U.S.A.
MAY 1986

ISBN 0-89629-305-X

CONTENTS

FOREWORD vii

Per Pinstrup-Andersen

1. SUMMARY 1

PART 1: A REVIEW OF THE EVIDENCE

2. INTRODUCTION 4

3. EMPIRICAL PATTERNS OF PARAMETERS AND THEIR RELATIONSHIP TO POLICY: A REVIEW OF PRINCIPAL STUDIES 11

4. GENERALIZATION OF PATTERNS 24

PART 2: THEORETICAL AND METHODOLOGICAL CONCERNS IN MEASURING DEMAND PARAMETERS FOR LOW-INCOME HOUSEHOLDS

5. RESTRICTIONS OF PARAMETERS FOR ESTIMATING CONSUMER RESPONSE WITH DISAGGREGATED COMMODITY GROUPINGS 43

6. ESTIMATION CONCERNS ASSOCIATED WITH CROSS-SECTIONAL DATA 55

7. CRITERIA FOR DISTINGUISHING GROUPS FOR PARAMETER ESTIMATION 63

8. OTHER ISSUES 69

9. CONCLUSIONS AND RESEARCH RECOMMENDATIONS 79

APPENDIX: SUPPLEMENTARY TABLES 81

BIBLIOGRAPHY 91

TABLES

1. Studies presenting price elasticities by income group . . . 12

2. Cross-tabulation of price elasticities and real income effects of price changes 26

3. Parameters of regression of Hicksian elasticities on log of income 27

4. Regressions of standardized substitution elasticities on log of income 30

5. Regressions of standardized substitution elasticities on income share 30

6. Regressions of standardized substitution elasticities on population grouped by income 31

7. Regressions of standardized uncompensated elasticities on population grouped by income 31

8. Regressions of standardized uncompensated elasticities on income share 32

9. Calorie elasticities for low-income families 37

10. Food expenditure elasticities for low-income families . . . 38

11. Meat product elasticities 81

12. Rice elasticities 83

13. Wheat and bread elasticities 85

14. Coarse grain elasticities 86

15. Root crop elasticities 88

16. Milk product elasticities 89

ILLUSTRATIONS

1. Price and income elasticities for lower-income consumers . . . 6

2. Price and income elasticities for upper-income consumers . . . 7

3. Standardized price elasticities on standardized income 8

4. Truncation of normally distributed calorie variable 64

ACKNOWLEDGMENTS

Many people contributed to this study. Howarth Bouis, Michael Demousis, Per Pinstrup-Andersen, and David Sahn all had a hand in the conceptualization and refinements of the project. Patricia O'Brien-Place and Roberta van Haeften of the Nutrition Economics Group, Office of International Cooperation and Development, U. S. Department of Agriculture, provided support and advice on many aspects of the report. The report greatly benefited from many insightful comments and suggestions made by Angus Deaton and by John Strauss on earlier drafts.

The author is grateful to the U. S. Agency for International Development, Bureau of Science, Office of Nutrition, for funding under DAN-1274-C-00-3077-00.

FOREWORD

The effect of government policies on poor people's food consumption and nutrition is determined largely by the resulting changes in incomes and prices and the response of the poor to such changes. Although responses of the poor to changes in income as measured by income elasticities of demand for food commodities have been estimated for a long time, few estimates of the responses of the poor specifically to price changes were available until the mid-1970s. During the last 10 years, however, a number of such estimates have been made using a variety of methods. The main purpose has been to estimate how changes in the prices of various food commodities affect food consumption by the poor as compared with the population at large.

This report summarizes the methodological approaches used and their empirical results and synthesizes the empirical results in an attempt to identify generalizable findings and shortcuts that may be used to approximate price responses by the poor from average estimates. It provides new insights into the adjustments low-income households make in food consumption in response to price changes and suggests ways of measuring the magnitudes of such adjustments.

Per Pinstrup-Andersen

1. SUMMARY

Planners and government officials regularly use measurements of a population's response to changes in incomes and prices in their formulations of food policy. Only in recent years, however, have analysts attempted to quantify the extent to which the poor are more responsive to price changes than wealthier consumers. This report reviews the evidence of those attempts and discusses the econometric problems raised by the study of the food demand of groups within a population.

Fifteen studies that have estimated price response by income group are compared in this report. They cover 11 countries and differ in their methods of estimation, in the assumptions underlying the choice of functional form, and in the periods over which their data were collected. Some general patterns emerge. The disaggregate price elasticities of the studies are frequently large in absolute value, exceeding 1 in a third of the estimates. Thus, although it is clear that consumers readily substitute other foods and nonfoods for a food item when that item's price rises, these studies provide statistical confirmation that the poor are more likely to make such substitutions than the well-off. Such substitution is in addition to the changes in food consumption that the poor make following a price rise that is attributable to a reduction in real income.

A number of rules of thumb are identified. For example, it is estimated that a 10 percent increase in income leads to declines in substitution elasticities of between 1 and 3 percent. Similarly, it is estimated that the price elasticity for rice of the poorest 10 percent of a population will be 80 percent higher than the mean value for the whole population. Similar relationships were estimated for meat, milk, root crops, wheat, and coarse grains. In all cases, the pattern of declining price responsiveness with increased income (or ranking in income) was statistically significant.

Responses to income changes were indicated by estimates of income elasticities for food expenditures and calories. Food expenditures for families that consume 1,750-2,000 calories per person per day will increase by 8.2 percent with a 10 percent increase of income. Calorie intake will increase, however, by only 4.8 percent, as a portion of the increased expenditure is used to increase the perceived quality of the diet. Income response explains more of the variation of food expenditures than of calorie intake.

The policy implications and uses of such parameters include estimates of leakage of subsidies to nonfood items. Increases in the incomes of the poor do lead to increases in calorie consumption

greater than those of the overall population, but transfers cannot be expected to be used solely to raise calorie intake. However, when propensities to spend on food are high, it is also unlikely that in-kind transfers will reduce demand for agricultural products as much of the additional income will be spent on food. With larger price responses, the poor are more likely to increase their food consumption following the introduction of price subsidies or decrease it when domestic food prices rise. Food consumed mainly by the poor--for example, coarse grains--for which the poor are price-responsive, can be identified and by doing so, pricing policies can be targeted. It is important, however, to note that an increase in the food consumption of one item due to price changes is partially offset by decreases in the consumption of others. While the net effect can be low in some countries, it is frequently appreciable even for the poor.

The estimation of price elasticities by income group is hindered by the scarcity of data with sufficient variation in prices. Time-series data generally do not report consumption by groups, and therefore most, though not all, estimation has been done with cross-sectional data. Restrictions on parameters derived from theory and from assumptions about the nature of consumer utility make it possible to estimate reductions of parameters. This computational advantage comes at the price of unrealistic behavioral models when dealing with a number of food items and is not recommended for food policy analysis.

Cross-sectional studies may generate price parameters that differ from those of time series, with the parameters from the former generally being larger. Evidence for this is mixed, however, and there is a need to obtain panel data or other disaggregate data for several periods to explore this pattern further. Cross-sectional studies have the additional problem of including nonconsumers. This can lead to serious estimation biases that can be handled by techniques that study the probability of a purchase as well as the amount purchased.

If one distinguishes subsamples of a population to be studied by the amount of calories consumed rather than by income, serious biases are also possible. The theoretical prediction is that income elasticities will be underestimated when the sample is subdivided by intake.

Another concern for policy is whether sources of household income, distinguished by gender or by type of employment, affect income and price parameters. Although there is empirical evidence that household demographic profiles affect demand and a theoretical foundation for their inclusion in demand studies, there is less experience with sources of income. Similarly, determinants of the distribution of food within households have proven hard to quantify. They are, however, important for understanding how households interact with each other and for applying demand theory to practical problems.

PART 1: A REVIEW OF THE EVIDENCE

2. INTRODUCTION: THE EFFECTS OF FOOD POLICY, INCOME, AND PRICE CHANGES ON HUMAN NUTRITION

A complex web of interactions between policies, income, and prices contributes to malnutrition and, therefore, a government may influence the nutrition of its population through a variety of actions. Some improvements in nutrition may be achieved through programs that do not appreciably change the economic environment or a family's physical endowment--for example, through health care and education programs. However, prices and incomes are the principal determinants of a family's food intake and, hence, its nutrition. Consequently, a government's food policies become a major influence on the nutrition of a population, whether or not such policies are designed with nutrition as a primary goal.

Governments have several instruments that they can use to bring about changes in household food consumption. They may, for example, influence price through marketing boards, price floors and ceilings, or by import policies. The first two, however, also affect income policies whereas import policies contribute to and reflect a variety of foreign exchange quantity and rate regulations. Indeed, as the understanding of the intricacies of the interaction of macro- and microeconomic factors has improved, it has become increasingly clear that the freedom a government has to determine instruments are far fewer than the number of goals it may hope to achieve. This interdependence of the instruments of policy stimulates interest in developing finer tools for policy planning. This, in turn, stimulates an interest in greater precision in measuring the reactions of groups of consumers and producers to changes in their endowments and in prices.

In most societies where malnutrition is widespread, households with malnourished members respond to changes in income and prices differently than society as a whole. While knowledge of the average price response of a population may be enough to determine a market-clearing price, it will not enable a planner to know how different parts of a population will change their consumption following price changes. A related point is that the absence of information on commodity substitution limits a planner's ability to influence the consumption of specific groups through price changes without introducing disincentives, costly general subsidies, or targeting schemes that would strain the administrative resources of a country.

Reliable estimates of the effects that changes in prices and incomes have on groups of households with malnourished members are scarce, however, and their use in designing food policy has been limited. Only in the last 10 years have efforts been made to distinguish the response of poor households to prices from the response of the whole population.

There is no consensus on whether it is necessary or feasible to make empirical studies of how much poor households readjust their purchases following price changes. Although few studies have focused on how much demand for food by low-income households is influenced by changes in the economic environment, most that have indicate that the poor do respond differently than the general population. This is illustrated in Figures 1-3.

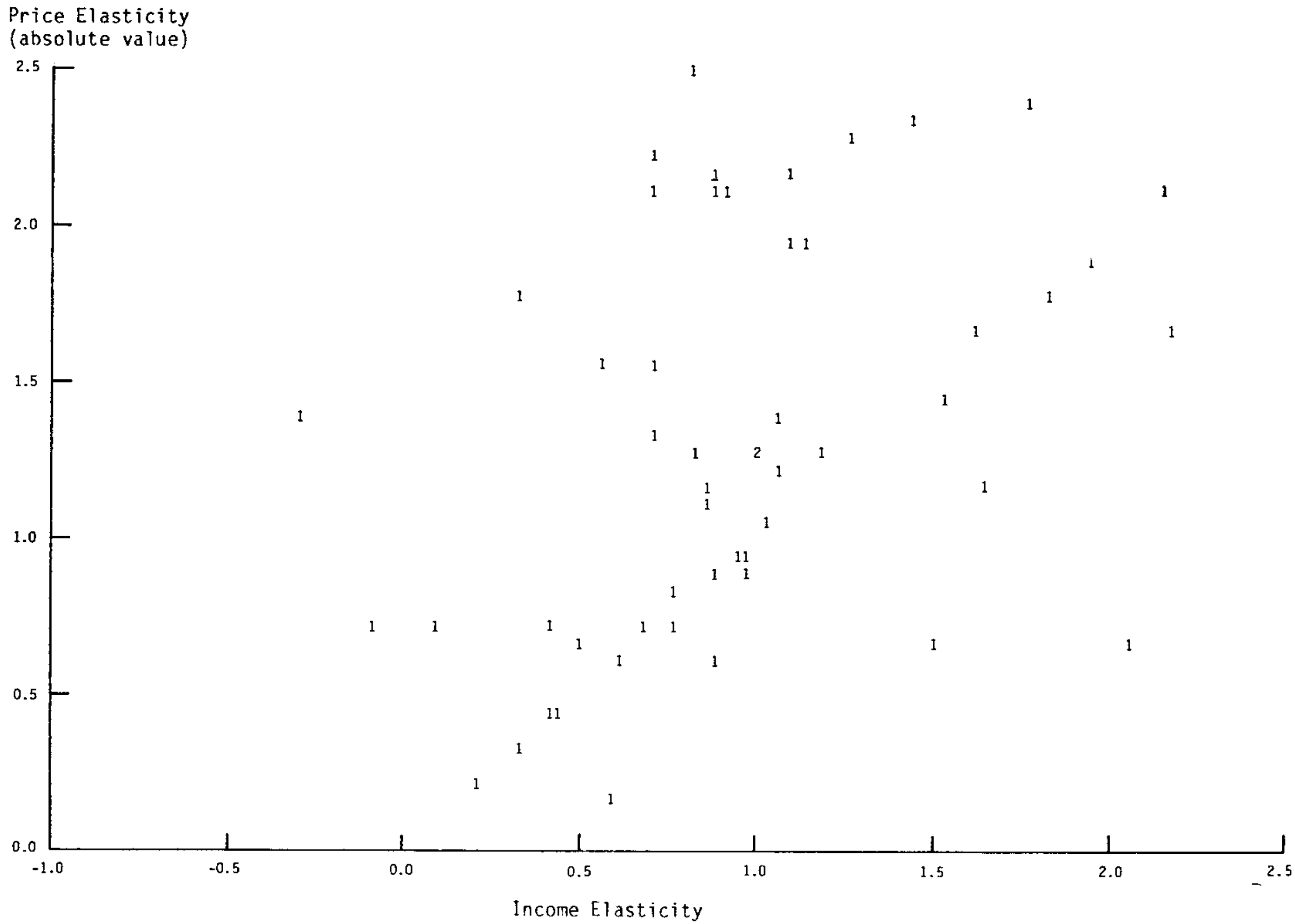
Figure 1 shows a set of price elasticities and income elasticities for the poor for a number of disaggregated food items. Elasticities for upper-income consumers are shown in Figure 2. The points are derived from surveys and estimates discussed at length later in the report. The data points give the percentage change of consumption of various food items following either a percentage increase in income or a percentage decrease in the price of the food. Whereas the data points are scattered, reflecting differences in areas and commodities covered, the points for the low-income consumers are, in general, higher and further to the right than the points for the upper-income consumers. This implies that both income and price elasticities are larger for the poor.

Figure 3 smooths out much of the variance between countries by standardizing the price elasticities of different income groups for each commodity in each country by dividing them by the mean value of the price elasticity for that commodity in the country. Similarly, income was standardized by dividing the group's mean value by the sample mean income. Virtually all points that represent price responses greater than the mean (standardized elasticities greater than one) are found in the portion of the graph corresponding to groups with incomes below the national average.

This study analyzes the patterns of food purchasing behavior illustrated in these graphs. The review assesses the current state of knowledge revealed by existing studies covering different economic environments. Any generalizable findings from these studies that may be useful for planners will be identified. In part, it is hoped that such findings will reduce uncertainty when policy must be made with limited information. In addition, current knowledge should be useful for guiding future research on the determinants of food acquisition by the poor.

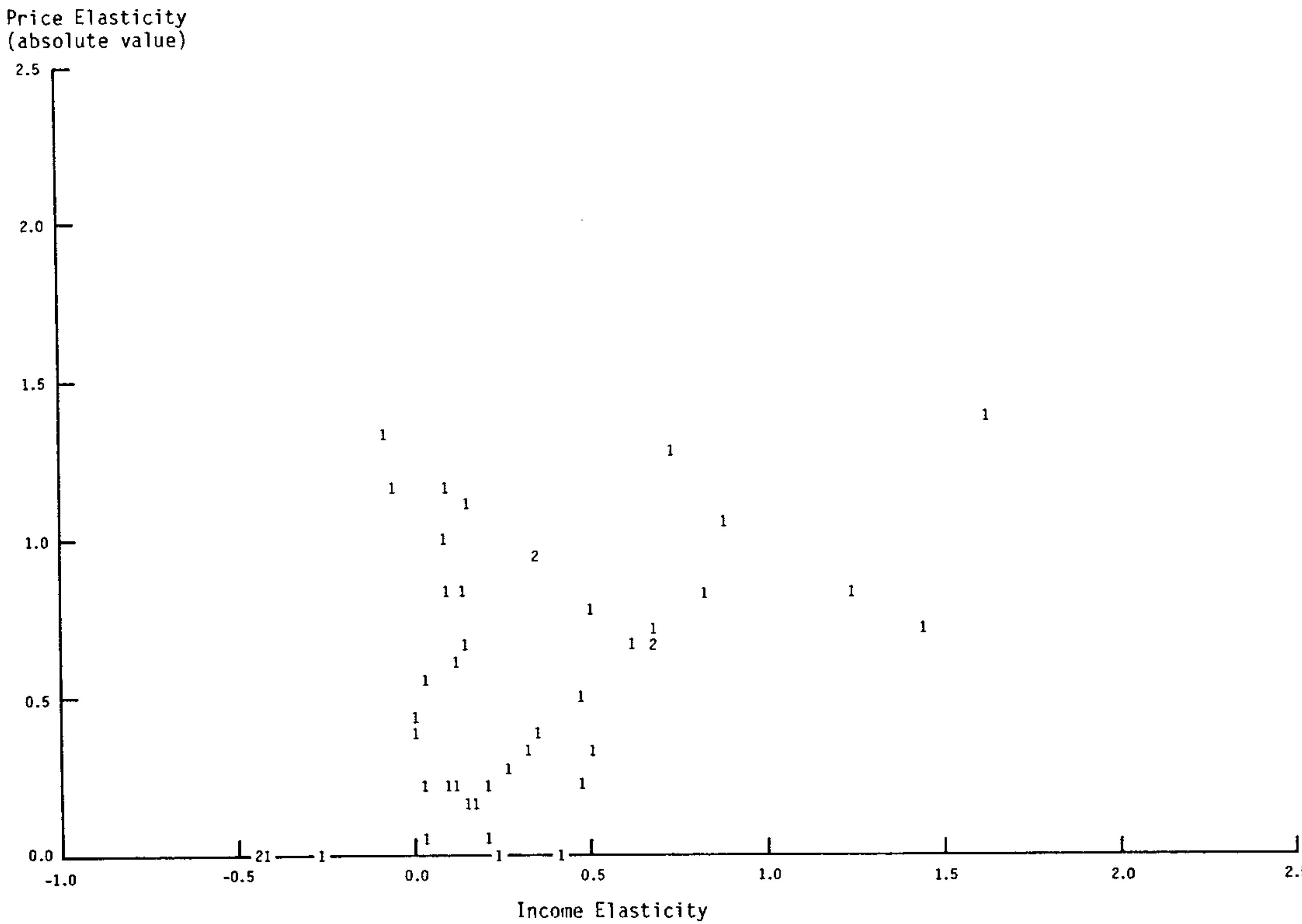
The attractiveness of certain policy measures may hinge on knowledge of how different groups would respond to them. At times neither the effect of a policy nor the need for measures to compensate households whose welfare would be reduced by proposed policies is apparent from theoretical or qualitative knowledge and can only be known from empirical results.

Figure 1--Price and income elasticities for lower-income consumers



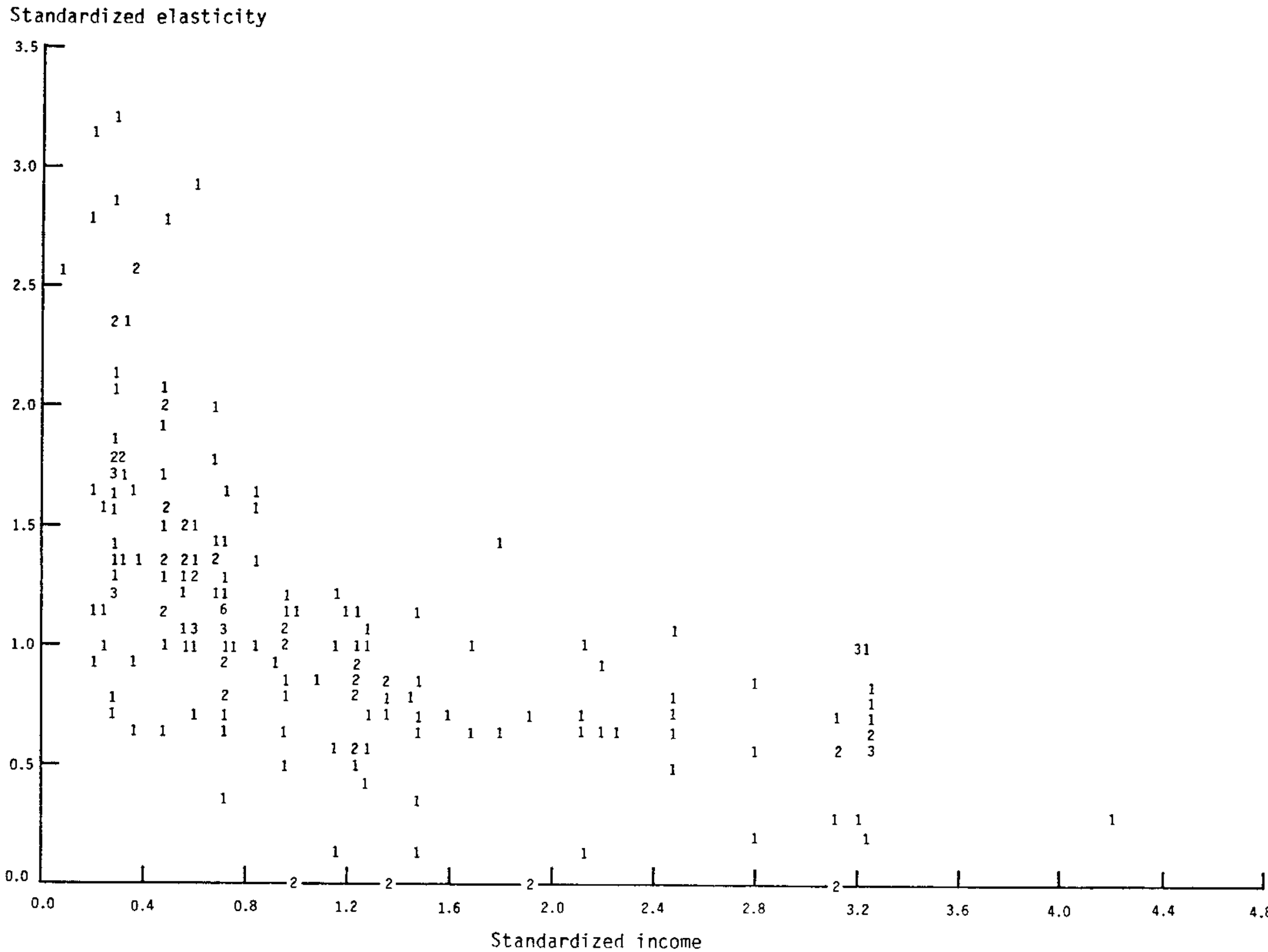
Note: The numbers in the figure show where more than one point falls.

Figure 2--Price and income elasticities for upper-income consumers



Note: The numbers in the figure show where more than one point falls.

Figure 3--Distribution of standardized price elasticities by standard income



Notes: The numbers in the figure show where more than one point falls. Elasticities are standardized for each commodity by dividing the income group's elasticity in each country by that country's mean elasticity for the commodity. Incomes are standardized in a similar manner.

The response of the poor to food price changes is a special part of welfare analysis. Most economists argue that real income is the main measure of household welfare and that changes in quantities of goods consumed are, in part, welfare-preserving adjustments that maximize well-being with a given income. The specific concern with food consumption diverges from pure consumer sovereignty and reflects the social process of transfer programs.[1] It also reflects the externalities of nutrition in health and human capital development and the possibility that the maximization of the welfare of an individual and a household might differ. This paper focuses on specific nutritional concerns, although the economists' concept of welfare should not be forgotten.

Interest in the responses of the poor is not new. What is new is the application of econometric techniques to new data sources. The scarcity of the data needed to conduct such studies has been the principal barrier to directly estimating parameters disaggregated by income groups.

Cross-sectional data may provide an acceptable basis for estimating income parameters and the income effects of price changes. However, they may not provide reliable estimates of price parameters unless they refer to several times or geographical locations and thus provide sufficient and relevant price variation. Time series that have data by income group are even scarcer than cross-sectional data.

The costs of establishing such a data base are high and the time needed frequently exceeds the time available to planners. An alternative is methodological innovation. Using economic theory and advances in computerized techniques, a number of researchers have explored ways to estimate demand parameters with limited price variations. Chapter 3 discusses 15 studies that report such estimates using a variety of techniques and data from 11 countries.

Policy planners may not always have the data necessary for such estimates. For this reason, the available evidence is analyzed in Chapter 4 and patterns from those studies are illustrated. As this is intended to assist policy planners, efforts have been made to minimize the technical language and algebra in the text. But since many of the innovations and much of the debate about the meaning of the results involve econometrics, Part 2 includes a discussion of the methodology. Some readers may prefer that it precede the discussion of results, while for others it may be too technical. No attempt has been made to produce a state-of-the-art consumer theory. Rather, Part 2 discusses particular problems and methodologies that are important when data are disaggregated by income groups and by commodities. It also discusses features of cross-sectional data used to estimate price parameters.

---

[1]See, for example, James Tobin, "On Limiting the Domain of Inequality," Journal of Law and Economics 13 (October 1970): 263-277; and Lester C. Thurow, "Cash Versus In-Kind Transfers," American Economic Review 64 (May 1974): 190-195.

In principle, the estimation of the response of low-income consumers to price and income changes is no different from a general study of consumer demand. There are no properties derived from demand theory unique to low-income households. Just as the techniques for measuring demand used with data from the developed world differ little from those used with similar data from low-income countries, the econometrics of consumer demand are largely unaffected by the differences of income within a country. Yet these differences pose unique problems when such measures are undertaken, problems that stem from the goals of the research and the nature of the data available.

Special care is also necessary when analyzing data from developing countries because market imperfections, quantity restrictions, and other departures from textbook estimation procedures are often important determinants of demand.

Part 2 is not intended for the specialist in econometrics. It is aimed at policy analysts who hope to use and evaluate parameters obtained from econometric studies and at general practitioners who are called upon to be familiar with, but not necessarily at, the frontier of econometric research.

A brief review of systems of demand is provided, despite the existence of more comprehensive studies, as the choice whether or not to use such techniques is always vexing. Similarly, as price parameters are usually estimated with time-series data, a section on the pitfalls of estimation with cross-sectional data is presented.

