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ECONOMIES OF SCALE IN THE FOOD STAMP PROGRAM

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I. OVERVIEW OF ECONOMIES OF SCALE IN THE FOOD STAMP PROGRAM

The larger the household, the greater are its nutritional needs. At the same time, the larger the household, the greater the cost advantages it can reap in food purchasing, storage, and preparation--simply because of its increased food usage. A large household can take advantage, for example, of "economy size" packages, with less danger of spoilage and other waste related to the size and form of packaging. Economies of scale as used in the Food Stamp Program are designed to adjust food stamp benefits for this cost advantage, with the goal of enhancing equity across households in the food usage per person that their benefits can buy.

The concept is straightforward. How to measure it for use in the benefit calculation, however, is less so. The fundamental reason for this difficulty is that two other major factors also affect food consumption. The first is the age and sex composition of the household. Infants and the elderly need less food than prime adults; women tend to need less than men. The second is income. The higher the income level of the household, the weaker is the incentive to economize on food costs (in terms of both price and waste). The measurement problem is that household composition and income level also vary with household size because of the characteristics of American households. Any observed differences in food consumption across households of different sizes, therefore, include not only economies of scale differences but also differences in age/sex composition and in income-induced incentives to economize.

The Food Stamp Act of 1977 mandates household size adjustments that "take into account economies of scale." At least implicitly, therefore, it recognizes the possibility of including other adjustment factors. In practice, however, economies of scale are the only size adjustment factor currently included in the benefit calculation.

There are thus two issues which must be kept distinct. The first is whether to include adjustments for nutritional need differences across households resulting from differing age/sex composition in addition to those attributable strictly to economies of scale. The second is whether the economies of scale adjustment factors currently in use which are based on data almost 20 years old, should be updated. This report addresses the second issue by reviewing the role of the adjustment factors, their conceptual basis, and the relative merits of different approaches to their revision.

The Food Stamp Benefit Calculation

Current Food Stamp Program legislation--The Food Stamp Act of 1977 as amended--gives the intent of the program:

> It is hereby declared to be the policy of Congress, in order to promote the general welfare, to safeguard the health and well-being of the Nation's population by raising levels of nutrition among low-income households . . . a food stamp program is herein authorized which will permit low-income households to obtain a more nutritious diet through normal channels of trade by increasing food purchasing power for all eligible households who apply for participation.

All households with gross income below 130 percent of the poverty line, net income (after certain deductions) below the poverty line, and assets within allowable limits are eligible for food stamps. (The gross income

eligibility limit is not used for households containing an elderly or disabled person.) Those with no income or income that does not exceed their deductions, called zero net income households, are eligible for the maximum benefit, called the allotment standard. This amount is set according to a measure of minimal dietary adequacy (discussed below) and incorporates the household size economies of scale adjustment.

Basis for the Allotment Standard: Thrifty Food Plan. The 1977 legislation specifies that the allotment standard is to be based on the Thrifty Food Plan. This is the least costly of four food plans, developed by the Agricultural Research Service in 1974-1975 and updated with 1977-1978 data. These plans specify the amounts of foods of different food groups that households might use to provide nutritious diets for their members. The four plans vary in the costs of the particular foods chosen to satisfy the nutritional requirements. The Thrifty Food Plan includes the largest proportions of the foods that are economical sources of nutrients. Because nutritional requirements vary according to age and sex, the Thrifty Food Plan provides amounts of food for 12 different types of household members, the updated costs of which are published monthly by the U.S. Department of Agriculture. The monthly cost of the Thrifty Food Plan for the 12 types as of June 1984 is shown in Table I.1. These amounts can be totaled for a specific household configuration to determine the cost of the Thrifty Food Plan for any household.

Although the allotment standard is based on the Thrifty Food Plan, however, it is not identical with it. In its report accompanying the 1977 Act, Congress recognized the "enormous complexity of determining allotments keyed to individual households circumstances" in the context of a national

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TABLE I.1

MONTHLY COST OF THE THRIFTY FOOD PLAN, JUNE 1984

Age	Younger Children	Teenage Girls and Women	Teenage Boys and Men
Under 2	$41.40		
3-4	44.90		
6-8	55.10		
9-11	65.30		
12-14		$68.10	$68.60
15-19		68.10	71.50
20-54		68.20	75.80
55+		67.40	69.00

the cost of the Thrifty Food Plan for a family of four, specified in the legislation as consisting of "a man and a woman twenty through fifty-four, a child six through eight, and a child nine through eleven years old." The June 1984 monthly cost of the Thrifty Food Plan for this particular four-person family equals $264.40, or $66.10 per person. The allotment standard is based on the cost of the TFP for an earlier month. For example, the current allotment was implemented in November 1984 based on the cost of the TFP for June 1984. Under current legislation, the allotment will be updated again on October 1, 1985.

The economies of scale adjustment is made by adding or subtracting a certain proportion of this per-person allotment for different household sizes, and multiplying the new per-person allotment by household size. The economy of scale factors currently in use and the per-person and household allotment standards that result are shown in Table I.2. They were developed in 1975 by the Consumer and Food Economics Division, Agricultural Research Service, based on food consumption data collected in 1965.[1]

Obviously, since the age/sex differences reflected in the Thrifty Food Plan are not carried over into the household definition used for the allotment standard, a recipient household's food stamp allotment standard

TABLE I.2

ECONOMIES OF SCALE FACTORS, HOUSEHOLD ALLOTMENT STANDARDS, AND PER PERSON ALLOTMENT STANDARDS BY HOUSEHOLD SIZE: NOVEMBER 1984

	Household Size						
	1	2	3	4	5	6	7+
Economies of Scale Factors	+20%	+10%	+5%	0	-5%	-5%	-10%
Per-Person Allotment Standard	$79.00	$72.50	$69.33	$66.10	$62.60	$62.67	$59.43
Household Allotment Standard	$79	$145	$208	$264	$313	$376	$416

consisting of prime-age mother and father and three high-school-age sons would have a Thrifty Food Plan costing $337.82, compared with its allotment standard of $313.[1]

The three lines in Figure I.1 show the current economy of scale adjustment factors, compared with both a hypothetical set of factors with larger adjustments and a hypothetical set with smaller adjustments. As can be seen, larger adjustments lead to a steeper tilt in the curve; smaller adjustments lead to a flatter tilt. Because of the pattern of American household characteristics, a set of adjustment factors that steepens the tilt will redistribute benefits from larger to smaller families compared to the current system. It will also redistribute benefits from younger to older recipients. In addition, it will increase total program costs, because there are more recipients in households with less than four members than in households with more than four. A set of adjustment factors that flattens the tilt will reverse these effects.

Quantitative Importance of the Economies of Scale Adjustment. The economies of scale factors in the allotment standard constitute only one component of the benefit calculation. It is important to bear in mind, however, that they are a very important component. Changes in them can substantially affect household benefit levels, and therefore total program costs, more than other types of changes in the benefit calculation. A comparison of the effect of the change in the earned income deduction from 20

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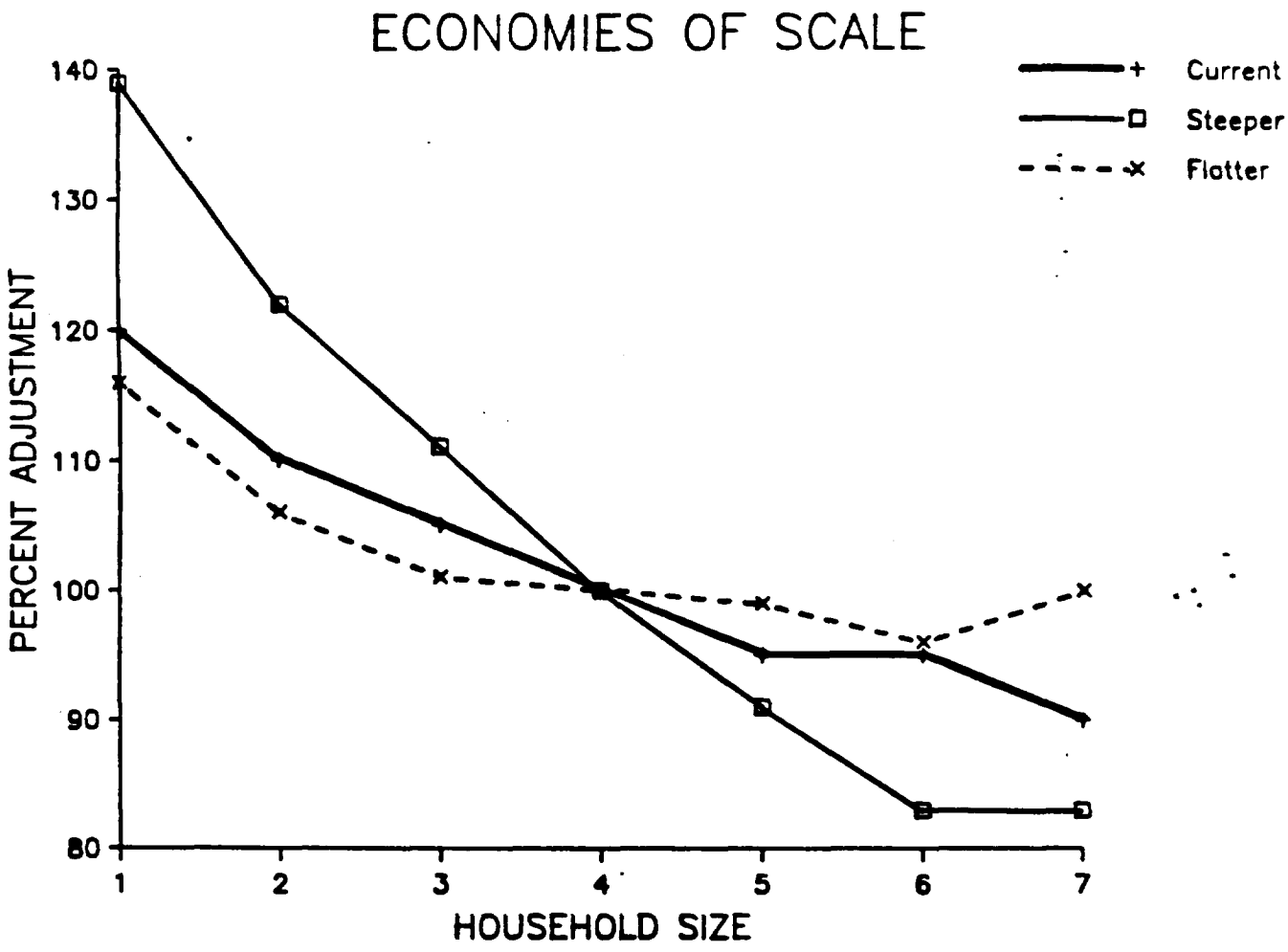
[1]Because the cost of the Thrifty Food Plan is used as the minimum practical cost of a nutritionally adequate diet, cases like the latter have given rise to policy concerns about adequacy. Cases like the former have given rise to analogous concerns about program cost. These concerns are outside the scope of the economies of scale adjustment and therefore outside the scope of this paper.

FIGURE I.1

SLOPES OF ADJUSTMENT



EFFECTS OF STEEPER OR FLATTER SCALE ADJUSTMENTS

Household Size	Current Allotment	Steeper Scale[1] Allotment Difference	Flatter Scale[2] Allotment Difference
1	$ 79	+ $12	- $3
2	$145	+ $16	- $5
3	$208	+ $12	- $8
4	$264	--	--
5	$313	- $13	+$14
6	$376	- $47	+ $4
7	$416	- $32	+$46

[1]Price-Sharma Model V
[2]Morgan et al Combined Quality Model

percent to 18 percent, made in the 1981 legislation, will help make the point.

Let us take a two-person household with a monthly income of $300, all of which is earned, and entitled to the standard deduction of $95. If the earned income allowance had remained at 20 percent, with no other change in the benefit formula, this household's monthly benefit in November 1984 would have been $101. The policy change from 20 percent to 18 percent has reduced this household's monthly benefit to $99. If the policy decision had gone the other way, and the earned income allowance had been increased by two percentage points to 22 percent, this household's monthly benefit would be $103. In each case, the change amounts to only two dollars a month.

The possible changes to the adjustment factor for a two-person household suggested by recent research span the range of about five percentage points above and below the current adjustment factor of 10 percent. (Remember that this is an addition of 10 percent to the per-person allotment standard for the prototypical four-person family specified in the legislation.) If the top of the range were chosen, the adjustment factor would become 15 percent; if the bottom were chosen, the adjustment factor would become 5 percent. In terms of our two-person household in the example, the current formula yields a monthly benefit, as before, of $99. If the adjustment factor for a two-person household were raised to 15 percent, and everything else stayed the same, this household's monthly benefit would increase to $106. If the adjustment factor were lowered to 5 percent, this household's monthly benefit would be reduced to $92. In either case, the effect on this example household would be over three times

as great as the effect implied by the recent change in the earned income allowance.

Moreover the total impact on recipients and program cost is much greater because changing the economies of scale adjustment affects all recipient households except a small number of households receiving the minimum benefit. The change in the amount of benefits is the same for all households of a given size irrespective of income level, unlike the change in the earned income deduction, which affects only recipients with earnings, or changes in the 30 percent tax rate, which affects only those with net income.

Reasons for the Report

The amount of the allotment standard is updated usually once per year according to current legislation. There is also the presumption that the economies of scale adjustment factors will be periodically revised. Improvements in food preservation, packaging, or marketing technologies, for example, can be expected to change the relationship between the volume of food usage and the price of food usage per unit. Changes in taste are also likely to occur over time, with concomitant changes in the possibilities of economizing by bulk buying and so on.

But such changes occur more gradually over time than price changes. They are also more difficult to measure and to isolate from other changes. Finally, Congress is concerned about changes in the economies of

scale factors.[1] For all these reasons, a policy decision to reassess the economies of scale factors with a view to possible changes in them is not to be undertaken lightly. The time may now have come, however, when such a reconsideration is indicated. The current set of economies of scale factors is based on work that was done nearly a decade ago, using data collected nearly two decades ago. In the intervening years, new data sources have become available and new methodologies suggested for their measurement.

The current adjustment factors were calculated using a statistical regression model in which (1) dietary standards established by nutritional experts were used to specify nutrition standards, and (2) per capita food costs were estimated using a sample of 1965 National Household Food Consumption Survey households with incomes above the poverty line. The new data sources are the 1977-1978 and 1979-1980 Nationwide Food Consumption Surveys (NFCS). The new data have already been used to revise the Thrifty Food Plan. The new methodological suggestions take several forms:

- o changing the way the dietary standards are established, either by augmenting and refining the expert measures of dietary needs, or by replacing them with actual food consumption patterns of households, or by using some combination of the two;

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[1] As Report 809, Fiscal Year 1985 of the House Appropriations Committee states it (p. 98): "The Committee feels that any change from the current method of calculating household economies of scale should be accomplished by legislative action rather than regulation. Therefore the Committee directs that no change will be imposed by administrative action." The Senate Appropriations Committee report contains similar language.

- using a sample of households below the poverty line for the per capita food estimation, on the grounds that poor households have systematically different buying opportunities from non poor ones;

- altering the methodology altogether, by using price indices directly reflecting variation in unit-volume food prices paid by households of different size.

The rest of this report presents a conceptual framework for measuring economies of scale (Chapter II), provides a critical review of the methodology underlying the current adjustment factors as well as more recent research (Chapter III), and shows the effects of six alternative proposals for change on the benefits of different types and sizes of households and on program costs (Chapter IV).

The purpose of the report is to provide the basis for making an informed choice about the various options. The basic choice is fourfold:

- to leave the adjustment factors unchanged

- to keep the same methodology and update the factors with the 1977-1978 and 1979-1980 data

- to choose a revised methodology for the update

- to examine and compare the methodological alternatives more thoroughly than has been done to date, with the objective of revision in the future.

II. ECONOMIES OF SCALE IN HOUSEHOLD FOOD CONSUMPTION: CONCEPTUAL BASIS AND RESEARCH ISSUES

As discussed in Chapter I, current legislation requires that Food Stamp Program allotment standards be set using household size adjustment factors that take into account economies of scale. In this chapter we present the conceptual basis for expecting economies of scale in household food usage and discuss the research issues that must be resolved if economies of scale are to be correctly estimated.

A. CONCEPTUAL BASIS

The concept of economies of scale in household food consumption stems directly from an economic efficiency concept developed in production economics. Economies of scale in production exist because of the nature of either the available technologies or the financial and market context of the industry. Where these are present, firms by virtue of their size or scale of operation alone can exploit and enjoy certain economies in purchasing, manufacture, or distribution that are not available (or much less readily available) to their smaller competitors. The key element underlying the concept of economies of scale in food consumption is that large households enjoy certain cost advantages over small households strictly because of their greater size.

Two sources of economies of scale in household food consumption have been identified. The first is the lower unit prices associated with purchasing food items in bulk. Large households are more able to take advantage of bulk purchases, particularly of perishable items, than are small households. The second source of scale economies is that large households may

be able to use food more efficiently than small households. For example, small households may experience greater unavoidable food spoilage due to the perishability of food items even in nonbulk package sizes. In addition, small households may experience relatively greater waste of items used in food preparation, such as cooking oil.

Empirical studies of food consumption have consistently shown that large households tend to have lower food expenditures per person than small households (see Table II.1). However, economies of scale represent only one factor contributing to these observed differences. Other important factors which are only indirectly related to household size and thus conceptually distinct from economies of scale include: (1) differences in food cost economizing efforts and (2) differences in age/sex composition.

Efforts at food cost economizing, for example, may take the form of: (1) reducing food costs by accepting a diet lower in quality or quantity and (2) reducing the cost of obtaining a given diet through more effective food management techniques (including more strenuous efforts at avoiding spoilage and other waste.) Such methods of reducing food costs are available to all households irrespective of household size. They are not, therefore, due to economies of scale. But they may be statistically correlated with household size through associations with per capita income. For example, per capita income decreases on average as household size increases. Therefore, since households with low income can be expected to make greater efforts to economize, large households on average can be expected to make greater efforts at economizing on food costs than small households.

