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HOUSEHOLD ECONOMIES OF SCALE IN CONSUMPTION: THEORY AND EVIDENCE

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This study incorporates household economies of scale in consumption into a utility-theoretic model of household demands. Economies of scale are modeled as arising through (possibly congestible) household public goods, through increasing returns in household production, and/or through discounts for bulk purchases. The effects of economies of scale are isolated from other influences on demands by the assumption that individuals are identical and are symmetrically treated within households. Economies of scale parameters for five goods are estimated using a theoretically plausible demand system specification and data from the U.S. Consumer Expenditure Survey on expenditures by all-adult households. Results suggest the existence of significant economies of scale in the consumption of all of the included goods (food, shelter, clothing, household furnishings and operations, and transportation), with economies being especially pronounced in the consumption of shelter.

KEYWORDS: Household demand, economies of scale, public goods, equivalence scales.

1. INTRODUCTION

CAN "TWO LIVE AS CHEAPLY AS ONE," as the old saying goes? The notion that larger households may benefit from economies of scale in consumption, i.e., that the cost per person of maintaining a given material standard of living may fall as household size rises, often arises in the literature on household composition and demand. The presence or absence of economies of scale is important for the determination of incomes needed by households of various sizes and compositions to reach a given standard of living. These "household income equivalence scales" are in turn important in the measurement of income distribution and the prevalence of poverty, and in the setting of standards for public welfare benefit payments.

Household economies of scale in consumption may arise from various sources. First, some goods are likely to be public within the household. Consumption by one household member may not rule out, or rule out completely, the consumption of the same good by another member. Lazear and Michael (1980) suggest that "electric light in a room, the beauty of art work on the wall, [and] the security provided by a locked bolt on the door," are examples of public goods. Other goods such as "household equipment, much of home furnishings, and even the cost of housing itself" may be to some extent public, as suggested by the Bureau of Labor Statistics (1948). These are more likely to be congestible rather than pure public goods, with the flow of services to each member inversely related to the number of members who must share the good. The benefits from sharing the goods may come from "reduced excess capacity due to indivisibility,"

[1] This paper was written while I was employed by the Division of Price and Index Number Research, U.S. Bureau of Labor Statistics. The views expressed herein are mine alone and do not reflect the policies of the Bureau of Labor Statistics (BLS) or the views of other BLS staff members. I would like to thank Angus Deaton, Eugene Smolensky, Robert Pollak, fellow researchers at the Bureau of Labor Statistics, and an anonymous referee of this journal for many valuable suggestions.

as suggested by Lazear and Michael (1980), who noted that "...a telephone, TV, shower, refrigerator space, etc. is often idle and the utilization rate can be raised by increases in family size." The sharing of goods could conceivably lead to significant decreases in the per person cost of maintaining a standard of living, as the sharing of goods reduces the need to purchase individual allotments for each member.

Second, households may experience increasing returns in household productions of goods and services. For example, if the presence of an additional person adds relatively little to the time costs of cooking a meal, the total time-and-money expense per person will drop with household size. Decreasing costs in household production may result in reduced monetary expenditures if, for example, the increased return to household production time causes larger households to substitute purchases of more unprocessed foods for expensive convenience foods or eating out.

Last, larger households may be able to take advantage of bulk discounts in purchasing.[2] They may be able to buy "economy size" products or take advantage of promotional discounts like "two for one" sales (and still consume the entire quantity of the product purchased before it becomes old, stale, out of fashion, or otherwise unusable).

A major problem in the investigation of household economies of scale is that their effects are in general not empirically identifiable. Observed household demands may be expected to vary with household size not only because of economies of scale, but also because of the varying preferences or needs of household members, from infants to grandparents. The degree to which the needs of different members are given weight in household decision-making can also be expected to influence final demands. Lazear and Michael (1980) have perhaps accomplished the most ambitious work to date in seeking to determine how the "rate of transformation of dollars into service units" varies with household size and composition, but their methodology rests on a weak theoretical basis. The reduced form demand equations they estimate are not consistent with individual utility maximization, nor is any explanation given as to an underlying household decision process. By including in their study households with children, they were forced to come up with estimates of the amount a child would consume "had he or she lived in a single person household," by extrapolating from demand equations estimated over single-adult households. Singh (1972) has also sought to measure household economies of scale, but he used a model of household demand which is known to suffer from a fundamental problem of underidentification (Muellbauer (1977)).