Although the focus of an estimation can be determined largely by the use the parameters will be put to, there are some concerns raised by statistical and welfare theory that should also be considered. These are also discussed in the second part.

Finally, Part 2 introduces problems in the estimation of parameters for food policy use that are not essential for measuring price responses but are particularly relevant to food policy analysis. These include problems arising from different sources of income producing different spending patterns, decisionmaking within a household, and the distribution of household purchases. The report concludes with an outline of research questions relevant to the study of food acquisition by low-income households.

3. EMPIRICAL PATTERNS OF PARAMETERS AND THEIR RELATIONSHIP TO POLICY: A REVIEW OF PRINCIPAL STUDIES

Food policy encompasses facets of agricultural policy, nutrition, and equity as well as aspects of many countries' overall development strategy.[2] Many of the data needs of planners in this diverse area are served with information on aggregate market supply and demand and the parameters derived from them. However, when goals of one set of policies interferes with others--as, for example, when policies to stimulate agricultural production jeopardize the nutrition of poor consumers--it is useful to be able to understand the behavior of individuals and subgroups as well as markets. This, quite briefly, is the motivation for giving attention to the response of the poor to price and income changes.

Examples of the application of analyses of disaggregated data to policy choices are myriad. Parameters specific to income groups are used, for example, to design efficient transfer and subsidy programs,[3] to project the effects of development strategies on the nutrition of the poor, to estimate the linkages between one type of development program and other parts of the economy,[4] and to devise priorities for agricultural research.[5] Nevertheless, while it has long been recognized that income parameters may differ among income groups, interest in estimating and applying price parameters by income groups is new. This is partly because the need for such information was not recognized before, but it also reflects the difficulty of generating the appropriate data and applying econometric techniques that can derive such parameters. In recent years, however, a number of studies have derived price responses disaggregated by income group (see Table 1). The actual elasticities for these reports are presented in the Appendix, Tables 11-16. The studies reported here are not a subset of the studies that report price elasticities estimated by income group; they are virtually all of the completed studies with

---

[2] C. Peter Timmer, Walter Falcon, and Scott R. Pearson, Food Policy Analysis (Baltimore, Md.: Johns Hopkins University Press, 1983).

[3] Shlomo Reutlinger and Marcelo Selowsky, Malnutrition and Poverty (Baltimore, Md.: Johns Hopkins University Press, 1976). Also, Marcelo Selowsky, "Target Group-Oriented Food Programs: Cost Effectiveness Comparisons," American Journal of Agricultural Economics 61 (December 1979): 988-999.

[4] John W. Mellor, The New Economics of Growth: A Strategy for India and the Developing World (Ithaca, N.Y.: Cornell University Press, 1976); and "Food Price Policy and Income Distribution in Low-Income Countries," Economic Development and Cultural Change 27 (October 1978): 1-26. Also, Richard A. King and Derek Byerlee, "Factor Intensities and Locational Linkages of Rural Consumption Patterns in Sierra Leone," American Journal of Agricultural Economics 60 (May 1978): 197-208.

[5] Per Pinstrup-Andersen, Norha Ruiz de Londono, and Edward Hoover, "The Impact of Increasing Food Supply on Human Nutrition: Implications for Commodity Priorities in Agricultural Research and Policy," American Journal of Agricultural Economics 58 (May 1976): 131-142.

Table 1--Studies presenting price elasticities by income group

Study/ Year	Country or Region	Approach	Aggre- gation	Time Series	Commod- ities Covered
Pinstrup- Andersen, et al. (1976)	Cali, Colombia	Frisch	1,479 households	No	22 goods
Rosen- berger (1978)	United States	Single Equation	7,500 households	No	fluid milk
Timmer and Alderman (1979)	Indonesia	Single Equation	1,800 cells	3 rounds	rice, cassava
Thomson (1979)	United States	Frisch/ Single Equation	5,482 households	No	28 goods
Ahmed (1981)	Rural Bangladesh	LES	234 cells	No	10 goods
Murty and Radha- krishna (1981)	India	Nasse modification of LES	288 cells	20 years[a]	9 goods
Dixon (1982)	Java, Indonesia	Single Equation	Unspeci- fied cells	3 rounds	rice, cassava, gaplek
Strauss (1982)	Sierra Leone	QES	138 households	No	6 goods, leisure
Bouis (1982)	Philippines	Single Equation	Unspeci- fied cells	16 quarters[b]	maize, rice, wheat
William- son-Gray (1982)	Brazil	Single Equation	343 cells	No	16 goods
Pitt (1983)	Rural Bangladesh	Single Equation	5,750 households	4 quarters	9 goods

(continued)

Table 1--Continued

Study/ Year	Country or Region	Approach	Aggre- gation	Time Series	Commod- ities Covered
Pinstrup-Andersen, et al. (1983)	Urban Sudan	LES	4,930 households	Monthly, one year	7 goods
Murty (1983)	India	LES	288 cells	20 years[a]	9 goods
Trairat-vorakul (1983)	Thailand	Single Equation	11,450 households	Monthly, one year	16 goods
Sahn (1984)	Sri Lanka	Single Equation	4,753 households	No	12 goods

Sources: Complete reference information for these studies is in the bibliography.
Notes: LES stands for linear expenditure system; QES stands for quadratic expenditure system.
[a]Covered 1950/51-1970/71.
[b]Covered years 1974-1977.

such information available in English known to the author. A few studies, mainly pioneering methodological work and estimates using systems of demand, are mentioned in the text but are not included in the general discussion because the level of commodity aggregation was suited to only a few food policy uses. The studies reported below differ in their approach. Each approach has its advantages and drawbacks, but as this is not a manual of demand estimation, the main concern is with the general patterns of price responses by income.

Application of Frisch Technique

One of the first attempts to identify the price response of low-income consumers for use in food policy analysis was made by Pinstrup-Andersen and colleagues.[6] The econometric technique

[6]Ibid. Also see Per Pinstrup-Andersen, "Decision-Making on Food and Agricultural Research Policy: The Distribution of Benefits from New Agricultural Technology Among Consumer Income Strata," Agricultural Administration 14 (January 1977): 13-25; and Per Pinstrup-Andersen and Elizabeth Caicedo, "The Potential Impact of Changes in Income Distribution on Food Demand and Human Nutrition," American Journal of Agricultural Economics 60 (August 1978): 402-412.

used in these studies was developed by Frisch in 1959 (see Part 2 for a discussion of methodologies) but apparently was not applied to food policy work before. The method allows for the estimation of a complete matrix of own- and cross-price parameters with limited data, primarily cross-sectional data without price variation. The importance of the study, then, is not so much the econometric results, which can be criticized because of the severe restriction imposed by the methodology, but their application.

Having derived the matrix, Pinstrup-Andersen and colleagues investigated the direct and indirect effects on calorie consumption of a hypothetical shift in the supply curve that might result from agricultural research on 22 commodities. The exercise was carried out with three sets of assumptions about the costs of research and two sets of supply elasticities. By illustration, they found that the commodities given priority in order to meet goals of reducing calorie deficits, under the assumptions that equal percentage increases had equal costs and that supply elasticities were zero, were rice, sugarcane, maize, and cassava. If increases of equal quantities had identical costs, the priorities would shift to oilseeds, sugarcane, maize, and rice. Other crops would be given priority if increasing protein were the objective.

Pinstrup-Andersen also used these parameters to estimate the gains in consumer surplus that would follow a shift in supply. He found, for example, that for the poor the greatest gains when supply elasticities were zero came from increases in rice production, but when they were unity the greatest gains came from increases in the supply of beef. With different commodity bundles consumed by the upper-income groups, changes in beef supply made the largest contribution to consumer surplus under both assumptions. Changes in the supply of rice made, at best, only the fifth largest. Pinstrup-Andersen and Caicedo used these parameters in yet another context. They estimated the nutritional effects of changes in income distribution under fixed and expanding food supplies. With fixed supplies, prices rose more rapidly, virtually negating the nutritional effect of the distribution-mediated income growth. With expanding supplies, redistribution led to a large improvement in nutrient intake.

The studies of Pinstrup-Andersen and his colleagues were criticized by Brandt and Goodwin, who correctly noted limitations of the Frisch methodology.[7] Whether the research priorities or effects of different distribution scenarios would vary qualitatively with different techniques of estimation has not been directly investigated. These studies, however, indicate the contribution to food policy analysis that an understanding of the price responses of selected income groups can make.

---

[7]Jon A. Brandt and Joseph B. Goodwin, "The Impact of Increasing Food Supply on Human Nutrition--Implications for Commodity Priorities in Agricultural Research and Policy: Comment," American Journal of Agricultural Economics 62 (August 1980): 588-591.

DIRECT ESTIMATES USING CROSS-SECTIONAL DATA

United States

Rosenberger's study was directly influenced by the study of Pinstrup-Andersen et al. and attempted to estimate income class-specific price parameters directly without the restrictive assumptions of the Frisch methodology.[8] She studied the consumption of fluid milk using cross-sectional data from the United States. Since the Federal Milk Order System establishes prices for milk on a regional basis that is unlikely to be correlated with any significant determinant of demand, the variances of the cross-sectional prices were virtually free of the identification problems that can occur with other uses of regional price variations. Using a semi-log demand equation and dummy variables in interaction with price terms (log P x income group dummy variables), she estimated the differences between the price parameters of each of 13 income groups and the price parameter of the highest income bracket. With one exception, the price elasticity declined in absolute value from the poorest income group to the wealthiest; from -2.10 to -0.22, with a weighted mean of -0.82. Rosenberger then used the parameters to estimate the effect on milk and calcium consumption that would follow the phased deregulation of the fluid milk market.

Thomson's study was designed to compare estimation methodologies.[9] Using the same data as Rosenberger, she compared elasticities derived from the Frisch methodology with direct single-equation estimates for 20 commodities. Rather than using dummy variables, she ran separate regressions for each of four income groups. For all but two commodity groups (baked goods and tea and coffee), the price parameters of the lowest income stratum had the highest absolute values. Thomson did not calculate compensated price elasticities but, in view of the low income elasticities (only those for alcoholic beverages were greater than 0.5) and the high degree of disaggregation that would lead to small budget shares, it is reasonably certain that these patterns indicate that the poor in the United States have a greater propensity to substitute between food items.

Indonesia

Similar approaches were used by Timmer and Alderman and by Dixon.[10] These studies used a log-log quadratic equation to estimate

---

[8]A. Rosenberger, "The Impact of the Federal Milk Marketing Order System on Dairy Product Consumption" (M. A. thesis, Cornell University, 1978).

[9]A. Thomson, "Nutrition, Food Demand and Policy" (Ph.D. dissertation, Stanford University, 1982).

[10]C. Peter Timmer and Harold Alderman, "Estimating Consumption Parameters for Food Policy Analysis," _American Journal of Agricultural Economics_ 61 (December 1979): 982-987; John A. Dixon, _Food Consumption Patterns and Related Demand Parameters in Indonesia: A Review of Available Evidence_, Rice Policies in Southeast Asia Project Working Paper 6 (Washington, D.C.: International Food Policy Research Institute, 1982).

income terms and interaction terms with dummy variables to estimate price terms. Timmer and Alderman focused on basic staple commodities in order to evaluate the possibility of mitigating the effect of rising rice prices on nutrition with policies affecting maize and cassava in Indonesia. Using cell means from regions and income groups in three separate rounds of a household survey, they found that price elasticities for rice and cassava declined in absolute terms as incomes increased, as did cross-price elasticities of cassava with rice prices. Estimates of rice quantities that changed with cassava prices were not significant, nor were similar estimates with maize. Dixon used this methodology on Java and added dried cassava and sweet potatoes to the analysis, but found no clear patterns in the elasticities for these two commodities. This may be due, in part, to the aggregation of consumers and nonconsumers and the wide confidence intervals in the resulting estimates.

Thailand

Trairatvorakul's study resembles the above in that it uses a single-equation methodology (log-log quadratic) and primarily cross-sectional data.[11] He ran separate regressions for income strata and also for subsamples stratified by calorie intake. His study differs from the others in that it introduced price exogenously using regional monthly data and therefore avoided the possibility that price and income would be correlated because of quality effects. It does, however, bias the measurement of quantities for any household whose price differed from the average in the region (see Part 2). For 10 of the 16 commodities, the poor proved more price responsive. The difference was statistically significant for 8 of these commodities. These included beef, chicken, eggs, nonglutinous rice, and saltwater fish, but not freshwater fish, pork, prepared noodle plates, and sugar. Trairatvorakul also estimated cross-price effects, finding chicken and pork to be significant gross substitutes for rice for middle- and upper-income consumers but not for the poorest quartile. Pork and chicken also appeared to be substitutes for each other in the higher-income brackets. A number of the cross-price effects estimated were insignificant, and a few had unexpected signs. This difficulty was also reported by Timmer and Alderman and by Thomson.

Trairatvorakul used these parameter estimates in conjunction with supply elasticities and information on income and landholdings to project the short-run effects on consumption that would follow a change in rice prices. Among his findings was that the net gains to the rural poor would be small, as many purchase rice rather than sell it. For the urban poor, the calculated reduction in calorie consumption in the short run was large.

---

[11]Prasarn Trairatvorakul, The Effects on Income Distribution and Nutrition of Alternative Rice Price Policies in Thailand, Research Report 46 (Washington, D.C.: International Food Policy Research Institute, 1984).

Brazil

Another study using a methodology similar to Timmer and Alderman is one by Williamson-Gray in which 198 cell means from a survey of 55,000 Brazilian families were used.[12] The price variations in this study were regional; for all income groups the average price paid by the lowest income group in a given subregion was used as the independent variable. As in the studies mentioned above, Williamson-Gray found that the poor were more responsive to prices. The compensated and uncompensated price elasticities of the poorest 30 percent were not more negative than those of the middle 50 percent of the population for dairy products alone out of 16 commodities or commodity groupings. The pattern with the estimates for the middle-income group and the upper-income bracket was similar. Dairy price elasticities were again an exception to the basic trend and, in addition, the elasticities for legumes for the higher income group and the poor were virtually identical (-0.61, -0.46, -0.63 for the three income groups).

The differences in compensated price elasticities were frequently pronounced. For example, the elasticity for the cereal group was -0.74 for the poor, -0.16 for the middle, and not significantly different from zero for the rich. The corresponding parameters for roots were -1.39, -0.76, -0.23, and for meat and fish, -0.50, -0.11, -0.10. Williamson-Gray also estimated cross-price responses. Although generally the significance of many estimates was low, some were highly significant. For example, the uncompensated cross-price elasticities for the quantity of rice with the price of wheat were 1.71, 1.09, and 0.79 for the three groups. Conversely, the elasticities with the quantity of wheat and the price of rice were 1.03, 1.07, and 0.29. Rice and cassava were substitutes; maize was a gross complement to both rice and legumes. The latter were substitutes, with the estimates for meat and fish with the price of legumes being 1.10, 0.83, and 0.65.

Disch used the same data as Williamson-Gray to estimate four systems of demand, preferring the translog on various grounds.[13] The price elasticities in this system were, in general, in agreement with the other systems explored, particularly the almost ideal demand system. Allowing for the greater aggregation of grain in Disch's study, his results are close to Williamson-Gray's. He also observed that the absolute values of own-price elasticities declined as income increased, except for the upper 4 percent, for which his results were unreliable. However, he did not observe such a pattern with cross-price effects. This may be explained by the inability to use nonfood

---

[12] Cheryl Williamson-Gray, Food Consumption Parameters for Brazil and Their Application to Food Policy, Research Report 32 (Washington, D.C.: International Food Policy Research Institute, 1982).

[13] A. Disch, "Agricultural Policies and Real Income Changes: An Application of Duality Theory to Brazilian Agriculture" (Ph.D. dissertation, Yale University, 1983).

price data and in so doing to impose Cournot aggregation. Also, his elasticities varied by income group because budget shares differed; parameters of the model were estimated from the complete sample without covariance terms.[14]

Williamson-Gray used her results to examine the efficiency of using food substitutes to increase the calorie consumption of the poor. She modeled options with equal fiscal costs of subsidies on milk, rice, and wheat products. The results indicate that subsidies on wheat would actually increase calorie deficiencies because the cross-price effects for the poor were so pronounced. Subsidies on milk, on the other hand, would lead to net increases in calorie consumption, but the greatest share of the benefits would accrue to the wealthy. Hence the subsidies would be inefficient tools for meeting nutritional goals. Rice subsidies, however, have positive effects mainly for the poor, reflecting the large estimated own-price elasticity for that group.

Bangladesh

Pitt's study of rural Bangladesh differs from the above studies in several respects.[15] The price variations in his study were due both to seasonal supply shifts and to the spatial variation of the 800 villages surveyed in a country with poor transportation. As the estimates were made using household data with 5,750 observations, Pitt used a methodology designed for data with a significant percentage of nonconsumers. Unlike most of the studies above, he did not estimate price parameters for different groups by separating the sample or by introducing dummy variables. Instead the price parameters are of the form $\beta ij = \beta ij^0 + \beta\gamma ij*\log$ (expenditures). This has the advantage that price parameters vary continuously rather than discretely by income but constrains the change in price parameters to be monotonic (see Part 2). Pitt's form, then, modifies the semi-log function, which in its basic presentation has elasticities that vary inversely with quantities. If a good is normal, then, the elasticities decline in absolute value as income rises even if $\beta\gamma ij$ is zero. However, he found that for most of the nine commodities, $\beta\gamma ij$ was positive, so that own-price responsiveness decreased with income. For example, for the poorest tenth percentile, the uncompensated price elasticity for rice was -1.30 while it was -0.83 for the 75th percentile. The compensated elasticities for these percentiles were -0.57 and -0.26. Similarly, their pure substitution elasticities for wheat were -0.73 and -0.09. Only for fish, mustard oil, and onions were the compensated own-price elasticities larger in absolute value for the higher-

[14]Since the approach uses the same data as Williamson-Gray and does not point to any anomalies in her work, only Williamson-Gray's results are included in the regressions below. Despite some theoretical advantages of the translog system, Disch's study was not designed to test patterns in parameters by income group and, therefore, was excluded.

[15]Mark M. Pitt, "Food Preferences and Nutrition in Rural Bangladesh," Review of Economics and Statistics 65 (February 1983): 105-114.

income group than for the poor. Pitt also established cross-price parameters (without symmetry restrictions). Cross-price parameters, unlike own-price parameters, showed no clear pattern with relation to expenditure.

Since Pitt's study covers commodities that make up 95 percent of calorie intake, he was able to establish nutrient price elasticities that are the weighted sum of individual commodity elasticities weighted by their share in total nutrient intake. Despite the differences in own-price responses for rice mentioned above, cross-price effects make the net uncompensated calorie elasticity for changes in the price of rice greater in absolute value for the well-off than for the poor (-0.52 compared to -0.48). A different pattern was observed for wheat, the calorie intake of the poor increasing by 2 percent following a 10 percent decline in wheat prices compared to the increase in the calorie intake of the middle classes of 0.3 percent. Wheat and potatoes were the only commodities for which the nutrient elasticities of the poor for protein, calories, two minerals, and three vitamins were all negative. For other commodities, the cross-price effects offset the own-price response for at least one nutrient.

Sri Lanka

Sahn's analysis of the 1980/81 household expenditure survey for Sri Lanka includes a technique to account for entry into the market for commodities such as bread, milk, and meat.[16] This and related techniques are discussed below. As most families consume such goods as coconuts, fish, rice, spices, sugar, and vegetables, estimates for these goods were obtained using ordinary least squares. Price variations were generally spatial, although the survey was conducted in two rounds over seven months. Covariance techniques were used to control for differences between the rural areas, urban areas, and estates.

Of the 13 commodities studied, 8 had significantly smaller absolute price elasticities for the upper income groups. This pattern was particularly pronounced for fish, milk, and pulses. The uncompensated own-price elasticity for rice also declined slightly with higher incomes. However, as the budget share of rice and income elasticities both declined sharply with income, the compensated substitution elasticity for rice was lower in absolute value for the lower income groups. Furthermore, unlike in many of the other studies, there were no significant differences in the price elasticities of bread or wheat of specific income groups.

[16] David E. Sahn, "Food Consumption Patterns and Parameters in Sri Lanka: The Causes and Control of Malnutrition," International Food Policy Research Institute, Washington, D.C. 1985.

ESTIMATES COMBINING TIME-SERIES AND CROSS-SECTIONAL DATA

Philippines

In the studies reported above, large and significant price responses were obtained from a household survey undertaken in less than one year. Can such patterns be duplicated using time-series data or combinations of time series and cross sections? A study by Bouis provides some evidence to answer that question.[17] He used quarterly data from 1,000 interviews conducted over 15 quarters from 1974 to 1977. The estimates, which combined the time series and cross-sectional data, were run separately for 4 income groups in each of 12 regions. The commodities studied were maize grits, rice, and wheat. Although the absolute value of the own-price elasticities for rice generally declined as income rose, in some maize-consuming regions the middle-income groups were more responsive to prices than either the poor or the well-off. Such a pattern was observed for both rice and maize.

An additional noteworthy point of Bouis' study is that the measured price responses were frequently large--between -2 and -1. While such magnitudes are common in cross-sectional studies, Bouis' estimates have the flavor of time series, with spatial differences minimized by the separate regional regressions.

India

With the exception of the studies by Pinstrup-Andersen and colleagues and by Disch, the studies discussed up to this point used single-equation techniques with no restrictions derived from demand theory. Although such an approach is important for its flexibility, it will be worthwhile to see if the general patterns are also found in studies that use a systems approach to estimation (the merits and shortcomings of such an approach are discussed in Part 2). Murty's studies of demand for food in India are a unique attempt to estimate income-specific price parameters using time-series data.[18] Both studies estimate separate systems of demand for five urban and five rural income groups using cell means from rounds 2-25 of the Indian National Sample Survey collected between 1950/51 and 1970/71. Each round of this survey contained 12 or 13 cell means. The estimations, then, combine some of the properties of time-series and of cross-sectional techniques.

---

[17]Howarth Bouis, "Rice Policy in the Philippines" (Ph.D. dissertation, Stanford University, 1982).

[18]K. N. Murty, Consumption and Nutrition Patterns of ICRISAT Mandate Crops in India, Economics Program Progress Report 53 (Pantancheru: International Crops Research Institute for the Semi-Arid Tropics, 1983); and K. N. Murty and R. Radhakrishna, "Agricultural Prices, Income Distribution and Demand Patterns in a Low Income Country," paper presented at the First International Working Conference on Computer Applications in Food Production and Agricultural Engineering, Havana, Cuba, October 1981.

In the study Murty coauthored with Radhakrishna, demand was modeled using a modification of the linear expenditure system (LES) proposed by Nasse, which allows the underlying additivity assumption to be relaxed.[19] Six food groups and three nonfood groups were included. The pattern of declining absolute values of own-price elasticities with rising income was observed in these estimates, with values for the meat, milk, and sugar groups exceeding unity for many income groups. The full matrix of price and income elasticities from this study was used to model the effects of income transfer schemes. As in the study by Pinstrup-Andersen and Caicedo, the effects were, to a degree, sensitive to the assumptions of the approach to redistribution but also indicative of the pressures on cereal prices that such a policy would introduce. The study also illustrated the importance of food price stabilization for other sectors, as the real income effects of a cereal price change leads to significant changes in the demand for other goods.

Murty's 1983 study, which used the standard LES, concentrated on the demand for the five cereals that made up the aggregate group in the earlier study. It also included three other food groups and one nonfood group. As in Bouis' study, which used time series and cross sections, the pure substitution direct-price elasticities were frequently between -2.50 and -1.00. For example, the estimated own-price responses for the poorest rural expenditure group were -1.39 for superior cereals and -2.29 for sorghum. The corresponding elasticities for the wealthiest rural expenditure class were -0.39 and -0.96. Similar patterns were estimated with cross-price terms. Murty then used the own- and cross-price elasticities to calculate the calorie intake elasticities for each group. Because superior cereals include rice and wheat and, therefore, have the largest share of total calories, changes in the group's prices were most influential in the changes in total calorie intake. Some caution needs to be taken when using these estimates because the LES excludes negative income elasticities (see Part 2). For example, the estimated elasticities for millet and sorghum were positive, although the data presented (for 1973/74, outside the actual period of estimation) indicated that those grains were clearly inferior goods for all expenditure groups in urban areas.

OTHER ESTIMATES USING SYSTEMS OF DEMAND APPROACHES

Two other studies within the set reported here used the LES system with separate estimates for different expenditure groups. Ahmed used cell means from the data set analyzed by Pitt.[20] As both

---

[19] P. Nasse, "Analyse des Effets de Substitutions dans un Systeme Complet de Fonctions de Demande," Annales de L'INSEE 5 (1970): 88-100.

[20] Raisuddin Ahmed, Agricultural Price Policies Under Complex Socioeconomic and Natural Constraints: The Case of Bangladesh, Research Report 27 (Washington, D.C.: International Food Policy Research Institute, 1981); Pitt, "Food Preferences and Nutrition."

the commodity aggregation and the means of reporting results by income group differ, a direct comparison of results of Ahmed's study with Pitt's is not possible. Pitt reports rice and wheat separately and finds that the 75th expenditure percentile had own-price elasticities of -0.83 and -0.06, whereas in Ahmed's study the own-price estimate for foodgrains for the richest half of the population was -0.38. Similarly, Pitt reported the price elasticity for pulses to be -0.51, and Ahmed's LES estimate for an aggregation of pulses and vegetables was -0.32. The LES estimates for an aggregation of eggs, fish, meat, and milk was -0.35 in Ahmed's study, lower than the elasticity observed by Pitt for fish, the principal component of this aggregation. Taking into account that Ahmed's elasticities for the poor are for the poorest half of the population and that Pitt defines the poor as the 10th percentile, the impression is that the LES estimates are less price responsive. There is no independent means of ascertaining where the "true" elasticities fit between these reports.

The study of price responses in urban Sudan used data from 4,930 households to estimate elasticities for seven commodity groups.[21] Separate LES were estimated for five expenditure groups. The estimated own-price elasticity for bread for the poorest 12.5 percent of the population was -0.83. The corresponding elasticity for the wealthiest half of the population was -0.22. On the basis of such estimates, the effect of an uncompensated change in the price of bread (subsidized at the time of the analysis) on nutrition was analyzed. It was predicted that a net reduction of 175 calories in the daily diet of the poor would follow a 50 percent increase in bread prices.