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TABLE II.1

Weekly Home Food Consumption
Per Person by Household Size

Household Size	1977 - 1978		1965 - 1966	
	All	Low-Income	Non-Low-Income	Low-Income
1	$22.15	$18.57	$13.19	$8.21
2	19.34	14.82	11.28	7.83
3	17.54	15.13	10.20	7.07
4	15.88	13.98	9.26	6.39
5	14.57	13.25	8.54	6.49
6	14.50	12.93	7.76	6.07
7+	13.20	11.83	7.20	5.07

SOURCE: National Food Consumption Survey 1965-1966 and the Nationwide Food Consumption Survey (NFCS), 1977-1978. Note that the dollar values given represent both the amount of food eaten by household members and the amount of food lost through waste and spoilage.

The second source of observed variation in per capita food expenditures among different sized households which is conceptually distinct from economies of scale is the composition of the household. It is a basic fact of nutrition that the food requirements of individuals vary by age and sex. Young children need less food than teenagers and adults, elderly persons need less than younger adults, and women generally need less than men. But age/sex composition is clearly related indirectly to household size since, for example, one-person households contain only adults or older teenagers while many larger households contain young children.

B. RESEARCH ISSUES

Any research effort designed to measure economies of scale must be able to separate out the effects of discretionary economizing efforts and age/sex composition from the direct effect of household size on per capita food costs, with all other factors held constant.[1] An estimate of economies of scale is not observable directly from survey data, however, because variation in per capita food expenditures by household size contains elements of each of the three factors at work. Estimating economies of scale, therefore, requires the development of a research strategy designed to isolate the effect of economies of scale from the other factors.

Two different approaches have been recommended for isolating economies of scale in household food consumption from the effects of discretionary

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[1]The money cost of food is not its only cost. A more comprehensive measure would include the value of time required for shopping and meal preparation, travel costs of shopping, and costs of storage and preparation. Although each of these is clearly a potential source of economies of scale, they cannot be included in estimation of such costs because surveys of food consumption do not collect such information.

economizing efforts and household sex/age composition. The first approach involves specifying a conceptual model which seeks to explain household food expenditures in terms of various household characteristics, such as income, household size, and age/sex composition. The effects of these factors, holding all others constant, is then estimated using survey data on household food consumption. The pure effect of household size on per capita food costs provides the economies of scale estimates. The second approach involves direct measurement of the variation in food prices faced by households of different size. The reported price information is then used to construct an index which reflects the overall variation in unit food prices by household size. This approach uses survey data on unit prices paid by households for a variety of food items.

The successful application of either of the two approaches to estimating economies of scale in household food consumption requires that certain key research issues be addressed. The issues relevant to each approach are discussed in turn.

The Modeling Approach

Models of household behavior designed to explain food expenditures fall into two general categories: "normative" and "preference-based." In each type of model, household food expenditure is specified as a function of various explanatory variables such as household income. The distinction is that normative models use a set of standards set by nutritional experts regarding the relative dietary needs of individuals in different age/sex categories. These standards are then used to derive a measure of the nutritional quality of the household's diet, which is included as an explanatory variable in the model. In addition, normative models often use

nutritional standards to develop a proxy measure of the age/sex composition of each household. One such measure is the household's per capita cost of obtaining the Thrifty Food Plan.

In contrast to the normative approach, the preference-based approach does not rely on the judgments of nutritional experts, but instead estimates the relative dietary needs of individuals in various age/sex classifications from observed consumption patterns reflected in survey data. This is accomplished by including in the model a set of explanatory variables representing the number of household members in various age/sex categories. The estimated coefficient of each of these household composition variables represents the additional money that would be spent on food as an individual of a particular age/sex category is added to the household. Underlying this approach is the standard microeconomic theory of household behavior in which households are presumed to choose that collection of goods and services which is most preferred, given the income available to the household. This approach judges different diets on the basis of household preferences rather than on the basis of standards set by nutritionists.[1]

Although there are important differences between the two approaches, their basic goal is the same: to statistically estimate the magnitude of economies of scale from observed variations in household food expenditures.

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[1]It should not be inferred from this that there is in fact no diet quality information reflected in the survey data. Preferences reflect three things: (1) bulk, the amount people eat to assuage hunger, (2) taste preferences, and (3) variety. Some nutrition research on developing countries suggest that at the bottom of the income distribution, additional income is used to increase bulk (this is correlated with calorie intake, but not necessarily other nutrient value). When calorie intake rises above a certain relatively low level as a result of income rising, however, the increase in calories consumed may slow, giving way to increases in nutrient value.

It is to be expected, therefore, that several of the same issues must be confronted and resolved whichever approach is used. Major ones are:

Model Specification

Data

Measurement of Food Expenditures

Each is discussed below.

Model Specification. Observed variations in per capita food expenditures among different sized households may result from economies of scale, variation in food cost economizing efforts, or variation in household composition. Any model designed to estimate economies of scale must provide a mechanism for isolating the effect of economies of scale from the effects of the other two factors. In order to achieve this, the model must include those variables necessary to fully account for variations in age/sex composition, and it should include any variables thought to be important in determining the level of effort expended in economizing on food costs.

In addition to the issue of which variables are to be included in the model, there is the issue of functional form. This refers to how the variables enter into the model and how they are functionally related to one another. The simplest approach is to specify per capita food expenditures as a linear function of a variety of explanatory variables (such as household size, per capita income, and age/sex composition). Under a linear specification, the effect of any explanatory variable on per capita food expenditures is independent of the value of that or any other explanatory variable. However, such a simple approach may not fully capture the

relationships that exist. For example, the effect of an additional household member on per capita food expenditures may vary with household size. (Indeed, the current adjustment factors include such variation.) In addition, the value of some explanatory variables may influence the effect of others; for example, the effect of household size on per capita food expenditures may vary with per capita income or age/sex composition. This is called an interactive effect. A desirable property of any model designed to measure economies of scale is that it not preclude such nonlinear and interactive relationships. In general, the fewer a priori restrictions imposed by the model, the more accurate will be its estimates.

Sample Used For Estimation. Recent applications of the modeling approach have employed data collected from the 1977-1978 and 1979-1980 Nationwide Food Consumption Surveys (NFCS). An important issue which has arisen in this research is the question of what sample of households should be used in the analysis. For example, various studies have employed samples representing low-income households only, non-low-income households only, or the entire population. The choice among these various samples is potentially important if economies of scale vary with household income.

In considering the choice of samples, it is important to keep in mind that economies of scale estimates have two applications at USDA. First, the estimates are used in the setting of Food Stamp Program allotment standards. For this purpose, estimates generated from a low-income sample may be appropriate. But second, economies of scale estimates are used to estimate the costs of the food plans published by the Human Nutrition Information Service. For this purpose, it may be desirable to use estimates representing the average magnitude of scale economies for the

entire population. Thus, if economies of scale vary significantly with household income, the appropriate sample to be used in deriving estimates depends on the intended use of those estimates.

There are reasons to suspect that economies of scale may indeed be different for low income and higher income households. For example, as noted, one of the sources of economies of scale is the greater ability of large households to take advantage of the lower unit prices associated with bulk purchases. But there may be greater variation in the unit prices paid by different sized households among higher income groups than among lower income groups. Large households in the higher income groups may have greater access to larger, more competitive supermarkets in affluent suburban areas, for example, which may offer more opportunities for bulk purchases than the smaller stores common to poorer neighborhoods of inner city areas. In addition, the ability to take advantage of bulk purchases may depend on the use of kitchen appliances such as refrigerators and freezers. These may be less readily available to large households in the lower-income groups than to their higher-income counterparts. If this is true, it is inappropriate to base adjustment factors for the Food Stamp Program on economy of scale estimates generated from a nonpoor sample of households.

Using a low-income sample for this purpose has its own potential disadvantage, however, because the Food Stamp Program may be an important factor affecting food expenditures among low income households. If food stamp recipients are included in the sample, observed variations in food expenditures among different sized households in a low-income sample will reflect the effects on those expenditures of the benefit formula (which

includes, among other things, the current household-size adjustment factors). Unless these effects are fully accounted for in the model, the economies of scale estimates are likely to be systematically biased.

Measurement of Food Expenditures. Since all the regression model studies to be reviewed in Chapter III use data from the National Food Consumption Survey of 1965-1966 or the Nationwide Food Consumption Surveys (NFCS) of 1977-1978 and 1979-1980, their measure of food expenditures is the same. It is food purchases plus net reductions in the household inventory plus a measure of food produced at home. Thus, it includes the amount of food lost through waste and spoilage in addition to that consumed by household members. The measure excludes the value of meals purchased away from home.

The exclusion of meals purchased away from home from the measure of food expenditures raises a potential problem, in that the proportion of meals purchased and consumed away from home is probably related to household size. For example, single people may eat more meals away from home than people in large families. Unless this is accounted for in the model, the estimate of economies of scale will be biased by the inclusion of variation in fact due to differences in the number of meals eaten at home. Therefore, any application of the modeling approach to estimating economies of scale should control for differences among households in the proportion of meals eaten at home.

In addition to the issues of model specification, data, and measurement of food expenditures, which are common to both normative and preference-based models, there is a fourth issue that applies to the former: measurement of diet quality.

Measurement of Diet Quality. Normative models use standards set by nutritional experts regarding the dietary requirements of people in different age/sex categories. Such standards are used to derive a measure (or set of measures) of the nutritional quality of the household diet, which is included as an explanatory variable in the model. Unfortunately, there are general weaknesses associated with all available measures of nutritional quality. The studies reviewed in Chapter III have experimented with a wide variety of measures of nutritional quality, and have tested the sensitivity of the estimated economies of scale factors to these different measures. Until a measure of nutritional quality becomes available which does not suffer from the general weaknesses associated with currently available measures, there is no clearcut choice of which measure to use in analyses of this kind.

The specification of nutritional quality measures is complicated by the fact that they must be constructed from survey data in which total food waste is included with, and indistinguishable from, actual consumption. The inclusion of food waste in measures of nutritional quality to be used as control variables has potentially serious consequences for the reliability of estimated economies of scale factors. Part of the variation in food waste across household size is associated with differences in discretionary economizing behavior and should be controlled for in the estimation procedure. The remaining variation is associated with economies of scale and should be reflected in the estimated adjustment factors. The inclusion of total food waste in measures of nutritional quality to be used as control variables introduces the possibility of controlling for rather

than measuring the waste attributable to economies of scale. This would bias the adjustment factors in the direction of a flatter tilt.

[redacted]

This approach is simpler than the estimation of a statistical model and there are fewer research issues to be confronted in its implementation. There is, however, a fundamental substantive limitation. The price index approach cannot capture the potentially substantial economies of scale associated with the greater ability of large households to avoid spoilage and other sources of waste. This failure to capture the full magnitude of economies of scale will affect the adjustment factors in the direction of a flatter tilt. Within this inherent limitation, implementation of the Grace Commission recommendation requires that two research issues be confronted.

The first concerns the question of which sample of households to employ when constructing the price indices. The price indices contained in the Grace Commission report were taken from a study which used a sample of households representative of the entire U.S. population. However, if the Grace Commission recommendation is to be used to specify household-size adjustment factors for the Food Stamp Program, a low-income sample would more closely reflect that segment of the population. The earlier discussion of the statistical modeling approach noted a potential disadvantage to employing a low-income sample. That disadvantage relates to the need for the model to fully account for the effect of the Food Stamp Program on food expenditures. However, since the Grace Commission recommendation is based on price information reported directly by households and does not involve the estimation of a statistical model, this concern is not applicable.

The second research issue relates to the need for the price indices to reflect a pure economies of scale effect, with all other effects

excluded. Specifically, the price indices should not reflect variations across household size in the quality, grade, and brand of food items selected--sources of price variation which are associated with discretionary economizing behavior rather than economies of scale. Price indices are constructed by using the average prices reported by each household size group to compute the cost to each size category of a standard market basket of food items. The problem is that no data base exists that is large enough to permit such a computation and also contains sufficiently detailed data to capture differences in the quality, grade, and brand of food items selected. Unless or until such data are collected, any estimation of economies of scale adjustment factors using price indices will be affected by the inclusion of discretionary economizing as well. Since discretionary economizing is likely to be greater at the low end of the income scale, and since per capita income falls as the size of the recipient household rises, this effect will result in an overestimation of the variation in prices across household size attributable to economies of scale.

III. CRITICAL REVIEW OF ALTERNATIVE ECONOMIES OF SCALE ESTIMATES

In this chapter we use the four major research issues discussed in Chapter II as criteria for evaluating (1) the research which underlies the current economies of scale adjustment factors, (2) the two major bodies of research using the more recent NFCS data, and (3) the Grace Commission's recommended strategy.

A. THE CRITERIA

Four major research issues were identified in the previous chapter as needing to be satisfactorily resolved if the resulting estimates of economies of scale adjustment factors are to be unbiased.

The first is model specification. To provide unbiased estimates a model must satisfy two basic conditions. It must be able to isolate discretionary food economizing efforts and the age/sex composition of the household from the effects of household size per se. In order to achieve this, all variables necessary to account for compositional differences must be included, as well as any variables potentially important in determining the effort expended in economizing on food costs. We discuss this condition under the heading control variables. In addition, it must minimize a priori restrictions on the form of the model in order to allow for systematic relationships among variables that may change as those variables take on different values. We discuss this condition under the heading functional form.

The second criteria is the sample used for estimation. If, as is plausible, economies of scale differences are themselves related to income

level, the use of samples which include or are restricted to non-low-income households will tend to provide biased estimates of the economies of scale adjustment factors faced by the food-stamp-eligible population. But if a low-income sample is used, the effects of the Food Stamp Program itself on food consumption must be removed from the estimates.

The third is the measurement of food expenditures. The first issue here is food waste. In the expenditure data reported in the surveys, food waste is included with, and indistinguishable from, consumption. Part of the variation in waste across household size is attributable to differences in discretionary economizing behavior and must be controlled for by including, for example, a measure of income. The remaining variation in waste is associated with economies of scale and should be captured in the estimated adjustment factors. The second issue is meals away from home. The value of consumption reported in the surveys does not include meals purchased away from home. Thus, for example, a single person household eating all meals away from home would have a reported consumption value of zero. Meals eaten away from home must be controlled for, therefore, because of the likelihood that their incidence is related to household size.

The fourth is measurement of diet quality. The specification of a measure of diet quality to be used as a control variable should be guided by two concerns. First, the measure should adequately reflect diet quality from a nutritionist's perspective. Second, the measure should not be highly correlated with food waste, which is a potential problem since it must be constructed from survey data in which waste is included with consumption. The danger here is that some of the variation in waste

attributable to economies of scale may be controlled for rather than measured, resulting in biased estimates. As noted in Chapter II, there are general weaknesses associated with all currently available measures of diet quality. In the absence of a single preferred measure, researchers should test the sensitivity of their results to a variety of measures which best satisfy the stated criteria.

We now proceed to our review of specific studies. The chapter discussion concentrates on the main general concerns relevant to the policy debate. The reader who is also interested in the historical antecedents of the methodology in current use and more technical detail on the alternative modeling approaches is directed to Appendix A.

B. PETERKIN AND KERR (1975): THE CURRENTLY USED ESTIMATES

The economies of scale factors currently used both in the food stamp benefit formula and to make family size adjustments in the Thrifty Food Plan were derived by applying multiple regression techniques to data collected in the National Household Food Consumption Survey, Spring 1965, using a normative approach to the measurement of diet quality. The research was done by Peterkin and Kerr, of the Consumer and Food Economics Division, Agricultural Research Service.

Control Variables

Household size was defined by Peterkin and Kerr in a very particular way. Instead of using a simple count of household members, they added the total number of meals eaten from the home food supply by each household member during the survey week. They then divided this total by 21 (based on three meals per person per day) in order to control for the

fact that the survey data on food consumption do not include the value of meals purchased outside the home. Differences in food requirements due to age/sex differences were controlled by using the household's per capita cost of obtaining the USDA low-cost food plan published in 1975, (uncorrected, of course, for economies of scale), weighted by the proportion of meals eaten from the home food supply by each individual. Differences in discretionary economizing behavior were controlled for by per capita income, measured as after-tax income for the year prior to the survey, and by measures of the nutritional quality of the household's diet.

Functional Form

The basic functional form was a linear specification. However, the restrictive effect of this specification was mitigated by estimating the model separately for households in each of seven overlapping household size categories. This procedure allows for various nonlinear relationships. For example, the impact on per capita food costs of an additional household member, as well as the impact of changes in the other explanatory variables, is allowed to vary with household size. However, more general nonlinear relationships are not allowed; for example, the impact of changes in income is not allowed to vary with the level of income.

Sample Used for Estimation

The economies of scale factors were estimated with a non-low-income sample, specifically those households who reported after-tax incomes above the poverty line. This sample was chosen because of the relatively small numbers with below-poverty incomes, although the authors did note that preliminary estimates with 1,000 low-income households did not produce "sufficiently different" or "sufficiently conclusive" results to "warrant

the use of different household size adjustment factors for food plans at lower cost levels."

Measurement of Food Expenditures

Because the Food Consumption Survey data were used, waste was included. Meals eaten away from home were controlled for as specified above.

Measurement of Diet Quality

Since there are general weaknesses associated with all currently available measures of nutritional quality, Peterkin and Kerr used five different measures or combinations of measures of quality:

1. Diet Score. This is the sum of percentages of the 1963 Recommended Dietary Allowances (RDA) for food energy and seven nutrients.[1] The allowable maximum for each is 100 percent.

2. Number of RDAs Met. This is the number of nutrients for which food used in a given houshold provided at least the RDA for the household members taken together.

3. Nutrient Density Ratio (NDR). For each nutrient, the NDR represents the ratio of (1) the quantity of that nutrient per 1,000 calories in the household diet to (2) the household's RDA for that nutrient per 1,000 units of the household's RDA for calories. Thus, if the nutrient density (quantity of the nutrient per 1,000 calories) in the diet is identical to that specified in the RDAs, the NDR for that nutrient is 1.0. An overall measure of the NDR for the household diet was obtained by summing the NDRs for each of the seven nutrients, with the maximum allowable value for each nutrient set at 1.0.

