Review of Income and Wealth
Series 38, Number 3, September 1992

METHODS OF ESTIMATING HOUSEHOLD EQUIVALENCE SCALES: AN EMPIRICAL INVESTIGATION

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This paper presents empirical evidence regarding key assumptions of the Rothbarth and Barten methods of constructing household equivalence scales. The assumption of separability in the Rothbarth model is investigated by examining the implied intra-household allocation of specific goods and by examining studies of economies of scale in household consumption. The assumption of the exogeneity of the distribution parameters in the Barten model is related to the results of empirical studies of clothing expenditures. This paper suggests that empirical evidence fails to support the assumptions maintained in these theoretically sophisticated models of household income equivalence.

1. INTRODUCTION

Household equivalence scales, in theory, provide a way to meaningfully compare material levels of living across households with different demographic compositions. Definition of such scales is important to the study of income distribution, as well as to formation of public policies regarding the appropriate size of transfer payments or child support awards. In practice, the questions of their precise definition and of the best method of estimation have been controversial. *Ad hoc* definitions, such as the three-value scale used by the Organization for Economic Cooperation and Development where first adult counts as 1, the second as 0.7, and each child as 0.5 (Ringen, 1991), and definitions based on simple assumptions, such as the Engel method which determines scales by examining the shares of income households spent on food, predominate in the empirical income distribution literature. Such methods have, however, often been criticized for having inadequate theoretical bases. Among the methods which have been suggested as more theoretically sound are the "Rothbarth" and "Barten" approaches, the relative merits and demerits of both of which have recently been discussed at length by Deaton and Muellbauer (1986) and Gronau (1988). This paper seeks to shed more light on the issue by presenting empirical evidence as to the validity of crucial underlying hypotheses of the Barten and Rothbarth methods.

Section II investigates the empirical validity of the separability assumption crucial to the Rothbarth model. While attempts have been made to test this assumption before (Gronau, 1991; Deaton, Ruiz-Castillo, and Thomas, 1989), this paper examines the question from two new angles: the first pertaining to the implications of the model for the intra-household allocation of specific goods, and the second related to the possible presence of "family" goods, or goods that are public within the household. It is shown that the presence of family goods may explain the non-sensical results regarding specific goods.

Section III addresses the assumption of exogeneity of goods-specific adult-equivalence scales in the Barten model. The validity of this assumption has not been empirically tested, even though the model has received strong endorsement from Deaton and Muellbauer (1986) for its presumed theoretical generality, and has become the basis for much empirical work (e.g. Muellbauer, 1977; Jorgenson and Slesnick, 1987; Blundell, 1980; van der Gaag and Smolensky, 1982).

II. The Rothbarth Method and Empirical Evidence on Separability

A. *The Rothbarth Method*

Household equivalence scales measure the economic size of households of any composition in terms of some standard unit. For example, if a household of two adults and three children requires twice the income of a childless couple to reach a given welfare level, the larger household is measured as having a size of two "couple-equivalents." Implementation of such comparisons, of course, requires some measure of "welfare" that is comparable across households.

The use of expenditures on goods consumed only by adults as an indicator of the adults' welfare level has been associated with the work of Rothbarth (1943).[1] Since consumption of certain adult-specific goods, usually identified as adult clothing, alcohol, and tobacco, can often be directly observed in households with children as well as in childless households, this method is empirically very convenient. The welfare level of a couple with children who are observed to spend \$50 per month on observable adult-specific goods is presumed to be the same as that of a childless couple who also spend \$50 per month on the same group of goods. Dividing the income (or total expenditure) of the with-children household (call this X) by the income (or total expenditure, X^A) of the childless household found to have the same level of expenditure on adult-specific goods, one derives the household "equivalence scale," (X/X^A) which expresses the relative cost of attaining a given adult welfare level across the with and without-children household types. The equivalence scale exercise is often converted into an exploration of intra-household "allocation" of consumption or of the "cost of children" by noting that total expenditures on adults are presumed to be the same across the two households. Total expenditure on children can then be inferred as a residual, by subtracting the income of the welfare-equivalent childless household from the income of the with-children household $(X^C = X - X^A)$.