One further use of a systems approach is included in this review. Strauss used a quadratic expenditure system (QES) to study demand for seven commodities in rural Sierra Leone.[22] His study differs from the others reported in two major respects. First, the QES is more flexible than the LES, even though it uses restrictions derived from demand theory. Second, as household labor supply is included in the study, the labor-leisure trade-off was measured.

Strauss estimated a single system from a sample of 138 households. Differences in price elasticities by income group came from the quadratic nature of the system. The variation of the price parameters, then, is continuous with expenditures. Again, the compensated own-price elasticities declined with expenditures, although not for all food commodities. They did so for the two largest food groups (in expenditure terms)--fish and rice and animal products. The uncompensated elasticities for roots and for oil increased slightly with

---

[21]Per Pinstrup-Andersen, Joachim von Braun, Tongjit Uy, and Winifred Floro, "Impact of Changes in Income and Food Prices on Food Consumption by Low-Income Households in Urban Khartoum with Emphasis on the Effect of Changes in Wheat Bread Prices," International Food Policy Research Institute, Washington, D.C., April 1983, (mimeographed).

[22]John Strauss, "Determinants of Food Consumption in Rural Sierra Leone: Application of the Quadratic Expenditure System to the Consumption-Leisure Component of a Household-Firm Model," Journal of Development Economics 11 (December 1982): 327-354.

expenditures. In this community, the large budget share of rice led to negative gross substitution with roots when the rice price increased. Few of the compensated cross-price elasticities for food reported by Strauss were appreciable, as the majority were less than 0.1. Little substitution occurred between goods and leisure; the effect of a wage change was largely due to changes in income.

4. GENERALIZATIONS OF PATTERNS

In a study published in 1971 Weisskopf presented regression results, which he used to argue that structuralist models of development are incorrect in assuming that substitution between food and other aggregate groups is low.[23] A decade later Ray felt the need to test the relationship of budget shares to prices.[24] Similarly, though convinced that consumers are responsive to prices, at least to the prices of disaggregated foods, Timmer found it worthwhile to ask whether substitution elasticities are constant for all income groups.[25]

One of the goals of this report is to discover patterns in existing studies that address such broad questions. It may be possible to use those patterns to establish a general rule. To be sure, there will always be exceptions to such rules, but it may be possible to use the pattern as a reference that can be used to explain the exceptions, or at least be a starting point from which to conduct inquiries.

Planners may not have enough data to estimate parameters that can be used to fix the precision of projections and to verify or refute other patterns. If so, it may be useful to have rules of thumb that can narrow the uncertainty of any assumptions that must be used.

PATTERNS IN OWN-PRICE ELASTICITIES

Magnitude

Theory offers few guidelines about how price parameters change as incomes rise. The Slutsky decomposition shows that the total price effect can be decomposed into a substitution effect and a real income effect:

$$Eij = eij - wj\,\eta i; \qquad (1)$$

Price elasticity = Substitution elasticity - budget share of goods with price change x income elasticity of good being measured.

---

[23] R. Weisskopf, "Demand Elasticities for a Developing Economy," in *Studies in Development Planning*, ed. Hollis B. Chenery (Cambridge, Mass.: Harvard University Press, 1971).

[24] R. Ray, "The Testing and Estimation of Complete Demand Systems on Household Budget Surveys: An Application of AIDS," *European Economic Review* 17 (March 1982): 349-369.

[25] C. Peter Timmer, "Is There 'Curvature' in the Slutsky Matrix?" *Review of Economics and Statistics* 63 (August 1981): 395-402.

When the income elasticity for this jth good is less than one, the budget share declines with income and, therefore, the real income effect of a price change declines with income, even if the income elasticity is constant for all income groups. However, the substitution effect may be, and usually is, larger than the real income effect. This is especially true with disaggregated commodities. For example, in the data sets discussed in Chapter 2, the real income effect exceeded 10 percent of the total price effect in less than one-third of the estimates for specific meat products, and most of those were derived using additive systems. In no case did the real income effect reach 25 percent of the total elasticity. It was higher for rice, as the budget share for rice was large in a number of samples, particularly those from Bangladesh and Indonesia. As indicated in Table 2, the real income effect is almost always less than 0.25, while most price elasticities greatly exceed that value. The use of the easily derived real income effect, then, would only be useful, if useful at all, for items, particularly aggregate groups, that have a large share of the budget. However, even the real income effects of aggregate groups are likely to capture only a small share of the total price effect.

The sizes of the elasticities reported in the Appendix show that the poor are quite price responsive and that most elasticities decline with increased income (see Appendix Tables 11-16). Often the absolute value of an elasticity for specific food items exceeds one, indicating that expenditures on the items decline following a price increase. Even the average elasticities for individual commodities over all income groups are frequently greater than one (see Table 2). These values may be higher than conventional wisdom implies. Do they, in fact, measure a response different than what is generally denoted by the term "price elasticity"? Timmer and Alderman suggest that the results measured from cross-sectional data are long-run responses that should exceed the short-run adjustment, perhaps by as much as a factor of two, although there is no theoretical explanation for the size of the differences. However, Ray found price elasticities for food as an aggregate measured in cross section to be -1.16 in rural India and -1.28 in urban India. The comparable time-series results were -0.68 and -0.62.[26] The combined cross section and time-series results of Murty and Radhakrishna, Murty, and Bouis, on the other hand, estimate some price responses that exceed those usually attributed to necessities. Furthermore, the studies of Williamson-Gray and Trairatvorakul, and the time-series studies from India as well, introduce prices exogenously and therefore do not attribute quality responses to price. Similarly, Rosenberger's study has a variable for price, which, although derived from household budget surveys, is for a commodity that not only is homogenous but that also has a price determined by an exogenous government policy unlikely to be correlated with a regional price index.

---

[26] R. Ray, "The Testing and Estimation of Complete Demand Systems."

Table 2--Cross-tabulation of price elasticities and real income effects of price changes

Number of Observations with values	Price Elasticities (Absolute Value) <0.25	0.25-0.50	0.50-0.75	0.75-1.00	>1.00	Total
Real income effects						
<0.25	33	28	37	28	64	190
0.25-0.50	0	0	4	1	6	11
0.50-0.75	0	0	0	3	1	4
Total	33	28	41	32	71	205

Source: Calculated from data in the Appendix, Tables 11-16.

Relationship of the Elasticities of Poor and Rich Consumers

Timmer seeks a regular pattern in the change of compensated price elasticities with income, noting that his approach is pragmatic rather than theoretical.[27] It is sometimes argued that poor people, having fewer items in their budgets, have fewer opportunities for substitution, hence that the absolute value of e_{ij} should be smaller for the group.[28] On the other hand, one could find virtually infinite substitution between two inexpensive calorie sources if consumption by the poor resembled demand for commodity characteristics from linear programming models. Almost all of the studies included in Table 1 include at least one inexpensive source of calories that can be a substitute for the main grain of that culture. Furthermore, it is possible, in principle, to disaggregate by quality so that the substitution of different grades of a commodity can be studied, although not infrequently the prices of the different grades are highly collinear. While neither the size nor the sign of the derivative of the elasticity of substitution with respect to income can, therefore, be conclusively predicted by theory, the functional form of an estimate may inadvertently constrain the relationship.

In Timmer's study the change of the absolute value at eij with respect to income is explored by regressing values of $|e_{ij}|$ estimated in flexible functions (specifically, from the Rosenberger and Timmer-Alderman studies above) on income,

$$|e_{ij}| = b_{ij} + c \text{ logIncome}. \qquad (2)$$

[27]Timmer, "Is There 'Curvature' in the Slutsky Matrix?"

[28]Laurence Fraser Jackson, "Hierarchic Demand and the Engel Curve for Variety," Review of Economics and Statistics 66 (February 1984): 8-15. Some inferior goods may be consumed only by the poor, however.

The b_{ij} terms for separate commodities were not significant, whereas the coefficient c had a value of -0.339 with a t-statistic of 8.3. This relationship will be examined using a larger data set and with separate commodity groups. In this exercise it is important to exclude those studies in which the price parameters are generated from the Frisch or other additive systems, as the additivity assumption severely restricts the price parameter. Table 3 presents different c parameters from versions of equation (2) estimated separately for five commodity groups.

The fits of these equations are poor, reflecting in part the heterogeneity of the data, categories and methods of estimation, and the influence of some extreme values for meat in Thailand and rice in Brazil. In order to deal with the latter outrider, the rice equation was reestimated using data for aggregate cereals for Brazil. A dummy variable for aggregate commodities was also included because rice was grouped with wheat and other grains in a few other studies as well. It was expected that the more aggregated a group, the lower the estimated elasticity. This is because substitutions within a group are masked. The equation was

$$|e_{ii}| = 1.26 - \underset{(4.29)}{0.20} \text{ LnIncome} - \underset{(3.62)}{0.38} \text{ aggregate}; \tag{3}$$

$R^2 = 0.46$.

Equation (3) indicates that with the modifications the estimates conform to the pattern observed with coarse grains, milk, and roots. The variable for aggregation included in the meat equation has the expected negative sign but is not significant. If the Thai data are removed, the R^2 values improve to 0.4 and the aggregation coefficient becomes significant. The coefficient of log of income drops to -0.22 and the t-value rises to 1.86, which is significant only at the 10 percent level.

Table 3--Parameters of regression of Hicksian elasticities on log of income

Parameter	Meat	Rice	Wheat/ Coarse Grains	Root Crops	Milk
Coefficient of LnIncome	-0.55	-0.08	-0.25	-0.25	-0.21
t-statistic	1.66	0.60	2.10	1.67	4.14
R^2	0.14	0.01	0.24	0.15	0.38
Degrees of freedom	17	38	14	15	28

With these modifications, the income coefficients are generally between -0.20 and -0.25. Equation (4) generalizes equation (2) for all commodities:

$$|e_{ii}| = 1.36 - \underset{(4.31)}{0.17} \text{ LnIncome}; \tag{4}$$

$R^2 = 0.14$.

This, then, supports Timmer's view of a generalizable pattern in compensated (Hicksian) elasticities, but the coefficient is somewhat smaller than he observed.[29] This is not an artifact of the adjustment of income for purchasing power parity. That adjustment was made in the current study but not in Timmer's. If equation (4) is run using income in dollar equivalents, the coefficient of LnIncome is -0.15.

With price elasticities generally between 0.5 and 1.5, this equation implies that a 10 percent increase in income will lead to a 1 to 3 percent decline in the compensated price elasticity; the larger decline coming from the smaller elasticity.

The results in equation (4) and Table 3 are important for hypothesis testing as they confirm that there is significant curvature in the Slutsky matrix for food commodities. To be sure, there are exceptions, as indicated by Bouis' results for Mindanao, by Strauss' estimates for root crops, and by Pitt's estimates for fish. Nevertheless, the general pattern reported here should serve as a standard against which individual cases can be tested. Hence, it improves upon a priori notions based on the assumption that the size of the substitution effect increases with income as the number of substitutes in a budget increases. The relationship in equation (4) has two limitations, however. First, it offers no insight into the reasons for such a pattern and, therefore, no guidance about when exceptions can be expected. Second, although the relationship between income and the elasticities is statistically significant, the estimating equation is heterogenous and has low predictive power. This second difficulty can be readily addressed. As mentioned above, one motive for this research is to provide guidelines for the use of policy parameters when data or time limitations rule out estimates of income elasticities for specific groups. Tables 4, 5, and 6 present three variations on regressions, using the ratio of the compensated elasticity for a specific group to the mean elasticity for the population as the dependent variable: e_{stand} = compensated elasticity of group/average elasticity for the country.

With such regressions it may be possible to calculate elasticities for specific groups that are consistent with aggregate price elasticities estimated from time series. Table 4 gives results simi-

---

[29]The coefficient in the aggregate equation is lower than the coefficients of individual commodities because there are no intercept terms for specific commodities.

lar to those in Table 3. The standardization poses particular problems with nonsignificant price responses (as in the Thai meat regressions), as such values have been set at zero. This both exaggerates the differences between the upper-income-group elasticities and the mean value for all groups and, by depressing the mean value aggregated from various groups, increases the ratio for the lower income groups. This contributes to the higher coefficients observed when the Thai data is included and to the lower R^2 values.

Table 5 gives results from regressions of e_{stand} on the ratio of group income to average income per capita. These again indicate that as income rises relative to the population mean, the elasticity falls. Note that as both incomes and elasticities are standardized by country mean values, there is little effect remaining for a specific country; the regressions are less cross-country regressions than within-country regressions. Table 5 shows improvement in the R^2 of all but one commodity regression. The fit of the figures in Table 6 is, in general, a further improvement. It shows a regression of e_{stand} on a population arrayed by income (the poorest decile being the 1st and the richest decile being the 10th). As examples of how these equations can be used, suppose that time-series estimation indicates that the countrywide compensated-price elasticity for wheat is -0.5. If the mean income is \$300, then the elasticity of a household with an income of \$100 would be -0.59,[30] while a family with \$500 would have an elasticity of -0.45. By the equation in Table 6, the elasticity of the household in the 1st decile of income would be -0.67. In this example, there is no guarantee that the calculations from Table 5 and 6 will be identical at any given income. Indeed, while there are some income distribution patterns that may generate identical estimates, such a result would be coincidental. The results in Tables 5 and 6 cannot be used to predict a sign change with the range of data used here, although this is possible with the former and, considering the maximum allowable value for percentile, it is not possible with the latter. To a degree the formulation in Table 5 is the more logical in that it deals with relative purchasing power rather than a ranking according to purchasing power. However, either those equations or the equations in Table 6 could guide first approximations of changes in consumption for policy projections in the absence of more complete data and analysis.

Recall that these equations indicate changes in the pure substitution effect. For policy use uncompensated elasticities are usually required, and it is necessary to add the real income effect to these substitution parameters. Such information is frequently available. If it is not, however, the relationships in Tables 7 and 8 can be used. These tables parallel the previous two tables but use a standardized uncompensated elasticity as the dependent variable (E_{stand} = group uncompensated elasticity/average uncompensated elasticity).

---

[30] This is $-0.5(1.25 - 0.214 \times 0.33)$.

Table 4--Regressions of standardized substitution elasticities on log of income

Commodity	Intercept	Coefficient of LnIncome	R^2
Meat (excludes Thai data)	1.32	-0.106 (1.43)	0.15
Meat (includes Thai data)	2.48	-0.380 (1.42)	0.11
Rice	1.25	-0.137 (1.38)	0.05
Wheat and other grains	1.48	-0.126 (1.38)	0.12
Root crops	1.76	-0.258 (4.34)	0.54
Milk	2.04	-0.243 (3.83)	0.35

Note: t-statistics are in parentheses.

Table 5--Regressions of standardized substitution elasticities on income share

Commodity	Intercept	Coefficient of Income Relative to Mean Income	R^2
Meat (excluding Thai data)	1.26	-0.265 (4.16)	0.59
Meat (including Thai data)	1.82	-0.579 (1.80)	0.16
Rice	1.10	-0.252 (2.26)	0.12
Wheat and other grains	1.25	-0.214 (2.05)	0.23
Root crops	1.30	-0.256 (3.97)	0.50
Milk	1.48	-0.356 (4.04)	0.38

Note: t-statistics are in parentheses.

Table 6--Regressions of standardized substitution elasticities on population grouped by income

Commodity	Intercept	Coefficient of Percentile	R^2
Meat (excluding Thai data)	1.34	-0.078 (3.93)	0.56
Meat (including Thai data)	2.21	-0.213 (2.56)	0.28
Rice	1.29	-0.096 (3.35)	0.23
Wheat and other grains	1.42	-0.081 (2.51)	0.31
Root crops	1.34	-0.063 (2.93)	0.35
Milk	1.68	-0.117 (5.40)	0.52

Note: t-statistics are in parentheses.

Table 7--Regressions of standardized uncompensated elasticities on population grouped by income

Commodity	Intercept	Coefficient of Percentile	R^2
Meat (excluding Thai data)	1.43	-0.083 (3.82)	0.55
Rice	2.06	-0.176 (6.63)	0.54
Wheat and other grains	1.47	-0.085 (2.68)	0.34
Root crops	1.38	-0.064 (2.79)	0.33
Milk	1.71	-0.119 (5.47)	0.52

Note: t-statistics are in parentheses.

Table 8--Regressions of standardized uncompensated elasticities on income share

Commodity	Intercept	Coefficient of Income Share	R^2
Meat (excluding Thai data)	1.34	-0.288 (4.14)	0.58
Rice	1.74	-0.502 (4.26)	0.32
Wheat and other grains	1.29	-0.229 (2.20)	0.26
Root crops	1.34	-0.260 (3.77)	0.47
Milk	1.51	-0.363 (4.08)	0.38

Note: t-statistics are in parentheses.

Since the budget shares of most commodities other than grains are small, it is not surprising that there is little difference between the results in the two sets of tables. Furthermore, since the budget shares of most foods decrease with rising income, as do most income elasticities, it can also be expected that the slopes of the regressions for uncompensated elasticities will generally be steeper than their counterparts.[31] When, however, income elasticities and budget shares are known with some accuracy, it seems preferable to use Tables 5 and 6 to fix the unknown component.

Timmer also reported a relationship that relates the change in food price elasticities as incomes change to the change in income elasticities. He proposed a rule of thumb:

$$\partial(\text{price elasticity}/\ \partial(\text{income}) = \tfrac{1}{2}\partial(\text{income elasticity})/\ \partial(\text{income}). \qquad (5)$$

Regressing income elasticity on the log of income, using only income elasticities estimated by subpopulation and, therefore, not functionally constrained, gave a value of -0.27 (t=6.78) for $\partial\eta\ /\partial$ LnIncome. The ratio of this coefficient from equation (4) is 0.63, close to but slightly higher than Timmer's rule of thumb.[32]

[31]The income elasticities themselves decline with income in a manner that is well known. If standardized income elasticities are regressed on population shares, the coefficients of population analogous to those in Tables 6 and 8 would be -0.11 for meat, -0.22 for rice, -0.11 for wheat, -0.22 for coarse grains, -0.50 for roots and -0.12 for milk.

[32]A similar estimate can be obtained by regressing η on $|e_{ii}|$ for those studies in which both parameters were estimated in a flexible manner. This gives a value of 1.42 with an R^2 of 0.42, implying a coefficient of 0.70 in equation (5).

Timmer speculates that the value of 1/2 in equation (5) is related to Frisch's income flexibility--the tendency of the marginal utility of money to equal -2.[33] This, however, is not a convincing explanation for an otherwise useful rule of thumb. Frisch's income flexibility is derived from additive utility. As the assumption of additive utility is not convincing for disaggregated commodity expenditures, income flexibility is not a solid support for an explanation of patterns in observed elasticities (see Part 2).

In an attempt to explain the curvature in the Slutsky matrix in terms of behavior, Bouis has hypothesized that the marginal utility of a food item can be decomposed into marginal utilities from increased calories, diet variety, and taste.[34] It is possible to substitute marginal utility from nutrient content for the first of these with equal generality. The second is intriguing because diet variety is not a property of the good itself but of its relation to other goods; the more the diet is concentrated on one good, the higher the marginal utility from variety obtained from increases in other goods. Taste is a subjective element common to most, if not all, preference orderings. If food intake is low, the marginal utility of nutrient content is high relative to the other components. Consequently, the marginal rate of substitution between items of similar nutrient composition (two cereals, for instance) would be high. As the diet concentrates on a few inexpensive sources of nutrients, the utility of variety for other items increases and diet diversity takes a larger role. Furthermore, as diets become varied and the marginal utility of nutrients declines, taste and status dominate marginal utility, and less substitution between items may take place. The poor purchase food, while the rich purchase particular foods. Bouis' framework has not yet been fully developed for empirically testable hypotheses. One implication can be checked on existing studies, however. In Bouis model, as well as a number of similar models, one would expect low-income people to substitute more than the general population within food groups but less between foods and nonfoods.

Both to develop an underlying model and to further food policy analysis, one would like an estimate of the change in calories that follows a change in the price of any single food. One needs then either a complete matrix of cross-price elasticities or a direct estimate of $\partial Kcal / \partial P_i$.[35] So far, this discussion and analysis has not

---

[33] Alan Brown and Angus Deaton, "Models of Consumer Behavior: A Survey," Economic Journal 82 (December 1972): 1145-1236.

[34] Howarth Bouis, "If There is Curvature in the Slutsky Matrix, What Do the Curves Look Like?" International Food Policy Research Institute, Washington, D.C. 1983 (mimeographed).

[35] Sahn, "Food Consumption Patterns and Parameters in Sri Lanka," reports results that show no differences in the two approaches. There is not, however, enough evidence to generalize about their relative efficiency. Note that an estimate of Kcal = f(Y,P) does not necessarily assert that utility is a function of calories and is, therefore, not inconsistent with standard demand analysis. If one accepts a model of the form $Q_i = f(Y, P_i, P_j)$ then $W_i Q_i = W_i f(Y, P_i, P_j)$ and $\Sigma W_i Q_i = \Sigma W_i f_i(Y, P_i, P_j)$. W_i is an arbitrary scalar. It can be the caloric content, although such an approach does not uncover the underlying parameters for each commodity.

focused on cross-price terms, as few disaggregated cross-price elasticities have been estimated satisfactorily. However, those reported are generally consistent with the pattern of declining absolute values with rising incomes. An exception would be Disch's study.

Timmer gives compensated price elasticities for calories from rice, cassava, and shelled maize in Indonesia: -0.023 for the poor and -0.648, -0.643, and -0.583 for the other income groups.[36] Pitt found small compensated changes in total calories with an increase of any food price despite widespread substitution. This occurs for both income groups reported. Similarly, the compensated change in calories with a change in the price of superior cereals, estimated for rural India by Murty using an LES, is negligible for the lowest rural income groups and only -0.08 for the rich. It is about -0.1 for those in urban areas. The changes following a change in the price of other grains would also be small.

Such results, however, are not universal. As Trairatvorakul points out, with rice dominating total calorie intake in Thailand, substitution for rice leads to reduced calorie intake. Although it is not indicated in his study, the goods substituted for rice are likely to be nonfood items. This was also observed in Sri Lanka. Similarly, using constant profit calorie elasticities with respect to rice prices and the income elasticities for calories reported by Strauss,[37] compensated price elasticities in Senegal can be calculated. In that study, whose results are somewhat unique in that the elasticities of total calories with respect to total expenditure are higher for upper-income groups than for lower, compensated calorie elasticities with respect to rice prices are -0.37 for the poorest income groups and -0.06 for the highest.

In Brazil, a 10 percent increase in rice prices would lead to a net decline of 4.5 percent of calories for the poorest 30 percent of the population and a decrease of 2 percent for the middle 50 percent of the population. Rice provided 19.6 percent of daily calories in Brazil in 1974/75. Changes in the price of cassava (15 percent of calories), sugar (13.5 percent of calories), or bread (8.3 percent) had no measurable effect on net calorie intake with direct estimates of total calorie intake on various prices. Using the matrix of cross-price elasticities provided by Williamson-Gray, a similar calculation can be made for the net effect of a change in the price of cereals.[38] Calculations done in this manner indicate that the compensated substitution elasticities for cereal prices are -0.4 for the poor and -0.16 for the middle-income group. Changes in calorie intake following changes in the prices of other goods are negligible. Unlike the Thai

---

[36] Timmer, "Is There 'Curvature' in the Slutsky Matrix?"

[37] John Strauss, "Joint Determination of Food Consumption and Production in Rural Sierra Leone: Estimates of a Household-Firm Model," Journal of Development Economics 14 (January-February 1984): 77-103.

[38] Williamson-Gray, Food Consumption Patterns for Brazil, pp. 66-71.

example, however, the large change in calories following a rice or cereal price change cannot be attributed to one commodity that dominates caloric consumption. Rather, cereals and both edible oils and sugar are highly complementary. A rise in the price of cereals would lead to reductions in the quantities of oil and sugar purchased. This effect, which declines in absolute value with increases in income, reinforces the direction of the change in the amount of calories from cereals consumed that follows a change in cereal prices.

PATTERNS IN INCOME ELASTICITIES

Basic guidelines about income elasticities already exist. Engel's law and, to a lesser degree, Bennet's law have achieved the type of veneration given in some cultures to the wisdom of the elders. Similarly, it is widely, if not universally, acknowledged that income elasticities for food items decline with income. Although there may be some questions about the rate at which they decline, any data set sufficient to estimate income elasticities should be sufficient to estimate the decline as well. Finally, if one needs more guidance, broad reviews of Engel elasticities, such as those of Houthakker and Weisskopf, are available.[39]

Houthakker's analysis of cross-sectional data confirmed Engel's law in that all elasticities for total food expenditures were less than one, although estimates from poorer countries were close to unity. Houthakker also found that the inclusion of variables for family size reduced the apparent income elasticity (this is treated in more detail in Part 2). He gives 71 estimates of elasticities from various samples and subsamples, most of them adjusted for family size. In 11 of those, generally samples from Southeast Asia and Ghana, as well as pre-oil-boom Libya, the elasticity exceeded 0.8. In 34 of those, including a number of estimates from different urban regions of the United States in 1950, the elasticity was between 0.6 and 0.8, whereas only 5 samples yielded estimates below 0.4.

Weisskopf's estimates differed from Houthakker's in that they are from time-series data, yet the results are similar. For 8 of the 16 countries he studied, the short-run results exceeded unity, while for another 7 the results exceeded 0.8. The estimates were below 0.4 for only one country, Israel.

These studies indicate that the elasticities for food expenditures are high. Although the results reported from such studies do not allow for estimates of marginal propensities to consume (MPCs), they are consistent with estimates of MPCs ranging from 0.3 to 0.6 in

[39] Hendrik S. Houthakker, "An International Comparison of Household Expenditure Patterns, Commemorating the Centenary of Engel's Law," Econometrica 25 (October 1957): 532-551; Weisskopf, "Demand Elasticities for a Developing Economy."

low-income countries, with 0.7 not being unlikely for low-income consumers in rural areas.[40]

With the exceptions noted above, the studies also confirm Engel's law. In addition, they confirm a pattern so regular as to be almost a corollary of Engel's law, that elasticities for food, as well as budget shares, decline with income. For all this, regularities in food expenditures provide only rough guidance for the nutrition components of food policy analysis.