This study investigates household economies of scale in isolation from the other factors of household composition that would be expected to influence household demands. The model and empirical work apply only to households where all members are assumed to have identical tastes and be symmetrically

[2] Bulk discounts can be included in the general rubric of "economies of scale," even though the concept is related to a dependency of price on quantity rather than to a production function. In the model to follow, it will be the case that any production effect can be interpreted as an implicit price effect, and vice versa.

treated in household decision-making. (In the empirical section, only all-adult households with "heads" aged 35 to 55 are studied.) The model is explicitly based on individual utility maximization, with household decisions in turn following from maximization of a household social welfare function. A simple specification of the effects of economies of scale leads directly into a formulation of demand functions. A quadratic expenditure system (QES) which includes parameters for economies of scale factors is estimated for five classes of goods. The resulting system has the appropriate Slutsky properties, and indicates substantial (and statistically significant) economies of scale for all included goods.

2. THE MODEL

Assume that individuals are identical and are symmetrically treated within households. Let the utility function of each (identical) individual be represented by $v_j = u(x_j)$ where x_j is the $I \times 1$ vector of the services of goods consumed by person j. With identical tastes and symmetric treatment, the service flows received by each household member are a function of only the quantity of household purchases, the number of other household members (among whom the goods must be divided or shared), and economies of scale. Economies of scale are assumed to be directly related to the number of household members.[3] Assume that the service flows received by each member are related to total household purchases of goods x by the functions $x_{ij} = c_i(J)x_i$, where J is the number of household members and $i = (1, 2, \ldots, I)$. If there are no economies of scale from any source, each member receives only a Jth portion of the good: $c_i(J) = 1/J$. If economies of scale exist, the household should be able to transform a dollar's worth of a good into more than $1/J$ dollar's-worth per member: $c_i(J) > 1/J$ for some or all i. The function $c_i(J)$, then, measures the proportion of total household purchases of good i which each person effectively consumes.

The household budget constraint is given by $p'x \leq Y$ where p is the vector of market prices and Y is total household income. Under the assumptions of identical preferences and symmetric treatment, the Samuelson model of household social welfare function maximization, extended to public goods by Nelson (1986b), can be used to aggregate individual preferences into a particularly simple form for household demands. In the Samuelson model, it is assumed that the household maximizes a household social welfare function $U(v)$, where v is the vector of individual utility levels. When the individuals' utility functions are

[3] In a strict sense, it could be argued that most economies of scale from household production or bulk purchasing should be directly related to the physical quantity (e.g. number of ounces, square feet, etc.) of the good produced or purchased, rather than to household size. Pollak and Wales, in fact, contend that economies of scale from household production or quantity discounts "do not involve demographic factors at all" (1981, p. 1540). Data on physical quantities are not, however, generally available from household consumption surveys; the aggregate "quantities" used in analysis are actually quantity *indexes*, derived by dividing expenditure on a group of goods by a group price index. If one assumes that changes in the demand for physical quantity are primarily related to the number of consumers in the household (while, in contrast, increases in income tend to raise the quantity index by increasing the quality of the goods consumed), then demographic factors are the appropriate arguments for the economies of scale functions.

identical and $U(\ )$ is symmetric, the problem reduces trivially to the maximization of $u(x_j)$ subject to the constraint that $\Sigma_i p_i(x_{ij}/c_i(J)) \geqslant Y$. Rearranging terms, the household demands are the same as those individual j would choose if the individual were in a single person household and faced modified prices $p_i^* = (1/c_i(J))p_i$ $(i = 1, 2, \ldots, I)$. Household demand functions, conditional on J, are simply

$$(1) \qquad x_i = q_i(p, Y|J) = \frac{1}{c_i(J)} q_{ij}(p^*, Y)$$

where $q_{ij}(\ )$ is the demand function of the individual (in a single person household) for good i.

