PN-ABD-188
62699

Assessments of Food Demand Trends: Methods and Preliminary Analysis

Technical Paper No. 1

June 1989

Center for Agricultural and Rural Development
Iowa State University

Ministry of Agriculture
Republic of Indonesia

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1. Introduction

Indonesia, like many developing countries, is facing rapidly changing food consumption patterns and changing patterns of food production. Rising Indonesian incomes, as well as economic reforms affecting prices, are changing the structure of consumer demand and creating different food crop requirements. The implications for many agricultural and food policies are significant. Changing consumer demand directly relates to food policy development, projections for food use, regional specialization, the adaptation of secondary food crops, and livestock feed requirements. In addition to changing prices and income, a broad range of socio-demographic factors affect the patterns of food consumption projected for both intermediate and longer term economic planning.

Indonesia has invested in an extensive and high quality series of national consumer expenditure surveys (SUSENAS) from which comprehensive data sets are presently available. These survey sample sizes are sufficiently large to support investigation of regional differences in food consumption and expenditure patterns and for evaluating temporal change. The survey data include detailed information on expenditures and consumption in relation to significant changes which have occurred over the survey period in relative prices and income and in the demographic and socioeconomic composition of the Indonesian population.

The information from the SUSENAS provides the basis for the analysis of changing food demand patterns. Estimated demand parameters can be useful both in developing national models, as well as better understanding projections of aggregate and regional food demand.

This paper provides a review of the economic theory of consumer behavior, methods for incorporating demographic effects in demand analysis,

and proposed methods for implementing the analytic work for Indonesia. Finally, preliminary analysis of three selected provinces has been included to illustrate the use of the SUSENAS data and analytical procedures which are being followed to identify groupings of foods, and other aggregations within the analysis.

2. Review of the Theory of Consumer Behavior

According to the theory of consumer behavior, a decision-making unit, here after "consumer", allocates income among many available commodities in such a manner that the satisfaction (utility) derived from consuming commodities is as large as possible. All the information pertaining to the satisfaction the consumer derives from consuming various commodities is contained in a preference ordering or utility function. This function reflects consumer tastes and preferences over all alternative commodity bundles. However, at any particular time period, only some of these bundles are available to the consumer because of limited income and the conditions under which income can be used to buy commodities.

The consumer choice problem stated above can be formally expressed as follows:

$$\max_{\underline{x}} : \quad u = v(\underline{x}') \qquad (1)$$

$$\text{subject to:} \quad \underline{x}'\underline{p} = y$$

where $\underline{x}' = (x_1, x_2, \ldots, x_r)$ is a commodity bundle, $\underline{P}$ is a rx1 vector of prices associated with the elements of $\underline{x}'$, y is the consumer's total expenditure (income), v(.) is the utility function, and u is the utility level. All prices are presumed fixed, i.e., they are determined by market forces that the consumer cannot influence. Similarly, y is also assumed fixed.

Under certain regularity conditions, the optimization problem (1) can be solved uniquely for $x_1,\ldots,x_r$ in terms of prices and income. The resulting set of Marshallian or "money demand" functions is

$$x_i = x_i\ (\underline{P}', \underline{y})\ ;\quad i = 1,2,\ldots,r \tag{2}$$

These functions specify the quantities of the r commodities that maximize utility for a consumer faced with prices $P_1,\ldots,P_r$ and having income y.

2.1 Demand Functions: General Restrictions

Being the solution to the utility maximization problem (1) the demand functions (2) satisfy a particular set of restrictions, namely,

the homogeneity condition

$$\sum_{j=1}^{r} P_j \frac{\partial x_i}{\partial P_j} + y \frac{\partial x_i}{\partial y} = 0 \qquad (i,\ j = 1,\ 2,\ldots,r), \tag{3}$$

the Engel aggregation

$$\sum_{i=1}^{r} P_i \frac{\partial x_i}{\partial y} = \sum_{i=1}^{r} \frac{\partial (p_i x_i)}{\partial y} = 1, \tag{4}$$

the Cournot aggregation

$$\sum_{i=1}^{r} P_i \frac{\partial x_i}{\partial P_j} = \sum_{i=1}^{r} \frac{\partial (p_i x_i)}{\partial P_j} = -x_j \qquad (i,\ j = 1,\ 2,\ldots,r) \tag{5}$$

and the symmetry condition

$$\frac{\partial x_i}{\partial p_j} + \frac{\partial x_i}{\partial y} x_j = \frac{\partial x_j}{\partial p_i} + \frac{\partial x_j}{\partial y} x_i$$