The main reason for this is that elasticities by items or by nutrients are far less regular than are those for total food expenditures. For example, in one of the few published studies that compare calorie elasticities, variations between countries appear to be large.[41] In that study, the poor in Sri Lanka were found to have elasticities for calories of only 0.18, while they had elasticities of 0.44 in India and 0.56 in Morocco.

It is, of course, expected that elasticities for calories will be less than those for total food expenditures. People want to increase the quality as well as the quantity of food purchased, especially as their physical capacity for food intake is saturated. The income elasticity for food expenditures can be decomposed to the sum of the income elasticity for calories plus the elasticity of the change in the price of calories (quality) with respect to income.[42] This latter term is surely positive and should dominate the total term as incomes rise.

An impression of the range and size of calorie and expenditure elasticities can be obtained by looking at Tables 9 and 10. The elasticities reported were all calculated with the same functional form:

$$\text{LKcal or LFX} = a + \beta \text{LTX} + \beta_2(\text{LTX})^2 + \beta_3\text{Number} \times \text{LTX} + \beta_4\text{Rural} \times \text{LTX} + C_1\text{Rural} + C_2\text{Number}, \quad (6)$$

where

LKcal = the logarithm of calories per capita per day;
LFX = the logarithm of food expenditures per capita per month;
LTX = the logarithm of total expenditures per capita per month;
Number = household size;
Rural = a variable defined as 1 if the household is from a rural area and 0 otherwise.

---

[40] See, for example, Peter B. R. Hazell and Ailsa Röell, Rural Growth Linkages: Household Expenditure Patterns in Malaysia and Nigeria, Research Report 41 (Washington, D.C.: International Food Policy Research Institute, 1983).

[41] Odin K. Knudsen and Pasquale L. Scandizzo, Nutrition and Food Needs in Developing Countries, Staff Working Paper 328 (Washington, D.C.: World Bank, 1979).

[42] $\partial \ln(P \times Kcal)/\partial \ln Y = \partial \ln Kcal/\partial \ln Y + \partial \ln P/\partial \ln Y$. If calories can be considered a measure of quantity, the second term on the right can be considered a quality elasticity.

Table 9--Calorie elasticities for low-income families

Country/Region	Urban	Rural	R^2
Sri Lanka	0.41	0.60	0.65
Thailand	0.26	0.29	0.28
Egypt	0.20	0.34	0.31
Sudan	0.30	0.33	0.42
Indonesia	0.55	0.61	0.63
Nigeria			
Funtua	. . .	0.94	0.72
Gusau	. . .	0.94	0.84
Malaysia			
Muda	. . .	0.65	0.76
Brazil[a]	0.10	0.23	0.99
Bangladesh[a]	0.40	0.40	0.99
Morocco[a]	0.54	0.77	0.99

Sources: The data for Sri Lanka are taken from Sri Lanka, Ministry of Plan Implementation, Department of Census and Statistics, "1980/81 Labour Force and SocioEconomic Survey Data Tape" (Colombo, 1983); the data for Thailand are from Thailand, National Statistical Office, "1975/76 Socioeconomic Survey Data Tape" (Bangkok, 1976); the data for Egypt are from International Food Policy Research Institute and Egypt, Institute of National Planning, "1981/82 Household Budget Survey" (Cairo, 1981/82); the data for Sudan are from Sudan, Department of Statistics, "1978/79 Household Expenditure Survey Tape" (Khartoum, 1979); the data for Indonesia are from Indonesia, Central Bureau of Statistics, _SUSENAS V_ (Jakarta: Central Bureau of Statistics, 1979); the data for Nigeria and Malaysia are from household survey data collected by the Cooperative Program of the Food and Agriculture Organization of the United Nations and the World Bank in the Muda region of Malaysia; the data for Brazil are from Fundacao Instituto Brasileiro de Geografia e Estadistica, "1974/75 National Household Expenditure Survey Tape" (Rio de Janeiro, n. d.); the data for Bangladesh are from Bangladesh, Census Bureau, "1976/77 Household Expenditure Survey Tape," (Dhaka, 1977); the data for Morocco are from Morocco, Ministry of Planning and Regional Development, "1971 Household Consumption and Expenditure Survey," reported in Odin Knudsen and Pasquale L. Scandizzo, _Nutrition and Food Needs in Developing Countries_, World Bank Staff Working Paper 328 (Washington, D. C.: World Bank, 1979). The approach used by Knudsen and Scandizzo is different than the one adopted here.

Notes: Low income is defined as the average income of families that consume 1,750-2,000 calories per capita per day.

[a]This figure is from aggregate data.

Table 10--Food expenditure elasticities for low-income families

Country/Region	Urban	Rural	R^2
Sri Lanka	0.72	0.86	0.91
Thailand	0.62	0.65	0.77
Egypt	0.71	0.68	0.75
Sudan	0.74	0.84	0.80
Indonesia	0.88	0.98	0.87
Nigeria			
Funtua	. . .	0.89	0.95
Gusau	. . .	1.04	0.96
Malaysia			
Muda	. . .	0.88	0.76
Brazil[a]	0.83	0.83	0.99
Bangladesh[a]	1.06	1.06	0.99

Sources: The data for Sri Lanka are taken from Sri Lanka, Ministry of Plan Implementation, Department of Census and Statistics, "1980/81 Labour Force and SocioEconomic Survey Data Tape" (Colombo, 1983); the data for Thailand are from Thailand, National Statistical Office, "1975/76 Socioeconomic Survey Data Tape" (Bangkok, 1976); the data for Egypt are from International Food Policy Research Institute and Egypt, Institute of National Planning, "1981/82 Household Budget Survey" (Cairo, 1981/82); the data for Sudan are from Sudan, Department of Statistics, "1978/79 Household Expenditure Survey Tape" (Khartoum, 1979); the data for Indonesia are from Indonesia, Central Bureau of Statistics, SUSENAS V (Jakarta: Central Bureau of Statistics, 1979); the data for Nigeria and Malaysia are from household survey data collected by the Cooperative Program of the Food and Agriculture Organization of the United Nations and the World Bank in the Muda region of Malaysia; the data for Brazil are from Fundacao Instituto Brasileiro de Geografia e Estadistica, "1974/75 National Household Expenditure Survey Tape" (Rio de Janeiro, n. d.); the data for Bangladesh are from Bangladesh, Census Bureau, "1976/77 Household Expenditure Survey Tape," (Dhaka, 1977).

Notes: Low income is defined as the average income of families that consume 1,750-2,000 calories per capita per day.

[a]This figure is from aggregate data.

The elasticities estimated in this manner vary by income. The values reported in Tables 9 and 10 are calculated using the average per capita monthly income of households with calorie consumption of 1,750-2,000 calories per day. It should be apparent that the calorie elasticities are on average less than the food expenditure elasticities. Respective means are 0.48 ± 0.26 and 0.82 ± 0.12.[43] Also note that the rural population generally has higher calorie and food expenditure elasticities than the urban at the incomes that correspond to equal consumption, and that the estimating equations for calories have lower R^2 terms, implying that they have less explanatory power than the food expenditure elasticities. Similarly, the standard deviation is smaller for food expenditure elasticities, which indicates that such elasticities vary less between countries than calorie elasticities do.

Implicitly, the average quality elasticity is 0.34 ± 0.22, which indicates that even if fewer calories are consumed than the average requirements, there is a tendency to shift to higher priced sources of calories. This quality elasticity, however, is on the average less than the calorie elasticity.

The studies reported here contain regressions on data sets available at IFPRI in 1984. Other studies have similar results.[44] But there are, of course, exceptions at both ends of the spectrum. Behrman and Wolfe found that income elasticities are quite low in Nicaragua and concluded that education effects are more important.[45] On the other hand, Lipton gives examples of income elasticities for food that exceeded one and of diet compositions that did not change as expenditures rose.[46] He proposed that such behavior be considered as a definition of poverty and for targeting nutrition programs.[47]

---

[43] The smaller variation of the food expenditure elasticities implies a negative correlation of calorie and quality elasticities.

[44] John O. Ward and John H. Sanders, "Nutritional Determinants and Migration in the Brazilian Northeast: A Case Study of Rural and Urban Ceara," Economic Development and Cultural Change 29 (October 1980): 141-163.

[45] Jere Behrman and Barbara L. Wolfe, "More Evidence on Nutrition Demand: Income Seems Overrated and Women's Schooling Underemphasized," Journal of Development Economics 14, (January-February 1984): 105-128.

[46] Michael Lipton, Poverty, Undernutrition, and Hunger, Staff Working Paper 597 (Washington, D.C.: World Bank, 1983); see also V. V. B. Rao, "Measurement of Deprivation and Poverty Based on the Proportion Spent on Food: An Exploratory Exercise," World Development 9 (April 1981): 337-354.

[47] Neville Edirisinghe and T. T. Poleman, "Behavior Thresholds as Indicators of Perceived Dietary Adequacy or Inadequacy," International Agricultural Economic Study 17, Cornell University, Ithaca, N.Y., 1983, propose a similar standard based on the observed point at which households begin to purchase calories from costlier but more preferred staples. Using such a criterion, the threshold in four countries was observed to be between 68 and 88 percent of reported calorie requirements.

CONCLUSIONS AND RECOMMENDATIONS FOR APPLICATION OF PARAMETERS

While there is a fair amount of evidence indicating that absolute values for compensated own- and cross-price elasticities decline with increased incomes, there is no general pattern showing that the net compensated calorie elasticity after a change in any commodity price is negligible for the poor. To be sure, it is low in many cases and in others the curvature is weak, but there are other cases in which total calories purchased by the poor decline with a price increase. This is also indicated by the number of examples that show large compensated elasticities for cereals taken as an aggregate. Again, such a case indicates that even the poor in many communities substitute other attributes of foods (and even nonfoods) for calories.

Were this not true, one could estimate the total effect on calorie consumption with estimates of income elasticities and budget shares. However, as discussed above, this would underestimate the nutritional effect in a sufficiently large number of cases to reinforce the importance of estimating a matrix of price and cross-price elasticities for the poor. This could either be by direct estimates or by using the approximations discussed earlier based on the sample of the ratio of specific group elasticities to market elasticities with rising incomes.

Why do the poor have a nonzero compensated substitution elasticity for calories? This question is analogous to the question of why the diet of even the poor does not conform with least-cost diets based on nutrient costs. It is not posed as an accusation of the poor, but as a challenge to nutrition policy planners. While it is recognized that all consumers make budgetary allocations based on subjective notions of personal welfare that might be different from a planner's narrow concerns, it is plausible that at some low level of food intake there will be virtually no substituting for food. It has already been discussed that the inflection point in Engel curves may be a useful tool for showing who the ultra-poor are. Similarly, it may be useful to use inflection points for compensated price elasticities of calories as an indicator of groups for which quality does not substitute for quantity.

Another task that could aid food policy analysis is verification of whether direct estimates of $\partial Kcal/\partial P_j$ differ from direct estimates of $\Sigma\ w_i \partial Q_i/\partial P_j$. It may be easier to estimate the former than the latter.

The difficulty in estimating cross-price terms, either in the aggregate or by groups, is basically a problem of econometrics and of data scarcity. Issues related to estimation techniques are discussed in the second part of this report. Other research tasks are discussed in its conclusion.

Ideally, one would like to derive appropriate parameters designed specifically to measure responses to policy changes being considered.

However, data are frequently not available and the time and expense of collection and analysis are often prohibitive. Changes in food expenditures following changes in income occur regularly enough that rules of thumb are probably useful guides. Marginal propensities of the poor to spend on food are in the range of 0.5-0.7, and elasticities are about 0.8. Calorie elasticities are approximately half those for the poor and are probably higher in rural areas than in cities.

Responses to price changes are, however, less regular. Price elasticities for meat and dairy products are frequently greater than one. There is evidence that in a number of cases, the price elasticities of staples are also about one. As such values are not universal, however, it is advisable in the absence of other data to estimate national or regional price responses from time-series data and to estimate group-specific values using Table 6 and estimates of income parameters and budget shares. If the latter are not available, a general relationship approximating that in Table 8 can be used. These methods are preferable to approximations based on real-income effects alone or on an assumption that the poor respond much as the general population does.

Attempts should be made to obtain cross-price parameters for major commodities for food policy analysis. Substitution between food commodities, including between major staples and coarse grains or root crops, is likely and will generally moderate the total effect of a price change. However, unless there is a major food item with a negative income elasticity, effects of income changes will generally reinforce each other rather than moderate a response.

Changes in both income and price policies can have important effects on nutrition. While price elasticities net of substitutions may be moderate, price changes following changes in subsidies or exchange rates may be greater in percentage terms than plausible income transfers or growth in the short-run. The consequences and potential to influence the effect on welfare can be understood best using price and income effects, disaggregated by commodities and income groups.

An understanding of differences in price and income elasticities by income group may also help in planning for second-round effects of government policies. That is, the potential for changes in employment opportunities that result from changes in purchasing patterns may be better understood with disaggregated parameters. Studies of development strategies using such parameters go beyond the more immediate nutrition concerns that are addressed here and are a logical counterpart of such concerns.

PART 2: THEORETICAL AND METHODOLOGICAL CONCERNS IN MEASURING DEMAND PARAMETERS FOR LOW-INCOME HOUSEHOLDS

5. RESTRICTIONS OF PARAMETERS FOR ESTIMATING CONSUMER RESPONSE WITH DISAGGREGATED COMMODITY GROUPINGS

Because the goals of food policy are diverse and many instruments of policy are used for single commodities, food policy analysis is most useful when it focuses on a set of disaggregated commodities. A complete matrix of parameters for n commodities would have n^2 price and cross-price parameters and n income parameters. As an example, if one is dealing with aggregate groups--say, food, other nondurables, and durables--there would be only 12 parameters to be estimated, whereas if one is dealing with 5 food commodities as well as the other 2 aggregate groups there would be 56 parameters to ferret out. Even this modest task is seldom possible with time-series data, as such series generally have too few observations. Furthermore, the observed prices may be sufficiently correlated to render individual parameters unstable. Using restrictions derived from either demand theory or assumptions about the nature of the underlying utility functions, however, one can reduce the number of parameters to be estimated. Such techniques are discussed briefly in the next section.[48]

Although these techniques for estimating systems of demand were derived for use with time-series data, they can be used with cross-sectional data as well.[49] As time-series data are usually collected in aggregation, they seldom carry enough information to make it possible to extract price responses by income groups. Cross-sectional data, on the other hand, are frequently available in a disaggregated form, and with enough degrees of freedom that the analyst need not set restrictions on the parameters. Nevertheless, reliance on cross-sectional data for the estimation of price parameters introduces problems of interpretation and of estimation not usually present when estimating with time series. Such issues are discussed in the second section below.

---

[48]As such techniques are applied to general estimation tasks as well as to the special tasks discussed in this report, the discussion is necessarily brief. For further discussion, see Brown and Deaton, "Models of Consumer Behavior", and Angus Deaton and John Muellbauer, Economics and Consumer Behavior (New York: Cambridge University Press, 1980). Both reviews are excellent. See also Louis Philps, Applied Consumption Analysis (New York: North-Holland Press, 1974); A. Powell, Empirical Analytics of Demand Systems (Lexington, Mass.: D. C. Heath and Co., 1974); and Grant Scoble, The Theory of Estimation of Complete Systems of Consumer Demand Equations: An Annotated Bibliography, Economics Special Report 56 (Raleigh, N. C.: North Carolina State University, 1980).

[49]C. Lluch, "Consumer Demand Functions for Spain 1958-64," European Economic Review 2 (1971); and Lawrence J. Lau, W. L. Lin, and P. A. Yotopolous, "The Linear Logarithmic Expenditure System: An Application to Consumption-Leisure Choice," Econometrica 46 (July 1978): 843-868.

SYSTEMS OF DEMAND

A number of techniques for estimating complete systems of demand have been developed. Such systems, which estimate all income, price, and cross-price parameters for groups of commodities, do not necessarily include restrictions on parameters--a number are quite flexible. However, use of complete demand systems is a prerequisite for applying many of the restrictions needed to reduce the number of parameters to be estimated.

Many such restrictions are general conditions derived from any arbitrary utility function ($u = f[x]$) and consumer maximization of utility subject to a budget constraint. For example, theory requires symmetry in the Slutsky matrix of compensated price effects. As n^2 price parameters may be decomposed into compensated price effects and income effects, imposing this condition a priori reduces the number of parameters by $(n/2)(n-1)$.

Furthermore, if all expenditures, including savings, exhaust the budget, the adding-up criterion can be used to eliminate one equation.[50] In addition, one can impose the condition that each estimating equation is homogenous of degree zero. As this condition implies that increasing all prices and incomes by the same proportion leaves demand unchanged, it is also referred to as the absence of money illusion. If this restriction holds, one additional parameter in each equation is redundant and need not be estimated. Not all these restrictions are fully independent, and taken together they reduce the system to $(n/2)(n + 1) - 1$ parameters to be estimated.

Note that these restrictions are not particularly severe. Indeed, the adding-up criterion is basically an accounting device. If the analyst derives the demand equations from any specified direct or indirect utility function, this condition will automatically hold. Such a starting point will also generate conditions under which symmetry and homogeneity can be imposed.[51] Alternatively, an analyst can begin by specifying a demand equation and imposing such restrictions on it, although the restrictions may then only hold locally.

It is also possible to impose n restrictions on the main diagonal of the Slutsky matrix (compensated own-price elasticities are known to be zero or negative) as well as require the matrix to be of a negative semidefinite form. These provide an opportunity to use prior inform-

---

[50]This criterion can be further decomposed into the Engel and Cournot aggregations. The former states that the sum of all income elasticities weighted by the budget shares equals one ($\sum w_i \eta^i = 1$), while the latter states that the sum of all own- and cross-price Marshallian elasticities for the ith commodity weighted by the corresponding jth budget share equals the negative of the budget share of the ith good ($\sum_j w_j E_{ji} + w_i = 0$).

[51]Indirect utility functions have certain theoretical advantages as a starting point. See Lawrence J. Lau, "Complete Systems of Consumer Demand Functions Through Duality," in Frontiers of Quantitative Economics, vol. 3, ed. M. D. Intrilligator (New York: North Holland, 1977), pp. 59-85; and Deaton and Muellbauer, Economics and Consumer Behavior.

ation in appropriate statistical techniques. They may also be used to test the results of the estimation, but they do not reduce the number of parameters to be estimated.

Theory, then, helps to reduce the parameters by approximately half. If n represents more than a few aggregates of commodities, this is still a large number. Another set of restrictions that can be used pertains to the separability of commodities. It is not derived from demand theory, but implies that the underlying utility function has special properties. These properties are discussed by Goldman and Uzawa and by Pollak.[52]

For example, estimation is simplified if the utility function has the form

$$u = f[u_r(q_i,q_j) + u_s(qk) + \ldots]. \tag{7}$$

This form has the property referred to as strong or additive separability. This implies that the marginal utility of any goods belonging to one group is independent of the quantities of goods in any other group. The commodities can then be rearranged into two subgroups:

$$u = f[u1(q_i,q_j) + u2(q_k) + \ldots]. \tag{8}$$

With only two commodity blocks, only $N_R + 1$ parameters have to be estimated for each commodity. This is especially useful if food groups can be placed in a block strongly separable from other additively separable groups.[53]

A special case of strong separability in which every group consists of only one commodity is known as want independence or additivity and allows for the estimation of a complete system of demand given only income elasticities and one price derivative. This procedure, derived from Frisch, then reduces the number of estimated parameters to (n-1) income derivatives and one own-price derivative from which the compensated price derivatives can be derived.[54] The own-

[52]Steven Marc Goldman and Hirofumi Uzawa, "A Note on Separability in Demand Analysis," Econometrica 32 (July 1964): 387-398; Robert A. Pollak, "Conditional Demand Functions and the Implication of Separable Utility," Southern Economic Journal 37 (April 1971): 423-433.

[53]See P. S. George and G. King, Consumer Demand for Food Commodities in the United States with Projections for 1980, Giannini Foundation Monograph 26 (Davis, Cal.: University of California, 1971); and Alain de Janvry, J. Bieri, and A. Nunez, "Estimations of Demand Parameters Under Consumer Budgeting: An Application to Argentina," American Journal of Agricultural Economics 54 (August 1972): 422-430.

[54]Ragner Frisch, "A Complete Scheme for Computing All Direct and Cross Demand Elasticities in a Model with Many Sectors," Econometrica 27 (April 1959): 177-196. In actuality, the Frisch method requires income elasticities, budget shares, and an estimate of the money flexibility parameter (elasticity of the marginal utility of income with respect to income; money flexibility is not observed directly but is derived for one independently estimated price elasticity).

price derivatives can be calculated from the Cournot aggregation. This method has been used to estimate a complete system of demand for various income groups using cross-sectional data.[55]

Another system of demand that is widely used, in part because of the computational advantage gained from the underlying additive utility and in part because it is easier to use in large general equilibrium models, is the LES. Less flexible than Frisch's method in that it restricts the underlying Engel curves to be linear, it has the advantage of estimating the price parameters (and by inference, money flexibility) internally rather than deriving them from an exogenous source. In some applications, the price variance has been derived from a single cross-sectional source.[56] If no price variation is reported, it is still possible to generate a parameter matrix using assumptions about base, or committed expenditures, or by making additional assumptions to modify the system into the extended linear expenditure system (ELES), which includes savings behavior. Similarly, one can use wage data and assumptions based on the theory of time allocation,[57] or demographic data and a theory of measurement of household composition derived from Barten,[58] to derive a complete matrix of parameters without observations of prices.

TESTING OF RESTRICTIONS FOR DEMAND ANALYSIS

Such convenience in estimation comes at a cost, however. Disaggregated food commodities are, intuitively, not additive, as some systems assume. Although the satisfaction obtained from an increase in total food may be independent of the amount of housing, it is less likely that the utility derived from an additional unit of rice is independent of the quantity of bread consumed. Furthermore, Frisch's method and the LES imply that all goods are substitutes and none are inferior goods. Finally, the labor or demographic theories referred to above are themselves restrictive and not without plausible alternatives.

The assumption of additivity has been tested empirically in a number of studies. It has fared poorly. Statistical tests of the

---

[55]Pinstrup-Andersen, de Londoño, and Hoover, "The Impact of Increasing Food Supply."

[56]Lluch, "Consumer Demand Functions for Spain," and Robert A. Pollak and Terence J. Wales, "Estimation of Complete Demand Systems from Household Budget Data: The Linear and Quadratic Expenditure Systems," American Economic Review 68 (June 1978): 348-359. The authors use this system and the less restrictive quadratic expenditure system to estimate parameters from more than one linked cross-sectional survey.

[57]R. Betancourt, "The Estimation of Price Elasticities under Additive Preferences," International Economic Review 12 (1971): 283-292.

[58]Anton P. Barten, "Family Composition Prices and Expenditure Patterns," in Economic Analysis for National Economic Planning, ed. P. Hart, G. Mills, and J. Whitaker (Woburn, Mass.: Butterworth Publishers, Inc. 1964), pp. 277-292. See also Howard Howe, "Cross-Section Application of Linear Expenditure Systems: Response to Sociodemographic Effects," American Journal of Agricultural Economics 59 (February 1977): 141-148.

restrictions have generally led to its rejection.[59] Furthermore, comparisons of parameters derived from additive systems with other systems have indicated wide divergences in values.[60] Brandt and Goodwin found that the divergence was small for aggregate groups but noteworthy with disaggregated groups. Deaton points out that Frisch's method implies that the price elasticities are approximately proportional to the income elasticities and that the approximation would be closer the smaller the budget share of that good.[61] Individually, each of the empirical tests and comparisons may be subject to reservations, as they may reflect problems with the functional forms employed rather than with additivity per se. They may reflect the difficulty in comparing time series with cross-sectional estimates. But collectively they point to the conclusion that additive systems should be used in disaggregated food policy analysis only with extreme caution.

While additivity provides the most powerful set of restrictions to use in obtaining parameters for food policy analysis, it is worthwhile investigating tests of the other restrictions discussed above. Although these restrictions are intuitively more appealing than additivity and may be derived from demand theory, statistical tests frequently reject them.[62] As Christensen et al. pointed out, the rejection of such restrictions logically precludes a test of additivity, although theoretical restrictions may be imposed, despite rejection, for further work.[63] While the negativity of the diagonal terms of the Slutsky matrix was not rejected in any of the tests reported, symmetry was rejected in about half the cases. So was homogeneity (which unlike symmetry can be imposed on single-equations). Deaton and Muellbauer report similar rejection of homogeneity and symmetry using a functional form different than any reviewed by Barten.[64] While Barten does not counsel abandonment of demand theory in guiding empirical work, noting that the alternative, agnosticism, is not attractive, these results are disturbing nevertheless.

Perhaps some behavioral factors have been ignored. For example, the weak condition of homogeneity may be rejected as money illusion, may be a short-run phenomenon and would not appear in a more dynamic

---

[59]Anton P. Barten, "The Systems of Consumer Demand Functions Approach: A Review," Econometrica 45 (January 1977): 23-51, reports the results of a number of estimations. See also Angus Deaton, "Specification and Testing in Applied Demand Analysis," Economic Journal 88 (September 1978): 524-536.

[60]Angus Deaton, "The Measurement of Income and Price Elasticities," European Economic Review 6 (1975): 261-274; Thomson, "Nutrition, Food Demand, and Policy"; J. Brandt and J. Goodwin, "The Impact of Increasing Food Supply on Human Nutrition."

[61]Angus Deaton, "A Reconsideration of the Empirical Implication of Additive Preferences," Economic Journal 84 (June 1974): 338-348.

[62]Barten, "The Systems of Consumer Demand Functions Approach."

[63]Laurits R. Christensen, Dale W. Jorgenson, and Lawrence J. Lau, "Transcendental Logarithmic Utility Functions," American Economic Review 65 (June 1975): 367-383.