4. Number of NDRs of 1.0. This is the number of nutrients for which the household diet had an NDR of 1.0.

[1]The seven nutrients are protein, calcium, iron, vitamin A, thiamin, riboflavin, vitamin C.

5. Food Energy Level (FEL). This is the ratio of calories in the household diet to the RDA for calories for that household, expressed as a percentage with an allowable maximum of 150 percent.

Since these measures are constructed from data in which total waste is included along with consumption, there is a danger that they will be highly correlated with waste. Peterkin and Kerr attempted to minimize this correlation by truncating the measures at maximum allowable values defined in relation to the RDAs. In addition, by experimenting with a variety of measures, they minimized the likelihood of basing their final results on a single measure of nutritional quality for which correlation with waste is especially severe.

Results

Measures (1), (2), (3) were each used in a separate estimation, measures (3) and (5) were included together, and measures (4) and (5) were included together. Table III.1 shows the index of per capita food costs as reported, the five indices corresponding to the five diet quality specifications, and the index that averages the estimates from the five specifications. The adjustment factors used in the Food Stamp benefit calculation to correct the 4-person household estimates for the household sizes are the estimates in the last column rounded to the nearest 5 percentage points as follows:

1 person	120
2 persons	110
3 persons	105
4 persons	100
5 or 6 persons	95
7 or more persons	90

TABLE III.1

ECONOMIES OF SCALE FACTORS, PETERKIN AND KERR (1975),
BY DIET QUALITY SPECIFICATION, NON-LOW-INCOME SAMPLE, 1965

Household size (persons)	As reported	Diet score	No. of RDA met	NDR	FEL and NDR	FEL and no. of NDR of 1.0	Average of five specifications
1	142	123	121	118	122	119	121
2	122	112	110	110	110	109	110
3	110	104	104	104	103	102	103
4	100	100	100	100	100	100	100
5	92	96	96	96	98	98	97
6	84	94	94	92	96	96	94
7	78	92	91	89	95	95	92
8	81	92	91	89	96	96	93
9	74	91	91	89	97	96	93

NOTE: Expressed as an index of per capita food costs with a 4-person household = 100. Estimated from the 1965 National Household Food Consumption Survey, 1965. The regression model controlled for per capita income, age/sex composition, and diet quality.

RDA = Recommended Daily Allowance
NDR = Nutrient Density Ratio
FEL = Food Energy Level

Overall Assessment

The Peterkin-Kerr methodology scores relatively well on the four criteria developed in Chapter II. Per capita income and various nutritional quality measures were used to control for discretionary economizing behavior. These choices are sound, although the addition of socioeconomic variables--such as education, occupation, ethnic background, region of residence, and degree of urbanization may have enabled the model to control even more fully for economizing differences. The linear specification, as noted, is restrictive on the face of it, but the estimation of the model for households in each of several overlapping intervals of household size has the effect of relaxing this restrictiveness considerably. An explicitly nonlinear specification that allows for variable interactions would have been even less restrictive. The sample used for estimation--non-low-income households--is a potential weakness, given the expectation that opportunities for economies of scale may differ by income level. However, the authors reported that they obtained very similar results using a low income sample. Unlike later studies which have employed low income samples, controlling for food stamps was not a serious issue since the program was virtually nonexistent in 1965. The range of diet quality measures used seems sensible; and averaging across five different combinations of the measures used, given the fact that there are weaknesses associated with each, also guards against the potential danger of capturing an overly narrow aspect of diet quality.

C. MORGAN, JOHNSON, AND BURT (1981-1983)

Morgan et al., in a University of Missouri study, derived and compared several sets of economies of scale factors, applying multiple

regression techniques to data collected in the Nationwide Food Consumption Surveys (NFCS) for 1977-1978 and 1979-1980. Their approach was also normative, and their work resulted in three papers which provide the basis for the review here.[1] One of the potential values of this work was the intent to update the Peterkin and Kerr estimates with the NFCS data for 1977-1978 and 1979-1980. As is discussed below, however, methodological and measurement differences between the two bodies of work turn out to preclude the possibility of direct comparisons.

Control Variables

As in the Peterkin and Kerr work, Morgan et al. controlled for age/sex differences by using the household's per capita cost of purchasing a specific diet plan. However, Morgan et al. did not use the cost of the low-cost plan for this purpose, as Peterkin and Kerr did; instead, they used the cost of the 1975 Thrifty Food Plan at the time of the 1977-1978 survey. Discretionary economizing efforts were controlled for as in Peterkin-Kerr by using the household's per capita income, but here again the measure was different. Before-tax income for the month prior to the survey was used rather than after-tax income for the year prior to the survey as used by Peterkin-Kerr. (The Morgan et al. diet quality measures were different also, as described below.)

[1]These are Morgan, Johnson, and Burt (1981); Morgan et al (no date); and Morgan, Johnson, and Burt (1983). The third paper essentially repeated some of the results of the second paper, with additional methodological detail.

Functional Form

The basic functional form was the same linear specification as used by Peterkin-Kerr, also estimated separately for seven overlapping household size categories to allow for nonlinear relationships.

Sample Used for Estimation

Morgan et al. used two different samples for their estimation work, but neither of the two was a non-low-income sample as used by Peterkin-Kerr. Morgan et al. used a low-income sample for the specifications which repeated Peterkin-Kerr's measures of diet quality, and both a low-income sample and the NFCS basic sample (i.e., a sample representing the whole income spectrum) for additional measures of diet quality.

Measurement of Food Expenditures

Because NFCS data were used, waste was included as in the Peterkin-Kerr work. Meals eaten away from home also were controlled in the same way as Peterkin-Kerr. But Morgan et al. made no attempt to account for the effect of the Food Stamp Program on food expenditures. This, given their use of samples that included low-income households, is likely to result in biased estimates. The problem did not exist for Peterkin-Kerr because they excluded low-income households from their sample.

Measurement of Diet Quality

In their first paper, Morgan et al. (1981) used the same five measures and combinations of measures as Peterkin-Kerr. They were not defined in the same manner, however, because the Peterkin-Kerr measures were based on RDA established by the National Academy of Sciences-National Research Council in 1963, whereas Morgan et al. used the revised set of

standards published in 1974. In the other two Morgan et al. papers a new measure was introduced:

- o Lowest RDA. This is designed to capture serious deficiencies for a particular nutrient, and is defined as the lowest percentage of the RDA in the households diet of the seven nutrients assessed.

Lowest RDA was used as the sole measure of diet quality in one specification and combined with NDR and FEL in another.

Lowest RDA is a new measure of nutritional quality introduced by Morgan et al., and it has not yet received a critical evaluation by nutritionists. With the exception of the study by Price and Sharma discussed below, it has not been used in any other studies by nutritionists. Therefore, until Lowest RDA has received a thorough professional review, any estimates derived from models using this measure should be treated with some caution.

Results

The combination of two different samples, two different survey years, and two specifications of diet quality in addition to the five used by Peterkin-Kerr yield three sets of estimates of economies of scale factors.

First, Morgan et al. repeated the five Peterkin-Kerr specifications of diet quality (with the revised RDAs as noted) using the 1977-1978 NFCS data. The economies of scale factors produced by this exercise are shown in Table III. 2. As can be seen, the resulting tilt is distinctly sharper than the tilt of the Peterkin-Kerr estimates. It should be kept in mind in interpreting these results, however, that Morgan et al. used a different measure of per capita income, estimated their model on a low-income sample,

TABLE III.2

ECONOMIES OF SCALE FACTORS, MORGAN ET AL. (1981),
BY DIET QUALITY SPECIFICATION, LOW-INCOME SAMPLE, 1977-1978

Household size (persons)	As reported	Diet score	No. of RDA met	NDR	FEL and NDR	FEL and no. of NDR of 1.0	Average of five specifications
1	133	132	131	128	130	129	130
2	106	114	115	112	114	114	114
3	108	105	105	104	106	106	105
4	100	100	100	100	100	100	100
5	95	95	95	94	95	95	95
6	93	91	91	89	92	92	91
7	82	89	89	82	90	90	88
8	92	85	86	80	86	86	85
9	79	79	79	84	79	78	80

NOTE: Expressed as an index of per capita food costs with a 4-person household = 100. Estimated from the Nationwide Survey of Food Consumption in Low Income Households (NFCS), 1977-1978. The regression model controlled for per capita income, age/sex composition, and diet quality.

RDA = Recommended Daily Allowance
NDR = Nutrient Density Ratio
FEL = Food Energy Level

and did not control for the effect of the Food Stamp Program on food consumption. The first two differences render the estimates noncomparable with Peterkin-Kerr, but not necessarily biased. The third difference, however, introduces a substantial likelihood of bias.

Second, Morgan et al. use the 1979-1980 data to estimate two of the Peterkin-Kerr diet quality measures(Diet score and the combination of NDR and FEL) and two additional specifications-- Lowest RDA by itself and NDR, FEL, and Lowest RDA combined--which they estimated also for 1977-1978. The Morgan et al. results for the 1979-1980 low-income sample are compared with their results for the 1977-1978 low-income sample in Table III.3. As can be seen, the tilts for the 1979-1980 estimates are substantially flatter than the tilts of the 1977-1978 estimates for the smaller household sizes, although the reverse is true for larger household sizes. This is an example of the fact that the relative steepness of a set of adjustment factors can vary over the range of household size categories. The potential bias from failure to control for the Food Stamp Program effects does not account for this because it characterizes the 1979 estimates as well. However, the major changes in the Food Stamp Program in 1979 could have changed the extent and even the direction of the bias.

The final exercise performed by Morgan et al. was to calculate economies of scale factors for the NFCS basic sample (i.e., representing all income groups) for 1977-1978, holding everything else the same as in the calculations for the 1977-1978 low-income sample. The bias from failure to control for Food Stamp Program effects will be less for the basic sample but not completely removed. These estimates are compared with the 1977-1978 low-income sample estimates in Table III.4. The two sets of

TABLE III.3

COMPARISON OF ECONOMIES OF SCALE FACTORS, MORGAN ET AL. (NO DATE), BY DIET QUALITY SPECIFICATION, LOW-INCOME SAMPLE, 1977-1978 VERSUS 1979-1980

Household Size	Diet Score		FEL and NDR		Lowest RDA		FEL, NDR, and Lowest RDA	
	1977-78	1979-80	1977-78	1979-80	1977-78	1979-80	1977-78	1979-80
1	132	117	130	111	118	109	116	106
2	114	110	114	104	106	104	106	102
3	105	105	106	102	101	103	101	102
4	100	100	100	100	100	100	100	100
5	95	90	95	93	97	92	99	94
6	91	84	92	89	92	87	96	90
7	89	78	90	85	93	79	100	84
8	85	70	86	82	94	73	99	80
9	79	72	79	85	95	76	100	84

NOTE: Expressed as an index of per capita food costs with a 4-person household = 100. Estimated from the Nationwide Surveys of Food Consumption in Low Income Households (NFCS) 1977-1978 and 1979-1980. The regression models controlled for per capita income, age/sex composition, and diet quality.

RDA = Recommended Daily Allowance
NDR = Nutrient Density Ratio
FEL = Food Energy Level

TABLE III.4

ECONOMIES OF SCALE FACTORS, MORGAN ET AL. (NO DATE), BY DIET QUALITY SPECIFICATION, TWO SAMPLES, 1977-1978

Household Size	Diet Score		FEL and NDR		Lowest RDA		FEL, NDR, and Lowest RDA	
	Low Income	Basic	Low Income	Basic	Low Income	Basic	Low Income	Basic
1	132	135	130	127	118	123	116	119
2	114	118	114	113	106	112	106	109
3	105	107	106	104	101	105	101	103
4	100	100	100	100	100	100	100	100
5	95	94	95	96	97	95	99	96
6	91	94	92	95	92	93	96	94
7	89	94	90	95	93	93	100	93
8	85	94	86	95	94	92	99	93
9	79	99	79	98	95	92	100	95

Estimated from regression models which control for per capita income, age/sex composition, and the specified measures of the nutritional quality of household diets.

estimates are relatively close, although use of the basic sample seems to increase the tilt somewhat.

Overall Assessment

The first point to make is the important one made earlier. The Morgan et al. methodology, even when the diet quality measures are the same, is different enough from that used by Peterkin-Kerr to make it impossible to use comparisons of the two bodies of work to draw any conclusions about whether or not the economies of scale in food consumption have changed between the National Food Consumption Survey of 1965-1966 and the Nationwide Food Consumption Surveys (NFCS) of 1977-1978 and 1979-1980.

The second point is that, as in the case of the Peterkin-Kerr work, the inclusion of socioeconomic variables--such as education, occupation, ethnic background, region of residence, and degree of urbanization--may have enabled the model to control more completely for differences in discretionary economizing behavior.

The third point is that Morgan et al.'s use of a low-income sample to estimate food expenditures imparts a potentially substantial bias to their results because they failed to control for the effects of the Food Stamp Program on those expenditures.

The fourth point is that the variations in the extent of economies of scale between one household size and another seem much more volatile in the Morgan et al. estimates than in the Peterkin-Kerr work. For example, for many specifiations of the model, the estimated impact of economies of scale on the per capita food costs of 2-person households relative to 4-person households is greater than the absolute difference in reported per capita costs between the two. The estimated economies of scale factors

reported in Table III.2 imply that the per capita costs of obtaining equivalent diets are 14 percent greater for 2-person households than for 4-person households; however, the reported per capita costs of 2-person households are only 6 percent greater than those of 4-person households. Peterkin-Kerr did not obtain such a result for any houshold size. In addition, the difference in the Morgan et al. estimated scale factors between 1977-1978 and 1979-1980 are surprisingly large. For 1- and 2-person households, for example, for both the diet score and the FEL and NDR specifications the two estimates actually fall on opposite sides of the Peterkin-Kerr estimates, although Peterkin-Kerr used data collected more than a decade earlier. In addition--in spite of differences in methodology and the more than 10-year gap between the two data bases--the Morgan et al. 1977-1978 estimates for the diet score measure are closer to the Peterkin-Kerr estimates than to their own 1979-1980 estimates for all household sizes except 3-person households.[1]

D. PRICE AND SHARMA (1981-1983)

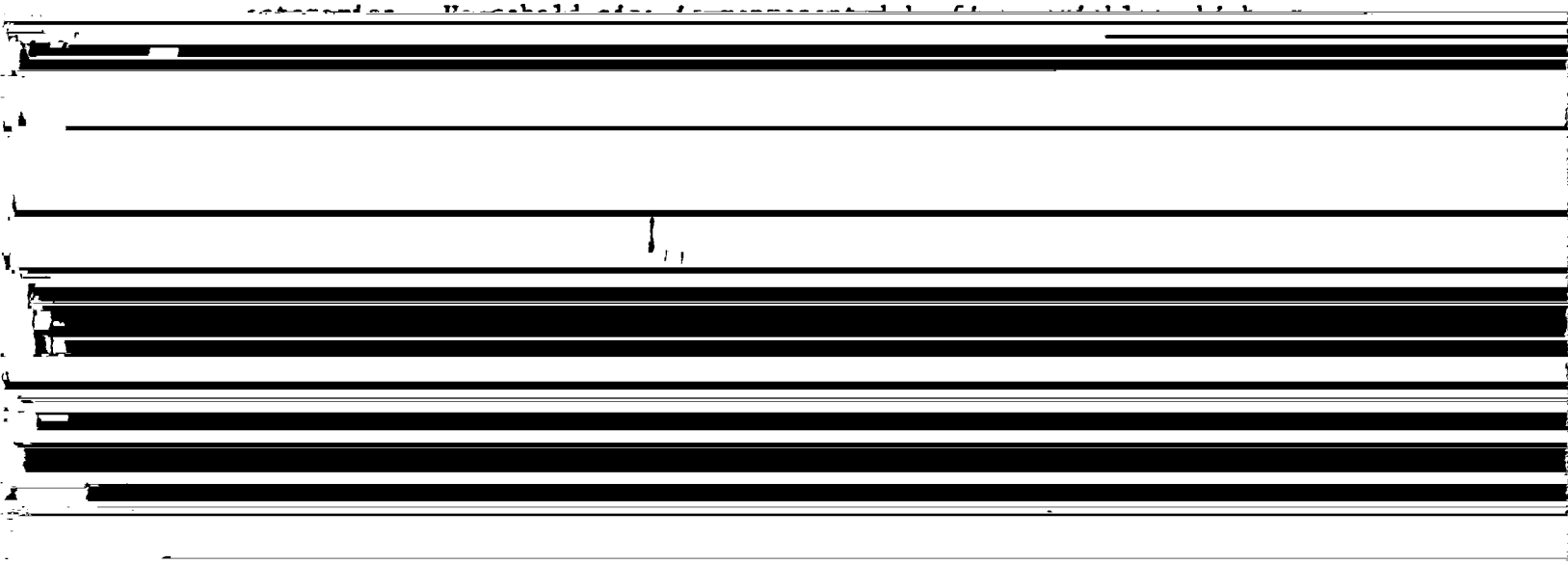
The Price and Sharma work, summarized in a series of five reports submitted to USDA, uses a regression framework and data from the 1977-1978 and 1979-1980 NFCS to estimate economies of scale factors. Unlike the work of Peterkin-Kerr and Morgan et al., which are both strictly normative, the

[1]Estimates for four-person households are always 100, by definition.

Price-Sharma work includes both normative and preference-based specifications.[1] Their variable definitions and functional forms also differ substantially from the work reviewed so far.