These demand functions are of the same form as those of the Barten (1964) or "scaling" model of incorporation of demographic effects, which has seen frequent use in the household equivalence scale literature (e.g., Muellbauer (1977), Pollak and Wales (1981)). The Barten model in general rests on a weaker theoretical base than the Samuelson model, being dependent on assumption of the existence of a household dictator and of exogenous constraints in the form of goods-specific equivalence scales (Gorman (1976), Bojer (1977)). The functional equivalence of the Samuelson and Barten models in the case of identical preferences and symmetric treatment, however, allows the familiar Barten techniques to be used in estimation. Letting $m_i = 1/c_i(J)$ and writing equation (1) in share form,

$$(2) \qquad \frac{p_i q_i(p, Y|J)}{Y} = \frac{m_i(J) p_i q_{ij}(p^*, Y)}{Y}.$$

The $m_i(J)$ function may be interpreted as representing "equivalent household size" for good i in the vocabulary of the Barten model literature.

Although only the effects of economies of scale, and not their specific sources, can be identified from household demand information, an investigation of how different sources of economies of scale might enter the $c_i(J)$ functions may aid in the understanding of the model. Suppose that $c_i(J) = a_i(J) b_i(J)$, where the function $a_i(J)$ reflects economies of scale associated with household production and bulk discounts, and the function $b_i(J)$ reflects the "degree of publicness" of good i, that is, the degree to which economies of scale may arise from sharing of the good within the household. Reasonable restrictions on these functions are

$$\text{(i)} \qquad a_i(1) = 1, \quad a_i(J) \geq 1, \quad \partial a_i/\partial J \geq 0,$$

$$\text{(ii)} \qquad b_i(1) = 1, \quad 1/J \leq b_i(J) \leq 1, \quad \partial b_i/\partial J \leq 0.$$

The first restriction makes consumption in single-person households the base for measurement of economies of scale from production or discounts. The other restrictions on $a_i(J)$ imply that increased household size is associated with increased economies (rather than diseconomies) of scale in private goods. The restriction on $b_i(\ )$ when $J = 1$ simply states that single persons always receive one hundred percent of their purchases. Publicness vs. privateness is only an issue in multiperson households. At the lower limit, $b_i(J) = 1/J$, the good is purely private, i.e., each person receives a Jth portion. At the upper limit of one, the good is purely public; each member benefits from one hundred percent of the household purchase.[4] Between values of $1/J$ and 1, the good is partially public, or congestible. The last restriction, on the derivative of $b_i(J)$, implies that congestion increases (and hence this economy of scale factor decreases) with household size. The $c_i(J)$ function can then be interpreted as representing purely the degree of publicness of a good (if it is assumed that $a_i(J) = 1$), or purely the degree of increasing returns or bulk discounts effective for private good (if it is assumed that $b_i(J) = 1/J$), or some combination of (congestible) publicness, increasing returns, and bulk discounts (in general).

3. EMPIRICAL SPECIFICATION AND DATA

For estimation purposes, the quadratic expenditure systems (QES) estimated by Howe, Pollak, and Wales (1979) was chosen as representing a reasonable compromise between the desire for a theoretically plausible representation of the demand functions of the individual consumer and the exigencies of obtaining parameter estimates from actual computation.[5] Denoting by x and p the complete vectors of goods and prices facing a household of a single individual, demand functions in this system are specified as

$$\text{(3)} \qquad x_i = \beta_i + \frac{\alpha_i}{p_i}\left(Y - \sum p_m \beta_m\right) + \left(\gamma_i - \frac{\alpha_i}{p_i}\sum p_m \gamma_m\right) \times \prod p_m^{-2\alpha_m} \times \left(Y - \sum p_m \beta_m\right)^2 \qquad (i, m = 1, 2, \ldots, I)$$

where $\sum a_i = 1$, Y is defined as the total expenditure on the goods in the system, and the parameters to be estimated are denoted by the Greek letters α, β, and γ. These demand functions are homogenous of degree zero in prices and total expenditure, and satisfy the Slutsky symmetry conditions. The frequently used, but undesirable, restriction of additivity of preferences is not imposed except in the special case where $\gamma_i = 0$ for all i. To reduce the problem of heteroskedastic-