or

$$k_{ij} = k_{ji} \quad (i,j = 1, 2, \ldots, r). \tag{6}$$

Finally, the substitution terms k_{ij} (in addition to the symmetry condition) also have the following properties:

$$\sum_{j=1}^{r} k_{ij} p_j = 0 \qquad (i, j = 1, 2, \ldots, r) \tag{7}$$

$$k_{ii} < 0 \qquad (i = 1, 2, \ldots, r). \tag{8}$$

The homogeneity, Engel aggregation, and Cournot aggregation conditions result from the fact that the demand functions (2) must satisfy the budget constraint. The homogeneity condition implies what is sometimes referred to as "absence of money illusion", i.e., it implies that a proportionate change in all prices and income will leave the quantities demanded unchanged. The Engel and Cournot aggregation conditions imply that changes in prices and income result in reallocation of quantities that do not violate the budget constraint. The symmetry condition and conditions (7) and (8) are implications of the so-called "Slutsky equation" or "fundamental equation of the theory of value" (Barten, 1964).

The restrictions (3) - (8) apply to any demand system that is obtained by utility maximization. They are always effective, whatever the form of

the utility function, and that is why they are sometimes referred to as "general restrictions". These restrictions are useful in empirical work. First, they provide a means for testing the consistency between the theory and observed consumer behavior. Second, imposition of these restrictions substantially reduces the number of parameters to be estimated for a complete demand system. Finally, from an econometric viewpoint, imposition of these restrictions will result in more efficient parameter estimates. In other words, a restriction, however general, is informative and thus better than no restriction at all.

2.2 Demand Functions: Specific Restrictions

Although the imposition of the general restrictions on a demand system reduces the number of parameters to be estimated, the remaining number of parameters might still be too large for estimation purposes. As a result, more specific demand restrictions are usually imposed. These additional restrictions enter the estimation process in two different fashions. First, certain parameters of the demand functions are set equal to zero. This, so-called ad hoc approach, is equivalent to omitting certain (usually price) variables from the demand functions. The major problem with this approach of imposing restrictions on the demand system is the interpretability of the results, i.e., the results are identified with the researcher and comparison to other studies is difficult if not impossible (Johnson et al., 1984).

The alternative is to return to the optimization decision problem (1) and add additional information in the form of simplified behavioral assumptions, i.e., specify the functional form of the utility function.

The advantage of this approach is that the restrictions are based on behavioral assumptions and that results from one study are comparable to those from other studies using similar approaches.

The most common behavioral assumption used is the assumption that the utility function is separable. The idea of separability is that commodities that possess similar characteristics can be grouped. The fundamental consumption problem then can be viewed as occurring in two or more stages. This process is illustrated in Figure 1. In the first stage, the consumer allocates income among broad groups of commodities. The second stage involves the allocation of group expenditures to the individual commodities within each group (Samuelson, 1947-48). Further stages may follow in the same fashion. Within groups, substitution among commodities is unrestricted, whereas the substitution among commodities belonging to different groups is restricted. The degree to which substitution among commodities belonging to different groups is restricted depends on the type of separability assumed. For the definitions of different types of separability and the restrictions implied by each type on the substitution terms k_{ij}, see Goldman and Uzawa, (1964) or Johnson, et al., (1984).

2.3 Demographic Effects in Demand Analysis

Demographic characteristics are major factors affecting family expenditure patterns. Households differ in size, age-sex composition, race, religion and other characteristics and, in general, other things being equal we expect households with different demographic profiles to have different expenditure patterns.

In general, we can model the effects of household characteristics on demand by assuming that the household demand functions depend not only on prices and total expenditure but also on a set of household characteristics, i.e., the demand functions of a particular household are given by

$$x_i = x_i(\underline{p}', y, \underline{\eta}'); \; i = 1, 2, \ldots, r \tag{9}$$

where x_i is the quantity demanded by the household of the ith commodity, $\underline{p}' = (p_1, p_2, \ldots, p_r)$ is a vector of prices with p_i being the price of the ith commodity, y is total expenditure of the household, and $\underline{\eta} = (\eta_1, \eta_2, \ldots, \eta_s)$ is a vector of household characteristics. A change in the vector of household characteristics $\underline{\eta}'$, <u>ceteris paribus</u>, may result in a change of the quantity demanded of x_i, as well as a change in the shape and location of the demand function itself.