Control Variables

In the Price-Sharma work, household composition is represented by 15 variables which represent the number of household members in various specified age/sex categories. The coefficients of these variables reflect the relative food requirements of individuals in the different age/sex



weighted sums of the number of household members in the various age/sex categories.[2] Discretionary food economizing efforts are controlled for in two alternative ways. The first is a measure of "per adult equivalent" income, which is a generalization of per capita income. This is defined by dividing household income by an adjusted measure of household size in which different weights are assigned to persons in different age/sex categories to reflect varying requirements for total consumption. This income measure was defined using after-tax income for the year preceding the survey. The authors prefer their second formulation, however, which is their "expendi-

[1]Actually, most of the Price-Sharma specifications combine features of

ture quality index." The index was based on the concept of an elasticity, commonly used in economics, which in the present context reflects the responsiveness of the demand for a particular item to changes in total food expenditures. Elasticities may be thought of along a continuum, the high end of which represents luxuries (the first to be given up as income falls) and the low end necessities. The Price-Sharma estimated elasticities for 39 food items ranged from a maximum for shellfish to a minimum for dried beans. These estimated elasticities were used to estimate an index representing the diet quality of each household in the sample, the value of which increases the greater the proportion of the household food budget is spent on luxury items.

Functional Form

The functional form of the Price-Sharma model is multiplicative. In other words, in the regression equation the variables are multiplied together rather than added, as is the case with the linear form. It thus allows, indeed requires, the estimated relationships to be nonlinear. This makes the model more complex and computationally expensive to estimate. They estimate it in a three step procedure which allows them to reduce each step to a linear estimation.

Sample Used for Estimation

Price-Sharma estimated economies of scale factors for three samples: 1977-1978 NFCS-Low Income, 1979-1980 NFCS-Low Income, and 1977-1978 NFCS-Basic (i.e., the full income range). The effects of the Food Stamp Program were removed from the 1977-1978 estimates by excluding food stamp recipients from the sample. Food stamp recipients were not excluded

from the 1979-1980 low-income sample, however, at least in part because the remaining low-income sample would have been too small for confident estimations. To account for the effect of the Food Stamp Program, the authors included a variable signifying whether the household participated in the program or not.

As with all work using the NFCS or their predecessor, the National Food Consumption Survey, waste is included in the Price-Sharma food expenditure data measure. Price-Sharma control for meals eaten away from home by using the number of meals eaten at home per person as a control variable.

Measurement of Diet Quality

As noted, Price-Sharma estimated models with different combinations of four measures of diet quality. The first three are entirely normative:

- Food Energy Level. This is basically the same as the analogous measure in Peterkin-Kerr, except that it is not constrained to a maximum of 150 percent of RDA.
- Lowest RDA. This is the same as the analogous Morgan et al. measure.
- Lowest NDR. This is the lowest nutrient density ratio among the seven nutrients specified. (These are the same seven as used by Peterkin-Kerr.) The previously reviewed authors did not use this measure. It is designed, like the Lowest RDA, to focus on the low end of the deprivation scale.

Since Price and Sharma chose not to truncate Food Energy Level as Peterkin and Kerr had done, the variable becomes a measure of the total quantity of food used. Since this total quantity includes waste, the untruncated measure is likely to be more highly correlated with waste than a truncated measure. Therefore, estimates obtained by Price and Sharma using this measure as a control variable may be biased in the direction of a flatter

tilt, since some of the variation in waste attributable to economies of scale may be controlled for rather than measured.

The fourth measure used is the expenditure quality index mentioned above. It should be noted in this connection that the expenditure quality index, although preference-based in the sense that it is estimated on survey data measuring actual food consumption does contain a normative component. Food Energy Level (FEL) was included as an explanatory variable in the regression used to estimate the elasticities for each food group.[1]

Price-Sharma calculated economies of scale factors for six specifications of their model corresponding to different combinations of variables. Each specification included the 15 variables representing the number of individuals in different age/sex categories as well as the five household size variables described above. The specifications differed with regard to the additional explanatory variables included, as summarized in Table III.5. As can be seen, Models II, III, IV, and VI contain normative diet quality measures. Only Model II, however, is a purely normative model. The others also include the expenditure quality index which, although it serves as a control for discretionary food economizing, also serves as a measure of the luxury-necessity composition of the diet. Model II and III uses the expenditure quality index in combination with FEL and Lowest NDR; Model IV uses it in combination with Lowest NDR only; Model VI uses it in combination with Lowest RDA only. Model V is a purely preference-based specification, using the expenditure quality index alone.

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[1]Thus, the elasticity estimates indicate the responsiveness of demand for a given food group to changes in total food expenditure of the household, holding constant the total number of calories in the diet.

TABLE III.5

SIX SPECIFICATIONS OF THE PRICE-SHARMA MODEL

Model	Explanatory Variables
I. Basic Model	1. After Tax Income 2. Number of Meals at Home Per Person
II. Comprehensive Model	1. After Tax Income 2. Number of Meals at Home Per Person 3. FEL 4. Lowest NDR 5. Northeast Region 6. Rural NonFarm 7. Spanish Origin
III. Expenditure Quality Model 1	1. Expenditure Quality Index 2. Number of Meals at Home Per Person 3. FEL 4. Lowest NDR 5. Northeast Region
IV. Expenditure Quality Model 2	1. Expenditure Quality Index 2. Number of Meals at Home per Person 3. Lowest NDR 4. Northeast Region
V. Expenditure Quality Model 3	1. Expenditure Quality Index 2. Number of Meals at Home Per Person
VI. Expenditure Quality Model 4	1. Expenditure Quality Index 2. Number of Meals at Home Per Person 3. Lowest of RDA 4. Northeast Region

NOTE: Each specification of the model also includes the 15 variables representing the number of individuals in various age/sex categories as well as the five household size variables described in the text.

FEL = Food Energy Level (not constrained to a maximum of 150 percent of RDA for calories)
NDR = Nutrient Density Ratio
RDA = Recommended Daily Allowance

Results

The economies of scale factors estimated by Price-Sharma for the six model specifications using the low-income and basic samples of the 1977-1978 NFCS are shown in Table III.6. As can be seen, the Comprehensive model, estimated with after-tax income, FEL and Lowest NDR, and other variables produces much the flattest tilt and practically the same estimates for both samples. As noted above, since Price and Sharma did not truncate FEL, this variable may be highly correlated with total food waste. Thus, some of the variation in food waste associated with economies of scale may be controlled for rather than measured, biasing the estimates in the direction of a flatter tilt. The Basic model, with no diet quality measure, produces a somewhat sharper tilt, especially for the basic sample. The Expenditure Quality models, in contrast, all produce sharper tilts for the low-income than for the basic samples and, except for Expenditure Quality 1 (the only one to include the untruncated FEL as a diet quality measure), much sharper tilts for both samples than the models that do not include the expenditure quality index.

The economies of scale factors estimated by Price-Sharma for the low-income sample for both years of the NFCS are compared in Table III.7. For the Basic and Comprehensive models, the 1979-1980 estimates have sharper tilts than those for 1977-1978. They are also different enough for the two years to suggest caution in their interpretation. The two sets of estimates for two of the three Expenditure Quality Models (the fourth could not be compared) are much closer. Such differences as there are indicate

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TABLE III.6

ECONOMIES OF SCALE FACTORS, PRICE-SHARMA (1981-1983), TWO SAMPLES, 1977-1978

Household Size (persons)	I. Basic		II. Comprehensive		III. Expenditure Quality 1		IV. Expenditure Quality 2		V. Expenditure Quality 3	VI. Expenditure Quality 4	
	Low Income	Basic	Low Income	Basic	Low Income	Basic	Low Income	Basic	Basic[a]	Low Income	Basic
1	122	135	113	112	122	118	153	141	139	139	134
2	113	122	103	105	109	106	128	124	122	119	117
3	105	111	101	100	104	102	114	111	111	110	107
4	100	100	100	100	100	100	100	100	100	100	100
5	90	93	94	97	96	97	91	91	91	94	93
6	88	89	94	95	92	91	81	82	83	87	86

[a]Expenditure Quality Model 3 was not estimated with the low-income sample.

TABLE III.7

ECONOMIES OF SCALE FACTORS, PRICE-SHARMA (1981-1983), LOW-INCOME SAMPLE, 1977-1978 and 1979-1980

Household Size (persons)	I. Basic		II. Comprehensive		III. Expenditure Quality 1		IV. Expenditure Quality 2		V. Expenditure Quality 3[a]	VI. Expenditure Quality 4	
	1977-78	1979-80	1977-78	1979-80	1977-78	1979-80	1977-78	1979-80		1977-78	1979-80
1	122	155	113	126	122	118	153	142		139	135
2	113	130	105	110	109	109	128	127		119	119
3	105	112	101	103	104	101	114	116		110	106
4	100	100	100	100	100	100	100	100		100	100
5	90	93	94	94	96	96	91	93		94	96
6	88	76	94	89	92	89	81	68		87	80

NOTE: Expenditure Quality Model 3 was not estimated with the low-income sample.

flatter tilts for the smaller household sizes with the 1979-80 sample, in contrast to the Basic and Comprehensive Models, but steeper tilts for the larger household sizes.

Overall Assessment

The Price-Sharma work obviously differs substantially more from the Peterkin-Kerr and Morgan et al. work than they differ from each other. The multiplicative functional form is more complex and computationally expensive than the 5-specification linear approach. The Price-Sharma approach to defining variables to control for household composition and discretionary economizing efforts is reasonable although, as noted, there is probably some residual age/sex effect in their estimates, which would increase the tilt in their adjustment factors, other things equal. Their specification of the expenditure quality index is an important contribution and deserves careful consideration as an additional candidate for measuring diet quality.

It is obvious, as it is for the Morgan et al. research, that differences in variable definition and sample can make major differences in the value and tilt of the adjustment factors. Even so, the Price-Sharma estimates for the low-income sample, when compared over the two survey years, are much closer than those of Morgan et al. It should also be noted that for the Basic and Comprehensive Models, though not for the Expenditure Quality Models, the year to year differences are in the opposite direction from those of the Morgan et al. estimates.

E. THE GRACE COMMISSION REPORT (1982)

In its recent report on potential federal government cost reductions, the President's Private Sector Survey on Cost Control (the Grace Commission) criticized the methodology by which the current USDA economies of scale factors were derived. The Commission recommended a set of scale factors "more in-line with the actual differences in purchasing costs that occur based on family size."

The Grace Commission's primary criticism of the current USDA economies of scale factors is that the methods used to control for differences in diet quality across household size were inadequate. The Commission report stressed that one of the reasons for the observed variation in per capita food costs across household size is that small households tend to consume diets of higher quality than larger households and expressed general skepticism about the ability of statistical models to adequately control for differences in diet quality. It therefore recommended that economies of scale factors be based on estimates of the differences in food prices paid by different sized households.

The Commission report specifically recommended that USDA economies of scale factors be based on a set of price indices estimated by Peterkin (1972) which reflect the differences in food prices paid by households of different size.

The price indices estimated by Peterkin were based on data collected in the 1965-66 Household Food Consumption Survey. In that survey, an interviewer asked the household member what foods had been used at home during the previous week, how much of each food was used, and how much it cost. The unit-volume cost for each food used by the household was

estimated by dividing its reported cost by the reported volume bought. To estimate the overall differences in food prices paid by different sized households, the cost of a standard market basket of 400 food items in amounts used by 4-person households in a week was determined from the average prices reported by each household size.

There are two major limitations associated with the Grace Commission recommendation for using such price indices as economies of scale adjustment factors for the Food Stamp Program. First, this approach does not capture the potentially substantial economies of scale associated with the greater ability of large households to avoid spoilage and other sources of waste. This failure to capture the full magnitude of economies of scale will affect the adjustment factors in the direction of a flatter tilt. Secondly, the market basket used to construct the price indices was not defined with sufficient detail to capture differences in the quality, grade, and brand of food items. Therefore any estimated variation in prices across household size may result from two factors: (1) the price advantages available to larger households by purchasing items in bulk and (2) differences across household size in the quality of food items selected. The latter source of price variation is associated with discretionary economizing behavior rather than economies of scale. Since discretionary economizing is likely to be greater at the low end of the income scale, and since per capita income falls on average as household size rises, the estimated price indices will overestimate the variation in prices across household size attributable to economies of scale. These two limitations are partially offsetting.

In addition to the above limitations, the specific index recommended by the Grace Commission is based on out-dated survey information. The methodology employed by Peterkin for estimating price indices has been applied in two recent studies to data from the 1977-1978 NFCS. Ritzmann (1982) used the Spring 1977 NFCS data for all income levels; Kerr (1983) used the NFCS low-income sample for the entire 1977-1978 survey period. The Peterkin index and the two more recent indices are shown in Table III.8. The comparison between the Ritzmann and Peterkin price indices suggests that price variations across household size declined slightly from 1965-66 to 1977-78. However, the differences between the two sets of price indices are very small and may not be statistically significant. The comparison of the Kerr and Ritzmann price indices suggests that the variation in prices across household size may be greater for low income households than for the general population. Here again, caution in interpretation is indicated, given the inability to control for variations in the quality, grade and brand of food items.

F. CONCLUSION: NEXT STEPS

Three conclusions are clear from this review. First, substantial methodological progress has been made since the current adjustment factors were calculated in the search for ways to identify and isolate the effects of economies of scale on household food consumption from other influences. Second, all the methods reviewed have strengths and weaknesses as they currently stand. Since the strengths and weaknesses are to a large extent different for the different approaches, there is now an excellent opportunity to develop a methodology which incorporates the strengths of each without their weaknesses. But third, the new approaches are so

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TABLE III.8

ESTIMATED PRICE INDICES BY HOUSEHOLD SIZE, DIFFERENT SAMPLES, 1965–1966 AND 1977–1978

	1965–1966 Data	1977–1978 Data	
Household Size	Peterkin (1972) All Income	Ritzmann (1982) All Income[a]	Kerr (1983) Low Income
1	109	107	114
2	105	102	107
3	101	101	106
4	100	100	100
5	99	100	101
6+	98	99	98

[a]This is the NFCS Basic Sample, measured for the Spring of 1977 only.

different from the old methodology and so different in turn from one another that it is not possible to draw any confident conclusions about how economies of scale in food consumption might have changed between 1965 and the late 1970s, or even to be sure that they have changed.

The most important item on the research agenda is to use the recent survey data to obtain the best possible economies of scale estimates for a sample of households representative of the population of food stamp recipients. This work should build on the studies reviewed above, incorporating the strengths of each and eliminating the weaknesses. Of particular importance when using a low income sample is ensuring that the effects of the Food Stamp Program itself on food expenditures are controlled for. Another important item on the research agenda involves answering the following question: Have the economies of scale in food consumption available to households of different size changed since 1965? This is a relatively straightforward question to answer. All it requires is that exactly the same model, estimation procedure, sample, and variable definitions be applied to all three sets of data: the 1965 National Food Consumption Survey and the two waves of the NFCS. Which ones are chosen is not a crucial issue, although an obvious choice would be the Peterkin-Kerr specifications, so that the estimates with the new data would be directly comparable to adjustment factors now in effect.

If, as is likely, changes in packaging and preservation technology and changes in tastes have altered economies of scale adjustment factors, the next question is how best to revise them. Achieving the answer to this question is not so straightforward, but systematic testing of the individual components of the different models and variable definitions for sensitivity of the estimates to changes in one, holding the others constant,

could yield the information necessary to make an informed choice. The following tests provide examples of the kinds of work that would be extremely helpful for such a sensitivity analysis.

- Correct for the effect of the Food Stamp Program in the Morgan et al. specification by including a program participation dummy and including the benefit amount as an additional control variable.
- Estimate the Morgan et al. model using the Price-Sharma expenditure quality index as a control variable instead of income.
- Use a common set of nutritional measures to estimate both models. Because Lowest RDA is a new measure that has not yet received a critical review by nutritionists, other measures of diet quality may be preferred at this time.
- Experiment with various socioeconomic variables in addition to income or the expenditure quality index to help control for discretionary food economizing.
- Experiment with more flexible functional forms, including introducing some nonlinear forms into the Peterkin-Kerr methodology, not only for income but for other variables as well.

This work remains to be done. In the meanwhile it is useful to be able to assess the changes, in terms of individual impacts and overall budget costs, that the various sets of estimates already calculated would make if implemented in the food stamp benefit calculation. The final chapter presents the range of possible changes that are to be expected. We compare the expected impacts of six alternatives to the current system. Our main criterion of choice was to use the adjustment factors preferred by the analysts themselves, tempered by the need to maximize comparability to the extent possible and to address the concern about Lowest RDA as a diet quality measure.

IV. RECIPIENT IMPACTS AND PROGRAM COSTS UNDER ALTERNATIVE ECONOMIES OF SCALE ESTIMATES

There still remains uncertainty as to the extent of economies of scale opportunities available to households of different sizes in the 1980s. This is due to the lack of comparability between the methodology used to calculate the currently used estimates and the various methodologies used to reestimate adjustment factors on recent NFCS data, combined with various weaknesses in each of the methodologies that has been tried. Notwithstanding this uncertainty, it is useful to work through the food stamp benefit calculation for a representative subset of the numerous estimates discussed in Chapter III, in order to assess their relative impacts on recipients and program costs.

The potential impact on the distribution of benefits and on program costs is examined by recomputing allotments, benefits, and costs under each alternative for a representative sample of recipient households drawn from the August 1982 Integrated Quality Control sample. The allotment standards are based on the Thrifty Food Plan as revised to represent the effect in November 1984. Thus, all the data in the tables in this chapter are in 1984 dollars except for those related to aggregate cost impacts, which are in fiscal year 1985 dollars. (Technical information on the methodology used in the simulations is provided in Appendix B.)

A. THE ECONOMIES OF SCALE FACTORS SELECTED

Six sets of economies of scale factors will be simulated. Their major characteristics are shown in Table IV.1. Several criteria guided the selection of the six sets of estimates. First, we chose the 1977-1978 estimations for all alternatives to the current system in order to ensure comparability at least with regard to NFCS survey wave. Second, we chose estimates for the low-income sample to the extent possible. The Price-Sharma ones are the exception in this regard because their model V was not estimated for the low-income sample. We, thus, chose the basic sample for both Price-Sharma models to enhance comparability along that dimension. Our third criterion was to include the sets of estimates which the analysts themselves preferred. Morgan et al. preferred their combined quality model; Price-Sharma preferred their models V and VI. Note that Price-Sharma V is the least normative of the models estimated here because its only normative component is the inclusion of percent of RDA for calories as a control variable in the otherwise preference-based expenditure quality index. The quasi-replication was selected in order to have some comparability with the current factors. Finally, we added the Morgan et al. 2-factor specification because of the views of some experts that overall diet measures are better indicators of short-term diet quality than are minimum levels of specific nutrients.