The Rothbarth method has been explained in terms of the theoretical assumption of separability by Olson (1983), Deaton and Muellbauer (1986), and Lazear and Michael (1988), and most recently and in most detail, by Gronau (1988). Put briefly, Gronau explains that if, one, parents' preferences over their own consumption do not change with the presence of children, and, two, the presence of children has only income effects on parental consumption, then the level of consumption of adult goods is an indicator of household (understood as adult)

[1] "Household welfare" is identified with the utility of the adults from their own consumption of goods and services, in both the Rothbarth and Barten models. See Nelson (1991) for a discussion of this assumption.

welfare.[2] The first assumption, about the shape of the parents indifference mappings will here be called the assumption of "stable preferences," while the second, which refers to the outcome of the parental choice problem, will be called "separability."

In mathematical notation, one can think of the problem of a household with children as being the maximization of a function $U[u^A(q^A), u^C(q^C)]$, where $u^A(q^A)$ is the utility function of the adults defined over their own consumption of the goods vector q, and $u^C(q^C)$ is a similar subfunction defined over children's consumption.[3] The "stable preferences" assumption says that adults with and without children have the same preferences over their own consumption: the $u^A(q^A)$ function does not depend on household composition. For childless adults, $u^C(\cdot)$ and $U[\cdot]$ are undefined, and the "household" problem reduces to the maximization of $u^A(q^A)$. While in some contexts the presence of two subfunctions in a general maximization problem for households with children is directly suggestive of separability, greater caution is required here because of possible complications in the budget constraint due to the "family" nature of some goods. More precisely, the separability assumption says that we can write the demand function for any good i consumed by the adults as $q_i^A = g_i^A(p, X^A)$, where p is the vector of market prices of goods q, and X^A is the amount of household income allocated to adult consumption. The presence of children should affect adult consumption only through changes in X^A. Measured on the same indifference curve, the parent's marginal rates of substitution between goods should be unchanged by the addition of children. The distinction between the assumption of stable preferences, which is made in virtually all equivalence scale models, and the additional assumption of separability, which is uniquely required by the Rothbarth approach, is important if implicit relative price changes are allowed, as will be shown below. Since, as put by Gronau (1988, p. 1203), the theoretical justification of the Rothbarth method "stands or falls on the assumption of separability," the examination of its plausibility merits further empirical and theoretical evaluation.

Various tests of the separability assumption have been proposed. Deaton, Ruiz-Castillo and Thomas (1989) test for demographic separability of various possible groupings of adult goods by testing whether the effects of children on consumption of each of the goods in the group is proportional to the effects of changes in total expenditure on each. They investigate whether there exist *subsets* of goods consumed by adults on which the presence of children has only income effects. Gronau (1991) attempts to empirically test the separability assumption with respect to "adult goods" by substituting his final estimate of total adult consumption expenditure into his equations predicting demand for adult goods, in place of total household expenditure. He takes the fact that interaction terms between total household expenditure and the presence of children then become statistically insignificant as support for the separability hypothesis. Discovery that children have only income effects on some subsets of goods is insufficient

[2]One might add a third condition, that the adult goods must also be monotonically related to total adult expenditure (Gronau, p. 1196). However, this property generally holds in practice and so is not controversial.

[3]Compare to Lazear and Michael, 1988, equation (4.21); Gronau, 1988, equation (3).

by itself to justify the use of an adult-good aggregate as a welfare measure, however, since the effect of children on the adults' consumption of goods outside of that aggregate is still unknown. The use of expenditure on such a group as a measure of adult welfare must either be justified *a priori* (Deaton and Muellbauer, 1986) or by the more thorough-going assumptions of stable preferences and separability of *all of* the adults consumption from the influence of children, as presented by Gronau (1988). Gronau's (1991) attempt to test the more general assumption of separability of all of adult consumption by comparing the elasticities of substitution between goods yields a less favorable result. This paper sheds further light on the separability hypothesis by, first, examining its empirical implications for intra-household allocation of expenditure on specific goods, and second, by examining the empirical evidence available on key parameters which determine the extent to which the method is invalidated by the existence of household economies of scale.