The underlying assumption behind the demand functions (9) is that households of different characteristics have different preferences. The demand functions (9) are then derived from a utility maximization problem in which the household maximizes its utility function, conditional on these characteristics, subject to its budget constraint; i.e., the demand functions (9) are the solution to the following maximization problem

$$\begin{aligned} &\text{maximize:} \quad u = v(\underline{x}' \mid \underline{\eta}') \\ &\text{subject to:} \quad \underline{x}'\underline{p} = y \end{aligned} \tag{10}$$

where $\underline{x}' = (x_1, x_2, \ldots, x_r)$ is a vector of quantities for the r commodities available to the household. It is assumed that the household views $\underline{p}'$, y, and $\underline{\eta}'$ as fixed.

As the solution to the utility maximization problem (10), the demand functions (9) satisfy the usual restrictions, i.e., equations (3) - (8). Regarding the effects of a change in the vector of household characteristics, we notice that

$$\sum_{i=1}^{r} p_i \frac{\partial x_i}{\partial \eta_k} = \sum_{i=1}^{r} \frac{\partial (p_i x_i)}{\partial \eta_k} = 0; \; k = 1, 2, \ldots, s \tag{11}$$

i.e., a change in η_k, <u>ceteris paribus</u>, causes a reallocation of expenditure among the consumption categories. Since total expenditure remains unchanged, any increases in the consumption of some commodities must be balanced by decreases in the consumption of others. In general, the sign of the effect on $p_i x_i$ of a change in η_k cannot be determined <u>a priori</u>.

There are two basic approaches to proceed with the estimation of the demand functions (9). First, all households in the sample can be partitioned in groups such that each group is comprised of households with homogeneous characteristics. Then, separate demand functions of the form $x_i = x_i(\underline{p}', y)$ can be estimated individually or as a system within each group. This approach allows all of the parameters of the demand system to depend on household characteristics but does not require us to specify the form of the relationship between these parameters and the household characteristics. The main drawback of this approach is that it requires extensive data. The substantial variations in household characteristics require a large number of sample partitions and a sufficient number of observations within each partition for reliable parameter estimates.

With the second approach, the demand system (9) is estimated by introducing assumptions which relate the behavior of households with different characteristics. This approach can be decomposed into two separate but interrelated steps. In the first step, the parameters of the demand system that depend on household characteristics are specified. In the second step the functional form relating each of these parameters to the household characteristics is specified. Under this approach only a subset of the parameters of the demand system depend on the household characteristics; and also inferences can be made about households with a particular set of characteristics from observations on households with different sets of characteristics, a type of inference that is not possible under the first approach.

Certainly, the second approach is more appealing. However, before it can be used in applied studies the question "which parameters of the demand system are related to household characteristics and what is the functional form of such a relationship?" has to be answered. In general, this question is empirical, and it can be tested against the more general hypothesis that additional (or perhaps all) parameters of the demand system depend on household characteristics.

Various procedures have been developed for incorporating demographic variables into demand systems (Barten, 1964; Pollak and Wales, 1978, 1980, 1981). All these procedures replace the original demand system (2) with a related one that contains additional parameters. The specification is completed by postulating a functional form relating the newly introduced parameters to a set of demographic variables.

A detailed review of these procedures is beyond the objectives of this paper. However, a list of them along with the corresponding demand and

utility functions is shown in Figure 2. It is worth noting that all procedures result in demand functions that, in general, are consistent with the theory of consumer behavior (Pollak and Wales, 1981).

All procedures yield demand functions that usually are nonlinear in some of the parameters to be estimated. Hence, nonlinear estimation methods must be employed. Despite significant developments in computer hardware and software, nonlinear estimation methods still have some drawbacks (convergence, convergence to a local rather than a global solution, etc.) and major problems may occur in empirical applications.

3. Implementations for the Indonesian Study

3.1 Data Sources

The available data on food and nonfood consumption from three SUSENAS surveys (1981, 1984, and 1989) will be used in this study. These surveys, which were carried out throughout the entire geographic area of Indonesia, used a multistage sampling design which differentiated between urban and rural areas. At the final stage, a number of households was drawn from the selected primary sampling unit (PSU) in a systematic fashion.

Data in all SUSENAS surveys were collected by direct interview of the head of the selected households or of the household member that best knew the conditions in the household. The interviews were carried out by trained data collectors from the Central Bureau of Statistics staff. The time reference was one week for food items and one month and/or one year for nonfood items.