[64]Deaton and Muellbauer, "An Almost Ideal Demand System."

analysis. Deaton argues that money illusion occurs when inflation is accelerating, as the consumer does not face all prices simultaneously but compares current prices with recollections of other commodity prices.[65] Barten, however, cites the six-year separation of data covered in Lluch's study as an example of a rejection of homogeneity in which there should have been ample time for dynamic adjustment.[66] Clearly, there are grounds for further work on money illusion and the dynamics of consumers' adjustments to changes.

A more basic explanation can be offered for the sobering results cited by Barten. Demand theory is based on the behavior of the individual consumer, while most empirical studies, especially those involving time series, require the aggregation of individual data. (Aggregation of commodities also presents difficulties related to index number problems, the solutions of which are intimately connected to issues of separability.)

If q is a vector of goods and P is a vector of prices, then, according to microeconomic theory,

$$q_n = f_n\ (y_n, P), \tag{9}$$

where n denotes the individual.

To form an average,

$$\overline{q} = (1/N)(\Sigma q_n) \text{ and } \overline{y} = (1/N)(\Sigma y_n). \tag{10}$$

One estimates

$$\overline{q} = f(\overline{y}, P), \tag{11}$$

but in general (11) is not a behavioral equation. Note that from equations (9) and (10),

$$\overline{q} = (1/N)\Sigma f_n\ (y_n, P), \tag{12}$$

which does not necessarily equal (11).

An analogous problem can be observed if $q = f(y,P,Z)$, where Z is a vector or matrix of consumer characteristics, perhaps age or race. For example, if q is not independent of age or a linear function of age, information on age distribution is required, unless, of course, average age and the age distribution are constant throughout the time series. One has less theoretical guidance on Z, and the characteristics included are frequently discrete dummy variables, but the

[65] Angus Deaton, "Involuntary Savings Through Unanticipated Inflation," American Economic Review 67 (December 1977): 899-910.

[66] Lluch, "Consumer Demand Functions for Spain."

relevant issues are the same. Both the translog system and the almost ideal demand system can be aggregated consistently.[67] Aggregation, of course, is less of a problem if the sample is a cross-section, although such data may contain only cell means for analysis.

Muellbauer discusses the conditions under which equations (11) and (12) are equivalents.[68] Obviously, if every consumer were the representative consumer often alluded to, there would be no problem. Also, estimates from grouped data will be consistent if the budget share allocated to each good is independent of y. This implies, of course, linear Engel curves with unitary elasticities. Actually, this condition of linear Engel curves can be relaxed. This should be apparent intuitively. If the demand function were either strictly concave or convex in income, then

$$\alpha f(y_1) + (1 - \alpha)f(y_2) \lessgtr f[\alpha y_1 + (1 - \alpha)y_2], \tag{13}$$

which would not give aggregations that would be consistent. Muellbauer suggests the use of y_0, a representative income not necessarily equal to $(1/N)\Sigma y_n$ as a representative income that takes account of the income distribution. Unless the income distribution is constant, y_0 will vary over time or regions even if average y does not. Muellbauer, however, offers no empirical evidence and the question of whether restrictions imposed on demand systems will fare better when y_0 or some other consideration of income distribution is taken into account is, as yet, unanswered.

Deaton indicates another possible reason for rejecting homogeneity; he suggests that the consumer might maximize utility subject to a rationing constraint that requires the consumption of one or more goods to be fixed exogenously.[69] In the example investigated, rationing was defined broadly to include housing, assumed to be fixed in the short-run. Therefore, the study resembles an investigation of production functions with fixed factors. Deaton found that a rationed effect model with housing constrained rejected homogeneity for only one of the seven commodities tested, although the homogeneity was rejected for the total system. This was compared to four rejections out of eight for the same data without the restriction on housing. Quantity restrictions, kinked budget constraints, and other market imperfections, then, may contribute to the difficulty of applying restrictions derived from theory to observed behavior. These may be of particular interest when studying developing economies.

---

[67]Christensen, Jorgensen, and Lau, "Transcendental Logarithmic Utility Functions"; Deaton and Muellbauer, "An Almost Ideal Demand System."

[68]John Muellbauer, "Aggregation, Income Distribution, and Consumer Demand," Review of Economic Studies 62 (October 1975): 525-543.

[69]Angus Deaton, "Theoretical and Empirical Approaches to Consumer Demand Under Rationing," in Essays on the Theory and Measurement of Consumer Behavior, In Honor of Sir Richard Stone, ed. Angus Deaton (New York: Cambridge University Press, 1981), pp. 55-72.

RESTRICTIONS BY JUDICIOUS CHOICE

Frequently, instead of estimating a complete system of demand parameters, analysts choose to concentrate on income and own-price parameters and a subset of cross-price parameters chosen by the researcher as the most likely candidates for substitution or complementation. This can be done with a single equation and is, in effect, equivalent to assuming that $\partial q_i/\partial P_k = 0$ for a subset of commodities. If the assumption is not true, then it leads to missing variable bias for the included parameters, provided that the variables omitted and included are correlated. In general, however, it would be inconsistent to assume that the omitted price elasticities are all zero if the Cournot aggregation and symmetry are to hold. For example, if only own prices are included in an equation, the Cournot aggregation and symmetry imply that the own-price elasticity is -1. Perhaps. But the analysis should not begin with such an assumption.[70] A similar argument can be made about the real income effect from the Slutsky decomposition, although it is possible but not likely for $E_{ij} = e_{ij} - w_j\eta_j = 0$ even when w_j and η_j do not equal zero. Exclusion of all cross-price terms, then, must rest either on the possibility that they are not statistically different from zero and not actually zero, perhaps because the variance of price is small, or that the prices are uncorrelated with the included price. This is not as unlikely as it may seem, for if the analysis is conducted with real prices and if the omitted group of goods is composed of many commodities, then the price index for the aggregate good may be uncorrelated even if some of the components are not. This is an empirical question that may be verified if the data are available.

Cross-price parameters may be difficult to estimate, but they are nevertheless important for food policy analysis. If a set of goods is excluded, the derived parameters must be applied cautiously. For example, suppose that the demand for rice is being estimated and that the principal substitute, bread, has a fixed price. Statistically, then, no derivative with respect to the price of bread can be estimated. Therefore, there will be no missing variable bias for the own-price parameter for rice, but there may be one if rice prices are not included with bread estimates. If one is concerned with the total consequences for food or calorie consumption of a change in rice prices, the net demand for wheat must be included. In general, it is not unlikely that low-income consumers in many areas where so-called inferior grains are consumed are particularly likely to substitute between major sources, depending on their relative prices. The potential effect of a change in the price of a major staple on nutrition in such a community, then, could be either underestimated or overestimated if own-price elasticities are used in isolation and avenues for mitigating policy interventions are overlooked. Pinstrup-Andersen et

---

[70] T. Young, "Single Equation Demand Estimation," European Review of Agricultural Economics 9 (No. 1, 1982): 103-105, makes a similar argument using homogeneity, in which including only own-price responses implies that the income elasticity equals the negative of the price elasticity.

al. took the ratios of the total effects of a change in the price of a good on consumption by the poor. These ratios were 1.19 for rice, 1.33 for cassava, 1.39 for potatoes, and only 0.51 for milk and 0.55 for beef.[71] Williamson-Gray found that the net effect of a subsidy on wheat was an insignificant decrease in calorie consumption because of substitutions.[72] Yetley and Tun found the total effect of a change in the rice price was only 55 percent of the own-price effect alone.[73]

Similar differences in net and total effects were reported by Pitt.[74] These studies used different methodologies and different data. Collectively they remind the food policy analyst that, although they are difficult to estimate, cross-price parameters can have a major effect on food consumption.

Choice of Functional Form

Another type of restriction that has been used with income-specific price elasticities is a functional relationship that is an interaction of price and income terms. While many of the studies reporting price parameters by income group have used covariance techniques, interaction of dummy variables and price elasticities, or a division of the sample into subsamples, it is possible to estimate equations of the form $Q = \beta(Y, P, Y \times P)$. This, intuitively, has an advantage over covariance techniques because price elasticities are disjunct in covariance methods; a small change of household income at the extreme of an arbitrary division of the sample can lead to a marked change of price elasticities for that household. If, on the other hand, the price parameter is specified with a continuous second derivative with respect to income, one can test whether $\partial^2 Q / \partial P \partial Y = 0$ with statistical techniques. If the null hypothesis is rejected, then the price elasticities vary continuously with income. By Young's theorem, however, the income elasticity will vary by price. An early test of such an interaction was designed not to test whether price elasticities differ across income groups, but whether quality effects would require that if $\partial \bar{P} / \partial Y > 0$, then income and price would interact so that higher priced items would tend to be luxuries and less expensive ones necessities.[75] Cramer's study found no effects in time-

---

71Pinstrup-Andersen et al., "Impact of Changes in Income and Food Prices."

72Williamson-Gray, Food Consumption Parameters for Brazil, pp. 41-42.

73Mervin J. Yetley and Sovan Tun, Household Demand Analysis for Assessing Nutritional Impact of Development Programs, Staff Report AGES810806, Agricultural Development Branch, Economic Research Service, U.S. Department of Agriculture, Washington, D.C., 1981.

74Pitt, "Food Preferences and Nutrition."

75J. S. Cramer, "Interaction of Income and Price in Consumer Demand," International Economic Review 14 (June 1973): 351-363.

series analysis. He did, however, find a number of positive interactions using cell means for each of 40 quarterly cross-sectional surveys. This is consistent with the quality hypothesis, but equally consistent with the general view that the absolute values of price elasticities are smaller for more affluent consumers.

When estimating a relationship that includes a price-times-income interaction, the rate of change of price elasticities as income rises is constrained to a specific form.[76] Although this may be sufficient for generating the parameters for subsequent policy work, it cannot be used for specifying relationships as in Part 1.

Functional forms may indicate variations of price elasticities that are constrained by the form or are artifacts of it. A variety of estimating equations generate elasticities that are functions of quantities consumed or budget shares.

As an illustration, consider the AIDS that is derived from a flexible approximation of an unknown cost function.[77] The own-price elasticity (uncompensated) from this model is

$$[(\gamma_{ij} - B_i\alpha_i - B_i\Sigma\gamma_{ik}\log P_k)/\ w_i\ ] - 1, \tag{14}$$

where the γ, B, and α are estimated parameters and w_i is the budget share of the ith good. Calling this expression

$$[f'(p)\ /\ w_i] - 1 \tag{15}$$

then,

$$\partial \left\{ [(f'(p)/w]-1 \right\} \ /\ \partial y = - [f'(p)/w^2]\ (\partial w_i/\partial y). \tag{16}$$

Generally, f'(p) is invariant with respect to Y, but w_i clearly is not. This result implies that with AIDS, the poor will be less price responsive (will have a less negative elasticity) than the rest of the population under either of two conditions. The first is when $\partial w_i/\partial y > 0$ and f' is positive. The former relationship describes a luxury good ($\eta > 1$) and, in this system, the latter denotes that the price elasticity lies between 0 and -1. The second is when $\partial w_i/\partial y < 0$ and f'(p) is negative. This is a situation in which the commodity is a necessity or inferior good and E_{ii} is less than -1. These conditions do not always hold, as some studies that used the AIDS show.

This illustration is not meant to imply that AIDS is unique in its implications for the changes of price response by income groups. Similar illustrations could be derived for almost any estimation

---

[76] An example of such a study is Pitt, "Food Preferences and Nutrition."

[77] This illustration is presented in elasticity terms that clearly differ from the Hicksian price parameter. The example could be constructed in derivative terms as well, but the point should be clear with the simpler calculations here.

technique, whether derived directly from theory or based on a more pragmatic approach. The question is whether any such pattern that is built into an estimation conforms to reality. To answer it, one needs either to allow the parameter to vary in a flexible manner, as it did in many of the examples given in the previous section, or to estimate parameters for different subgroups and compare the results.[78]

The main focus of this study is on the estimation of price parameters. This is not because the estimation of income parameters yields no issues of interest. Indeed, some of those are addressed below. In general, however, estimating income parameters for low-income consumers involves no different or more severe statistical problems than those found in general population estimates.

In estimating income parameters, the major issue is the choice of functional form. As with the estimation discussed above, the choice of underlying Engel functions generally entails assumptions about changes in elasticities as incomes change. Theory provides little assistance in this--mainly the Engel aggregation--and even that is often secondary to goodness of fit. Other considerations are the expected curvature, the possibility that consumption will be saturated, and the likelihood that there is either a minimum amount of consumption or a minimum amount of expenditures for entry into the market. For example, linear relationships imply that the marginal propensity to consume is constant. Although that is not likely to conform to experience, the linear form underlies a number of demand studies. Log-linear relationships are also widely used because the coefficient of an estimating equation yields elasticities directly. The linearity of the (transformed) function allows for easy manipulation in larger models. The form, however, requires that elasticities be constant for all amounts of consumption. Again, this is unlikely and, indeed, if a good is a luxury item--that is, if the income elasticity is greater than one--the budget share would increase without limit until it accounted for all income. However, the form is useful as a local approximation.

There are a number of other forms in common use--for example, inverse, log-inverse, and semi-log equations, as well as budget share equations that regress budget shares on the logarithm of income. All the forms may be modified to allow income elasticities to change at different levels of income with different demographic characteristics.

Each of these forms have their proponents and uses for which they are most appropriate. Prais and Houthakker have shown the implications of many of these forms, which will usually diverge less at the mean of the sample than at the extremities,[79] although for many

---

[78]AIDS is a second-order expansion of an arbitrary indirect utility function. In principle, a third-order expansion would give the necessary flexibility but surely cannot be estimated.

[79]See S. J. Prais and Hendrik S. Houthhaker, The Analysis of Family Budgets (Cambridge: Cambridge University Press, 1971).

policy applications, the response of the lower-income groups is important, not the average response. Other forms, such as Box-Cox transformations and Fourier transformations offer greater flexibility although they are difficult to interpret.[80] Furthermore, as they are polynomial or trigonometric expansions, they are difficult to estimate, especially when many variables are included.

---

[80] For Box-Cox transformations, see Jorgen Aaness and Asbjorn Rodseth, "Engel Curves and Systems of Demand Functions," European Economic Review 20 (January 1983): 95-121; and J. Blaylock and R. Green, "Analysis of Flexible Engel Functions," Agricultural Economics Research 32 (October 1980): 12-20. For Fourier transformations, see Michael K. Wohlgenant, "Conceptual and Functional Form Issues in Estimating Demand Elasticities for Food," American Journal of Agricultural Economics 66 (May 1984): 211-215.

6. ESTIMATION CONCERNS ASSOCIATED WITH CROSS-SECTIONAL DATA

INTERPRETATION OF PARAMETERS

Given the problems noted in restricting the number of parameters to be estimated for disaggregated demand responses, such work is generally done with large cross-sectional data sets. Such sets not only have greater degrees of freedom but also have an advantage in the type of information they provide. Time-series data disaggregated by income groups is seldom available, although, as discussed below, a price- and income-interaction term may, in principle, allow one to circumvent such a deficiency. In addition, cross-sectional data frequently contain demographic information, the importance of which has been noted in a number of studies.[81] Even functions designed with consistent aggregation cannot be expected to be able to explore demographic effects as deeply as disaggregated data. Generally, the average and the distribution of a demographic variable, say, family size, changes little over time but varies widely in a cross-section.

Estimates of price parameters using cross-sectional data and made with either systems or single-equation methodologies are increasingly common. Nevertheless, it is important to recognize that the interpretation of the parameters generated differs from the interpretation of the more conventional time-series estimates.

That estimates from cross-sectional data differ from time series has been known for some time. Kuh observed that the coefficient for capital stock in investment functions generated by time series exceeded the coefficient from cross sections, while the coefficients for profits from cross sections were typically twice as large as those from time series.[82] Similarly, Peterson calculated an agricultural supply response from an international cross-sectional data set that was much larger than those commonly observed from time-series data.[83] A comparison of demand estimates using time series and pooled cross sections (cell means) for 17 years of Indian data found time-series price elasticities for food to be smaller in absolute value than those

---

[81] See, for example, the review by Robert A. Pollak and Terence J. Wales, "Demographic Variables in Demand Analysis," Econometrica 49 (November 1981): 1533-1551. A less theoretical approach is reported by John Adrian and Raymond Daniel, "Impact of Socioeconomic Factors on Consumption of Selected Food Nutrients in the United States," American Journal of Agricultural Economics 58 (February 1976): 31-38.

[82] Edwin Kuh, "The Validity of Cross-Sectionally Estimated Behavior Equations in Time Series Applications," Econometrica 27 (April 1959): 197-214.

[83] Willis L. Peterson, "International Farm Prices and the Social Cost of Cheap Food Policies," American Journal of Agricultural Economics 61 (February 1979): 12-21.

from cross sections.[84] The studies in Part 1 are predominantly cross-sectional. This may account for the large price responses observed.

The major reason proposed for these phenomena is the differences between short-run and longer-run adjustments to a change. This is best known in supply response analyses, in which lagged variables are used to gain perspective on the dynamics of adjustments. An example of demand models in which the previous period's consumption is included as a regressor can be found in Pollak.[85] The positive coefficients generally observed for such lagged variables are interpreted as indicators of consumer habits.[86] The habit-formation hypothesis poses a problem in that most welfare theories assume that tastes are exogenous, which is clearly not tenable in a habit-formation model. The interpretation of parameters derived from cross-sectional data as long-run responses also presents this difficulty.

Other constraints and disequilibria may also influence the time-series analysis. These include constraints on labor-leisure choice, housing, and temporary or permanent shortages of goods in settings with price rigidities. There is a large literature on disequilibrium and rationing, broadly defined.[87] One general conclusion that can be drawn from the literature parallels the more widely known condition from production literature that short-run cost functions lie within the long-run envelope. Short-run responses with fixed (human or other) capital costs, then, are smaller than long-run substitution effects.[88] But compared to production studies little has been done on the distribution and time frame of lagged adjustments in consumer behavior.

Time-series estimates may also underestimate actual responses by virtue of aggregation. For example, suppose that aggregate income grows but that the growth is concentrated among upper-income groups, which usually have low elasticities for staple food. In such a case, parameters derived from a methodology that does not include income distribution will be misleading if they are extrapolated to the poor.

---

[84] Ray, "The Testing and Estimation of Complete Demand Systems."

[85] Robert A. Pollak, "Habit Formation and Dynamic Demand Functions," Journal of Political Economy 78 (July-August 1970): 60-78. See also Laura Blanciforti and Richard Green, "An Almost Ideal Demand System Incorporating Habits: An Analysis of Expenditures on Food and Aggregate Commodity Groups," Review of Economics and Statistics 65 (August 1983): 511-515.

[86] Deaton and Muellbauer, Economics and Consumer Behavior, Chapter 13 points out that dynamic time-series analysis is frequently based on static one-period utility maximization subject to one-period budget constraints and discusses an alternative model based on aggregation and interhousehold social relationships. See also Robert A. Pollak, "Habit Formation and Long-Run Utility Functions," Journal of Economic Theory 13 (October 1976): 272-297.

[87] See Deaton, "Theoretical and Empirical Approaches."

[88] See Robert A. Pollak, "Conditional Demand Functions and Consumption Theory," Quarterly Journal of Economics 83 (February 1969): 60-78.

Shares of total consumption of a normal good by the upper-income groups will exceed their share in the population. Both aggregate income and price responses will reflect these quantity weights and will, therefore, reflect the presumably lower elasticities of the upper-income brackets.

But, as Kuh has pointed out, differences between studies of time-series and of cross-sections reflect the biases of both approaches. What are the potential biases in cross-section analysis? An important consideration is the source of the price variation used for the estimates. Household budgets are often analyzed with the assumption that all individuals face the same prices at a given time. In single-period surveys, then, there would be no price variation and price parameters would not be estimable without strong assumptions. Prices are frequently not even collected or reported in such surveys. The assumption that price variation is insufficient is obviously not valid for the numerous cross-sectional surveys from which price parameters have been estimated. What are the sources of such price variations?

Some may be temporal, reflecting seasonal rounds of the survey. Such estimations, in effect, pool cross-sectional and time-series data, albeit over a short time span.

Generally, for such estimations the researcher includes covariance terms or more sophisticated variance-component models.[89] If income and prices are already included, however, dummy variables for rounds are proxies for unknown, possibly nonmarket effects. Of course, if the seasonal effect influences tastes, as for ice cream or festival foods, the interpretation is straightforward. With a staple grain, however, a significant variable for a round may reflect cash constraints or changes in labor, and through them, energy output. Interpretation should be in accord with the analyst's understanding of such factors.

Even when only a single round of a survey is conducted over a wide area, differences in climate may create differences in the cropping cycle. For example, in any given month, some regions will be closer to harvest than others and will, therefore, have different local prices. Similarly, even when trade is involved, differences in transportation networks will create differences in regional prices. Such spatial price differences may reflect the real costs of marketing and may persist even in a competitive economy. For the purpose of demand estimates, however, competition need not be assumed; collusion among sellers and local monopoly behavior shift the supply curve and may not interfere with the identification of the demand curve.

An assumption that is critical, however, is that there are no unspecified regional differences in the demand curves. Otherwise, differences in prices caused by shifts in supply cannot be

[89] G. S. Maddala, Econometrics (New York: McGraw Hill, 1977), Chapter 14; and Yair Mundlak, "On the Pooling of Time Series and Cross-Section Data," Econometrica 46 (January 1978): 69-85.

distinguished from those caused by shifts in demand, and a classic simultaneity bias may occur. In such a case, a positive bias in the price parameters can be expected. But with individual or cell means from a number of towns or villages within a number of larger districts, a portion of the bias can be removed by covariance analysis. For example, Timmer and Alderman used dummy variables for six regions, urban residence, and the effects of different rounds in their study of cross-sectional data aggregated by province.[90]

When spatial variations in prices reflect differences in markets, it is important to ascertain whether these differences are nominal or real. Studies of cross-sectional data, like analyses of time-series data, should deflate income and prices by cost-of-living or similar price indexes. Which price indexes to use and how to use them have been major topics of discussion in consumption and welfare theory. Two related but distinct issues are important here. One use of price indexes is to allow systems to be estimated using real income so that symmetry restrictions can be imposed.[91] Some systems, such as AIDS, estimate the index internally and nonlinearly. However, substitution of an externally derived price index not fully consistent with the parameter estimates allows for linear estimation and has been shown to impose little bias on time-series estimates (no comparison has been made for cross-section estimates). A prerequisite for internally estimated real-income deflators is the inclusion of all prices and commodity groups in the estimates.

This, then, requires a second and distinct use of price indexes. If one imposes homogeneity but does not impose symmetry restrictions on the compensated substitution, then the Marshallian relationship can be estimated without a real income deflator, since under homogeneity, $f(Y,P) = f(Y\lambda,P\lambda)$ where $\lambda = 1/\text{Index}$. This, however, does not avoid the need for an index of nonfoods or some other aggregate of commodities. Exclusion of such an index would create missing variable bias, as discussed above. Exclusion, then, of regional cost-of-living deflators or of regional price indexes for other goods poses a problem that is more severe the less homogenous the demand function and the greater the missing variable bias. Occasionally the effects of changes in prices (regional differences) that are nearly uncorrelated with other prices is investigated. An example is Rosenberger's investigation of exogenous federally determined milk prices. In such a case the consequence of excluding a price index is probably small. It is not always small, however, and when data are available the importance of regional price indexes should be investigated.

There are other reasons for differences in prices observed in cross-sectional data. The best known is differences in quality. Most

---

[90] Timmer and Alderman, "Estimating Consumption Parameters."

[91] For a discussion of this and related issues see Gurushri Swamy and Hans Binswanger, "Flexible Consumer Demand Systems and Linear Estimations: Food in India," American Journal of Agricultural Economics 65 (November 1983): 675-684.

cross-sectional data do not include direct observations on market prices of a standard or indicator commodity. They include, instead, individual prices or expenditures that include quality premiums. One can, therefore, expect a bias in estimating price responses. This problem is more complex than just commodity aggregation, for not only is one dealing with an aggregation of goods of various quality but also with a price that could belong to any one component of the aggregation. A preliminary step in the analysis of a cross-sectional data set from which prices are derived by dividing observed expenditures by quantities is to determine whether prices are correlated with income. If they are, one needs to determine an indicator price, by region and season, that reflects a constant quality.

A data set will often report expenditures but not prices. Whereas independent observations on market prices can be used in regression with the assumption that the prices of different qualities of a commodity are correlated, it is not possible to use them to derive quantities. If the indicator price is, for example, from a quality used predominantly by the poor, division of expenditures by this price will probably overestimate the quantity consumed by the rich. This is a drawback in some of the studies reported in Part 1.

Another sort of bias comes when the price per unit is itself a function of the quantity purchased. If there are large discounts for large purchases, then the association of high prices and small purchases may reflect a chain of causality going from quantity to price and not vice versa. This will exaggerate the own-price response.

NONCONSUMPTION

One remaining problem typical of cross-sectional surveys is the issue of nonconsumption. Not all respondents will have consumed a given good during the period covered in the survey. Nonconsumption is more likely the more disaggregated the commodity groups and the shorter the recall period. If the data include observations on use, including stock draw-down or buildup or the flow of services from durables rather than the purchase of durables, then nonconsumption is less likely.

From the standpoint of estimation, nonconsumption or zero-value observations may bias the estimates. If the true model is

$$q = \beta x + u \text{ or } u = q - \beta x, \tag{17}$$

then, because $q \geq 0$ for all cases, the distribution of u is nonnormal, and further, $E(u) = 0$, which leads to biases in OLS estimation. Tobin originally stated the problem and devised an estimation procedure called Tobit's probit or Tobit to deal with it.[92] The procedure is a

[92]James Tobin, "Estimation of Relationships for Limited Dependent Variables," *Econometrica* 26 (January 1958): 24-36.

maximum likelihood technique. Pitt used such a model in his analysis of food demand in Bangladesh and showed that it is inappropriate for models that have expenditures or budget shares as dependent variables.[93] McDonald and Moffit showed that the parameters from a Tobit estimation can be decomposed into two components:[94]

$$\partial Q/\partial X = F(z)\ (\partial Q^*/\partial X) + E(Q^*)\ (\partial F(z)/\partial X). \qquad (18)$$

The total change in Q is composed of the change in Q conditional upon Q being above the limit, weighted by the probability that it is above the limit, plus the change in that probability weighted by the expected value of Q, if it is above the limit.