B. *Empirical Evidence on Separability from Goods-Specific Disaggregation*

One way of examining the plausibility of Gronau's separability hypothesis is suggested by the following: if the assumptions of stable preferences and separability are true, then not only is the total value of adult consumption the same in equal-welfare with-child and childless households, but the value of consumption of *disaggregate goods, item by item,* should also be the same. Formally, since adult consumption levels in both the with child and without child households are presumed to be generated by the same function, $q_i^A = g_i^A(p, X^A)$, and the difference between expenditures on a good for two households with equal X^A can therefore only be explained as expenditures on children, one can infer expenditures on children from $p_i q_i^C = p_i q_i - p_i q_i^A$, where q_i is total consumption of good i by the with-child household. This approach does not lead to a formal statistical test of the hypothesis, but tells us what the assumptions imply about the allocation of specific goods so that we might use reasonable standards of judgement in determining whether we are satisfied with its conclusions.

The plausibility of the assumptions are examined here using the empirical specifications of the Rothbarth model suggested by Gronau (1991), and to check robustness of the results, those of Deaton and Muellbauer (1986) as well. The data are for white households with zero to three children under age sixteen, taken from the 1972–73 United States Consumer Expenditure Survey.[4] Details of the specifications and the data are contained in the Appendix. The first stage of the analysis simply replicated the earlier efforts of Gronau and Deaton and Muellbauer by calculating the share of total expenditure which a typical or reference household with children (constructed as a household with expenditure and socio-demographic variables at their sample means) devotes to adult consumption (i.e. X^A/X), through comparison of the amount it spends on identifiable adult

[4]This is also the data source used by Gronau (1991) and Lazear and Michael (1988). The data were made available by the Inter-university Consortium for Political and Social Research. The data were originally collected by the U.S. Department of Labor, Bureau of Labor Statistics. Edward Lazear and Robert Michael provided programs helpful in data selection and recoding.

goods with the amount spent by a household with the same social characteristics but no children.

In the second stage, predicted expenditures on each of several categories of goods were generated for the reference with-children household (i.e. the p_iq_i's), and for the childless household at the level of income which makes it welfare-equivalent to the reference with-child household (i.e. the $p_iq_i^A$'s). These latter are, by assumption, identical to adult consumption in the with-child household. Children's consumption can be imputed by subtracting imputed adult consumption from predicted total household consumption in each category. Rather than impose my own goods categories on the data, I simply used the structure of goods categories present on the summary data tape as issued by the Bureau of Labor Statistics.

The results of applying the separability assumption are shown in Table 1. The first numerical column in the table displays sample mean budget shares computed from data on all households with children, as a guide for gauging the relative importance of the specific categories in the household budget. I followed Gronau (1991) in using adult clothing as the sole adult good in replicating his overall consumption allocations. For the Deaton and Muellbauer variant, I compared the use of adult clothing alone with the use of a more aggregate measure which includes adult clothing, alcohol, and tobacco. As can be seen at the bottom

TABLE 1

IMPLIED SHARES OF CONSUMPTION EXPENDITURES

				Deaton and Muellbauer's (1986) Form			
		Gronau's (1991) Form		Adult Clothing		Adult Goods	
Category	Share of Household Budget	Adults	Children	Adults	Children	Adults	Children
Food	0.20	0.74	0.26	0.75	0.25	0.77	0.23
Transportation	0.19	0.80	0.20	0.83	0.17	0.88	0.12
Shelter	0.18	0.74	0.26	0.76	0.24	0.78	0.22
Recreation	0.09	0.81	0.19	0.85	0.15	0.90	0.10
Clothing	0.07	0.66	0.34	0.68	0.32	0.71	0.29
Household furnishings	0.06	0.71	0.29	0.73	0.27	0.77	0.23
Fuel and utilities	0.05	0.80	0.20	0.81	0.19	0.82	0.18
Health care	0.03	0.82	0.18	0.82	0.18	0.84	0.16
Domestic services	0.02	0.39	0.61	0.39	0.61	0.42	0.58
Health insurance	0.02	1.12	−0.12	1.03	−0.03	1.05	−0.05
Phone	0.02	0.97	0.03	0.93	0.07	0.96	0.04
Tobacco	0.02	0.91	0.09	0.90	0.10	0.91	0.09
Personal care	0.01	1.11	−0.11	1.06	−0.06	1.10	−0.10
Miscellaneous	0.01	0.92	0.08	0.85	0.15	0.88	0.12
Alcohol	0.01	0.89	0.11	0.88	0.12	0.92	0.08
Dry cleaning and laundry	0.01	1.07	−0.07	1.05	−0.05	1.09	−0.09
Reading	0.01	0.94	0.06	0.92	0.08	0.95	0.05
Private education	0.00	0.32	0.68	0.38	0.62	0.40	0.60
Public education	0.00	1.35	−0.35	1.15	−0.15	1.16	−0.16
Total consumption expenditures	1.00	0.77	0.23	0.79	0.21	0.82	0.18