The economies of scale factors currently used and the six alternatives estimated on the 1977-1978 data are shown in Table IV.2. As can be seen, our alternatives include both steeper and flatter sets of adjustment factors than those currently used. Only two of the five are flatter, however: Morgan et al.'s preferred set and the updated Grace Commission's

TABLE IV.1

ALTERNATIVE ECONOMIES OF SCALE FACTORS SIMULATED

	Current	Morgan et al.			Price-Sharma		Grace Commission
	(Peterkin-Kerr)	Quasi-Replication	Combined Quality	2-Factor	V	VI	Updated Market Basket
Model	5-equation linear	----------	5-equation linear----------		multiplicative 3-stage estimation----		price index
Sample	non-low-income	----------	low-income----------		basic----------		low-income
Data Base	1965	----------	1977-1978----------		1977-1978----------		1977-1978
Diet Quality Measure	Average of 5 (1963 RDAs)[a]	Average of (1974 RDAs)[a]	NDR,FEL Lowest RDA	NDR and FEL	Expenditure Quality Index	Expenditure Quality Index and Lowest RDA	Standard Market Basket

[a]The five Peterkin-Kerr diet quality measures are: diet score, number of RDAs met, NDR, Number of NDR of 1.0, FEL (maximum of 150 percent of RDA).

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TABLE IV.2

ECONOMIES OF SCALE FACTORS FOR SELECTED ALTERNATIVES

Household Size	Current (Peterkin-Kerr)	Morgan et al.			Price-Sharma		Grace Commission
		Quasi-Replication	Combined Quality	2-Factor	V	VI	Updated Market Basket
1	120	130	116	130	139	134	114
2	110	115	106	114	122	117	107
3	105	105	101	106	111	107	106
4	100	100	100	100	100	100	100
5	95	95	99	95	91	93	101
6	95	90	96	92	83	86	98
7	90	90	100	90	83	86	98
8+	90	85	99	84	83	86	98

market basket. That four out of the five regression estimates selected yield steeper tilts provides some indication that the tilt of economies of scale factors may in fact have become steeper since the 1965 estimates were made. As will be seen in the microsimulation results below, making the adjustment tilt steeper than the current tilt will redistribute benefits from large to small households in comparison with the current program. Because of the composition of U.S. households, this will result in greater relative benefits to elderly recipients. The steeper tilt also will increase program costs because more recipients are in small than in large families.

B. RECIPIENT IMPACTS

The allotment standards implied by the alternative economies of scale adjustment factors are shown in Table IV.3. Note that these define the maximum benefits of the program (i.e., the benefits that go to households with no net income). As expected, the different alternatives have substantially different effects on the generosity of the maximum benefit by family size. Under the current system, the allotment standard for a 1-person household is $79 a month. Two alternatives would reduce the allotment standard slightly: the combined quality model (to $77) and the Grace Commission price index (to $75). All the other alternatives would raise it by at least $7 a month, and the Price-Sharma Model V would raise it by as much as $13 a month (to $92). At the other end of the household size scale, under the current system the allotment standard for a 6-person household is $376. This would be lowered substantially under both the

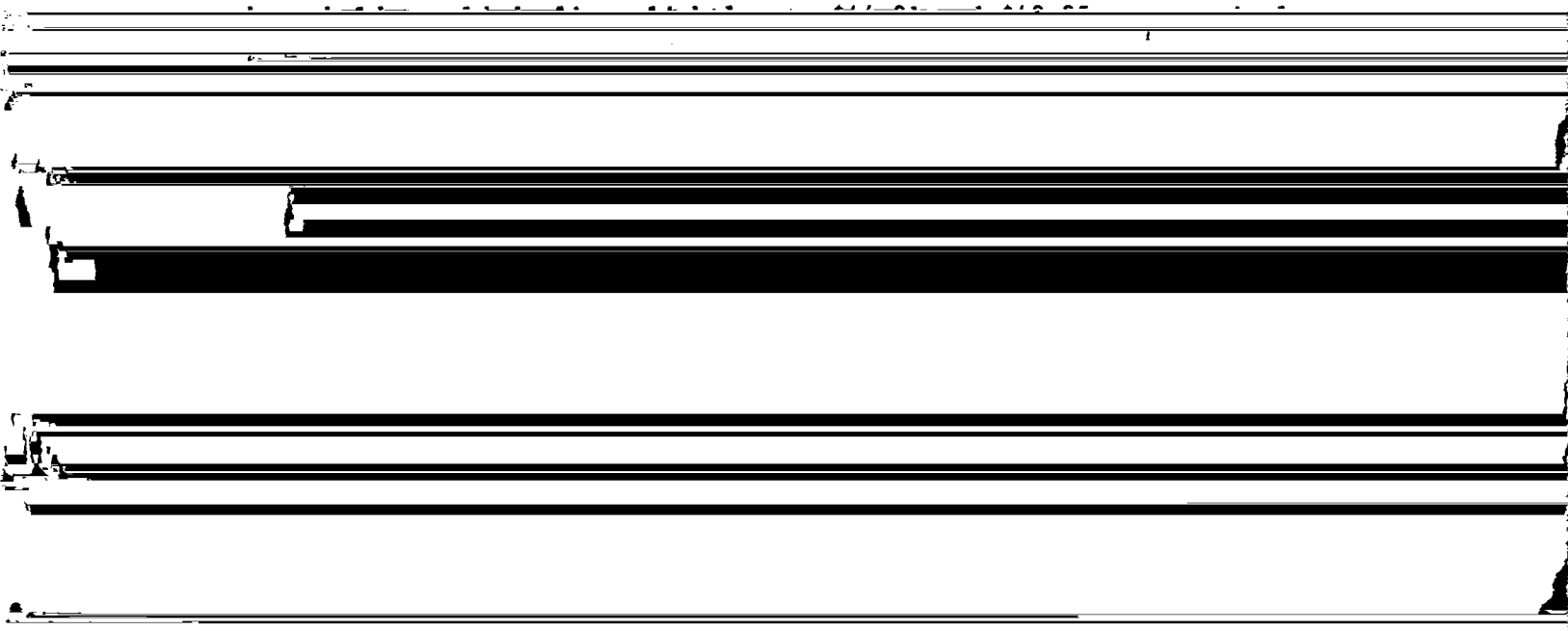
TABLE IV. 3

ALLOTMENT STANDARDS FOR CURRENT AND ALTERNATIVE ECONOMIES OF SCALE FACTORS (NOVEMBER 1984)

Household Size	Current (Peterkin-Kerr)	Morgan et al.			Price-Sharma		Grace Commission
		Quasi-Replication	Combined Quality	2-Factor	V	VI	Updated Market Basket
1	79	86	77	86	92	89	75
2	145	152	140	151	161	155	141
3	208	208	200	210	220	212	210
4	264	264	264	264	264	264	264
5	313	314	327	314	301	307	334
6	376	357	381	365	329	341	389
7	416	416	462	416	384	398	453
8	476	449	524	444	439	455	518

Price-Sharma V and VI models, to $329 and $341 resepctively. It would also be lowered, but less drastically, by the quasi-replication model. The Morgan et al. combined quality model and Grace Commission market basket alternatives are the most generous to the largest household sizes, raising the allotment standard to $381 and $389, respectively.

The allotment standard, of course, is only equal to the monthly benefit for households with no other net income. For other households, the rest of the benefit calculation comes into play, including the tax rate, the allowable deductions, the earned income allowance (for those who earn) and the minimum benefit. These factors contained in the benefit calculation modify the distribution of benefits implied by the allotment standards in isolation. Table IV.4 shows the average per capita monthly benefit under each alternative.[1] This provides a straightforward measure of recipient impact. As can be seen, the impact can be substantial. Under the current system, 1-person households receive a per capita benefit averaging $46.55. Under the two plans with a flatter tilt (Morgan et al. combined quality and the market basket) the average benefit for 1-person



Under all the other alternatives it would increase by at least $5, and for

TABLE IV.4

PER CAPITA MONTHLY AMOUNT OF BONUS STAMPS BY HOUSEHOLD SIZE
BASED ON CURRENT AND ALTERNATIVE ECONOMIES OF SCALE FACTORS

Household Size	Current (Peterkin-Kerr)	Morgan et al.			Price-Sharma		Grace Commission
		Quasi-Replication	Combined Quality	2-Factor	V	VI	Updated Market Basket
1	46.55	52.05	44.31	52.05	57.40	54.50	43.35
2	48.21	51.38	45.68	50.76	55.92	52.70	46.30
3	47.52	47.52	44.86	48.18	51.50	48.84	48.18
4	44.04	44.04	44.04	44.04	44.04	44.04	44.04
5	40.19	40.19	42.81	40.19	37.55	38.86	44.14
6	39.70	36.39	40.35	37.71	31.77	33.74	41.67
7	39.40	37.57	45.61	37.21	34.80	36.77	44.66
All households	44.29	44.91	44.17	45.03	45.98	45.17	45.06

would reduce it, with the bottom of the range being Price-Sharma V, at $34.80 a month.

The reader is reminded that the average benefit by household size under the food stamp benefit calculation is not the same as it would be if each household had its benefit calculated according to the individualized Thrifty Food Plan (TFP). This is because of the age/sex differences across households. Nor does the average benefit bear the same relationship to the TFP for all household size groups as is illustrated in the following example:

Household A		
Thrifty Food Plan (individualized allotments)		Food Stamp Program Allotment
Father	$75.80	$66.10
Mother	68.20	66.10
Child Age 3	44.90	66.10
Subtotal	$188.90	$198.30
Scale Adjustment	x1.05	x1.05
Amount	$198.35	$208.82
Household B		
Elderly Woman	$67.40	$66.10
Scale Adjustment	x1.2	x1.2
Amount	$80.88	$79.32

The average monthly benefit as a percent of what it would be under the individualized TFP for each household size group is as follows:

Size 1 =	92%	Size 5 =	109%
2 =	106%	6 =	111%
3 =	111%	7 =	108%
4 =	112%		

Note that these percentages will be the same for any set of adjustment factors, as long as the same economies of scale are applied to the TFP as to the food stamp allotment standard, because they depend on the age/sex composition of the household size group, not the tilt of the economies of scale adjustment.

Before we go from recipient impacts to impacts on program costs, we should note two things about the two plans we have been referring to as having a flatter tilt than the current system: the Morgan et al. combined quality model and the Grace Commission's updated market basket. First, the market basket factors used in the simulations were based on the 1977-78 NFCS data for the low income sample. This is in contrast to the factors used by the Grace Commission which were based on 1965-66 data for all income levels as discussed in Chapter III. That difference results in an increase rather than a decrease in average monthly benefits. Second, there are important differences between the Morgan et al. combined quality model and the updated market basket. Although they look very similar for most household sizes, they differ substantially for two household size categories: 3-person and 5-person households. On each side of the 4-person household anchor, the market basket has more generous adjustment factors than the combined quality model. These differences lead to more generous allotment standards and monthly benefits.

B. PROGRAM COST IMPACTS

This examination of the cost of alternative adjustment factors focuses on two issues. The first is how much aggregate benefits and, hence, the program cost would change under each of the alternatives. The second issue is the degree of redistribution of benefits across household size categories with changes in the economies of scale factors. We look at these two issues in turn.

Table IV.5 shows overall program budget impacts estimated for the various alternatives. The aggregate annual benefit amount projected to Fiscal Year 1985 is $10.48 billion. The only one of the simulated alternatives that would save money is the Morgan et al. combined quality model. Even this would result in a cost savings of only $25 million a year. This compares to the Grace Commission updated market basket which, although similar in terms of the flatter tilt, is estimated to increase aggregate annual benefits by $184 million as a result of larger benefits for 3-person and 5-person households. As is expected, Price-Sharma model V would be the most expensive, increasing the aggregate annual benefit amount by $395 million. How do these aggregate benefit differences work themselves out for particular household sizes? Table IV.6 provides the answer. The two plans with the flatter overall tilts (Morgan et al. combined quality model and the market basket) cost less than the current system for 1- and 2-person families. The combined quality model also costs less for 3-person households, although as noted the updated market basket partially counterbalances the savings for the smallest households by costing more for the 3-person households. For 5-person and larger households the program cost of these two alternatives is greater. For all

TABLE IV.5

PROGRAM BUDGET IMPACTS BY ECONOMIES OF SCALE ALTERNATIVE

Household Size	Current (Peterkin-Kerr)	Morgan et al. Quasi-Replication	Morgan et al. Combined Quality	Morgan et al. 2-Factor	Price-Sharma V	Price-Sharma VI	Grace Commission Updated Market Basket
Aggregate Annual Bonus[a]	10.479	10.624	10.454	10.652	10.874	10.684	10.663
Annual Change	---	+1.3%	-0.2%	+1.6%	+3.8%	+2.0%	+1.8%
Relative to Current Plan	---	+0.145	-0.025	+0.173	+0.395	+0.205	+0.184

[a]Billions of dollars, projected fiscal year 1985.

TABLE IV.6

CHANGE IN PROGRAM COST FROM CURRENT PLAN BY HOUSEHOLD SIZE
(Millions of dollars per year, Projected Fiscal Year 1985)

Household Size	Current (Peterkin-Kerr)	Morgan et al.			Price-Sharma		Grace Commission
		Quasi-Replication	Combined Quality	2-Factor	V	VI	Updated Market Basket
1	0	142	-58	142	280	205	-82
2	0	113	-90	91	275	160	-68
3	0	0	-132	33	197	65	33
4	--	--	--	--	--	--	--
5	0	0	88	0	-89	-45	133
6	0	-64	13	-39	-154	-116	38
7+	0	-45	154	-54	-114	-65	130
Overall	0	145	-25	173	395	205	184

the other alternatives, the program cost for 1- and 2-person households is increased. The quasi-update indicates no change for 3- and 5-person households. Program costs are reduced for larger households under the quasi-update. The Morgan combined quality model and the market basket models increase program costs for larger household sizes, with the greatest cost increases occurring in the 7+ person household size for the combined quality model.

Program cost impacts by different age/sex groups are shown in Table IV.7. Of the two plans with the flattest overall tilts, the Morgan et al. combined quality model increases program costs for all age/sex groups except older women and older men. The market basket increases costs for all groups except older women. The Morgan et al. 2-factor model saves money on children and teenagers, but the extra cost for the adult and elderly groups more than outweighs this saving. The Price-Sharma models save on all groups except the elderly, but the increased cost for older women and older men outweighs those savings by a substantial margin, particularly for Price-Sharma model V.

When considering program cost and benefit distribution effects, there are no easy choices. The Morgan et al. combined quality model is the only alternative included in the simulations which reduces program costs compared with the current economies of scale adjustment factors. But its cost savings come at the expense of older women and older men. All the other alternatives increase program costs overall. But each reduces benefits for some groups. The two models with the sharpest tilts (Price-Sharma V and VI), as expected, benefit older women and older men at the expense of other groups, particularly young children and teenagers.

TABLE IV.7

CHANGE IN PROGRAM COST FROM CURRENT PLAN BY HOUSEHOLD CHARACTERISTICS[a]
(Millions of dollars per year, Projected Fiscal Year 1985)

Household Characteristics	Current (Peterkin-Kerr)	Morgan et al.			Price-Sharma		Grace Commission
		Quasi-Replication	Combined Quality	2-Factor	V	VI	Updated Market Basket
Young Children	0	-31	66	-11	-25	-53	190
School Children	0	-68	122	-43	-145	-121	230
Teenage Girls	0	-48	105	-37	-102	-79	158
Teenage Boys	0	-51	122	-42	-118	-86	170
Adult Women	0	-2	57	28	66	-13	257
Adult Men	0	-8	86	6	-43	-34	148
Older Women	0	78	-38	76	173	113	-28
Older Men	0	24	-13	24	61	34	1

[a]Columns do not sum to overall amount because household savings or costs may appear in multiple classifications.

In summary, this chapter has shown how benefits would be redistributed across recipient households of different sizes and types as well as how aggregate program costs would be impacted by alternative economies of scale factors. That examination indicates that most of the alternatives will reduce benefits to one group or another and, in addition, all except one alternative increases program costs. The potential impact on recipients and program cost when combined with the current uncertainty as discussed in Chapter III about the true economies of scale available to households are reasons to proceed cautiously in deciding to make program changes in this area.

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APPENDIX A

COMPARATIVE RESEARCH FINDINGS ON ECONOMIES OF SCALE ADJUSTMENT FACTORS IN THE FOOD STAMP PROGRAM

In this Appendix, we will review in greater technical detail than in Chapter III the various new empirical studies designed to estimate economies of scale in household food consumption. These new studies will be evaluated on the basis of the criteria discussed in Chapter II and compared to the study which generated the current USDA economies of scale factors.

To provide some historical background, this Appendix begins by reviewing an early attempt by Murray (1962) at estimating economies of scale with data from the 1955 Survey of Household Food Consumption. We next discuss a study by Peterkin and Kerr (1975), in which a more sophisticated methodology was applied to data from the 1965 Household Food Consumption Survey, to estimate the economies of scale factors currently used by USDA. We next review a set of studies recently conducted by researchers at the University of Missouri and Washington State University which employed data from the 1977-78 and 1979-80 Nationwide Food Consumption Surveys. Some of these new studies have employed the same basic methodology as that employed by Peterkin and Kerr; others have experimented with new methodologies.

A. Murray (1962)

The study by Murray was an early attempt at estimating economies of scale, using data from the 1955 Survey of Household Food Consumption and relying on relatively simple graphic and algebraic methods. The methodology employed by Murray involved a two-step procedure. The first step estimated the per capita food costs required by households of different size to reach a specified level of nutritional adequacy. The second step adjusted these costs to control for the variation in age/sex composition, and hence nutritional requirements, across household size.