Tobit estimations are constrained in that the same parameters must be used to explain both entry and quantity responses. To identify the determinants of entry, one can use a method introduced by Heckman for labor participation studies.[95] It uses a probit designed for zero-one predictions for estimating entry and an OLS modified to account for the selection procedure for response conditional upon entry. The two estimates can be combined as in equation (18).

Tobit and probit estimations are nonlinear and relatively expensive. In addition, they are not available in many of the most common packaged programs designed for large cross-sectional surveys. Nor can they be easily modified to include restrictions across equations. While the bias of using OLS when Tobit is appropriate can be calculated in terms of the true parameters and variance, Tobit itself involves assumptions about the appropriate model and, unlike OLS models, it is biased when the error term is heteroskedastic.[96]

Greene illustrates the sample truncation bias under the conditions in which Tobit is appropriate. This bias can be large.[97] He also offers an approximation in which the bias is corrected by dividing the OLS parameters by the proportion of nonlimit (nonzero) observations in the sample. This conclusion--that uncorrected OLS slopes are biased toward zero (the bias in the intercept is undeter-

---

[93]Pitt, "Food Preferences and Nutrition."

[94]John F. McDonald and Robert A. Moffitt, "The Uses of Tobit Analysis," Review of Economics and Statistics 62 (May 1980): 318-321.

[95]James J. Heckman, "Sample Selection Bias as a Specification Error," Econometrica 47 (January 1979): 153-161. Another explanation of the technique is presented in Zvi Griliches, B. Hall, and J. Hausman, "Missing Data and Self Selection on Large Panels," Annales de L'INSEE 30-31 (1978): 137-176. For an application of Heckman's probit, or Hobbit, to food demand, see Harold Alderman and Joachim von Braun, The Impact of the Egyptian Food Ration and Subsidy System on Income Distribution and Welfare, Research Report 45 (Washington, D.C.: International Food Policy Research Institute, 1984).

[96]G. S. Maddala, Limited Dependent and Qualitative Variables on Econometrics (Cambridge: Cambridge University Press, 1983), p. 178 ff.

[97]William H. Greene, "On the Asymptotic Bias of the Ordinary Least Squares Estimator of the Tobit Model," Econometrica 49 (March 1981): 505-513.

mined) and that the bias is the same proportion for each parameter--depends on the assumption of normality. However, it appears to be generally true even when the dependent variables are not normally distributed; if they are bivariate dummy variables, for example. This result allows the application of OLS to limited dependent variable models.[98]

Note that unadjusted OLS results using only the nonzero observations are not warranted. Equation (18) makes it clear that these parameters overestimate the population parameters. If entry is random and Mf(z)/ Mx is zero, it would still be necessary to weight the restricted sample OLS parameters by the probability of consumption to give the true population parameters.[99]

The problem of zero-valued observations is mitigated when the data includes cell means for districts or income groups. Such aggregations generally include a number of positive values in each cell. If a researcher's concern is with average response to changes in income and prices, such information is sufficient. If one has a particular interest in the determinants of entry, cell means that include the percentage of nonzero observations within the cell are enough for the application of logit or probit models.

Aggregation in cross-sectional data is, of course, theoretically no different from aggregation in time series. It has the dubious advantage of seeming to improve the apparent statistical fit by averaging out random shocks within a cell,[100] but can fall victim to aggregation bias as discussed above. Furthermore, when different cells contain different numbers of households, cell means can introduce heteroskedasticity. This form of heteroskedasticity is based on the statistical theorem that the variance of the mean is inversely proportional to the number of observations. One then needs to weight each observation by the square root of n for an efficient estimation. Whether dealing with cell means or individual observations, heteroskedasticity may also be present if the error terms vary by income group or size of purchase. Prais and Houthakker discuss one such form--when

---

[98]Angus Deaton, Javier Ruiz-Castillo, and Duncan Thomas, "The Influence of Household Composition on Household Expenditure Patterns: Theory and Spanish Evidence." Research Program in Development Studies, Discussion Paper No. 112, Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, N.J., September 1985.

[99]There are a number of examples in which the predominant interest is in the parameter of the restricted sample model. For such models, OLS techniques are available as an alternative to the Heckman correction for sample selection bias. Such models are prevalent in labor economics but are less likely to be used for food policy. See R. J. Olsen, "A Least Squares Correction for Selectivity Bias," Econometrica 48 (November 1980): 1815-1820.

[100]This is only apparent. Estimations from grouped data are always less efficient than from disaggregated data. See J. S. Cramer, "Efficient Grouping, Regression, and Correlation in Engel Curve Analysis," Journal of the American Statistical Association 57 (1962).

the variance is proportional to the square of the predicted value--but more general patterns may be discerned.[101]

Data may occasionally be available in a form that retains properties both of time-series and cross-sectional disaggregation. In some surveys, groups of consumers or panels are interviewed at regular intervals. With repeated observations on the same individuals over time, either changes in taste can be modeled endogenously or individual differences in taste can be removed using either covariance techniques for pooled cross-sections and time-series data or first differences. Such data, however, are expensive to collect and are rarely available.[102]

[101]For a discussion of heteroskedasticity, see G. Judge, W. Griffith, R. Hill, T. Lee, The Theory and Practice of Econometrics (New York: Wiley and Sons, 1980), Chapter 4. Also see H. White, "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity" Econometrica 48 (May 1980): 819-838.

[102]O. Ashenfelter, Angus Deaton, and G. Solon, "Does It Make Sense to Collect Panel Data for Developing Countries?" Woodrow Wilson School of Public and International Affairs Discussion Paper No. 119, Princeton University, Princeton, N.J., 1985, discusses the advantages and limitations of such data sets.

7. CRITERIA FOR DISTINGUISHING GROUPS FOR PARAMETER ESTIMATION

This report has been prompted by the need to identify the demand parameters of subsets of a population for use in food policy analysis. It is worthwhile, then, to consider how the criteria for subdividing the population are determined. Such criteria are needed regardless of the functional form; they are needed whether or not a systems approach is used, and whether the subdivisions will be applied with covariance analysis or with separate estimations of separate samples. Even when the parameters vary continuously rather than discretely, any table or scenario used to present the findings to policymakers will report the parameters by subgroups. The division is, of course, influenced by the availability and expected application of the data, but frequently the choice is less clear-cut than a division by a discrete characteristic such as region, employment category, or sex of the household head.

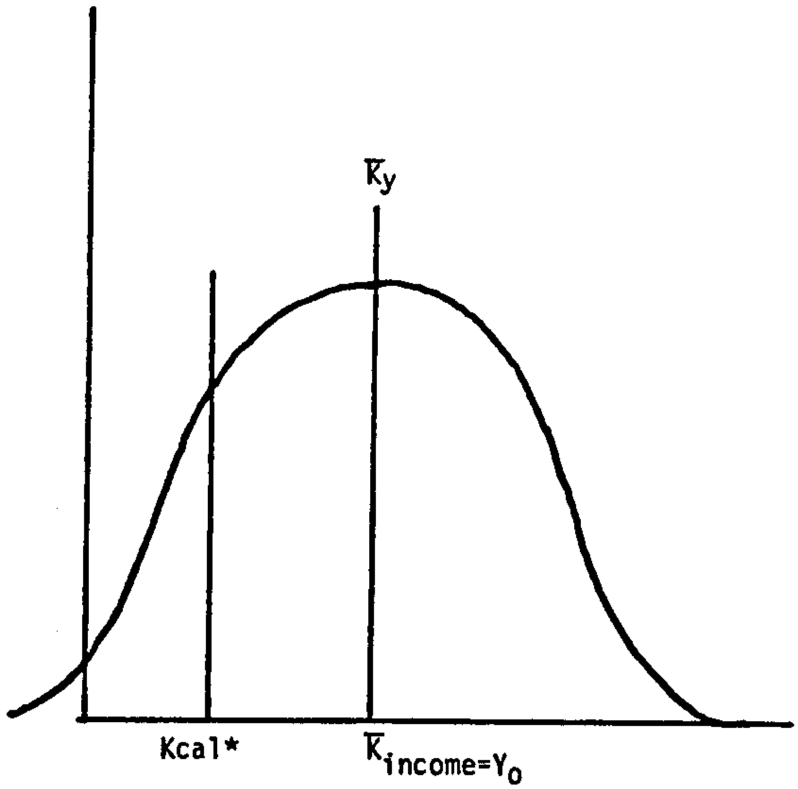
As the goal here is to formulate nutrition policy, one seemingly logical choice is to subdivide the sample by calorie consumption and estimate separate parameters for severe or moderately calorie-deficient households. There are, however, statistical and practical limitations to this.

From a statistical standpoint, subdividing the sample using the dependent variable for truncation introduces the same nature of bias that stimulated the development of the Tobit model. Suppose that Observed Kcal = True Kcal ± error. Presume this error is a recording error and equal for all levels of Kcal, distributed normally with the mean at zero. Suppose also that the analyst picks a cutoff at Kcal*, as in Figure 4. Given the normal distribution, if Kcal* is less than $\bar{K}y$, more cases in which Observed Kcal < Kcal* < True Kcal will be included in the subsample than cases in which Observed Kcal > Kcal* > True Kcal are excluded. Under such conditions, the error in the truncated sample is not distributed normally and has a mean value less than zero. Furthermore, the distribution of the error will be heteroskedastic as it will vary by income. This is so because $\bar{K}y$ increases with income while Kcal* is a constant. The bias in the error due to truncation will vary by income groups even though, under the original assumptions, the error was unaffected by the level of Kcal.

The discussion has been in terms of measurement error but, given the known importance of individual variation of calorie requirements, it can be restated.[103] A sample divided by calorie consumption, in

[103] The importance of individual variation is discussed by a number of authors. See George H. Beaton, "Energy in Human Nutrition: Perspective and Problems," Nutrition Reviews 41 (1983): 325-340. Beaton also makes the point that requirement is a normative concept.

Figure 4 — Truncation of normally distributed calorie variable



effect, aggregates two types of consumers. Suppose the population has four subgroups, low-income consumers with and without high biological needs for food and high-income consumers with and without high biological needs for food. (Family aggregation complicates matters but is tangential here. As changes in activity change requirements, the term "requirements" is used here in the sense of what would be consumed if activity were not curtailed because too few calories were available.) The low Kcal group will include individuals with high requirements for food but limited resources and individuals with low demand but adequate resources. The income elasticities generated reflect what happens to consumption in the group when income increases. They will be averages of the low response of the low-requirement/high-income group and the average response of the bulk of the low-income group. This is, again, a missing variable bias, for a variable denoting requirements is missing. One can expect $\partial Kcal/\partial requirements > 0$ and, since the truncated sample includes mainly high-income/low-requirement individuals and low-income individuals with varied requirements, requirements in the truncated sample (though not in the overall sample) will be negatively correlated with income. This will bias income elasticities downward.[104]

---

[104]This point is made more formally in A. S. Goldberger, "Linear Regression after Selection," Journal of Econometrics 15 (April 1981): 356-366.

An analogous point can be made with price responses in which the truncated sample includes both high- and low-requirement groups at high prices and only low-requirement groups with low prices. In such a case, requirements and price in the truncated sample will be positively correlated. While missing variable bias is a general problem with estimation, the essential point of this discussion is that truncation by the value of the dependent variable can exacerbate the problem by introducing correlation of the missing variable and the independent variable where none had existed before. The same kind of problem exists if, instead of separate regressions made on a subsample, different parameters are estimated by covariance techniques.

The analysis is more commonly done on individual commodities than on calories. The problem with using a Kcal cutoff is, then, somewhat mitigated, but as Kcal is actually a linear transformation of the sum of the commodities, the error in a few commodities may dominate the error in Kcal and the truncation can still introduce estimation errors.

REAL INCOME AND HOUSEHOLD DEMOGRAPHICS

The most common alternative to subdivision of the sample by caloric intake is subdivision by income.[105] Alternatively, one can subdivide by employment category, region, or sex of household head, depending, in part, on the expected use of the data. For example, if the data will be used for a program to lower the consumer price by improving or subsidizing transportation of food to a region in which post-harvest prices are remarkably high, then a regional breakdown may be sufficient, although the remaining cross-sectional price variability will be limited. More commonly, however, the targeting or planning refers to the "poor" defined either by consumption of certain goods, especially food and shelter, or by the income that makes it possible to purchase a certain amount of goods. These two concepts are different.[106] The former assumes that different goods have social weights that reflect a concept of one-dimensional equity--that is, the view that society considers equity on the consumption of a certain bundle of goods more important than equity overall. The latter is founded more on the concept of consumer sovereignty, assuming basically that, since a household maximizes its utility subject to price and budget constraints, it is sufficient to look at the size of income at which nutritional goals or other consumption goals can be met by the household. As mentioned, using the former criterion in estimation is likely to create econometric biases. Even when it is administratively more convenient to identify low-consumption groups than low-

---

[105]Frequently the sample frame of a household survey is based on a stratified design. It may be possible, then, to separate households from different strata if that information is available.

[106]For a discussion of poverty indicators, see Michael Lipton, Poverty, Undernutrition and Hunger. Also see A. K. Sen, Levels of Poverty: Policy and Change, World Bank Staff Working Paper 401 (Washington, D.C.: World Bank, 1980).

income groups, it may be advisable to estimate income and price parameters by income group and apply them to the low-consumption groups.

If income is used to distinguish subdivisions of the population, then the question remains whether household income, income per capita, or some other standardized income term is more relevant. The potential for misclassification is readily apparent if household income is used; a large poor household may rank above a single individual with a moderate income. The alternative of per capita income, however, has problems with economies of scale and the percentage of children in a household. If economies of scale exist for some commodities then a household with N individuals and M units of earning will be less well off than a household with 2N members and 2M units of earnings. Note that this is true even if there are no economies of scale for the consumption of foods, which are the central focus of the study. If some households have economies of scale in housing or transportation, then they have more disposable income for food items at the same per capita income. The issue here is the possibility of welfare comparisons based on some normalized income and not the importance of demographic variables in predicting consumption of a given good. The latter use of demographics can be achieved ad hoc, without theoretical underpinnings, by including such variables in any demand equation.[107] If, however, one wishes to go from a commodity-specific analysis to a method of comparing household income, some assumptions about consumer behavior are necessary.

For example, adult equivalency scales based on caloric requirements are commonly used to standardize households. Although this distinguishes the requirements for children and has some justification in aggregate food demand equations, it does not allow for economies of scale (after all, two adult males are exactly twice one), and it has no foundation in utility theory. Utility is not likely to be a function of calorie requirements.

Another means of scaling household income can be based on Engel's law, which holds that the budget share of food declines monotonically with increases in real income. It can be assumed, then, that two households that allocate identical budget shares to food have identical real incomes. This information can be used to compare the real incomes of families with different sizes and composition.[108]

Another method is based on a comparison of purchases of two bundles of goods--one that children share and another, containing such goods as tobacco and alcoholic beverages, consumed primarily by adults. It is assumed that the latter purchases indicate welfare,

---

[107]For reviews, see Deaton and Muellbauer, Economics and Consumer Behavior, Chapter 8, and Pollak and Wales, "Demographic Variables in Demand Analysis."

[108]Angus Deaton, "Inequality and Needs: Some Experimental Results for Sri Lanka," Population and Development Review, Supplement to Volume 8, (1983): 35-49.

independent of the number of children, and that differences in expenditures on these goods, controlled for nominal income, will reflect the costs of children. Note that this method does not handle the economies of scale of adult members and, as it reflects a partitioning of commodities, indirectly includes an assumption of additivity.

These methods, as well as others reported in the literature, do not necessarily scale household income equivalents identically.[109] It is beyond the purpose of this report to delve deeply into the implications of various methods of comparing household income when family sizes change. However, an analyst who intends to report parameters by various groups should have some understanding of the implications of the classifications. Another justification for the discussion of ranking of incomes is that some transfer programs base benefits partially on family size, thereby making implicit assumptions on the scale economies of children.

Having ranked households by some income measure--whether per capita or per household or some other scaled measure--a cutoff point for the target group is still needed. Occasionally, an official poverty line is given or defined in terms of either calories consumed or the ability to consume a certain amount. Alternatively, an arbitrarily determined percentile can be the focus--the poorest quartile or decile, for instance. There is one technique that allows the data to determine the group classifications internally. Rather than focusing on, say, the ith percentile of scaled income, the parameters can be allowed to switch at an internally determined point, using a maximum likelihood algorithm to search for the best switching point.110 This will give disjointed rather than continuous changes of parameters. Unfortunately, it cannot rigorously test whether any two coefficients are statistically different, although Akin et al. used such a method to determine a stratification and then made separate regressions on both strata. They then used a Chow test to determine statistical differences.

On the other hand, testing for statistical differences using covariance techniques is fairly straightforward. One can create dummy variables for any group and use a multiplication interaction in the regression for dummy x price. The test of whether the derivative with respect to price for that group differs from the general population will be the t-statistic for the parameter of the interaction variable. The total response of the group will be the sum of the general population response and the coefficient of the interaction term, while the variance will be the sum of the variance of the two

[109]See, for example, Angus Deaton, Three Essays on a Sri Lanka Household Survey, Living Standards Measurement Study, Working Paper 11 (Washington, D.C.: World Bank, 1981).

[110]See John S. Akin, David K. Guilkey, and Barry M. Popkin, "The School Lunch Program and Nutrient Intake: A Switching Regression Analysis," American Journal of Agricultural Economics 65 (August 1983): 477-485. Note, however, that switching regressions is expensive and not easily done.

parameters and twice their covariance. Alternatively, one can include interaction terms for all groups and then exclude an independent price term. The problem of collinearity when dummy variables for all subgroups are included will be avoided, as the intercept will not be a linear combination of the interactions. This gives the price parameter for each group; the difference between the price parameters can be tested, as above, with the standard error derived from the covariance of the parameters.

8. OTHER ISSUES

VARIATION OF PARAMETER BY SOURCE OF INCOME

Frequently one is interested in differences in consumption patterns from different sources of income rather than by size of income. Estimates that distinguish the source of income may be used to analyze the effects of transfer programs, patterns of consumption from earnings of different household members, or marginal propensities to consume (MPC) from cash as opposed to agricultural or in-kind earnings.[111] Not infrequently such tests fail to specify the constrained utility maximization that is used to generate the difference in the marginal propensity to consume by source of income.[112] Consequently, with such an omission, the tests at best fail to improve our understanding of the determinants of behavior. At worst, the tests reflect only statistical artifacts of misspecified functional forms.

For example, assume one decisionmaker with the objective of maximizing utility from three categories of goods:

$$\max u = f(X_1, X_2, X_3), \tag{19}$$

subject to $P_1X_1 + P_2X_2 = Y_1$, and $P_3X_3 = Y_2$, and where X_2 and X_3 can be distinguished conceptually but not in practice, so that an analysis of demand investigates consumption of $q_1 = X_1$ and $q_2 = X_2 + X_3$.

Such a situation may arise if Y_2 refers to on-farm production of foods also available on the market or to food stamps. Since q_2 can be purchased with currency Y_1 or Y_2, the two currencies are convertible. Before one can test for differences in MPC from different sources of income, one has to consider the effective exchange rate of Y_2 to Y_1. This includes transaction costs or rates of discount of Y_2. The appropriate demand function is $q = f[(Y_1 + \lambda Y_2),P]$ where λ is the discount rate. If the transaction costs are fixed costs of market entry rather than costs per unit of Y_2 then $q = f[(Y_1 + Y_2 - \lambda),P]$. The problem is compounded by the frequent lack of direct obser-

[111]For the effects of transfer programs, see Donald A. West and David W. Price, "The Effects of Income, Assets, Food Programs, and Household Size on Food Consumption," American Journal of Agricultural Economics 58 (November 1976): 725-730; and Shubh K. Kumar, Impact of Subsidized Rice on Food Consumption and Nutrition in Kerala, Research Report 5 (Washington, D.C.: International Food Policy Research Institute, 1979). For patterns of consumption from earnings of household members, see Jean Kinsey, "Working Wives and the Marginal Propensity to Consume Food away from Home," American Journal of Agricultural Economics 65 (February 1983): 10-19. And for marginal propensities to consume from cash earnings, see Benton F. Massell, "Consistent Estimation of Expenditure Elasticities from Cross-Section Data on Households Producing Partly for Subsistence," Review of Economics and Statistics 51 (May 1969): 136-142.

[112]For example, one must be careful to avoid assuming implicitly that the utilities of items consumed from the two sources of income are separable.

vations of Y_2. If Y_2 is estimated by P_3X_3, the usual problem of errors in variables must be considered.[113]

A variant of this hypothesis would be when one source of income is perceived as more transient than the other. For example, if a transfer program is expected to terminate in a brief time,[114] then the more transitory income would be discounted relative to the base income for the purpose of consumption.

This is essentially a measurement problem and not a behavioral issue, with which it is sometimes confused. That is, the problem reflects a difficulty in finding an appropriate measure of income rather than a problem in modeling preference order per se. This latter problem is illustrated when the objective is

$$\max u = u(z)\ (X_1), \tag{20}$$

where $u(z)$ indicates that preferences are determined endogenously by z, and subject to $P_1X_1 = Y_1 + Y_2$. Now suppose that

$z = z_1$ when $Y_2 = 0$ and

$z = z_2$ when $Y_2 > 0$,

or a more general relationship,

$z = f(Y_2)$.

This may come about when transfers (food stamps, feeding programs) are accompanied by educational programs or when participation in a program heightens consumer awareness of certain commodities in a manner similar to that in which name recognition and other advertising techniques are assumed to shift demand. Forms of moral suasion and community pressure may be relevant here.[115] The test for the effect of sources of income or demand in this case would be a test of whether $\partial q_i^2/\partial(Y_1 + Y_2)\partial Y_2 = 0$. The test whether $\partial q/\partial y_1 = \partial q/\partial y_2$ would be appropriate only if $f(Y_1 + Y_2)$ is linear or if Y_1 and Y_2 are nonsubstitutable in purchases.

Tests for differences of sources of income on MPC are sensitive to the specification of the Engel form. Sources of income and total income are frequently correlated because of, for example, eligibility

---

113Massell, "Consistent Estimation of Expenditure Elasticities."

114J. A. Hausman and D. A. Wise, "Discontinuous Budget Constraints and Estimation: The Demand for Housing," Review of Economic Studies 47 (January 1980): 75-96. A very different approach to this question is discussed in Mark Dynarski and Steve M. Sheffrin, "Housing Purchases and Transitory Income: A Study with Panel Data," Review of Economics and Statistics 67 (May 1985): 195-204.

115George J. Stigler and Gary S. Becker, "De Gustibus Non Est Disputandum," American Economic Review 67 (March 1977): 76-90, argue that such shifts in demand may be modeled without assuming changes in taste. Their approach is based on the accumulation of human capital and on the costs of acquiring information.

requirements for transfer programs or negative correlations of farm and nonfarm income. Observed differences in MPC may, then, reflect only the misspecification of the Engel relationship and the correlation of one source of income and an omitted variable.

The linear Engel relationship is clearly not the best choice, as MPC is expected to decline for items such as food as income rises. Yet as it is most amenable to algebraic manipulation, it will be used to illustrate some differences between the two models discussed above. In the former,

$$q_2 = \alpha + \beta(Y_1 + \lambda Y_2) = \alpha + \beta(Y_1 + Y_2) + \gamma Y_2, \tag{21}$$

where $\gamma = \beta(\lambda - 1)$. λ is a discount factor, presumably between 0 and 1, hence λ is presumed to be of opposite sign to β, and $|\lambda| < |\beta|$.

This constrasts with the case in which

$$q_2 = \alpha + \beta(Y_1 + Y_2) + \gamma[Y_2/(Y_1 + Y_2)], \tag{22}$$

or, in terms of covariance analysis,

$$q_2 = \alpha + \beta(Y_1 + Y_2) + \gamma D(Y_1 + Y_2), \tag{23}$$

where D is a dummy variable defined as 1 if the household participates in the program presumed to change MPC and 0 otherwise. In this case, the hypothesis is that $\gamma > 0$.

There are a number of variants to this approach. One could assume that preferences change in a functional manner and introduce an interaction term. For example, D could be the proportion of income in-kind, in which case, it becomes the introduction of in-kind earnings as the second regressor in the linear case of equation (23), or an interaction term in a logarithmic functional form. Alternatively and equivalently, one could formulate the problem as testing linear restrictions.

Having chosen the best form in this method, one can then test the restrictions on the parameters, either with linear constraints or with interaction terms. If the restrictions are accepted, the interpretation is straightforward--there is no observed difference in MPC from source of income. If, however, the restrictions are rejected, caution need be taken not only to distinguish between alternative hypotheses but also to ascertain whether the sample is homogenous. In transfer programs, recipients are frequently chosen on the basis of household characteristics. These characteristics may influence consumption decisions. The problem would be particularly worrisome if participation were voluntary or otherwise indirectly self-selecting. If z in equation (20) is a discontinuous variable, particularly a zero-one dummy indicating participation, it is not always possible to rule out the hypothesis that tastes differ before participation and not because of it. This issue is more relevant for transfer programs than it is for farm income. To a degree, however, the decision to produce or not to produce a crop may reflect tastes as well. This is discussed in the following subsection. If z is a continuous function of some measure of participation, years enrolled in the program, for example, then a causal interpretation is more plausible.

Note that neither equation (21) nor (22) results in a variant of equation (23) in which $\gamma > 1$. In an example in which Y_2 represents farm in-kind earnings, it is not uncommon to assume that with equal incomes and identical tastes, a farm household would consume more food than a nonfarm household. Such would not occur in the specification of equation (19) but could reflect instead the difficulty of evaluating the proper marginal prices or a form of equation (20).

ISSUE OF CONTROL OF FAMILY INCOME

Recently the assumption that a household can be characterized as having a single ordering of preferences has been challenged.[116] Even within a nuclear family, it is unlikely that all individuals order their preferences identically. The simplifying assumption that a household has a single purse controlled by one individual does not eliminate the possibility that an internal dynamic brings about compromise in budget allocations. Each member has the potential to influence the allocation process through combinations of threats, such as physical violence, pouts, tantrums, and rewards. In order to predict the outcome of a change of food policy, it is not important how the final agreement is reached if it is stable.[117] However, the weights given in equilibrium to the preferences of household members may be influenced by changes directly or indirectly affected by policy instruments. If so, demand parameters may vary according to factors that influence bargaining within the household.