[4] Assuming that a good could be purely public is not inconsistent with also assuming that a larger household could also benefit from increasing returns to household production or bulk discounts on that good. While the direct effect of economies of scale are to reduce household expenditures on a good, relative to what J single-person households would have to spend to reach the same standard of living, implicit price substitution effects should tend to distort expenditures towards goods with relatively high economies of scale (Muellbauer (1977), Nelson (1986b)). The quantity purchased of a purely public good by the J person household will probably be less than the total over the J single-person households, but (through substitution effects) may be more than the quantity purchased by one single-person household.

[5] Nelson (1986a) uses Deaton and Muellbauer's (1980) Almost Ideal Demand System to estimate a closely related model ("general Barten") using the same data as used here. Unfortunately, extensive experimentation with this model and data revealed severe convergence problems when more than three goods (representing 51% of the average household budget) were included.

ity, the equations are estimated in share form,

$$(4) \qquad s_i = \frac{p_i x_i}{Y} = \frac{p_i}{Y}\beta_i + \alpha_i\left(1 - \sum \frac{p_m}{Y}\beta_m\right) + \left(\gamma_i \frac{p_i}{Y} - \alpha_i \sum \frac{p_m}{Y}\gamma_m\right) \times \prod \left(\frac{p_m}{Y}\right)^{-2\alpha_m} \times \left(1 - \sum \frac{p_m}{Y}\beta_m\right)^2 + \varepsilon_i$$

where ε_i is an additive error term. Assumptions about the error terms take the following form. Denote by ε_j the vector of errors for the I goods equations for the individual (single person household) j. Allowing for covariance among the errors for a household, but assuming no correlation in the errors across households, the ε_j are assumed to be i.i.d. and distributed $N(0, \Omega)$. One equation is dropped from the system in estimation (without loss of information) since the covariance matrix is singular by construction.

The function determining the amount of the household purchases which each person effectively receives is specified as $c_i(J) = J^{-\delta_i}$, implying $m_i = J^{\delta_i}$. The value of $c_i(J)$ will be greater than or equal to $1/J$, as hypothesized, as long as δ_i is less than one, and will always be equal to one in single-person households. The share-form demand functions for households of varying sizes are simply the share-form demand functions of the individual (4) with, according to (2), each price scaled by m_i. The expenditure shares s_i are assumed to be functions of market prices, total household system expenditure, and household size; the household error terms, ε_h, are assumed to have the properties given above for ε_j. The δ_i are added to the list of parameters to be estimated. A value for a δ_i close to one implies a lack of economies of scale. Should the value of δ_i go below zero, very sizable, though not logically prohibited, economies of scale are implied.

Estimated values for δ_i can be interpreted as evidence of "the degree of publicness" on the one hand, *or* of the extent of economies of scale from household production or bulk purchases on the other, only if additional identifying assumptions are made. If it is assumed that a good is purely private, this implies a functional form for $a_i(J)$ of $J^{1-\delta_i}$, which has the properties required in (i) as long as $\delta_i < 1$. If, conversely, it is assumed that the good has no increasing returns from household production or bulk discounts, $b_i(J) = c_i(J)$, and meets requirements (ii) as long as $0 \leq \delta_i \leq 1$. In general one can only assume that economies of scale arise from a combination of factors. The only evidence yielded from the estimation of the δ_i parameters about the source of economies of scale is of a negative sort: if δ_i is estimated to be less than zero, one must conclude that economies of scale cannot be arising only from publicness of the good. Identifying assumptions can only be made on the basis of broader observation and reasoning: the model itself does not clearly identify for us the sources of economies of scale, only their effects.