For the purposes of this study, the information on individual households within each PSU was aggregated to obtain what hereafter is referred to as a <u>representative household</u>. This was done for two reasons:

(i) to reduce the enormous number of records involved to a smaller and more manageable number and (ii) to solve, to some extent, the problem of nonconsumption by individual households of certain food items during the time of the interview.

Furthermore, all food items were classified in one of the 13 food groups and the corresponding subgroups listed in Figure 3. Economic theory does not provide any guidance on the number or composition of food groups and this decision is usually made on an ad hoc basis by the researcher. The proposed list of food groups for this study was influenced partially by past studies of the Indonesian food sector, by the planned policy analysis, and by a common sense classification reflecting the similarity of food commodities from a consumer's viewpoint.

3.2 Budgeting Stages

The proposed model assumes that consumers follow a four-stage budgeting process. Consumers are assumed to first allocate their income between savings and current expenditure (consumption). This stage will not be modeled in our study. In the second stage, consumers are assumed to allocate total current expenditure between two categories (i) expenditure on food commodities and (ii) expenditure on nonfood commodities. The third stage involves the allocation of total food expenditure among the 13 food groups. Finally, a fourth stage, involving the allocation of total expenditure on certain food groups within subgroups will be employed.

3.3 Functional Form

To model the budget allocation decisions described in the previous section, an explicit functional form of the relationship between quantity

consumed and the variables that influence it (prices and total expenditure) is needed. Unfortunately, again economic theory does not provide any guidance in making this decision. Many mathematical functions for demand relationships have been suggested and utilized in empirical demand studies. After considering, various functions, the "linearized" form of the Almost Ideal Demand System (AIDS) was chosen for this study.

Among the many nice features AIDS possesses, we singled out the following: (i) it provides an accurate first order approximation to the true demand system implicit in the data, (ii) it satisfies the axioms of choice exactly and, hence, it can be used to test the theoretical restrictions, (iii) it aggregates perfectly over consumers, and (iv) in its linear form, it is relatively simple to estimate. Of all these features, the aggregation capability of AIDS is of special importance in this study since, as it has been mentioned, the information on individual households within each PSU has been aggregated to form the representative household.

The Marshallian demand functions, in share form, for the linear AIDS model are given by

$$w_i = a_i + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln (y/P); \qquad i = 1,2,\ldots, r$$

where w_i is the budget share of the ith commodity and P is Stone's geometric price index, i.e.,

$$P = \sum_{k=1}^{r} w_k \ln P_k$$

This demand system is easily restricted to satisfy symmetry ($\gamma_{ij} = \gamma_{ji}$, $\forall$ i,j), homogeneity ($\sum_j \gamma_{ij} = 0$, $\forall$ i), and the adding up conditions ($\sum_i \gamma_{ij} = 0$; $\sum_i \beta_i = 0$; $\sum_i a_i = 1$). It can be easily shown that the income, own- and cross-price elasticities are

$$\eta_i = 1 + \beta_i/w_i,$$

$$\epsilon_{ii} = \frac{\gamma_{ii} - a_i\beta_i - \sum_k \gamma_{ik} \ln P_k}{w_i} - 1$$

$$= \frac{\gamma_{ii} - \beta_i w_i - \beta_i^2 \ln \bar{y}}{w_i} - 1, \text{ and}$$

$$\epsilon_{ij} = \frac{\gamma_{ij} - a_j\beta_j - \sum_k \gamma_{jk} \ln P_k}{w_i}$$

$$= \frac{\gamma_{ij} - \beta_i w_j + \beta_i\beta_j \ln \bar{y}}{w_i}$$

3.4 Demographic Changes and Food Demand Projections

In the long-run, changes in population growth, age-sex composition, regional population shifts, etc., have significant implications for food demand in Indonesia. It is, therefore, imperative to understand how, under certain conditions, such demographic changes will affect consumer demand in the future.

Using demand response parameters from model (9) such projections are possible. Models have been developed that, under certain conditions, can estimate future food demands under alternative demographic profiles (Blaylock and Smallwood, 1986; Price, 1986). Generally speaking,

these projections are obtained by combining demand response parameters from models like model (9) with future demographic projections, after assuming constant relative prices and consumer preferences over time. This assumption, although restrictive, is usually justified by the fact that economists generally have little knowledge about the future course of these factors.