The first step of the Murray procedure involved estimating for each household size category the per capita food cost at which a specified proportion of households would reach a particular level of nutritional adequacy. The standard chosen was the level at which 75 percent of the households in each size category would meet two-thirds of the recommended allowances for each of eight nutrients. This standard was chosen to reflect the food consumption patterns of low income households, the group for which economies of scale were to be estimated. For each household size, the per capita food cost required to attain this standard was determined from a set of graphs constructed from the survey data illustrating the proportions of households meeting the specified level of nutritional adequacy at various intervals of per capita food cost. The resulting estimates, converted to an index with a value of 100 assigned to a 4-person household, are illustrated in Table A.1. The estimates range in value from 118 for a 1-person household to 87 for a 6-person household.

The second stage of the Murray study involved an adjustment to remove the effect of age/sex composition from these estimates, based on

TABLE A.1

ECONOMIES OF SCALE FACTORS FOR LOW INCOME HOUSEHOLDS, MURRAY (1962)[1]

Household Size			
Persons	Equivalent cost units	Includes effect of age/sex composition	Age/sex composition effect removed
1	0.75	118	123
2	1.61	113	109
3	2.38	108	106
4	3.11	100	100
5	3.85	93	94
6	4.58	87	88

NOTE: Estimated from a low-income sample of households from the 1955 Survey of Household Food Consumption. The estimates are expressed as indices of per capita food costs, with a 4-person household = 100.

estimated costs of the USDA low-cost food plan for individuals in various age/sex categories. This information was used to define a new measure of household size in terms of "equivalent cost units," where the weekly food plan cost of $6.70 for a 20-34 year old male was normalized at unity. Thus, a child 4-6 years of age, whose weekly food plan cost was $3.90, was assigned a value of 0.58 on the scale of equivalent cost units. For a sample of low income households, Murray computed the average number of equivalent cost units corresponding to each category of household size. These values are also displayed in Table A.1. The relatively low value for 1-person households is due to the large proportion of elderly women in this size category.

The estimates of household size in terms of equivalent cost units were used to form adjustment factors to remove the effect of age/sex composition from the per capita food costs derived in the first stage of the study. For each size category, the adjustment factor was defined as the ratio of the actual household size to the average size in terms of equivalent cost units. Multiplication by such an adjustment factor converts expenditures per person to a measure of expenditures per equivalent cost unit. Such adjusted measures, normalized to a value of 100 for a four-person household, are shown in the final column of Table A1. These measures, interpreted as economies of scale factors, reflect the variation in per capita food costs required by different sized households to reach a given level of nutritional adequacy after adjusting for differences in age/sex composition.

While the economies of scale factors estimated by Murray are of historical interest, they should not form the basis for current policy

decisions. Murray's estimates were derived from data collected in 1955, and there may have been changes in the magnitude of economies of scale since that time. Such changes could result from differences in food marketing practices and differences in the type of kitchen appliances commonly used. In addition, there are methodological problems associated with Murray's study. For example, the graphic analysis conducted in the first stage of the study is subject to considerable error. Subsequent studies have employed statistical modeling techniques, which are much more reliable than fitting graphs to data points by hand. Secondly, it is likely that Murray's economies of scale estimates are contaminated by the effect of discretionary economizing behavior. As we explained in Chapter II, it is likely that such discretionary behavior is correlated with household size through an association with per capita income. Thus, smaller households, with greater per capita incomes, would be expected to consume higher quality diets and to make less strenuous efforts at avoiding waste and spoilage than larger households. By focusing solely on a nutritional measure of household diets, it is unlikely that Murray has fully controlled for diet quality. In addition, no attempt was made to control for differences in the intensity of effort aimed at avoiding waste and spoilage. Subsequent studies have dealt with these problems by specifying statistical models in which per capita income is included as an explanatory variable to control for differences in discretionary economizing behavior.

B. Peterkin and Kerr (1975)

The economies of scale factors currently used by USDA were developed in 1975 by Peterkin and Kerr of the Consumer and Food Economics

Division, Agricultural Research Service.[1] These estimates were derived by applying multiple regression techniques to data collected in the National Household Food Consumption Survey, Spring 1965. The analysis employed a sample consisting of 4,376 urban and rural nonfarm households that reported money incomes net of federal and state income taxes above the federal poverty threshold.

The methodology employed by Peterkin and Kerr involves the use of a regression model to estimate the effect of household size on per capita food costs while controlling for differences in discretionary economizing behavior and age/sex composition. Peterkin and Kerr experimented with a variety of normative measures of the nutritional quality of household diets. Such measures of diet quality were used along with per capita income to control for differences in discretionary economizing behavior. In addition, the nutritional standards associated with the USDA low-cost food plan were used to control for the effect of age/sex composition on dietary needs.

An important aspect of the Peterkin-Kerr methodology concerns the manner in which certain key variables are defined. Peterkin and Kerr defined household size in terms of the total number of meals eaten at home. Specifically, household size was computed by dividing the total number of meals eaten from the home food supply during the survey week by 21 (based on three meals per person per day for seven days). Peterkin and Kerr controlled for the differences in food requirements across household size categories due to variations in age/sex composition by using the

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[1]This is now the Consumer Nutrition Division, Human Nutrition Information Service.

household's per capita cost of obtaining the USDA low-cost food plan.[1] The contribution of each household member to this estimate was weighted by the proportion of meals eaten from the home food supply during the week of the survey. Thus, the constructed variable controls for the effect of age/sex composition on home food costs while also controlling for differences in the proportion of meals eaten outside the home.

The different measures of nutritional quality experimented with by Peterkin-Kerr appear in Table A.2. As the table indicates, each can be criticized for ignoring important aspects of nutritional quality. Since there are weaknesses associated with all currently available measures, Peterkin and Kerr estimated five different specifications of their model which employed different measures of nutritional quality. In each of the first three specifications, a single measure of nutritional quality was used. They were: (1) diet score, (2) number of Recommended Dietary Allowances (RDAs) met, and (3) nutrient density ratio (NDR). In each of the final two specifications, a combination of two nutritional measures was used: (1) food energy level (FEL) and NDR, and (2) FEL and number of NDR equal to 1.0. The economy of scale factors recommended by Peterkin and Kerr were computed as a simple average of the estimates obtained from each of these five specifications.

It should be noted that the nutritional measures discussed above were computed from survey data which reflect the total amount of food used

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[1]Since this control variable was designed to reflect the pure effect of age/sex composition on household food costs, no adjustment was made for economies of scale.

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TABLE A.2

MEASURES OF NUTRITIONAL QUALITY USED BY PETERKIN AND KERR (1975)

	Measure	Definition	Critique
1.	Diet Score	Sum of percentages of the 1963 Recommended Dietary Allowances (RDA) for food energy and seven nutrients.[a] A maximum of 100 percent for food energy and each nutrient was used.	Diets that are slightly below recommended levels for several nutrients may be judged as equivalent to diets well below recommended levels for a particular nutrient.
2.	Number of RDAs Met	Number of nutrients for which food used in the household provided at least the RDA for household members.	Equal importance is given to meeting the RDA for each nutrient, and no importance is given to the magnitude of the shortfall for any nutrient.
3.	Nutrient Density Ratio (NDR)	Sum, for seven nutrients, of the ratios of nutrients per 1,000 calories in the household diet to nutrients per 1,000 calories in the RDAs for household members. A maximum ratio of 1.0 for any nutrient was used.	Same weakness as diet score. In addition, diets that are deficient in both nutrients and calories may not be accurately judged.
4.	Number of NDR of 1.0	Number of nutrients for which the household diet had an NDR of 1.0 or more.	Same weakness as number of RDAs met.
5.	Food Energy Level (FEL)	A measure of food energy (calories) in the household diet in relation to the RDAs for food energy of household members. A maximum of 150 percent of RDA for calories was used.	Relies on calorie intake as the sole measure of dietary adequacy and disregards the intake of specific nutrients.

[a]The seven nutrients specified by Peterkin and Kerr are protein, calcium, iron, vitamin A, thiamin, riboflavin, and vitamin C.

by the household, including that lost through spoilage and other forms of waste. Therefore, the extent to which the various measures may be correlated with the amount of food wasted should be carefully considered. As noted in Chapter II, using control variables that are highly correlated with waste may bias the economies of scale adjustment factors in the direction of a flatter tilt, since some of the variation in waste attributable to economies of scale may be controlled for rather than measured. Peterkin and Kerr attempted to minimize this problem by truncating the nutritional measures at maximum allowable values defined in relation to the RDAs. In addition, by averaging the results obtained from 5 different specifications, the authors reduced the likelihood of basing their estimates on a measure for which the correlation with food waste is particularly severe.

The basic strategy followed by Peterkin and Kerr for estimating economies of scale involved the estimation of a linear regression model in which per capita household food cost was specified as a function of household size, per capita income, nutritional quality of the household diet, and the measure of age/sex composition described earlier. Rather than estimating the model with their entire sample, Peterkin and Kerr estimated the model separately for households in each of seven overlapping intervals of household size. This procedure produced seven sets of regression coefficients that varied with household size. The estimation results indicate that the effect of household size on per capita food cost is highly nonlinear. For example, for the specification in which diet score was used as a measure of nutritional quality, the estimated coefficient of household size ranged from -.988 for the smallest size

interval to -.017 for the largest size interval. Similar results were obtained with each of the other specifications of the model. The coefficients of the other independent variables also exhibited variation across household size, although it was generally less pronounced.

Economies of scale factors were derived by using the estimated regression models to predict the per capita food cost corresponding to different values of household size while holding all other independent variables constant at their sample means. Economies of scale factors were estimated as the ratio of these predicted per capita costs to the predicted per capita cost for a four-person household. Table A.3 shows the scale factors generated by this method for each of the five measures of nutritional quality used as control variables. Also included in the table is an index reflecting the observed variation in per capita food cost across household size, which includes the effect of discretionary economizing behavior and age/sex composition in addition to economies of scale. The estimated economies of scale factors generally show little sensitivity to which of the five measures of nutritional quality is used. The estimates imply that roughly half the observed variation in per capita food costs between one-person and four-person households is due to economies of scale. The proportion of the observed variation between four-person households and other size categories attributable to economies of scale is generally in the range of 30-45 percent.

The Peterkin-Kerr study receives a generally favorable review when evaluated in terms of the criteria outlined in Chapter II. The first criterion we consider is model specification, which refers to the ability of the model to yield a pure estimate of economies of scale by successfully

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TABLE A.3

ECONOMIES OF SCALE FACTORS FOR HOUSEHOLDS ABOVE THE POVERTY THRESHOLD, PETERKIN AND KERR (1975)

Household size (persons)	Number of households in sample	As reported	Diet score	No. of RDA met	NDR	FEL and NDR	FEL and no. of NDR of 1.0	Average of five specifications
1	436	142	123	121	118	122	119	121
2	1245	122	112	110	110	110	109	110
3	977	110	104	104	104	103	102	103
4	808	100	100	100	100	100	100	100
5	476	92	96	96	96	98	98	97
6	245	84	94	94	92	96	96	94
7	126	78	92	91	89	95	95	92
8	34	81	92	91	89	96	96	93
9	29	74	91	91	89	97	96	93

NOTE: Estimated from a sample of households with after-tax incomes above the federal poverty threshold from the 1965 National Household Food Consumption Survey. All five specifications control for per capita income and age/sex composition.

controlling for differences in discretionary economizing behavior and age/sex composition. The success of this effort depends in general on the selection of appropriate control variables and on the functional form chosen for the model.

incomes above the federal poverty threshold. We noted in Chapter II that such scale factors would be inappropriate for use in the Food Stamp Program if significant differences existed in the economies of scale available to low income and non-low income households. Peterkin and Kerr noted that they had conducted a preliminary study of approximately 1,000 low income households and the "results were neither sufficiently different from those found here nor sufficiently conclusive to warrant the use of different household size adjustment factors for food plans at lower cost levels." In contrast to later studies which have used low income samples, controlling for the effect of food stamps was not a serious issue in this study, since the program was virtually nonexistent in 1965.

C. Morgan, Johnson, and Burt (1981-83)

In a series of studies recently conducted at the University of Missouri, the methodology developed by Peterkin and Kerr has been applied to data from the 1977-78 and 1979-80 Nationwide Food Consumption Surveys (NFCS). In addition to employing more current data, the authors of these studies extended the earlier work of Peterkin and Kerr in two respects. First, they experimented with different measures of the nutritional quality of household diets as control variables. Secondly, they experimented with different samples of households corresponding to different income levels.

1. Morgan, Johnson, and Burt (1981)

In Morgan, Johnson and Burt (1981), economies of scale factors were estimated for a sample of households from the Nationwide Survey of Food Consumption in Low Income Households, NFCS, 1977-1978. The same model and estimation strategies were used as those used by Peterkin-Kerr, although many of variables were measured differently. The results of this study are

summarized in Table A.4. As in the earlier study by Peterkin and Kerr, economies of scale factors are presented for five different specifications of the model corresponding to five different measures of nutritional quality. Also included in the table is an index reflecting the variation in reported per capita food costs across household size. Comparison of Table A.4 with Table A.3 reveals some important differences between the findings of this study and the findings of the earlier study by Peterkin and Kerr. First, the low income sample employed by Morgan et al. exhibits less variation in reported per capita food costs across household size than the non-low-income sample of Peterkin and Kerr. For example, reported per capita food costs in the Morgan et al. sample, expressed in the form of indices with a value of 100 assigned to four-person households, range in value from 133 for one-person households to 82 for seven-person households. The corresponding range of values for the Peterkin-Kerr sample is from 142 to 78. However, despite the smaller variation in reported per capita food costs in the Morgan et al. sample, that study finds a greater economies of scale effect. The average economies of scale factors reported by Morgan et al. range in value from 130 for one-person households to 88 for seven-person households, the corresponding range of values for the Peterkin-Kerr study is from 121 to 92.

The greatest differences between the findings of the Morgan et al. study and the Peterkin-Kerr study occur for one- and two-person households. Peterkin and Kerr found that roughly half the variation in reported per capita food costs between one-person and four-person households was attributable to economies of scale; Morgan et al., in contrast, estimated this proportion at over 90 percent. This would imply a net contribution of

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TABLE A.4

ECONOMIES OF SCALE FACTORS FOR LOW INCOME HOUSEHOLDS, MORGAN ET AL. (1981)

Household size (persons)	Number of households in sample	As reported	Diet score	No. of RDA met	NDR	FEL and NDR	FEL and no. of NDR of 1.0	Average of five specifications
1	1058	133	132	131	128	130	129	130
2	994	106	114	115	112	114	114	114
3	722	108	105	105	104	106	106	105
4	604	100	100	100	100	100	100	100
5	403	95	95	95	94	95	95	95
6	201	93	91	91	89	92	92	91
7	126	82	89	89	82	90	90	88
8	68	92	85	86	80	86	86	85
9	37	79	79	79	84	79	78	80

NOTE: Estimated for a sample of households from the 1977-1978 Nationwide Survey of Food Consumption in Low Income Households, (NFCS). All five specifications control for per capita income and age/sex composition. The estimates are expressed as indices of per capita food costs, with a 4-person household = 100.

less than 10 percent for the other two sources of variation in per capita food costs (i.e., discretionary economizing behavior and age/sex composition). The authors did not comment on whether such a finding is reasonable for their low income sample. Other important differences between the two studies occur for two-person households. For example, two-person households report much smaller per capita food costs relative to other household sizes in the Morgan et al. sample than in the Peterkin-Kerr sample. In addition, the estimated impact of economies of scale on the per capita food costs of two-person households relative to four-person households is greater than the difference in reported per capita costs between those two size categories. Such a result, which was not obtained by Peterkin and Kerr for any household size, implies that differences in discretionary economizing behavior and age/sex composition have a net negative impact on the per capita food costs of two-person households relative to four-person households. The authors did not comment on these important differences between their results and those of Peterkin and Kerr. One factor which may contribute to such differences is the difference in the demographic character of two-person hosueholds in the two samples. For example, two-person households in the non-low income sample of Peterkin and Kerr would be expected to contain a larger proportion of married couples and a smaller proportion of single parent families than the low income sample of Morgan et al.

Differences also exist between the Peterkin-Kerr and Morgan et al. studies regarding the measurement of income, nutritional quality of the diet, and age/sex composition. Income in the Peterkin-Kerr study was measured as annual after-tax income for the year prior to the survey; in

the Morgan et al. study it was measured as before-tax income for the month prior to the survey. The Peterkin-Kerr study based their measures of nutritional quality on the Recommended Dietary Allowances (RDA) established in 1963 by the National Academy of Sciences - National Research Council, while the Morgan et al. study based their measures on the revised set of standards established in 1974. Finally, the measure of age/sex composition used by Peterkin and Kerr was the household's per capita cost of obtaining the low cost food plan published in 1975; the measure used in the Morgan et al. study was based on the thrifty food plan published over the 1977-1978 period.

The major methodological concern we have regarding the Morgan et al. study is that it employed a low income sample of households but did not adapt the Peterkin-Kerr model to account for the effect of the Food Stamp Program (FSP) on food expenditures. The FSP is likely to affect food expenditures among low income households in two respects that are relevant for this analysis. First, participants in the FSP may have different food expenditure behavior than nonparticipants. Secondly, among participants the benefit formula affects the variation in food expenditures across household size. For example, allotment standards depend in part on existing economies of scale factors, and the various deductions may have different implications for households of different size. Morgan et al. did not include anything in their model to represent food stamp benefits; nor was there mention of including such benefits in their measure of income. As we discussed in Chapter II, the failure to account for the effect of the FSP on food expenditures among low income households is likely to result in biased economies of scale estimates.

Comparison of the Morgan et al. estimates with those of Peterkin and Kerr, thus, is complicated by three factors:

- Changes in economies of scale between the time the Peterkin-Kerr data were collected (1965) and the time the Morgan et al. data were collected (1977-78).
- Differences in the economies of scale available to low income households (Morgan et al. sample) and non-low-income households (Peterkin-Kerr sample).
- Differences between the two studies regarding the manner in which certain variables were measured.