The data used in this study are from the 1960/61 and 1972/73 United States Bureau of Labor Statistics Consumer Expenditure Surveys, to which regional price variables have been added. For full details on the data, see Lee (1982) and Dalrymple (1980). Lee classified goods into seven aggregate categories: food, shelter, fuel/oil/gas/electricity (FOGE), household furnishings/operations (HFO), clothing, transportation, and other.[6] For each of these aggregate goods, Lee obtained a price index in each geographical region and for each time period by combining Consumer Price Index and City Worker's Family Budget information. In accordance with the restrictive assumption of the model at hand, a subset of this data containing only observations for households with no children, whose "heads" were age 35 to 55, and all of whose members were in the consumer unit for the full year was selected for analysis. The resulting data set contains 971 observations: 565 from the 1960/61 survey and 406 from the 1972/73 survey. In this sample 43.9 percent of the households consist of a single person, 52.0 percent of two persons, and 4.1 percent of from three to seven persons. Means and standard deviations of variables for this subsample are given in the Appendix.

The scaled quadratic expenditure system was estimated using the nonlinear full information maximum likelihood procedure developed by Bard (1967), and adapted at the Bureau of Labor Statistics for estimation of QES parameters, elasticities, and Slutsky matrices by Robert Gillingham (Barnes and Gillingham (1984)). Convergent parameter estimates were not achievable, however, for the full system of demand equations, in spite of experimentation with starting values. The only recourse, using this data, was to estimate the demand system over a subset of goods (making implicit assumptions about separability of preferences between the included and excluded goods). The final demand system includes five goods which make up on average 77 percent of the total household budget.

4. ESTIMATION RESULTS

4.1. *Parameter Values*

Parameter estimates for the five-good quadratic expenditure system are given in Table I. Estimated values for the α, β, and γ are all statistically significantly different from zero at the 95 percent confidence level, except for the β parameter for shelter and the γ parameter for food.

The central questions raised in this paper, of course, concern the economies of scale parameters, δ_i. All the estimated δ_i's are less than one, and are statistically significantly so, indicating the presence of economies of scale for all goods. For clothing and transportation, the hypotheses that δ_i equals zero (i.e., in the polar cases, that the good has an increasing returns factor of J or is a pure public good) can also be rejected at a high confidence level. For food and household furnish-

[6] Shelter costs were measured on a "flow of services" basis. For homeowners shelter expenditures consist of mortgage interest payments, property taxes, property insurance premiums, and repairs and replacements. It is unfortunately not possible with this particular data set to distinguish between owners and renters, or to try alternate definitions of shelter costs such as equivalent rental value. It is also not possible to distinguish between certain groups that might be expected to differ in household production amounts and techniques, such as one vs. two-earner couples.

TABLE I

PARAMETER ESTIMATES FOR THE QUADRATIC EXPENDITURE SYSTEM[a]

	β_i	α_i	γ_i	δ_i
Food	−4.89	.362	.00078	.248
	(2.03)	(.02)	(.0006)	(.162)
Shelter	−.008	.137	.0019	−.996
	(.08)	(.017)	(.0003)	(.320)
HFO	−1.96	.107	.00088	.229
	(.75)	(.014)	(.0002)	(.222)
Clothing	−2.77	.151	.00048	.453
	(.89)	(.012)	(.00023)	(.133)
Transportation	−5.74	.243	.0016	.568
	(1.5)	(.022)	(.0004)	(.132)

[a] Figures in parentheses are asymptotic standard errors.

ings this hypothesis cannot be rejected. The estimated δ parameter for shelter is statistically significantly different from zero and *negative*. The point estimate of close to -1 implies very large economies of scale.