4. Preliminary Analysis

In order to develop data procedures, algorithms, and evaluate data groupings, three sample provinces were chosen for preliminary analysis. They include: Lampung, East Java, and South Sulawesi. Tabular analysis of the data is presented in a set of detailed tables for all of Indonesia, and Urban and Rural areas. These show the calculated number of primary sampling units, number of households, participation rates in food groups, average expenditures and average food group budget shares for 13 food groups and for more disaggregated food items within selected food groups.

The tables describe food consumption patterns for the three surveys (1981, 1984, and 1987) and provide information that will be used to decide minimum criteria for designated food group allocations and other controlling variables. For example, in addition to theoretical considerations the number of primary sampling units in the food group, the extent of participation in food group expenditures, and average budget shares would all be considered in decisions for merging food groups.

Table 1 shows the number of reporting primary sampling units for the 13 food groups, across the three surveys and three provinces. These primary sampling units form "representative households" and will be the

unit of observation for the analysis of demand. For analytical purposes, the small number of primary sampling units with any "beverage" transactions suggests further combining that food group with another (such as MISC, prepared and other food).

Table 2 shows participation rates by food group. This is the percent of primary sampling units with transactions of that type during the period of the survey. Again, participation rates for the beverages group, for example, are very low; participation rates for cereals, as expected, is nearly universal. The lack of observed transactions for a particular food group poses particular problems for the estimation of a system of equations.

Primary sampling units combine information from the individual households in the unit. Table 3 illustrates the number of individual households aggregated to form primary sampling units.

Average food expenditures (in rupiah) and food budget shares are shown in Tables 4 and 5 respectively. The food budget shares (Table 5) provide a useful way to compare the relative importance of the food groups among the food groups, provinces, and across time. As expected, cereals consistently represent the largest share of food expenditures. And, as will be analyzed further, eggs and dairy (DAIRY) and prepared and other foods (MISC) represent a growing share of the food budgets in all three provinces across the period of the surveys.

More disaggregated food groups, the final stage for consumer budgeting, are described in Tables 6 through 25. Again, participation rates and number of participating primary sampling units will determine the feasibility of the level of disaggregation; differences in food budget shares provide an indication of important trends in food use.

Finally, Table 26 shows the distribution by age class of the individuals in primary sampling units within the selected provinces. Although there is some change between 1984 and 1987, between 25 and 35 percent of individuals are 10 years old or younger. This will have important implications for projections of food demand and, clearly will be important in the subsequent analysis.