It is not possible to determine the relative importance of these three factors from the results presented in the two studies. An estimate of the change in the magnitude of economies of scale from 1965 to 1977-78 could be obtained from an exact replication of the Peterkin-Kerr methodology and variable definitions using data collected in 1977-78. Next, the sensitivity of estimated economies of scale factors to different methods of measuring variables could be determined by comparing the results obtained with one method of measuring variables to those obtained with another method for a particular sample of households. Finally, the differences in the economies of scale available to low income and non-low-income households could be determined by estimating the model separately for each sample in a particular survey year, extending the model to account for the effect of the Food Stamp Program on food expenditures.

2. Morgan, Johnson, Burt, and Brown (undated)

The focus of this paper was to use additional applications of the Peterkin-Kerr approach to compare the economies of scale estimates obtained using different samples of households and different measures of nutritional quality as control variables. The samples were derived from three data

sources: (1) 1977-78 NFCS, Survey of Food Consumption in Low Income Households (NFCS-LI), (2) 1979-80 NFCS-LI, and (3) 1977-78 NFCS, Basic (which is representative of the entire U.S. population).

One contribution of the Morgan et al. paper was the use of a measure of nutritional quality that had not been employed by Peterkin and Kerr. That measure, Lowest RDA, is defined as the percentage of the RDA provided by the nutrient that is the lowest of the seven nutrients assessed. The five measures employed by Peterkin reflect the overall quality of the diet; Lowest RDA is designed to capture serious deficiencies for a particular nutrient.

Table A.5 presents economies of scale factors estimated by Morgan et al. for low income households surveyed in 1977-1978 and 1979-1980. These estimates were obtained for the same basic model using four different measures of nutritional quality as control variables: (1) diet score, (2) nutrient density ratio (NDR) and food energy level (FEL), (3) Lowest RDA, and (4) NDR, FEL, and Lowest RDA. The estimates obtained for the 1977-1978 sample using diet score and NDR-FEL to control for nutritional quality were also reported in the previous Morgan et al. paper (see Table A.4). As in that previous paper, the model in this paper did not account for the effect of the Food Stamp Program on the food expenditures of low income households.

Two basic conclusions emerge from Table A.5. First, the use of Lowest RDA as a control variable can result in very different estimated scale factors from those obtained when other measures of nutritional quality are used. For example, adding Lowest RDA to the specification in which NDR and FEL are used to control for nutritional quality reduces the

TABLE A.5

ECONOMIES OF SCALE FACTORS FOR LOW-INCOME HOUSEHOLDS, MORGAN ET AL. (NO DATE)

Household Size		Diet Score		NDR and FEL		Lowest RDA		NDR, FEL, and Lowest RDA	
		1977-78	1979-80	1977-78	1979-80	1977-78	1979-80	1977-78	1979-80
1	132	117	130	111	118	109	116	106	
2	114	110	114	104	106	104	106	102	
3	105	105	106	102	101	103	101	102	
4	100	100	100	100	100	100	100	100	
5	95	90	95	93	97	92	99	94	
6	91	84	92	89	92	87	96	90	
7	89	78	90	85	93	79	100	84	
8	85	70	86	82	94	73	99	80	
9	79	72	79	85	95	76	100	84	

NOTE: Estimated using data from the 1977-1978 and 1979-1980 Surveys of Food Consumption in Low Income Households (NFCS). The estimates are derived from regression models which control for per capita income, age/sex composition, and the specified measures of the nutritional quality of household diets.

estimated scale factor for one-person households in the 1977-1978 sample from 130 to 116. The second conclusion emerging from the table concerns the important differences between the economies of scale factors estimated for low income households surveyed in 1977-1978 and those surveyed in 1979-1980. For example, for the specification in which NDR and FEL are used as control variables, economies of scale factors for the 1977-78 sample range in value from 130 for 1-person households to 90 for 7-person households; the corresponding range of values for the 1979-1980 sample is from 111 to 85.

Morgan et al. noted the large differences between the economies of scale factors estimated for the 1977-1978 and 1979-1980 samples, but they did not offer any reasons for those differences. The paper did not give any descriptive statistics, so it is not clear whether there are also important differences between the two samples with regard to reported per capita food costs. In addition, the paper did not present the regression estimates used to compute the scale factors for the two samples. One possible reason for the different results obtained with the two samples that deserves investigation concerns the 1979 amendments to the FSP, which eliminated the purchase requirement and replaced various deductions by a standard deduction. The issue that needs to be investigated is whether such changes in the FSP actually caused significant changes in the observed magnitude of economies of scale or whether such policy changes simply point out a serious misspecification in the model relating to the failure of the model to account for the effect of the FSP on food expenditures.

Morgan et al. also estimated economies of scale factors using data collected in the 1977-1978 NFCS-Basic survey, which includes households

from all income classes. The estimates are presented in Table A.6. Note that adding Lowest RDA to the specification in which NDR and FEL are used to control for nutritional quality results in noticeable reductions in the estimated scale factors for one- and two- person households. Similar results were obtained with low-income households. These results suggest that NDR and FEL may not be controlling fully for variations in nutritional quality and that scale factors derived from this specification of the model may overestimate the true magnitude of economies of scale. This issue deserves further investigation.

The scale factors estimated for the 1977-1978 basic sample were generally larger for households of size one through three than those estimated for the corresponding low-income sample. No definite pattern emerged for other sized households. Since the basic survey includes low-income households, the concern we expressed earlier about the failure of Morgan et al. to account for the effect of the FSP on food expenditures also applies to this analysis, although to a lesser extent. This concern is especially relevant given the significant differences in the scale factors estimated for low income households surveyed in 1977-1978 and those surveyed in 1979-1980. Unfortunately, Morgan et al. did not derive economies of scale factors for a sample of non-low-income households from the 1977-1978 survey. Such an analysis would provide a direct comparison with the Peterkin-Kerr study and would provide an estimate of the change in economies of scale from 1965 to 1977-1978. In addition, such an analysis would not require modeling the effects of the FSP.

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TABLE A.6

ECONOMIES OF SCALE FACTORS FOR THE 1977-78
NFCS-BASIC SAMPLE, MORGAN ET AL. (NO DATE)

Household Size	Diet Score	NDR and FEL	Lowest RDA	NDR, FEL, and Lowest RDA
1	135	127	123	119
2	118	113	112	109
3	107	104	105	103
4	100	100	100	100
5	94	96	95	96
6	94	95	93	94
7	94	95	93	93
8	94	95	92	93
9	99	98	92	95

NOTE: Estimated from regression models which control for per capita income, age/sex composition, and the specified measures of the nutritional quality of household diets.

3. Morgan, Johnson, and Burt (1983)

Finally, in a 1983 paper in the American Journal of Public Health, Morgan, Johnson, and Burt presented some of the results of the previous paper for the 1977-1978 low-income sample. Unlike the previous paper, this paper presented the regression estimates used to compute the economies of scale factors. The authors recommended the scale factors derived from the version of the model in which NDR, FEL, and Lowest RDA were used to control for nutritional quality (see Table A.5 above). The authors gave two reasons for recommending this specification. First, the regressions containing these three measures of nutritional quality had higher coefficients of determination (R^2) than had been obtained with other measures. Secondly, the authors noted their view that there are good grounds in nutritional science for this specification of the model, since the three measures capture different aspects of nutritional quality.

D. Brown, Johnson, and Burt (1982)

In another project carried out at the University of Missouri, economies of scale factors were estimated using a fundamentally different methodology than that employed in the previous studies. The results of this work are presented in the 1982 doctoral dissertation of Brown and in an unpublished paper by Brown, Johnson, and Burt submitted to USDA in 1982. We focus our discussion on the Brown dissertation. The data employed in that study was from the 1977-1978 and 1979-1980 NFCS.

The studies by Brown et al. differ from the previous studies in two important respects. First, these studies employed preference-based models. Secondly, in contrast to the previous studies, Brown et al. did

not remove the effect of age/sex composition from their estimated scale factors.

In contrast to the normative approach, the preference-based approach does not rely on the judgments of nutritional experts but instead estimates the relative food costs required by individuals in various age/sex categories from observed consumption patterns. This is accomplished by specifying a model which contains explanatory variables representing the number of household members in each of several age/sex categories. The estimated coefficient of each of these household composition variables represents the additional money that would be spent on food as an individual of a particular age/sex category is added to the household. Underlying this approach is the standard microeconomic theory of household behavior in which households are presumed to choose that collection of goods and services which is most preferred, given the household budget constraint.

The preference-based model employed in Brown's dissertation was derived by initially specifying the household's total weekly food cost as a linear function of household size and total weekly income, with no intercept term. This specification was extended in two respects to derive the more general model that was used to estimate economies of scale factors. First, the model was extended to capture the fact that the food requirements of households vary with age/sex composition. This was accomplished by replacing household size with a weighted sum of the number of household members in each of six age/sex categories. The weight corresponding to each age/sex category is a parameter in the model to be estimated and reflects the relative food costs required for individuals in that category.

In the most general version of the model, the coefficient of each age/sex variable was specified as a linear function of household size. This is equivalent to specifying the household's weekly food cost as a linear function of 13 variables: weekly income, six age/sex variables, and six interaction variables, each defined as the product of household size and an age/sex variable. A negative coefficient on an interaction variable means that food costs increase at a decreasing rate as members of the relevant age/sex category are added to the household. This is how economies of scale are reflected in the model. Since the coefficients on the six interaction variables are not constrained to be equal, the model allows the magnitude of the economies of scale effect to vary across age/sex categories.

Economies of scale factors were estimated from the most general version of the model using data from the 1977-1978 and 1979-1980 NFCS. Before presenting the results, we will discuss several aspects of the model specification in greater detail. First, the six age/sex categories specified were: (1) infants under 4 years of age, (2) children 4-10, (3) males 11-18, (4) males 19 and over, (5) females 11-18, and (6) females 19 and over. Secondly, the weekly income variable was defined to include the value of the food stamp bonus in addition to total money income. Thus, unlike the studies by Morgan et al. discussed earlier, the effect of food stamp benefits on food expenditures was accounted for in the model. However, one limitation of the model is that it implies an additional dollar of money income has the same effect on food expenditures as an additional dollar of food stamp benefits. Finally, no attempt was made to control for the fact that the measure of food expenditures does not include the value of meals purchased outside the home.

The regression estimates obtained by Brown are presented in Table A.7 for three different samples: 1977-1978 NFCS-Low Income, 1979-1980 NFCS-Low Income, and 1977-1978 NFCS-Basic. For each sample, estimated coefficients and standard errors are presented for the following independent variables: (1) six age/sex composition variables, (2) six interaction variables, each defined as the product of an age/sex variable and household size, and (3) household income. These estimates illustrate some important features of the model. We have noted previously that preference-based models are characterized by the fact that the relative food costs required for individuals in different age/sex categories are estimated from the data. In this model, the relative cost corresponding to each age/sex category consists of two components. The first component is a constant, given by the coefficient on the relevant age/sex variable. The second component allows this cost to vary with household size and is represented by the coefficient on the relevant interaction variable. We first consider the constant components. For the 1979-1980 NFCS-LI and 1977-1978 NFCS-Basic samples, the pattern of these coefficients across age/sex categories is generally consistent with prior expectations, ranging from a minimum value for infants to a maximum value for adult males. However, the coefficients obtained with the 1977-1978 NFCS-LI sample exhibit a pattern which is totally inconsistent with prior expectations. For example, the coefficent for adult males is significantly lower than the coefficient for infants. Brown did not comment on these estimates, but they clearly indicate that the model is not appropriately specified for the 1977-1978 low-income sample.

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TABLE A.7

ESTIMATED COEFFICIENTS AND RELATED STATISTICS FROM BROWN (1982)

Independent Variables	Coefficients (Standard Errors) Low Income 1977-78 NFCS-LI	Low Income 1979-80 NFCS-LI	Basic 1977-78 NFCS-B
Infants, ≤ 3 (n_1)	13.98 (1.194)	8.11 (1.452)	8.84 (1.133)
Children, 4-10 (n_2)	4.74 (0.698)	12.04 (1.173)	12.92 (0.833)
Males, 11-18 (n_3)	12.15 (1.294)	10.92 (1.783)	17.12 (1.011)
Males, 19+ (n_4)	7.90 (0.755)	17.96 (1.166)	18.73 (0.510)
Females, 11-18 (n_5)	14.79 (1.275)	15.64 (1.760)	13.37 (0.971)
Females, 19+ (n_6)	10.65 (0.629)	13.82 (0.923)	17.83 (0.458)
(Household size*n_1)	-1.81 (0.222)	.30 (0.269)	-.115 (0.234)
(Household size*n_2)	.74 (0.106)	-.56 (0.203)	-.54 (0.159)
(Household size*n_3)	-.72 (0.201)	-.19 (0.295)	-.44 (0.180)
(Household size*n_4)	.50 (0.161)	-2.10 (0.258)	-.56 (0.136)
(Household size*n_5)	-1.19 (0.207)	-.88 (0.292)	-.09 (0.174)
(Household size*n_6)	-.38 (0.164)	-.67 (0.199)	-1.22 (0.141)
Income	.12 (0.006)	.11 (0.009)	.01 (0.0007)
R^2	.89	.88	.86
Sample Size	3909	2531	10807

We next consider the coefficients on the six age/sex - household size interaction variables. As we discussed earlier, a negative value for such a coefficient reflects an economies of scale effect for the corresponding age/sex category. Of the 18 interaction coefficients estimated by Brown for the three samples, three have anomalous positive signs, two of which occur for the 1977-1978 low-income sample.

The estimated model was used to derive economies of scale factors by using the microeconomic framework for studying household behavior developed by economists, which is based on the assumption that households choose a set of goods and services which maximizes their well-being, subject to the limitations of a budget constraint determined by incomes and prices. The set of goods and services chosen by the household depends on its preferences, which are represented in this framework by a mathematical function whose parameters can be estimated from data on observed consumption patterns. The preference-based method of estimating economies of scale factors involves using this representation of preferences to compare the expenditures required by different sized households to reach a given level of well-being.

Although his methodology was based on the general principles outlined above, Brown greatly simplified the procedure by imposing certain restrictions on household behavior. Recall that Brown's model contains a weighted sum of the number of household members in various age/sex categories, where the weights reflect the relative food requirements for individuals in different categories. The restrictions imposed by Brown are that for each age/sex category the relative requirements for food are identical to the relative requirements for all other goods. By imposing

these restrictions, Brown derived a formula for economies of scale factors which did not require estimating the parameters of a particular mathematical representation for household preferences. The mathematical details of the derivation may be found in Brown (1982, pp. 61-5).

The formula for scale factors derived by Brown depends on both the size and age/sex composition of households. Brown did not address the issue of removing the effect of age/sex composition, so the scale factors he presented include the effect of both household size and age/sex composition on food costs. Table A.8 contains the combined household size-age/sex factors presented by Brown for three samples: 1977-1978 NFCS-LI Income, 1978-1979 NFCS-LI, and 1977-1978 NFCS-Basic. The most striking result contained in this table relates to the significant differences in the estimates for the 1977-1978 and 1979-1980 low income samples. Recall that the Morgan et al. studies discussed earlier also obtained significantly different results for those two samples. We noted earlier that because of the anomalous regression estimates obtained by Brown for the 1977-1978 low-income sample, his results for that sample should be treated with particular caution.

Since the estimates presented by Brown reflect the combined effect of economies of scale and age/sex composition on food costs, they are not directly comparable to the results presented in the previous studies. However, they may provide useful information regarding the general magnitude of economies of scale. The effect of age/sex composition on food costs is likely to operate in the same direction as economies of scale, implying higher costs for smaller households. If this is true for each

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TABLE A.8

BROWN'S (1982) FACTORS REPRESENTING THE COMBINED EFFECT OF HOUSEHOLD SIZE AND AGE/SEX COMPOSITION ON FOOD COSTS

	Sample		
Household size	1977-78 NFCS-LI	1979-80 NFCS-LI	1977-78 NFCS-BASIC
1	113	134	129
2	109	123	122
3	104	108	109
4	100	100	100
5	97	93	95
6	94	87	91
7	90	81	88
8	83	76	83

NOTE: The estimates were derived from regression models which control for income only.

size category in Brown's samples, the estimates in Table C.8 would provide an upper bound for the magnitude of economies of scale.

Brown's preference-based methodology may also prove useful for future research in this area. Such research should focus on extending the work of Brown in several respects. First, attention should be given to isolating the effect of economies of scale on food costs from the effect of age/sex composition. Secondly, we noted earlier that Brown did not control for the fact that his measure of food consumption did not include the value of meals purchased outside the home. Future work with preference-based models should focus on developing methods of controlling for this feature of the data. Finally, in deriving a formula for economy of scale factors, Brown imposed the restriction that the relative requirements for individuals in the various age/sex categories should be the same for all goods. These restrictions should be relaxed in future work.

E. Price and Sharma (1981-83)

In a series of studies recently conducted at Washington State University, Price and Sharma estimated economies of scale factors on data from the 1977-1978 and 1979-1980 Nationwide Food Consumption Surveys, using a methodology different from that employed in any of the previous studies. The results of this work are summarized in a series of five reports submitted to USDA between 1981 and 1983.

The Price-Sharma model included normative measures of the nutritional quality of household diets as control variables in some specifications. However, such standards were not used to control for age/sex composition. Instead, somewhat as in the preference-based model of Brown, the relative food needs of individuals in different age/sex categories were

estimated from the survey data. However, the Price-Sharma methodology differed from the preference-based methodology employed by Brown in not explicitly using the microeconomic theory of household behavior as a framework for deriving economies of scale factors. In this respect, the Price-Sharma methodology was more similar to that of Peterkin and Kerr, with economies of scale factors being derived directly from the coefficients of variables representing household size in a regression model.