4.2. *Economies of Scale Factors*

The interpretation of the δ_i parameters in terms of the functions outlined in the model are given in Table II, for the case where the number of household members is two. The first column shows calculations of m_i (2), the "equivalent household size" for each good. The closer the equivalent household size is to actual household size, the lower are the implied economies of scale. Economies of scale are highest for shelter ("two can live as cheaply as one-half") and lowest for transportation ("two can live as cheaply as 1.48"). The second column shows the calculated values of $c_i(2)$, the effective consumption factor. If there were no economies of scale, these should have all been equal to .5 (i.e., each of the two household members would get just fifty cents worth of services from each dollar's worth of household purchases).

Table III illustrates some possible interpretations of the $c_i(J)$ functions in terms of its presumed component factors of publicness and increasing returns.

TABLE II

SCALING FUNCTIONS

Evaluated at Number of Household Members = 2[a]

	"Equivalent" Household Size $m_i = J^{\delta_i}$	Effective Consumption Factor $c_i = J^{-\delta_i}$
Food	1.19	.84
Shelter	.5	2.00
HFO	1.17	.85
Clothing	1.37	.73
Transportation	1.48	.67

[a] *Note*: At household size = 1, all m_i and $c_i = 1$.

TABLE III

POSSIBLE ECONOMY OF SCALE FACTORS
Evaluated at Number of Household Members = 2[a]

	Pure Private		"Publicness" Only		Mixed (Example)	
	$a_i(J)$	$b_i(J)$	$a_i(J)$	$b_i(J)$	$a_i(J)$	$b_i(J)$
Food	1.68	50%	1	84%	1.4	60%
Shelter	4.0	50%	(1	200%)	2.5	80%
HFO	1.71	50%	1	85%	1.13	75%
Clothing	1.46	50%	1	73%	1.33	55%
Transportation	1.34	50%	1	67%	1.12	60%

[a] *Note*: a_i = multiplication factor for increasing returns ($= J^{1-\delta_i}$ if goods are purely private); b_i = percentage factor for sharing goods ($= J^{-\delta_i} \times 100$ if no increasing returns).

The first column shows the increasing returns ($a_i(J)$) factors under the assumption that the good is purely private (each member receiving 50 percent of the scaled-up services). The second $b_i(J)$, column shows the percentages of household purchases from which each member is assumed to benefit under the assumption of no increasing returns. The last column presents examples of possible mixtures of factors, such that $a_i(J)b_i(J) = c_i(J)$.

The hypothesis that economies of scale in shelter arise only from sharing of the good (and not at all from increasing returns in household production or bulk discounts) must be rejected purely on the basis of logic: it is not possible for each member to consume *over* one hundred percent of household purchases. A high factor of increasing returns, however, or a mixture of sharing and increasing returns cannot be logically ruled out. On an empirical level, the distinctively high estimate of economies of scale in shelter relative to other goods is consistent with insights from a crude comparison of budget shares across one and two person households in the sample. (A complete table is presented in the data Appendix.) The mean share of the budget going to shelter is substantially lower in the two person than in the one person households (seventeen percent versus twenty-six percent), while the budget shares of all other goods remain about the same or rise. In spite of the fact that two person households in the sample have total expenditures over fifty percent higher, on average, than single person households, mean shelter consumption (as measured by expenditure or the implicit quantity index) is just barely higher for the larger households. Unless one is willing to make rather extreme assumptions about the income elasticity (or inelasticity) of shelter expenditures, this crude comparison suggests that increased household size is itself responsible for a sizable shift in consumption away from shelter. Further investigation of the market for and consumption of housing may be necessary to explain (or refute) the very large absolute economies of scale in shelter implied by the estimation results.[7]

[7] The high value estimated for the effective consumption factor for shelter does not seem to be a quirk of the functional form or of the particular data set used. Similar results were obtained for several variations experimented with in preliminary estimation. Negative δ_i's were found for shelter using the same data but a three-goods, AIDS demand system (with a different functional form for m_i;