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Figure 1

Decision Tree for a Three-stage Budgeting Process

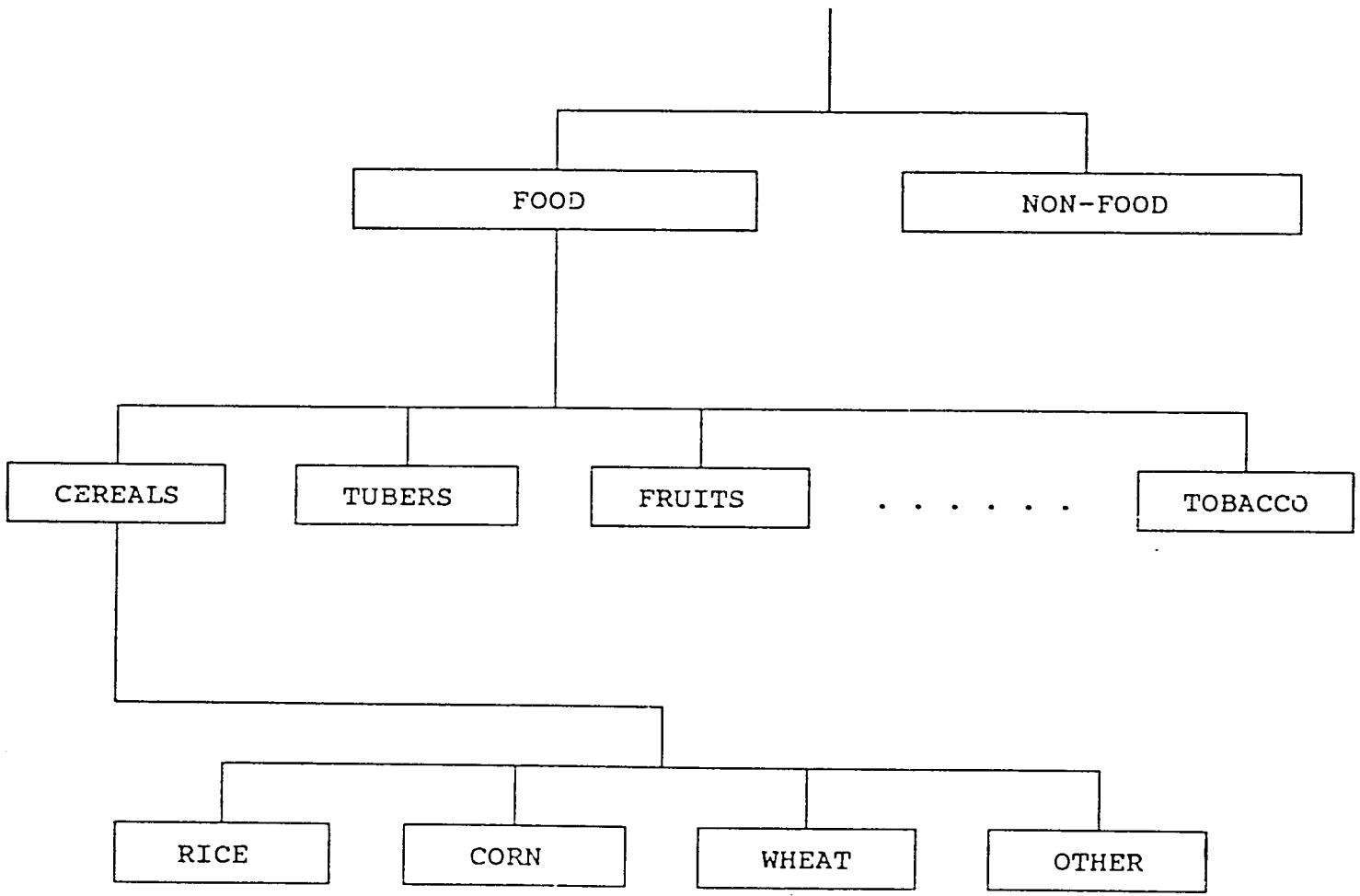

Figure 2

Demand and Utility Functions of Four Alternative Procedures for Incorporating Demographic Effects into Demand Systems.

Procedure	Demand Function[a]	Utility Function[b]
Translating	$x_i=d_i+\bar{x}_i(\underline{P}', y-\sum_{j=1}^{r} p_j d_j)$	$v[(x_1-d_1), (x_2-d_2), \ldots, (x_r-d_r)]$
Scaling	$x_i=m_i\bar{x}_i(p_1m_1, p_2m_2, \ldots, p_rm_r, y)$	$v[(x_1/m_1), (x_2/m_2), \ldots, (x_r/m_r)]$
Gorman	$x_i=d_i+m_i\bar{x}_i(p_1m_1, p_2m_2, \ldots, p_rm_r, y-\sum_{j=1}^{r} p_j d_j)$	$v[(x_1-d_1)/m_1, (x_2-d_2)/m_2, \ldots, (x_r-d_r)/m_r]$
Reverse Gorman	$x_i=m_i[d_i+\bar{x}_i(p_1m_1, p_2m_2, \ldots, p_rm_r, y-\sum_{j=1}^{r} p_j m_j d_j)]$	$v[(x_1/m_1)-d_1, (x_2/m_2)-d_2, \ldots, (x_r/m_r)-d_r]$

[a]The original demand function is: $x_i=\bar{x}_i(\underline{P}', y)$

[b]The original utility function is: $v(x_1, x_2, \ldots, x_r)$

Figure 3

List of Food Groups and Corresponding Subgroups

1. Cereals
   - Rice
   - Corn
   - Wheat
   - Other
2. Cassava and Root Crops
   - Fresh Cassava
   - Dried Cassava (Gaplek)
   - Potatoes
   - Sweet potatoes
   - Other
3. Fruits
4. Vegetables
5. Meat
   - Beef
   - Other red meat (Buffalo, Horse, Mutton, Pork)
   - Poultry
   - Processed meat (Dried, Canned, Smoked, etc.)
   - Other meat (Liver, etc.)
6. Fish
   - Fresh fish
   - Dry/Preserved fish
7. Eggs and Dairy
   - Eggs
   - Milk and milk products
8. Beans, Nuts, and Peas
   - Peanuts
   - Mungbeans
   - Soybeans
   - Other nuts and beans
   - Processed foods (soybean based)
   - Processed foods (peanut based)
   - Other
9. Fats and Oils
10. Non-alcoholic Beverages
11. Sugar and Condiments
    - Cane based
    - Other (corn, etc.)
    - Spices
12. Other Consumption
    - Prepared food and drinks
    - Other food
13. Alcoholic beverages and Tobacco products