This is a difficult issue to study. Only a few researchers have attempted to quantify the effects of the control of income by sex, which is a factor commonly assumed to influence the weighting of preferences within a household. Roger's review and Guyer's study of income control in Africa show some of the difficulties in modeling such behavior.118 These include the difficulty of defining the household as a single functional unit rather than as a web of obligations and benefits; the difficulty in obtaining information on the income of household members and the transfers between them, and the

---

[116]Beatrice L. Rogers, "The Internal Dynamics of Households: A Critical Factor in Development Policy," paper submitted to the U.S. Agency for International Development, October 1983; Christine Jones, "The Mobilization of Women's Labor for Cash Crop Production: A Game Theoretic Approach," American Journal of Agricultural Economics 65 (December 1983): 1049-1054.

[117]Stable weights are implied by Paul Samuelson, "Social Indifference Curves," Quarterly Journal of Economics 60 (February 1956): 1-22.

[118]Beatrice L. Rogers, "The Internal Dynamics of Households"; Jane I. Guyer, "Household Budgets and Women's Incomes," Working Paper 28, African Study Center, Boston University, Boston, Mass., 1980.

difficulty of modeling exchanges of services (including refraining from delivering on a threat) that are not monetarized, but contribute to the utility of household members. It is also important to know how information flows between household members. To the degree that one member can conceal income, that member avoids compensating actions by other members. Furthermore, control of income by female members is frequently linked with other variables. Households headed by females are frequently, but not necessarily, poorer or have different dependency ratios than other households. Also, if women in different households have different opportunity costs, either because of differences in education or other determinants of market wages or nonmarket productivity, then the price of time will differ. This, of course, will make goods that are time-intensive in consumption more costly for some households than others, even if cash prices are the same. It is difficult, then, to distinguish preferences from costs in such circumstances.[119]

In some contexts there are differences in the seasonality and regularity of female and male incomes that in and of themselves influence food purchases and are distinct from differences by sex in propensities to consume. Finally, a difficulty in generalizing about control of income is that most observations are made for a single culture. No universal rule as widely applicable as Engel's law has yet appeared from the studies of control of income.

As an example of the complexity of such relationships, consider Guyer's observations in Southern Cameroon. At first glance it appears that the society she studies is a near-polar case. Males earn income from different occupations than women and, furthermore, women bear most of the responsibility for purchasing food. However, in this small sample (26 women), 40 percent of the cash income of the married women came from husbands and 3 percent from other males. Unmarried women obviously received no income from husbands but received 17 percent of their income from other males. To determine the effects of different food policies, it is necessary to understand what influences the amount transferred between household members. Presumably males have an idea of the use women put the money to and may increase or decrease the transfer according to their notions of what a household should consume. While it is appealing to simplify the household by assuming that most of the increments to women's incomes are spent on food, while most of men's earnings are not,[120] the fact that food purchasing responsibilities are largely given to one sex is insufficient to establish the net effect of transfers. One can imagine a number of scenarios that could moderate the effect that increases of women's earnings have on household food availability, even if it were established that women's MPC on food is higher than males'. For example, if a male saw female earnings increase, he could decrease the

---

[119] Robert A. Pollak and Michael M. Wachter, "The Relevance of the Household Production Function and Its Implications for the Allocation of Time," Journal of Political Economy 83 (April 1975): 255-277, review the basic full model of a household (time included) and discuss the restrictions under which costs and preferences can be distinguished.

[120] While there is some evidence for such behavior, there are also a number of studies with rather different conclusions. See Rogers, "The Internal Dynamics of Households."

amount transferred. Similarly, increases in male earnings could lead to a greater absolute or even proportional amount of his earnings going to household needs. When purchasing responsibilities are less distinct and where types of employment are less segregated by sex, this issue is even harder to measure.

In another region of Cameroon, Jones found that there was little difference in either the amount of rice retained by the household or the amount spent on sauce ingredients when females controlled the disposition of the crop or headed the household. Women, however, maximized their personal rather than household income by their labor allocation. If all sources of income contributed equally to household well-being, this behavior would be inefficient. Even if the consumption effect is not measurable, this information supports the view that marginal propensities differ.

It is also important to distinguish between the concepts of households that are headed by females and households where women earn income. About 15 percent of the households in Sri Lanka are headed by women.[121] Likewise, about 14 percent of the households report that a woman is the major income earner. However, only two-thirds of the households where a woman is the largest income earner report that a woman is the head of household. Conversely, of those households where a woman is the head of household, only 60 percent report the major income earner is a woman. These figures admonish the researcher to distinguish carefully between the two concepts of households.

The relationship of female earnings to total household earnings is complex. Not only are there major differences between different cultures and within a given culture, but a number of economic and demographic factors determine how much market or nonmarket productive activity (as opposed to leisure) women engage in. From an econometric standpoint, it is necessary to recognize that female market participation is endogenous when using it to determine the effect on the demands for food.[122] Care should be taken to distinguish between the influence of exogenous variables on labor and their influence on demand.[123] For example, because changes in the earnings potential or nonlabor income of one member of a household will influence the labor decisions of another, it is not strictly correct to include individual sources of income as independent regressors, although examples of this can be found in the literature.

---

[121]David E. Sahn and Harold Alderman, "Testing for Differences in the Marginal Propensity to Consume From Income Earned by Men and Women," International Food Policy Research Institute, Washington, D.C., September 1984 (mimeographed).

[122]The econometric issues of female labor participation are discussed in J. Smith, ed., Female Labor Supply (Princeton, N.J.: Princeton University Press, 1980). This is presented from a perspective of developed countries, but the theoretical and econometric issues are relevant in most labor markets.

[123]Pollak and Wachter, "The Relevance of the Household Production Function."

EXPENDITURES AND FULL INCOME

Female labor participation is a special case of the joint determination of the consumption of goods and of leisure. A large literature explores the implication of consumer choice when a person faces a constraint on time as well as one on money. With leisure, L, providing utility, the consumer seeks to maximize the utility of goods and leisure subject to the constraint

$$pq + wL = Y_0 + wT, \tag{24}$$

where Y_0 is nonwage income, and w is the wage rate. The right-hand side of this equality is termed full income.[124]

While the most common applications of such an approach and more realistic extensions that consider constraints on the amount of labor available have been in studies of labor supply and of taxation, the use of wage rates and the cost of time are also relevant to food policy analysis. For example, the time cost of food preparation or acquisition should influence the consumer's choice of commodities and may account for some of the behavioral changes attributed to urbanization, including shifts from coarse grains to bread and the decline of breastfeeding. Actual measurement of such effects, however, is not common and is most prevalent in studies of transportation.[125]

More general is the measurement of the effect wage rates have on the total consumption of goods through their influence on labor supply. Because the wage rate appears on both sides of equation (24), the effect of a change in the price of leisure (the wage rate) differs from the normal Slutsky decomposition. In addition to the substitution effect and the real income effect, there is also the effect on earnings as the price of labor changes. This effect will be positive when wages increase and will offset the negative effect (if leisure is a normal good) due to the conventional real income effect.

Most applications of such principles in studying the poor developing economies have been in investigating whether the backward-bending labor supply curve is an empirical reality or a bias of colonial-era managers.[126] Application to food policy issues--although not necessarily focusing on the poor, however defined--has

[124]For a brief discussion of the use of a full income budget constraint, see Deaton and Muellbauer, Economics and Consumer Behavior, Chapter 4.

[125]Alderman and von Braun, in The Impact of the Egyptian Food Ration and Subsidy System, give evidence that longer search and waiting times discourage purchase of scarce subsidized goods in Egypt. Benjamin Senauer, David E. Sahn, and Harold Alderman report on the relationship of wages and the purchase of bread and rice in "The Effect of the Value of Time on Food Consumption Patterns in Developing Countries: Evidence from Sri Lanka," International Food Policy Research Institute, Washington, D.C., October 1985 (mimeographed).

[126]John Strauss, "Determinants of Food Consumption," finds total labor supply (as opposed to allocation between uses) relatively unresponsive to price with slight evidence of backward bending supply for the poorest households.

come in the literature on agricultural household models.[127] Such models recognize that farm households are both producers and consumers and that price changes will affect their behavior as consumers differently than their behavior as producers. Note that most of the available farm household models are separable. Production decisions are made first and the full income from these activities is then allocated between consumption of goods and leisure.

While the second step is conditional on the profits from the production decisions, estimation can be recursive rather than simultaneous. The effect of profits in such a model can be considerable. For example, Lau, Lin, and Yotopolous report an own-price elasticity for an aggregate group of agricultural commodities to be -0.720 when holding profits constant and 0.022 when they vary with a price increase.[128] Similarly, Strauss finds that the profits-constant, own-price elasticity for rice is -1.26 for the poor, whereas the total effect is -0.44. Moreover, the profit effect will influence the cross-price effect so that an increase in rice prices will lead to an increase in calories for the poor, whereas higher-income families will decrease their intake. Such results, of course, depend on the access to land and could differ if the poor are landless or nearly so. Note also that the profits effect, which accounts for much of the change in such models, differs from the labor-leisure choice. Whether analysis of the short-run effects of price policies that account for changes in profits but not the reallocation of family leisure will give misleading results in such environments is questionable. This is an area for future work.

Since the ability to allocate household resources, including time, between goods and leisure is a household choice, total expenditures as well as the earnings of individual household members are endogeneous variables. As mentioned, interhousehold allocation models are apt to be sensitive to the modeling of such a choice. However, the question whether the inclusion of full income into the analysis of household food demand will give different policy conclusions than the conventional approach remains of interest. Similarly, it is of interest to determine whether poverty defined in terms of full income will rank households differently than poverty defined in terms of expenditures or expenditures per capita.

DISTRIBUTION OF HOUSEHOLD PURCHASES

While a family probably has a concept of how food will be distributed when it decides how much food will be purchased, the questions of measuring how distribution and purchase affect nutrition are different. The total quantity of food purchased by the household is not a strong predictor of the effect on nutrition if the distribution among family members is unknown and if it differs greatly between households.

[127] I. J. Singh, L. Squire, and John Strauss, eds., Agricultural Household Models: Extensions, Applications and Policy (Baltimore, Md.: Johns Hopkins University Press, 1986).

[128] Lau, Lin, and Yotopoulos, "The Linear Logarithm Expenditure System.

Food distribution within a household may be biased by the sex or age of the recipient. Studies of such biases are reviewed by Lipton and by Carloni.[129] The former concludes that sex-based food discrimination is rare for adults and slightly less rare for children. What evidence exists is mainly from South Asia. As Chen et al. noticed, the effect of sex biases on nutrition reflects differences in the rates of visits to clinics as well as in household food allocations.[130]

There are two approaches to measuring the allocation of food within a household. One is to measure total food consumption and include demographic variables as regressors. The approach presumes that changes in household purchases with changes in demographics reflect the consumption of the different family members. As discussed above, it is not possible to distinguish the commodity weightings indicated by such a model from the total income weightings. So inferences from such a model do not clearly indicate individual intake.

A second approach measures individual family members' intake, either by recall or direct observation. This approach, obviously, has the advantage of using more information, especially if data on activity, illness, pregnancy, and lactation are recorded.[131]

Although both approaches are useful for food and nutrition policy, the issue relevant to this report is the interrelation of demographic variables with price and income parameters. First, as has already been discussed, price and income parameters are estimated with more accuracy when demographic information is included. Second, for the application of the parameters to policy, it is necessary to divide the MPC by the share of food going to the target groups. This, of course, will give lower MPCs (but will not affect elasticities), and these will be lower the more narrowly defined the target group.[132]

An important issue to be studied is whether distribution of food within a household varies during different times of the year or because of other factors. The most commonly proposed view is that the main male laborers increase their share as activities increase in

---

[129] Lipton, Poverty, Undernutrition and Hunger; Alice Stewart Carloni, "Sex Disparities in the Distribution of Food Within Rural Households," Food and Nutrition 7 (No. 1, 1981): 3-12.

[130] Lincoln C. Chen, Emdadul Huq, and Stan D'Souza, "Sex Bias in the Family Allocation of Food and Health Care in Rural Bangladesh," Population and Development Review 7 (March 1981): 55-70.

[131] R. Chaudhury, in a personal communication, observed that apparent biases are smaller when differences in activities and not average WHO energy requirements are used to standardize food requirements.

[132] For a discussion of leakages in the specific context of supplementary feeding programs, see George H. Beaton and Hossein Ghassemi, "Supplementary Feeding Programs for Young Children in Developing Countries," American Journal of Clinical Nutrition 34 (December 1982): 864-916.

peak seasons of the agricultural years. If so, women and children, whose activities also increase at this time, see a decline in their share of food. Moreover, each share in these periods may be part of a smaller whole because planting seasons generally coincide with periods of high food prices and low household stores.

A related issue is whether an individual's share of total household consumption is constant no matter what the income is or whether increments in food following an increase in income or a decrease in prices are distributed to or away from already favored members. For example, if a household conceptualizes individual minimum needs and recognizes social aspects of food, it may make efforts to see that all members reach the minimum. After this is achieved, increments may go disproportionately to favored members up to some point of diminishing utility, after which the share to other members will again begin to rise. If shares vary by income group, then $\partial Q_i/\partial Y = (\partial Q_H/\partial Y) \times share_i + (\partial share_i/\partial Y) \times Q_H$. As mentioned, $\partial share_i/\partial Y$ may follow a pattern that is complex and difficult to measure.

Finally, distribution may differ if the head of the household is a woman. This issue parallels the discussion above. It has, in addition, the problem of measuring distribution when most household demographics are not representative of the general population.

9. CONCLUSIONS AND RESEARCH RECOMMENDATIONS

A general pattern in which the absolute value of price elasticities declines has been observed for five commodity groups using a variety of estimation techniques. Most of these estimations were made with cross-sectional data, but similar patterns and sizes of results were observed using time-series data or combinations of time-series and cross-sectional data. Furthermore, a pattern of high income elasticities for food expenditures and lower elasticities for calories has been observed for a number of countries.

Two sets of recommendations can be made. One set is intended for planners who intend to apply price and income parameters to food policy analysis. The other is intended for analysts estimating such parameters. The former were included at the end of Part 1. The latter are below.

The implications of price elasticities derived from cross-sectional data need to be explored more fully. Central to the estimation of price parameters from cross-sectional data is the problem of the quality of commodities. How quality should be defined or measured is not clear, nor is the nature of the substitution between it and quantity. Until both theoretical and empirical work are done in this area, the meaning of cross-sectional estimates will be controversial. A few countries, including Bangladesh, Egypt, India, Indonesia, Philippines, and Sri Lanka, have conducted national household expenditure surveys for a number of years. While this study examines some analyses of combinations of time-series and cross-sectional analysis of such data, the potential is largely untapped. This is, in part, because of the difficulty of getting access to the relevant surveys, particularly in disaggregate form, and because the cost of analysis is often high.

An alternative and related approach would be to collect panel data. This is expensive, although national coverage with tens of thousands of households need not be undertaken. What is needed, at least initially, are studies of whether responses measured in such a manner differ from cross-sectional or aggregate time-series analyses. This need not be done on a national scale. In this respect, first-difference techniques or techniques of varying parameters could be explored.

Most developing countries intervene in the food allocation process. Many of these interventions create dual price systems, quantity restrictions, or similar market disequilibria. In such situations, consumer demand cannot be characterized in terms of price and income responses alone. Both the econometric consequences and the policy implications of these types of markets are largely unexplored.

When markets do not clear by price mechanisms, price policies may fail to achieve their objectives. Recognition of the characteristics of such markets and refinement of techniques to measure demand in such environments, then, should be a priority of applied research on consumer demand.

The returns to increased understanding of the distribution of food within the family and of the dynamics of budget allocation, especially in complex families, are surely high. This requires innovations in data collection and techniques to measure differences in parameters by source of income or type of household. This is especially true for the new concern with the role of women, but it also applies to household size and the birth order and sex of infants. Similarly, studies of in-kind transfers are fragmentary and likely to benefit from increased attention.

It is particularly important to include cross-price responses in the analysis of food policy. As aggregation of commodities generally obscures the effects of a number of specific policy instruments, it is important to continue to explore techniques that aid in estimating cross-prices. These include flexible functional forms, perhaps using combined time-series and cross-sectional data.

As the consequences of the collinearity of regressors depend in part on the variance of the dependent variable, it is useful to explore estimates of total calories consumed regressed on a set of food prices. These results should be compared to the effect elasticities estimated from individual commodities have on the number of calories consumed.

Such explorations can help ally practical policy-oriented research closely to theory with no sacrifice of applicability.

APPENDIX: SUPPLEMENTARY TABLES

Table 11--Meat product elasticities

Country/Study	Income	Income Elasticity	Absolute Value of Uncompensated Elasticity ($\lvert E_{ii} \rvert$)	Absolute Value of Compensated Elasticity ($\lvert e_{ii} \rvert$)
Colombia				
Pinstrup-Andersen et al. (1976)	10.374	1.52	1.46	1.30
	18.564	1.35	1.30	1.16
	27.339	0.99	0.99	0.87
	53.196	0.67	0.69	0.63
	122.109	0.47	0.50	0.45
	10.374	1.94	1.89	1.83
	18.564	1.65	1.61	1.55
	27.339	1.12	1.12	1.08
	53.196	0.82	0.82	0.79
	122.109	0.69	0.70	0.68
United States				
Thomson	36.853	0.20	0.15	0.15
	100.832	0.21	0.10	0.10
	159.057	0.25	0.11	0.11
	292.632	0.20	0.07	0.07
Bangladesh				
Ahmed	11.866	1.51	0.65	0.55
	20.876	1.14	0.48	0.37
Pitt	5.100	0.50	0.66	0.62
	25.500	1.02	0.97	0.90
Thailand				
Trairatvorakul	13.300	0.70	2.21	2.17
	28.000	0.58	0.00	0.00
	54.040	0.40	0.00	0.00
	13.300	0.42	7.18	7.16
	28.000	0.48	0.00	0.00
	54.040	0.23	2.25	2.24
Brazil				
Williamson-Gray	24.852	1.45	2.35	2.25
	53.656	0.74	1.29	1.25
	245.784	0.15	0.82	0.82
Sierra Leone				
Strauss	8.865	1.00	1.29	1.17
	14.400	0.92	0.92	0.84
	22.230	0.64	0.81	0.76

(continued)

Table 11--Continued

Country/Study	Income	Income Elasticity	Absolute Value of Uncompensated Elasticity ($\lvert E_{ii} \rvert$)	Absolute Value of Compensated Elasticity ($\lvert e_{ii} \rvert$)
Sudan				
Pinstrup-Andersen et al. (1983)	15.479	1.03	1.04	0.90
	19.665	0.97	0.92	0.79
	28.405	0.21	0.34	0.32
Sri Lanka				
Sahn (1984)	13.508	2.17	1.68	1.58
	70.422	0.50	0.35	0.32

Sources: Complete reference information for these studies is in the bibliography.

Notes: Insignificant results are reported as zero.
Income was adjusted for purchasing power parity.

Table 12--Rice elasticities

Country/Study	Income	Income Elasticity	Absolute Value of Uncompensated Elasticity ($\lvert E_{ii} \rvert$)	Absolute Value of Compensated Elasticity ($\lvert e_{ii} \rvert$)
Colombia				
Pinstrup-Andersen et al. (1976)	10.374	0.42	0.43	0.40
	18.564	0.39	0.40	0.38
	27.339	0.39	0.40	0.39
	53.196	0.26	0.26	0.25
	122.109	0.19	0.19	0.19
Indonesia				
Timmer and Alderman	5.148	1.16	1.92	1.49
	8.352	0.92	1.47	1.12
	13.068	0.68	1.16	0.94
	30.222	0.28	0.74	0.68
Dixon	14.550	0.33	0.31	0.19
	36.420	0.11	0.56	0.53
	93.480	-0.12	0.00	0.00
	8.944	0.83	1.28	1.03
	19.856	0.48	0.45	0.35
	44.688	0.13	0.18	0.16
United States				
Thomson	36.853	0.23	0.84	0.84
	100.832	0.03	0.09	0.09
	159.057	0.05	0.04	0.03
	292.632	0.02	0.03	0.03
Bangladesh				
Ahmed	11.866	0.87	0.62	0.20
	20.876	0.57	0.38	0.16
Pitt	5.100	1.19	1.30	0.57
	20.876	0.94	0.83	0.26
Thailand				
Trairatvorakul	13.300	0.41	0.74	0.64
	28.000	0.08	0.71	0.70
	54.040	0.00	0.46	0.46
Philippines				
Bouis	6.096	0.10	0.73	0.11
	14.064	0.10	0.69	0.67
	22.656	0.20	0.68	0.64
	53.184	0.00	0.40	0.40

(continued)

Table 12--Continued

Country/Study	Income	Income Elasticity	Absolute Value of Uncompensated Elasticity ($\lvert E_{ii} \rvert$)	Absolute Value of Compensated Elasticity ($\lvert e_{ii} \rvert$)
Brazil				
Williamson-Gray	24.852	0.85	4.31	4.25
	53.656	0.30	2.95	2.94
	245.784	-0.22	1.15	1.15
Sierra Leone				
Strauss	8.865	0.88	2.16	1.93
	14.400	0.67	0.78	0.62
	22.230	0.08	0.45	0.43
India				
Murty and Radha-krishna	5.680	1.05	1.39	1.05
	9.700	0.95	1.27	0.95
	14.780	0.81	0.69	0.42
	25.320	0.47	0.48	0.35
	65.060	0.34	0.39	0.32
	4.966	1.07	1.23	0.86
	9.048	0.84	1.14	0.87
	14.820	0.48	0.66	0.51
	25.428	0.20	0.29	0.24
	64.116	0.13	0.21	0.19
Murty	5.680	0.97	0.92	0.33
	9.700	0.89	0.78	0.28
	14.780	0.77	0.54	0.15
	25.320	0.44	0.20	0.03
	65.060	0.32	0.33	0.25
	4.966	0.96	0.89	0.41
	9.048	0.75	0.73	0.39
	14.820	0.49	0.36	0.17
	25.428	0.14	0.15	0.11
	64.116	0.15	0.18	0.16
Sri Lanka				
Sahn	12.508	0.68	0.70	0.49
	70.420	0.15	0.67	0.65

Sources: Complete reference information for these studies is in the bibliography.

Notes: Insignificant results are reported as zero.
Income was adjusted for purchasing power parity.

Table 13--Wheat and bread elasticities

Country/Study	Income	Income Elasticity	Absolute Value of Uncompensated Elasticity ($\lvert E_{ii} \rvert$)	Absolute Value of Compensated Elasticity ($\lvert e_{ii} \rvert$)
United States				
Thomson	36.853	0.10	0.16	0.16
	100.832	0.03	0.17	0.17
	159.057	0.05	0.27	0.27
	292.632	0.04	0.22	0.22
Brazil				
Williamson-Gray	24.852	1.09	1.96	1.91
	53.656	1.23	0.84	0.81
	245.784	1.45	0.73	0.73
Bangladesh				
Pitt	5.100	-0.10	0.72	0.73
	25.500	-0.24	0.06	0.06
Sudan				
Pinstrup-Andersen et al. (1983)	15.479	0.89	0.91	0.84
	19.665	0.78	0.74	0.69
	28.405	0.14	0.22	0.21
Sri Lanka				
Sahn	12.508	0.77	0.85	0.83
	70.420	0.09	0.85	0.85

Sources: Complete reference information for these studies is in the bibliography.

Notes: Insignificant results are reported as zero.
Income was adjusted for purchasing power parity.

Table 14--Coarse grain elasticities

Country/Study	Income	Income Elasticity	Absolute Value of Uncompensated Elasticity ($\lvert E_{ii} \rvert$)	Absolute Value of Compensated Elasticity ($\lvert e_{ii} \rvert$)
Colombia				
Pinstrup-Andersen et al. (1976)	10.374	0.63	0.63	0.60
	18.564	0.54	0.55	0.53
	27.339	0.44	0.44	0.43
	53.196	-0.26	0.00	0.00
	122.109	-0.43	0.00	0.00
Philippines				
Bouis	6.096	-0.30	1.37	1.40
	14.064	-0.56	1.53	1.56
	22.656	-0.50	1.47	1.49
	53.184	-0.10	1.32	1.32
Brazil				
Williamson-Gray	24.852	0.33	1.77	1.77
	53.656	0.15	1.09	1.09
	245.784	0.04	0.58	0.58
India				
Murty	5.680	1.25	2.29	2.19
	9.700	1.03	1.94	1.86
	14.780	0.40	0.68	0.66
	25.320	0.25	0.57	0.56
	65.060	0.36	0.96	0.95
	5.680	1.08	2.18	2.15
	9.700	1.22	2.44	2.41
	14.780	0.43	0.74	0.73
	25.320	0.59	1.28	1.27
	65.060	0.36	0.96	0.95
	4.966	0.70	1.54	1.49
	9.048	0.55	1.53	1.49
	14.820	0.53	1.95	1.93
	25.428	0.09	1.37	1.37
	64.116	0.10	1.16	1.16
	4.966	0.92	2.11	2.09
	9.048	0.72	2.10	2.09
	14.820	0.33	1.29	1.28
	25.428	0.07	1.00	1.00
	64.116	0.08	0.99	0.99

(continued)

Table 14--Continued

Country/Study	Income	Income Elasticity	Absolute Value of Uncompensated Elasticity ($\lvert E_{ii} \rvert$)	Absolute Value of Compensated Elasticity ($\lvert e_{ii} \rvert$)
Sudan				
Pinstrup-Andersen et al. (1983)	15.479	0.43	0.45	0.43
	19.665	0.33	0.32	0.31
	28.405	0.18	0.29	0.29

Sources: Complete reference information for these studies is in the bibliography.

Notes: Insignificant results are reported as zero.
Income was adjusted for purchasing power parity.