Interpretation of the remaining choices of economies of scale factors can only be attempted using a wider basis of reasoning, going beyond the information yielded by the model. For example, while it may be easy to conceive of household furnishings and operations, transportation, and shelter as having significant public aspects, it is probably most plausible to think of the economies of scale in food and clothing as arising from other sources of increasing returns. As no food item can constitute final consumption for more than one person, household production and bulk discounts are the most likely reasons for the multiplication factor of 1.68. Since the two-person households in the sample (which make up the bulk of multiperson households) are generally female-male couples, the prospects for sharing or bulk discounts in clothing purchases would seem to be slim. A multiplication factor of 1.46 might possibly arise from household production processes. For example, the sharing of laundry facilities (covered in HFO) may allow more frequent laundering of clothing, and hence a reduced necessary stock of clothing.

According to the estimated economies of scale factors, the five goods ranked in order of decreasing economies of scale are shelter, HFO, food, clothing, and transportation.

4.3. *Tests of Model Assumptions*

It was assumed, in accomplishing this estimation, that the QES estimates represent a plausible demand system, that the demand of multiperson households are adequately modeled as demand functions of individuals modified by economies of scale parameters of a specific functional form, and, more fundamentally, that individual tastes are identical. These assumptions are all, to some degree, testable.

To check whether the system, as estimated, satisfies the second order conditions for utility maximization and gives a reasonable representation of household demand, regularity conditions were checked with reference to the Slutsky matrix and elasticities were calculated. The Slutsky matrix is negative semi-definite at the mean of the logarithm of system expenditure, and at one and two standard deviations above and below the mean (with all other variables fixed at the sample means). Uncompensated own and cross price elasticities are given in Table IV. Food, clothing, and transportation appear to be own-price elastic, while shelter and HFO are own-price inelastic. Elasticities with respect to system expenditure show food and shelter to be relative necessities and the other goods to be relative luxuries. There seems to be no evidence that the demand system is ill-behaved.

Nelson (1986a)) and for QES estimation on this same data for three and four goods. Negative δ_i's were also found for shelter when the QES was estimated using the four-goods data set created by Barnes and Gillingham (1984) in which shelter costs for homeowners were measured by rental equivalence, though the standard errors for all δ_i's in this case were generally very large (owing to a relative scarcity of price variation). Price data in both data sets, however, rely heavily on interarea comparisons (Sherwood, 1975) derived from the same standard budgets published by the U.S. Bureau of Labor Statistics (1967). It might be interesting to see what sorts of estimates could be derived from a time-series study.

TABLE IV

UNCOMPENSATED OWN PRICE, CROSS PRICE AND SYSTEM EXPENDITURE ELASTICITIES

	Food	Shelter	HFO	Clothing	Transportation
Food	−1.05	−.027	.029	.110	.126
Shelter	−.020	−.725	−.024	.007	.005
HFO	−.003	−.114	−.098	.019	.018
Clothing	.207	−.070	.013	−1.37	.114
Transportation	−.019	−.163	−.042	.021	−1.26
Expenditure	.808	.758	1.05	1.11	1.47
Mean of log expenditure[a] = $3946.					

[a] System expenditure is defined here as the sum of expenditures on the five included goods.

The model presented constrains household size to affect household demands only through the scaling effect represented in the m_i parameters. The appropriateness of this assumption can be tested against the more general hypothesis that all parameters of the basic demand system may vary with household size. The model was estimated separately, without demographic parameters, for households with one, two, and three or more members. The estimates for the one and two member household systems satisfy the Slutsky conditions at the mean of the logarithm of system expenditure and at one and two standard deviations above and below the mean. The system for three or more members fails this test at all five points. It may be supposed that households of three or more adults with no children represent somewhat of an anomaly and may not be comparable with one and two adult households.[8] Assuming that the specification of the model in the more general case of demographic variation in all parameters is, in fact, correct, the standard likelihood ratio test for nested hypotheses can be used to test the hypothesis that the model underlying Table I constitutes an appropriate incorporation of household size effects. Table V contains the log likelihood values for the scaled model and the three disaggregate models. The χ^2 statistic (twice the difference between the log-likelihoods from the constrained and unconstrained models) leads to rejection of the hypothesis that household size effects have been correctly and entirely incorporated. While this result is discouraging, it is in keeping with other results in the literature. Muellbauer (1977) rejected scaling against disaggregation of family demands by the number of children, and Barnes and Gillingham (1984) rejected scaling against disaggregation into singles, couples, and families.