An important contribution of the work by Price and Sharma was the development of an "expenditure quality index" designed to control for differences in diet quality among households. The index was based on the concept of an elasticity, which is commonly used in economics. In this context, the elasticity for a particular food item reflects the responsiveness of the demand for that item to changes in total food expenditure.[1] Foods with high elasticities may be classified as luxuries; those with low elasticities may be classified as necessities. A good with a negative elasticity is classified as an inferior good, signifying that households consume less of that good as their total food expenditure increases. Price and Sharma estimated elasticities for 39 food items, and the estimates ranged in value from a maximum for shellfish to a minimum for dried vegetables. These estimated elasticities were used to estimate an index representing the diet quality of each household in the sample. That

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[1]The percent of RDA for calories was included as a control variable in the regression used to estimate the elasticity for each food group. Thus, the elasticity estimates indicate the responsiveness of demand for a given food group to changes in total food expenditure of the household, holding constant the total number of calories in the diet.

index was computed as the weighted sum of the elasticities for the 39 food items, with the weight for each item taken as its proportion of the household food budget. Therefore, the value of the expenditure quality index increases as a greater proportion of the household food budget is spent on luxury items.

The Price-Sharma model is specified in terms of the household's food cost "per equivalent person."[1] This is a generalized per capita concept where household size is represented by a weighted sum of the number of household members in 15 specified age/sex categories. The weights are parameters to be estimated and reflect the relative food requirements of individuals in the different age/sex categories. The household's food cost per equivalent person is specified as a multiplicative function of a set of independent variables. Corresponding to each independent variable is a parameter which appears as an exponent. In some specifications of the model, income per equivalent person is used in place of the expenditure quality index described above. This is a generalization of per capita income in which total household income is divided by a weighted sum of the number of persons in the household. The weights, which reflect the relative needs of persons in different age/sex categories for total consumption, were specified on the basis of estimates which have been reported the literature. This measure is conceptually superior to per capita income since it recognizes the fact that requirements for total consumption vary with age and sex. In addition, some specifications of the Price-Sharma model include various socioeconomic variables.

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[1]For a full technical discussion of the model see Price and Sharma, Report No. 3 (June 1983).

The parameters of the model were estimated in a complicated three-stage procedure. In the first stage, all the parameters for income per equivalent person (or expenditure quality index), nutritional quality of the diet, the number of meals eaten at home per person, and various socio-economic variables were estimated. This was accomplished by specifying 26 distinct subsamples within which household size and composition were fairly constant. For each subsample, the household composition variables in the model were collapsed into a single constant. The parameters corresponding to all the remaining independent variables were estimated separately for each of the 26 subsamples. Thus, 26 separate estimates were produced for the set of parameters. For each parameter, the mean of the 26 estimates was computed and substituted back into the model for subsequent analyses.

The second stage of the estimation procedure focused on estimating the parameters corresponding to the age/sex composition variables. This was accomplished by rearranging the equation so that all other variables appeared in multiplicative factors associated with the dependent variable, household food cost. For each household, these variables were used along with the mean parameter estimates generated above to compute an adjusted measure of household food cost. This adjusted measure of food cost was interpreted as the value of food used at home per household, corrected for differences in income per equivalent person, nutritional quality, number of meals eaten at home, and various socioeconomic variables. The rearrangement of the model we have described resulted in the adjusted measure of food cost being specified as a linear function of the various age/sex composition variables. The coefficients of these variables were estimated using standard linear estimation techniques.

In the final stage of the estimation procedure, variables were included in the model to capture the effect of economies of scale on household food costs. The household's adjusted food cost described above was specified as a linear function of 15 various age/sex composition variables and five variables representing household size. Each of these five household size variables was associated with a particular size category. For each household, four of these five household size variables were assigned a value of zero. The one nonzero value was assigned to the variable which represents the household's size category. For example, for a three-person household, all the household size variables were assigned a value of zero except the variable which represents size category three. The nonzero value assigned to such a variable was a weighted sum of the number of household members in the various age/sex categories. The weights were given by the estimated parameters of the age/sex composition variables obtained in the previous step.

The economies of scale factors presented by Price and Sharma were derived from the final stage of the estimation procedure described above. We noted that the household's adjusted food cost was written as a linear function of the age/sex composition variables and the five household size variables. Therefore, the final stage of the estimation procedure yielded updated estimates of the coefficients of the age/sex variables as well as estimates of the coefficients of the household size variables. The latter coefficients were interpreted as representing the effect of economies of scale on food costs. However, it should be recalled that the five household size variables were defined in terms of a weighted count of household members which reflected age/sex composition. Therefore, we would

expect the estimated economies of scale factors to include a portion of the effect of age/sex composition on food costs.

Price and Sharma estimated economies of scale factors for three samples: 1977-1978 NFCS-LI, 1979-1980 NFCS-LI, and 1977-1978 NFCS-Basic. The authors excluded food stamp recipients from both 1977-1978 samples because they argued that the purchase requirement in effect at that time would prevent an accurate estimation of economies of scale. They argued that if food stamp households spent little or nothing on food in addition to the total value of food stamps (purchase requirement plus bonus), the observed variation in food expenditures across household size would be determined largely by the parameters of the FSP. Food stamp recipients were not excluded from the 1979-1980 low income sample, since the purchase requirement was eliminated early in 1979. In addition, the authors noted that the 1979-80 sample was too small to permit exclusion of food stamp recipients. To account for the effect of the FSP on food expenditures for the 1979-1980 low-income sample, the authors included a food stamp participation dummy variable in their model. However, the value of food stamp benefits was not included.

Price and Sharma presented economies of scale factors for six specifications of their model corresponding to different combinations of independent variables. Each specification included 15 variables representing the number of individuals in different age/sex categories as well as the 5 household size variables described above. The specifications differed with regard to the additional explanatory variables included. These differences are summarized in Table A.9. Each of the first two specifications described in the table includes per capita income and the

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TABLE A.9

SIX SPECIFICATIONS OF THE PRICE-SHARMA MODEL

Model	Explanatory Variables
I. Basic Model	1. After Tax Income 2. Number of Meals at Home Per Person
II. Comprehensive Model	1. After Tax Income 2. Number of Meals at Home Per Person 3. Percent of RDA for Energy 4. Lowest Nutrient Density Ratio 5. Northeast Region 6. Rural NonFarm 7. Spanish Origin
III. Expenditure Quality Model 1	1. Expenditure Quality Index 2. Number of Meals at Home Per Person 3. Percent of RDA for Energy 4. Lowest Nutrient Density Ratio 5. Northeast Region
IV. Expenditure Quality Model 2	1. Expenditure Quality Index 2. Number of Meals at Home per Person 3. Lowest Nutrient Density Ratio 4. Northeast Region
V. Expenditure Quality Model 3	1. Expenditure Quality Index 2. Number of Meals at Home Per Person
VI. Expenditure Quality Model 4	1. Expenditure Quality Index 2. Number of Meals at Home Per Person 3. Lowest Percent of RDA 4. Northeast Region

Each specification of the model also includes 15 variables representing the number of individuals in various age/sex categories as well as the five household size variables described in the text.

number of meals eaten at home per person. The latter variable was included to control for the fact that the food expenditure data not include the value of meals purchased outside the home. The second model described in the table differs from the first in that it includes two measures of nutritional quality--percent of RDA for energy and Lowest NDR as well as three dummy variables representing: (1) residence in the Northeast, (2) residence in a rural nonfarm area, and (3) Spanish origin. These three dummy variables were selected from a variety of socioeconomic variables that were tested in preliminary analyses. In the final four specifications of the model, the expenditure quality index described above replaces per capita income as a control variable. These four specifications differ from one another with regard to the additional explanatory variables included.

Two of the measures of nutritional quality used as control variables by Price and Sharma differ somewhat from the measures employed in previous studies. First, the percent of RDA for calories measures the volume of food usage (measured in caloric content) relative to family needs. It differs from the food energy level (FEL) used by Peterkin and Kerr in that it is not truncated at 150 percent. Therefore, it gives full weight to quantities of food used in excess of 150 percent of the household's RDA. Second, measure of nutritional quality employed by the Lowest NDR among the nutrients specified is also used. It is designed, as is the Lowest RDA, to capture extreme values for a particular nutrient.

Before discussing the economies of scale factors estimated by Price and Sharma, we consider the estimated coefficients of the age/sex composition variables. These coefficients, called equivalence scales, represent the relative food requirement of individuals in different age/sex

categories. Table A.10 contains the estimates, normalized at a value of unity for males 19-50 years of age, obtained with Expenditure Quality Model 4. Estimates obtained with the other models followed the same general pattern, so they are not included in the table. The equivalence scales presented in the table were estimated from the 1977-1978 and 1979-1980 NFCS low-income samples as well as the 1977-1978 NFCS basic sample. These estimates are generally consistent with prior expectations. For example, they indicate that children need less food than adults, females need less than males, and older adults need less than young adults.

The economies of scale factors estimated by Price and Sharma are shown in Table A.11 for the six specifications of their model using three samples of households: the 1977-1978 and 1979-1980 NFCS low-income samples and the 1977-1978 NFCS basic sample. The major conclusion which emerges from this table is that the estimated scale factors show considerable variation across model specifications. For example, the estimated scale factors for one-person households in the 1977-1978 basic sample range in value from 141 for Expenditure Quality Model 2 to 112 for the Comprehensive Model.

Since the authors regard the expenditure quality index as being superior to income as a means of controlling for variations in diet quality, they recommend that a set of scale factors be selected from among those presented for the four expenditure quality models. However, they did not give any objective statistical basis for choosing among the various

TABLE A.10

EQUIVALENCE SCALES ESTIMATED BY PRICE AND SHARMA (1983)

	Age-Sex Category	Expenditure Quality Model 4		
		1977-78 NFCS-LI	1977-78 NFCS-BASIC	1979-80 NFCS-LI
1.	Child < 1 year	.326	.379	.574
2.	Child 1 - 2	.548	.562	.716
3.	Child 3 - 5	.716	.646	.752
4.	Child 6 - 8	.741	.706	.838
5.	Child 9 - 11	.908	.843	.927
6.	Male 12 - 14	1.010	.971	1.075
7.	Male 15 - 18	1.187	1.188	1.078
8.	Male 19 - 50	1.000	1.000	1.000
9.	Male 51 - 64	.984	1.013	.990
10.	Male 65+	.931	.892	.908
11.	Female 12 - 14	.919	.949	1.067
12.	Female 15 - 18	.907	.986	.995
13.	Female 19 - 50	.949	.942	1.152
14.	Female 51 - 64	.774	.863	.884
15.	Female 65+	.745	.783	.812

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TABLE A.11

ECONOMIES OF SCALE FACTORS, PRICE AND SHARMA (1983)

Model	Household Size 1	2	3	4	5	6
Basic Model						
1977-78 LI	122	113	105	100	90	88
1979-80 LI	155	130	112	100	93	76
1977-78 BASIC	135	122	111	100	93	89
Comprehensive Model						
1977-78 LI	113	103	101	100	94	94
1979-80 LI	126	110	103	100	94	89
1977-78 BASIC	112	105	100	100	97	95
Expend. Qual. Model 1						
1977-78 LI	122	109	104	100	96	92
1979-80 LI	118	109	101	100	96	89
1977-78 BASIC	118	106	102	100	97	91
Expen. Qual. Model 2						
1977-78 LI	153	128	114	100	91	81
1979-80 LI	142	127	116	100	93	68
1977-78 BASIC	141	124	111	100	91	82
Expen. Qual. Model 3[a]						
1977-78 BASIC	139	122	111	100	91	83
Expen. Qual. Model 4						
1977-78 LI	139	119	110	100	94	87
1979-80 LI	135	119	106	100	96	80
1977-78 BASIC	134	117	107	100	93	86

[a]Expenditure Quality Model 3 was not estimated with the low-income samples.

estimates. Instead, they noted that the choice "is not clearcut and involves issues where values come into play."[1] For example, Expenditure Quality Model 3, which does not include any nutritional measures as control variables, would be preferred by those who believe that diets should be judged solely on the basis of household preferences rather than on the basis of nutritional norms. Among the remaining three expenditure quality models which are based on a nutritional norm, the authors expressed a preference for Model 4 on the basis of their judgment that the measure of nutritional quality included in that model (Lowest RDA) is superior to those included in the other models. However, as we stressed earlier, there are general weaknesses associated with all currently available measures of nutritional quality.

The work of Price and Sharma receives a generally favorable review when evaluated from a methodological point of view. First, the authors devoted considerable attention to developing improved methods of controlling for variations among households in diet quality. We believe their expenditure quality index is a promising approach to controlling for such differences. Next, the models controlled for the fact that the food expenditure data exclude the value of meals purchased outside the home. In addition, they recognized the need to account for the effects of the Food Stamp Program when modeling the food expenditures of low-income households. Finally, we consider the functional form chosen for the Price-Sharma model. One of the major differences between this model and models employed in the previous studies is that variables such as per capita

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[1]Price and Sharma, Report No. 5 (November 1983), p. 20.

income and the nutritional quality of household diets are assumed to affect food expenditures multiplicatively rather than linearly. This specification requires a fairly complex estimation procedure. However, it is not known whether the Price-Sharma model fits the data better than the other models we have discussed. This issue deserves investigation, since it would be useful to determine whether there are benefits associated with the Price-Sharma functional form which justify the computational burden involved in estimating the parameters.

Despite the generally favorable review, the Price and Sharma work has not yielded an unambiguously preferable set of scale factors, either within its own estimates or in comparison with the estimates of others. The authors presented scale factors for three samples of households estimated for each of six specifications of their model. In some cases, the estimates varied considerably among model specifications and Price-Sharma did not provide an objective statistical basis for choosing among them. Instead, they noted that such a choice would depend largely on judgments regarding two issues. The first is the issue of whether diets should be judged strictly on the basis of household preferences or on the basis of a nutritional norm. The second concerns the question of which particular measure or set of measures of nutritional quality should be used as control variables if the latter option is followed. We have noted previously that there are weaknesses associated with all currently available measures, and there is no single measure that can be regarded as uperior to all others at this time.

APPENDIX B
METHODS USED FOR SIMULATING BENEFITS AND AGGREGATE COSTS

The data used to generate the monthly benefit amount and program cost estimates for Chapter IV of this report were from the August 1982 Integrated Quality Control sample. An extract was created from this file which excludes household observations missing any of the following information:

1. Sample weight
2. Reported gross income
3. Age of at least one household member
4. Sex of at least one household member

In addition, household observations from the states of Alaska and Hawaii were excluded from the analysis. The final analysis data set contained 6,559 observations.

Monthly bonus amounts were calculated for each household under the current basis of issuance with the current economies of scale factors (EOS) and under six alternative sets of EOS factors. The bonus amount was imputed for each household by simulating eligibility screens and benefit amount calculations using the household level data in the extract file. Allotment standards for the current plan and for each of the alternative sets of EOS factors were calculated by the following equation:

ALLOTMENT84 = HHSIZE * 66.10 * FACTOR

where ALLOTMENT84 is the maximum food stamp benefit (the allotment standard) at the June 1984 level, HHSIZE is the number of persons in the food stamp unit, $66.10 is the November 1984 per capita food stamp maximum

benefit for a food stamp unit of four persons, and FACTOR is the appropriate EOS factor (based on unit size). The EOS factors for selected alternatives appear in Table IV.2 by household size.

Because the household sample data represent August 1982, the simulation calculations were done in August 1982 dollars. The 1984 allotment standards were deflated to their August 1982 levels as follows:

ALLOTMENT82 = ALLOTMENT84 * exp(22 * (-0.0016843))

where 22 is the number of elapsed months and -0.0016843 is the monthly growth rate of the CPI for food at home over the 22 month period (MLR, Table 23). These November 1984 allotment standards appear in Table IV.3 by household size.

After checking households against the gross income and net income screens for food stamp program eligibility in effect in August 1982, bonus amounts under the various plans were calculated for each household. Eligible food stamp units with no more than two members were guaranteed a minimum bonus amount of $10 under all plans. The following equation computes the bonus amount:

BONUS82 = ALLOTMENT82 - (0.3 * NETINC)

where BONUS82 is the August 1982 bonus amount, ALLOTMENT82 is the allotment standard in August 1982 dollars for each alternative as computed above, 0.3 is the benefit reduction rate, and NETINC is household net income which was calculated using reported gross income and deduction data. The value of NETINC is determined by the following equation:

NETINC = GROSSINC - EID - DCARE - SHELTER - MEDICAL - STANDARD

where NETINC is the calculated net income, GROSSINC is the reported gross income, EID is the calculated earned income deduction, DCARE is the calculated deduction for dependent care expenses, SHELTER is the calculated excess shelter deduction, MEDICAL is the calculated medical deduction for households with elderly or disabled members, and STANDARD is the standard deduction. The deduction values were computed according to August 1982 food stamp program guidelines. All income and deduction amounts are monthly values in August 1982 dollars.

The August 1982 calculated bonus amounts were inflated back into June 1984 dollars in a manner similar to the process by which the 1984 allotment standards were deflated:

BONUS84 = BONUS82 / exp(22 * (-0.0016843))

where 22 is the number of elapsed months and -0.0016843 is the monthly growth rate of the CPI for food at home during the 22 month period (MLR, Table 23). The June 1984 calculated bonus amounts were used to generate the per capita monthly bonus stamp amounts under current and alternative EOS factors which appear in Table IV.4 by household size.

Due to the need for comparative plan cost estimates for fiscal year 1985, the monthly bonus amounts were adjusted to incorporate fiscal year 1985 aggregate annual bonus projections. Annual bonus figures in August 1982 dollars were calculated by multiplying the August 1982 monthly bonus amounts by 12. In order to arrive at the aggregate annual bonus figure projected by the Food and Nutrition Service for fiscal year 1985 under the current plan, and at similarly adjusted sums under each of the alternative plans, each household observation was adjusted by the ratio of 10.479/10.596. This adjustment factor is a ratio of the fiscal year 1985 projected aggre-

gate annual bonus amount in billions of dollars to the sum of the calculated annual bonus figures in billions of August 1982 dollars. The adjusted bonus amount sums generated for current and alternative plans by this method were used to calculate program budget impacts and the changes in program cost of various plans. These figures appear in Tables IV.5, IV.6, and IV.7.