Table 15--Root crop elasticities

Country/Study	Income	Income Elasticity	Absolute Value of Uncompensated Elasticity ($\lvert E_{ii} \rvert$)	Absolute Value of Compensated Elasticity ($\lvert e_{ii} \rvert$)
Colombia				
Pinstrup-Andersen et al. (1976)	10.374	0.22	0.23	0.22
	18.564	0.27	0.28	0.27
	27.339	0.24	0.25	0.25
	53.196	-0.41	0.00	0.00
	122.109	-0.44	0.00	0.00
Indonesia				
Timmer and Alderman	5.148	0.99	1.28	1.25
	8.316	0.68	0.82	0.81
	13.068	0.39	0.94	0.93
	30.222	-0.08	0.78	0.78
Dixon	8.944	0.85	1.09	1.06
	19.856	0.86	0.82	0.80
	44.688	-0.63	0.67	0.68
	8.944	0.83	2.49	2.46
	19.856	-1.02	2.06	2.08
	44.688	-2.90	1.00	1.04
Brazil				
Williamson-Gray	24.852	0.71	1.36	1.34
	53.656	0.50	0.76	0.76
	245.784	0.09	0.23	0.23
Bangladesh				
Pitt	5.100	1.61	1.68	1.66
	25.500	1.88	0.96	0.94
Sierra Leone				
Strauss	8.865	0.60	0.15	0.12
	14.400	1.00	0.26	0.20
Sri Lanka				
Sahn	12.508	1.07	1.33	1.31
	70.420	1.27	1.24	1.23

Sources: Complete reference information for these studies is in the bibliography.

Notes: Insignificant results are reported as zero.
Income was adjusted for purchasing power parity.

Table 16--Milk product elasticities

Country/Study	Income	Income Elasticity	Absolute Value of Uncompensated Elasticity ($\lvert E_{ii} \rvert$)	Absolute Value of Compensated Elasticity ($\lvert e_{ii} \rvert$)
Colombia				
Pinstrup-Andersen et al. (1976)	10.374	1.83	1.79	1.74
	18.564	1.65	1.62	1.57
	27.339	1.13	1.12	1.07
	53.196	0.63	0.64	0.62
	122.109	0.20	0.20	0.20
United States				
Rosenberger	11.508	0.87	2.10	2.08
	34.387	0.70	1.29	1.29
	57.540	0.66	1.14	1.14
	80.419	0.59	1.03	1.03
	103.435	0.54	0.84	0.84
	126.451	0.48	0.77	0.77
	149.467	0.47	0.59	0.69
	172.483	0.44	0.67	0.67
	195.499	0.45	0.65	0.65
	218.515	0.43	0.59	0.59
	247.148	0.46	0.55	0.55
	310.442	0.41	0.50	0.50
	459.909	0.46	0.00	0.00
	574.852	0.47	0.22	0.22
Thomson	36.853	0.41	1.58	1.58
	100.832	0.21	1.01	1.00
	159.057	0.16	0.52	0.52
	292.632	0.13	0.63	0.63
Bangladesh				
Pitt	5.100	2.52	1.08	1.02
	25.500	1.91	0.25	0.20
Sudan				
Pinstrup-Andersen et al. (1983)	15.479	0.94	0.96	0.90
	19.665	1.04	0.97	0.91
	28.405	0.35	0.56	0.54

(continued)

Table 16--Continued

Country/Study	Income	Income Elasticity	Absolute Value of Uncompensated Elasticity ($\lvert E_{ii} \rvert$)	Absolute Value of Compensated Elasticity ($\lvert e_{ii} \rvert$)
India				
Murty	5.680	1.75	2.40	2.35
	9.700	2.34	1.13	1.04
	14.780	1.89	0.88	0.79
	25.320	1.48	0.81	0.79
	65.060	0.67	0.69	0.66
	4.966	1.65	1.16	1.13
	9.048	2.06	0.66	0.60
	14.820	1.84	1.06	1.00
	25.428	1.45	1.12	1.00
	64.116	0.87	1.03	1.00
Sri Lanka				
Sahn	12.508	2.14	2.10	2.08
	70.420	1.62	1.39	1.36

Sources: Complete reference information for these studies is in the bibliography.

Notes: Insignificant results are reported as zero.
Income was adjusted for purchasing power parity.

BIBLIOGRAPHY

Aaness, Jørgen and Rodseth, Asbjørn. "Engel Curves and Systems of Demand Functions." European Economic Review 20 (January 1983): 95-121.

Adrian, John and Daniel, Raymond. "Impact of Socioeconomic Factors on Consumption of Selected Food Nutrients in the United States." American Journal of Agricultural Economics 58 (February 1976): 31-38.

Ahmed, Raisuddin. Agricultural Price Policies under Complex Socioeconomic and Natural Constraints: The Case of Bangladesh. Research Report 27. Washington, D.C.: International Food Policy Research Institute, 1981.

Akin, John S.; Guilkey, David K.; and Popkin, Barry M. "The School Lunch Program and Nutrient Intake: A Switching Regression Analysis." American Journal of Agricultural Economics 65 (August 1983): 477-485.

Alderman, Harold and Braun, Joachim von. The Impact of the Egyptian Food Ration and Subsidy System on Income Distribution and Welfare. Research Report 45. Washington, D.C.: International Food Policy Research Institute, 1984.

Ashenfelter, O.; Deaton, Angus; and Solon, G. "Does It Make Sense to Collect Panel Data for Developing Countries?" Woodrow Wilson School of Public and International Affairs Discussion Paper 119. Princeton University, Princeton, N.J., 1985.

Barten, Anton P. "Family Composition Prices and Expenditure Patterns." In Economic Analysis for National Economic Planning, pp. 277-292. Edited by P. Hart, G. Mills, and J. Whitaker. Woburn, Mass.: Butterworth Publishers, Inc., 1964.

__________. "The Systems of Consumer Demand Functions Approach: A Review." Econometrica 45 (January 1977): 23-51.

Beaton, George H. "Energy in Human Nutrition: Perspective and Problems." Nutrition Reviews 41 (1983): 325-340.

Beaton, George H. and Ghassemi, Hossein. "Supplementary Feeding Programs for Young Children in Developing Countries." American Journal of Clinical Nutrition 34 (December 1982): 864-916.

Behrman, Jere B. and Wolfe, Barbara L. "More Evidence on Nutrition Demand: Income Seems Overrated and Women's Schooling Underemphasized." Journal of Development Economics 14 (January-February 1984): 105-128.

Betancourt, R. "The Estimation of Price Elasticities under Additive Preferences." International Economic Review 12 (1971): 283-292.

Blanciforti, Laura and Green, Richard. "An Almost Ideal Demand System Incorporating Habits: An Analysis of Expenditures on Food and Aggregate Commodity Groups." Review of Economics and Statistics 65 (August 1983): 511-515.

Blaylock, J. and Green, R. "Analysis of Flexible Engel Functions." Agricultural Economics Research 32 (October 1980): 12-20.

Brandt, Jon A. and Goodwin, Joseph B. "The Impact of Increasing Food Supply on Human Nutrition--Implications for Commodity Priorities in Agricultural Research and Policy: Comment." American Journal of Agricultural Economics 62 (August 1980): 588-591.

Brown, Alan and Deaton, Angus. "Models of Consumer Behavior: A Survey." Economic Journal 82 (December 1972): 1145-1236.

Bouis, Howarth. "Rice Policy in the Philippines." Ph.D. dissertation, Stanford University, 1982.

________. "If There is Curvature in the Slutsky Matrix, What Do the Curves Look Like?" International Food Policy Research Institute, Washington, D.C., 1983 (mimeographed).

Carloni, Alice Stewart. "Sex Disparities in the Distribution of Food Within Rural Households." Food and Nutrition 7 (No. 1, 1981): 3-12.

Chen, Lincoln C.; Huq, Emdadul; and D'Souza, Stan. "Sex Bias in the Family Allocation of Food and Health Care in Rural Bangladesh." Population and Development Review 7 (March 1981): 55-70.

Christensen, Laurits R.; Jorgensen, Dale W.; and Lau, Lawrence J. "Transcendental Logarithmic Utility Functions." American Economic Review 65 (June 1975): 367-383.

Cramer, J. S. "Efficient Grouping, Regression, and Correlation in Engel Curve Analysis." Journal of the American Statistical Association 57 (1962).

________. "Interaction of Income and Price in Consumer Demand." International Economic Review 14 (June 1973): 351-363.

Deaton, Angus. "Inequality and Needs: Some Experimental Results for Sri Lanka." Population and Development Review, Supplement to Volume 8 (1983): 35-49.

________. "Involuntary Savings Through Unanticipated Inflation." American Economic Review 67 (December 1977): 899-910.

________. "A Reconsideration of the Empirical Implication of Additive Preferences." Economic Journal 84 (June 1974): 338-348.

________. "Specification and Testing in Applied Demand Analysis." Economic Journal 88 (September 1978): 524-536.

________. "The Measurement of Income and Price Elasticities." European Economic Review 6 (1975): 261-274.

________. "Theoretical and Empirical Approaches to Consumer Demand Under Rationing." In Essays on the Theory and Measurement of Consumer Behavior, in Honor of Sir Richard Stone, pp. 55-72. Edited by Angus Deaton. New York: Cambridge University Press, 1981.

________. Three Essays on a Sri Lanka Household Survey. Living Standards Measurement Study, Working Paper 11. Washington, D.C.: World Bank, 1981.

Deaton, Angus and Muellbauer, John. "An Almost Ideal Demand System." American Economic Review 70 (1980): 312-326.

________. Economics and Consumer Behavior. New York: Cambridge University Press, 1980.

Deaton, Angus; Ruiz-Castillo, Javier; and Thomas, Duncan. "The Influence of Household Composition on Household Expenditure Patterns: Theory and Spanish Evidence." Research Program in Development Studies, Discussion Paper No. 112. Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, N. J., September 1985.

Disch, A. "Agricultural Policies and Real Income Changes: An Application of Duality Theory to Brazilian Agriculture." Ph.D. dissertation, Yale University, 1983.

Dixon, John A. Food Consumption Patterns and Related Demand Parameters in Indonesia: A Review of Available Evidence. Rice Policies in Southeast Asia Project Working Paper 6. Washington, D.C.: International Food Policy Research Institute, 1982.

Dynarski, Mark and Sheffrin, Steven M. "Housing Purchases and Transitory Income: A Study with Panel Data." Review of Economics and Statistics 67 (May 1985): 195-204.

Edirisinghe, Neville and Poleman, T. T. "Behavior Thresholds as Indicators of Perceived Dietary Adequacy or Inadequacy." International Agricultural Economics Study 17. Cornell University, Ithaca N.Y., 1983.

Frisch, Ragnar. "A Complete Scheme for Computing all Direct and Cross Demand Elasticities in a Model with Many Sectors." Econometrica 27 (April 1959): 177-196.

George, P. S. and King, G. _Consumer Demand for Food Commodities in the United States with Projections for 1980._ Giannini Foundation Monograph 26. Davis, Cal.: University of California, 1971.

Goldberger, A. S. "Linear Regression After Selection." _Journal of Econometrics_ 15 (April 1981): 356-366.

Goldman, Steven Marc and Uzawa, Hirofumi. "A Note on Separability in Demand Analysis." _Econometrica_ 32 (July 1964): 387-398.

Greene, William H. "On the Asymptotic Bias of the Ordinary Least Squares Estimator of the Tobit Model." _Econometrica_ 49 (March 1981): 505-513.

Griliches, Zvi; Hall, B.; and Hausman, J. "Missing Data and Self-Selection on Large Panels." _Annales de L'INSEE_ 30-31 (1978): 137-176.

Guyer, Jane I. "Household Budgets and Women's Incomes." Working Paper 28, African Study Center, Boston University, Boston, Mass., 1980.

Hausman, J. A. and Wise, D. A. "Discontinuous Budget Constraints and Estimation: The Demand for Housing." _Review of Economic Studies_ 47 (January 1980): 75-96.

Hazell, Peter B. R. and Röell, Ailsa. _Rural Growth Linkages: Household Expenditure Patterns in Malaysia and Nigeria._ Research Report 41. Washington, D.C.: International Food Policy Research Institute, 1983.

Heckman, James J. "Sample Selection Bias as a Specification Error." _Econometrica_ 47 (January 1979): 153-161.

Houthakker, Hendrik S. "An International Comparison of Household Expenditure Patterns, Commemorating the Centenary of Engel's Law." _Econometrica_ 25 (October 1957): 532-551.

Howe, Howard. "Cross-Section Application of Linear Expenditure Systems: Response to Sociodemographic Effects." _American Journal of Agricultural Economics_ 59 (February 1977): 141-148.

Jackson, Laurence Fraser. "Hierarchic Demand and the Engel Curve for Variety." _Review of Economics and Statistics_ 66 (February 1984): 8-15.

Janvry, Alain de; Bieri, J.; and Nunez, A. "Estimations of Demand Parameters Under Consumer Budgeting: An Application to Argentina." _American Journal of Agricultural Economics_ 54 (August 1972): 422-430.

Jones, Christine. "The Mobilization of Women's Labor for Cash Crop Production: A Game Theoretic Approach." _American Journal of Agricultural Economics_ 65 (December 1983): 1049-1059.

Judge, G.; Griffith, W.; Hill, R.; and Lee, T. The Theory and Practice of Econometrics. New York: John Wiley and Sons, 1980.

Kakwani, N. C. "On the Estimation of Engel Elasticities from Grouped Observations with Application to Indonesian Data." Journal of Econometrics 6 (July 1977): 1-19.

King, Richard A. "Choices and Consequences." American Journal of Agricultural Economics 61 (December 1979): 839-848.

King, Richard A. and Byerlee, Derek. "Factor Intensities and Locational Linkages of Rural Consumption Patterns in Sierra Leone." American Journal of Agricultural Economics 60 (May 1978): 197-208.

Kinsey, Jean. "Working Wives and the Marginal Propensity to Consume Food Away from Home." American Journal of Agricultural Economics 65 (February 1983): 10-19.

Knudsen, Odin K. and Scandizzo, Pasquale, L. Nutrition and Food Needs in Developing Countries. Staff Working Paper 328. Washington, D.C.: World Bank, 1979.

______. "The Demand for Calories in Developing Countries." American Journal of Agricultural Economics 64 (February 1982): 80-86.

Kuh, Edwin. "The Validity of Cross-Sectionally Estimated Behavior Equations in Time Series Applications." Econometrica 27 (April 1959): 197-214.

Kumar, Shubh K. Impact of Subsidized Price on Food Consumption and Nutrition in Kerala. Research Report 5. Washington, D.C.: International Food Policy Research Institute, 1979.

Lau, Lawrence J. "Complete Systems of Consumer Demand Functions through Duality." In Frontiers of Quantitative Economics, vol. 3. Edited by M. Intriligator. New York: North-Holland, 1977, pp. 59-85.

Lau, Lawrence J.; Lin, W. L.; and Yotopolous, P. A. "The Linear Logarithmic Expenditure System: An Application to Consumption-Leisure Choice." Econometrica 46 (July 1978): 843-868.

Lipton, Michael. Poverty, Undernutrition and Hunger. Staff Working Paper 597. Washington, D.C.: World Bank, 1983.

Lluch, C. "Consumer Demand Functions for Spain, 1958-64." European Economic Review 2 (1971).

Maddala, G. S. Econometrics. New York: McGraw-Hill, 1977.

______. Limited Dependent and Qualitative Variables on Econometrics. Cambridge: Cambridge University Press, 1983.

Massell, Benton F. "Consistent Estimation of Expenditure Elasticities from Cross-Section Data on Households Producing Partly for Subsistence." Review of Economics and Statistics 51 (May 1969): 136-142.

McCarthy, F. Desmond. "Food Consumption, Income Distribution and Quality Effect." Food Policy 2 (February 1977): 79-82.

McCarthy, F. Desmond and Taylor, Lance. "Macro Food Policy Planning: A General Equilibrium Model for Pakistan." Review of Economics and Statistics 62 (February 1980): 107-121.

McDonald, John F. and Moffit, Robert A. "The Uses of Tobit Analysis." Review of Economics and Statistics 62 (May 1980): 318-321.

Mellor, John W. "Food Price Policy and Income Distribution in Low-Income Countries." Economic Development and Cultural Change 27 (October 1978): 1-26.

______. The New Economics of Growth: A Strategy for India and the Developing World. Ithaca, N.Y.: Cornell University Press, 1976.

Muellbauer, John. "Aggregation, Income Distribution, and Consumer Demand." Review of Economic Studies 62 (October 1975): 525-543.

Mundlak, Yair. "On the Concept of Non-Significant Functions and Its Implication for Regression Analysis." Journal of Econometrics 16 (May 1981): 139-149.

______. "On the Pooling of Time Series and Cross-Section Data." Econometrica 46 (January 1978): 69-85.

Murty, K. N. Consumption and Nutrition Patterns of ICRISAT Mandate Crops in India. Economic Program Progress Report 53. Patancheru: International Crops Research Institute for the Semi-Arid Tropics, 1983.

Murty, K. N. and Radhakrishna, R. "Agricultural Prices, Income Distribution and Demand Patterns in a Low-Income Country." Paper presented at the First International Working Conference on Computer Applications in Food Production and Agricultural Engineering, Havana, Cuba, October 1981.

Nasse, P. "Analyse des Effets de Substitutions dans un Systeme Complet de Fonctions de Demande." Annales de L'INSEE 5 (1970): 88-110.

Olsen, R. J. "A Least Squares Correction for Selectivity Bias." Econometrica 48 (November 1980): 1815-1820.

Peterson, Willis L. "International Farm Prices and the Social Cost of Cheap Food Policies." American Journal of Agricultural Economics 61 (February 1979): 12-21.

Phlips, Louis. Applied Consumption Analysis. New York: North Holland Press, 1974.

Pinstrup-Andersen, Per. "Decision-Making on Food and Agricultural Research Policy: The Distribution of Benefits from New Agricultural Technology Among Consumer Income Strata." Agricultural Administration 14 (January 1977): 13-25.

Pinstrup-Andersen, Per and Caicedo, Elizabeth. "The Potential Impact of Changes in Income Distribution on Food Demand and Human Nutrition." American Journal of Agricultural Economics 60 (August 1978): 402-412.

Pinstrup-Andersen, Per; Londoño, Norha Ruiz de; and Hoover, Edward. "The Impact of Increasing Food Supply on Human Nutrition: Implications for Commodity Priorities in Agricultural Research and Policy." American Journal of Agricultural Economics 58 (May 1976): 131-142.

Pinstrup-Andersen, Per; Braun, Joachim von; Uy, Tongjit; and Floro, Winifred. "Impact of Changes in Income and Food Prices on Food Consumption by Low-Income Households in Urban Khartoum with Emphasis on the Effect of Changes in Wheat Bread Prices." International Food Policy Research Institute, Washington, D.C., 1983 (mimeographed).

Pitt, Mark M. "Food Preferences and Nutrition in Rural Bangladesh." Review of Economics and Statistics 65 (February 1983): 105-114.

Pollak, Robert A. "Conditional Demand Functions and Consumption Theory." Quarterly Journal of Economics 83 (February 1969): 60-78.

__________. "Conditional Demand Functions and the Implications of Separable Utility." Southern Economic Journal 37 (April 1971): 423-433.

__________. "Habit Formation and Dynamic Demand Functions." Journal of Political Economy 78 (July-August 1970): 745-763.

__________. "Habit Formation and Long-Run Utility Functions." Journal of Economic Theory 13 (October 1976): 272-297.

Pollak, Robert A. and Wachter, Michael, L. "The Relevance of the Household Production Function and Its Implications for the Allocation of Time." Journal of Political Economy 83 (April 1975): 255-277.

Pollak, Robert A. and Wales, Terence J. "Demographic Variables in Demand Analysis." Econometrica 49 (November 1981): 1533-1551.

_______. "Estimation of Complete Demand Systems from Household Budget Data: The Linear and Quadratic Expenditure Systems." American Economic Review 68 (June 1978): 348-359.

Powell, A. Empirical Analytics of Demand Systems. Lexington, Mass.: D. C. Heath and Co., 1974.

Prais, S. J. and Houthakker, Hendrik S. The Analysis of Family Budgets. Cambridge: Cambridge University Press, 1971.

Quandt, Richard E. "A New Approach to Estimating Switching Regressions." Journal of the American Statistical Association 67 (June 1972): 306-316.

Rao, V. V. B. "Measurement of Deprivation and Poverty Based on the Proportion Spent on Food: An Exploratory Exercise." World Development 9 (April 1981): 337-354.

Ray, R. "The Testing and Estimation of Complete Demand Systems on Household Budget Surveys: An Application of AIDS." European Economic Review 17 (March 1982): 349-369.

Reutlinger, Shlomo and Selowsky, Marcelo. Malnutrition and Poverty. Baltimore, Md.: Johns Hopkins University Press, 1976.

Rogers, Beatrice L. "The Internal Dynamics of Households: A Critical Factor in Development Policy." Paper Submitted to U.S. Agency for International Development, October 1983.

Rosenberger, A. "The Impact of the Federal Milk Marketing Order System on Dairy Product Consumption." M. A. thesis, Cornell University, 1978.

Sahn, David E. "Food Consumption Patterns and Parameters in Sri Lanka: The Causes and Control of Malnutrition." International Food Policy Research Institute, Washington, D.C., 1985.

Sahn, David E. and Alderman, Harold. "Testing for Differences in the Marginal Propensity to Consume From Income Earned by Men and Women." International Food Policy Research Institute, Washington, D.C., September 1984 (mimeographed).

Samuelson, Paul. "Social Indifference Curves." Quarterly Journal of Economics 60 (February 1956): 1-22.

Scobie, Grant. The Theory of Estimation of Complete Systems of Consumer Demand Equations: An Annotated Bibliography. Economics Special Report 56. Raleigh, N. C.: North Carolina State University, 1980.

Selowsky, Marcelo. "Target Group-Oriented Food Programs: Cost Effectiveness Comparisons." American Journal of Agricultural Economics 61 (December 1979): 988-999.

Sen, A. K. Levels of Poverty: Policy and Change. World Bank Staff Working Paper 401. Washington, D.C.: World Bank, 1980.

Senauer, Benjamin; Sahn, David, E.; and Alderman, Harold. "The Effect of the Value of Time on Food Consumption Patterns in Developing Countries: Evidence from Sri Lanka." International Food Policy Research Institute, Washington, D.C., 1985 (mimeographed).

Singh, I. J.; Squire, L.; and Strauss, John, eds. Agricultural Household Models: Extensions, Applications and Policy. Baltimore, Md.: Johns Hopkins University Press, 1986.

Smith, J., ed. Female Labor Supply. Princeton, N. J.: Princeton University Press, 1980.

Stigler, George J. and Becker, Gary S. "De Gustibus Non Est Disputandum." American Economic Review 67 (March 1977): 76-90.

Strauss, John. "Determinants of Food Consumption in Rural Sierra Leone: Application of the Quadratic Expenditure System to the Consumption-Leisure Component of a Household-Firm Model." Journal of Development Economics 11 (December 1982): 327-354.

________. "Joint Determination of Food Consumption and Production in Rural Sierra Leone: Estimates of a Household-Firm Model." Journal of Development Economics 14 (January-February 1984): 77-103.

Swamy, Gurushri and Binswanger, Hans. "Flexible Consumer Demand Systems and Linear Estimation: Food in India." American Journal of Agricultural Economics 65 (November 1983): 675-684.

Taylor, Lance. Macro Models for Developing Countries. New York: McGraw-Hill, 1979.

Thomson, A. "Nutrition, Food Demand and Policy." Ph.D. dissertation, Stanford University, 1982.

Thurow, Lester C. "Cash Versus In-Kind Transfers." American Economic Review 64 (May 1974): 190-195.

Timmer, C. Peter. "Food Prices and Food Policy Analysis in LDCs." Food Policy 5 (August 1980): 188-199.

________. Is there 'Curvature' in the Slutsky Matrix?" Review of Economics and Statistics 63 (August 1981): 395-402.

Timmer, C. Peter and Alderman, Harold. "Estimating Consumption Parameters for Food Policy Analysis." American Journal of Agricultural Economics 61 (December 1979): 982-987.

Timmer, C. Peter; Falcon, Walter; and Pearson, Scott R. Food Policy Analysis. Baltimore, Md.: Johns Hopkins University Press, 1983.

Tobin, James. "Estimation of Relationships for Limited Dependent Variables." Econometrica 26 (January 1958): 24-36.

________. "On Limiting the Domain of Inequality." Journal of Law and Economics 13 (October 1970): 263-277.

Trairatvorakul, Prasarn. The Effects on Income Distribution and Nutrition of Alternative Rice Price Policies in Thailand, Research Report 46. Washington, D.C.: International Food Policy Research Institute, 1984.

________. "Food Demand and the Structure of the Thai Food System." D.B.A. dissertation. Harvard Graduate School of Business Administration, 1981.

Ward, John O. and Sanders, John H. "Nutritional Determinants and Migration in the Brazilian Northeast: A Case Study of Rural and Urban Ceara." Economic Development and Cultural Change 29 (October 1980): 141-163.

Weisskopf, R. "Demand Elasticities for a Developing Economy." Studies in Development Planning. Edited by Hollis B. Chenery. Cambridge, Mass.: Harvard University Press, 1971.

West, Donald A. and Price, David W. "The Effects of Income, Assets, Food Programs, and Household Size on Food Consumption." American Journal of Agricultural Economics 58 (November 1976): 725-730.

White, H. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." Econometrica 48 (May 1980): 819-838.

Williamson-Gray, Cheryl. Food Consumption Parameters for Brazil and Their Application to Food Policy. Research Report 32. Washington, D.C.: International Food Policy Research Institute, 1982.

Wohlgenant, Michael K. "Conceptual and Functional Form Issues in Estimating Demand Elasticities for Food." American Journal of Agricultural Economics 66 (May 1984): 211-215.

Yetley, Mervin J. and Tun, Sovan. Household Demand Analysis for Assessing Nutritional Impact of Development Programs. Staff Report AGES810806, Agricultural Development Branch, Economic Research Service, U.S. Department of Agriculture. Washington, D.C.: USDA, 1981.

Young, T. "Single Equation Demand Estimation." European Review of Agricultural Economics 9 (No. 1, 1982): 103-105.

Zellner, Arnold. "An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias." Journal of the American Statistical Association 57 (1962): 348-368.

Harold Alderman, a research fellow, joined the International Food Policy Research Institute in February 1981.

IFPRI 1776 MASSACHUSETTS AVENUE, N.W., WASHINGTON, D.C. 20036 U.S.A.