In order to focus on economies of scale, it was assumed in the theoretical development of the model that individuals have identical tastes.[9] One way to test if the data used are appropriate for this model is to estimate the unscaled

[8] Re-estimation of the scaled model over only one and two person households resulted in estimates nearly identical in all important respects to those shown in Table I. To save space, neither these nor the parameter estimates for the demographically disaggregated models are presented here. Tables are available on request.

[9] It was also assumed that individuals are treated symmetrically within the household. It is more difficult, however, to devise a test for this hypothesis (using these data).

TABLE V

HYPOTHESIS TESTS FOR DEMOGRAPHIC AGGREGATION[a]

	n	Number of Parameters	Log Likelihood	Total
Scaled model	971	19		3569.96
3 + members	40	14	173.80	
2 members	505	14	1998.18	3653.76
1 member	426	14	1481.78	
single females	234	14	847.39	1525.58
single males	192	14	678.19	

[a] χ^2 test statistic for including household size by scaling: 167.6; χ^2 test statistic for pooling female and male one member households: 87.6.

demand system separately for female and male single person households. These systems each exhibit Slutsky regularity at four of the five points tested, the cases of mean log expenditure plus two standard deviations being the only exceptions. The χ^2 test statistic shown in Table V leads to rejection of the pooling of single person households. Again, this is counter to the assumptions of the model. It is unclear to what extent this result undercuts the validity of the estimated economies of scale parameters; without an alternative seemingly appropriate group of subjects for testing of the model it is hard to see how estimation could be improved on this point.

5. CONCLUDING REMARKS

Economies of scale parameters, related to the degree of increasing returns or bulk discounts for private goods and/or the degree of congestion in household public goods, were estimated for five goods, using data on all-adult households within a specified age range. The results suggest significant economies of scale with household size in consumption of all included goods.

The existence of economies of scale in all goods implies that household "equivalence scales" should not rise as fast as household size. The variation in the sizes of the estimated effects across goods suggests that economies of scale are very important in the consumption of shelter, and substantially less important in the consumption of clothing and transportation. The use of a utility-theoretic model, with explicit representations of household decision-making and the sources of economies of scale, and the estimation of a plausible demand system constitute advances over previous research on household economies of scale.

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APPENDIX

Summary Statistics: Whole Sample

	Mean Budget Share	Standard Deviation of Budget Share	Mean Price	Standard Deviation of Price
Food	.227	.099	108.83	21.62
Shelter	.204	.126	114.17	26.43
FOGE	.043	.037	101.50	26.28
HFO	.096	.069	97.99	13.67
Clothing	.083	.055	109.11	18.65
Transportation	.161	.139	107.97	15.17
Other	.185	.089	109.77	21.28
	Mean Number of Members (J)	Standard Deviation of J	Mean Total Expenditure (Y)	Standard Deviation of (Y)
	1.62	(.658)	$6205.50	(4475.6)

Summary Statistics: Means for One and Two Person Households

	One Person Households			Two Person Households		
	Budget Share	Expenditure	Quantity Index[a]	Budget Share	Expenditure	Quantity Index[a]
Food	.227	$ 977	8.73	.226	$ 1546	14.41
Shelter	.256	1186	10.07	.167	1219	10.65
FOGE	.037	161	1.57	.047	314	3.19
HFO	.087	446	4.41	.102	757	7.85
Clothing	.078	357	3.25	.085	634	5.93
Transportation	.139	864	7.57	.185	1553	14.04
Other	.177	820	7.34	.190	1363	12.75
Total Expenditure		$4811			$7387	

[a] Defined as expenditure divided by the interarea price index.

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