of Table 1, the respective adult shares of total consumption imputed for households with children are 0.77, 0.79 and 0.82 according to these three specifications of the Rothbarth approach. The share of 0.77 exactly replicates Gronau's (1991) result. As the average number of children in with-children households is 1.86, the adults' shares reported in Table 1 translate into expenditures on each child being roughly one-quarter of the expenditure on each adult. This 1:4 ratio of child to parent consumption is the same as the ratio Deaton and Muellbauer derived for both Sri Lanka and Indonesia (1986, p. 734).

These overall share measures hide, however, a great deal of variation in the allocation of specific goods. Adults' consumption is inferred to be less than half of total household consumption of domestic services and private education (by all three specifications), but over 90 percent of telephone services and reading consumption, for example. For four goods implied adult consumption is by all measures over 100 percent, with the resulting implication of "negative consumption" by children.

Taking first the most obvious violation of logic, these negative expenditures, we can ask the question of to what extent their appearance calls into question the appropriateness of the assumption of separability. Negative values reflect cases in which the mean with-children household is predicted to spend absolutely *less* on the category than does the purportedly welfare-equivalent childless household. Taking the example of the Gronau form, determination of confidence intervals for the predicted means under the assumption that errors are normally and identically distributed demonstrates that the negative values cannot be simply dismissed as due to imprecision in estimation. For the cases of personal care and health insurance expenditures, 95 percent confidence intervals for the predicted mean expenditures by with-children household do not even overlap the corresponding 95 percent confidence intervals for expenditure by childless households. While the confidence intervals for dry cleaning and public education determined for the two household types do overlap, in neither case do either of the confidence intervals contain the point estimate for the other household type. There remain, of course, the argument that the illogical results could be due to data or specification problems, or the argument that because the categories for which the negative values appear each constitute less than 2 percent of the household budget, the damage to the separability assumption is not severe.

It can also be noted that all the specifications imply that children consume roughly 10 percent of household purchases of alcohol and tobacco. Ninety-five percent confidence intervals for predicted mean expenditures for alcohol and tobacco were constructed for the Gronau form. In neither case did the with-children confidence interval contain the without-children point estimate, or vice versa, though the confidence intervals do overlap. Whether one finds these values of child consumption of adult goods to be close enough to the theoretically implied values of zero child expenditures on "adult goods" is a matter of subjective judgement.

C. *Empirical Evidence on Separability from Work on Household Economies of Scale*

What may be most implausible about the item-by-item disaggregate results is not the implied negative expenditures or smoking and drinking children, which

might possibly be explained away by data problems, but the way in which the technique allows "allocation" of all items regardless of the possible presence of economies of scale. While it is simple to picture what it means for children to consume 34 percent of clothing—we put the receipts for adult suits and shoes in one pile, and the receipts for children's playsuits and tennies in another, and then calculate totals and percents—it is much harder to get an equivalent picture of what it means for children to consume 20 percent of fuel and utility expenditures, or 26 percent of shelter expenditures. Presumably parents and children benefit from the same heating and air conditioning, and all enjoy the family room and kitchen in addition to their more personal bedroom areas. The interpretation that "while everyone enjoys some of the good in common, children add *an additional* 20 percent to household fuel expenditures" is irrelevant here. The question at hand is the plausibility of the separability assumption.

The possible impact of economies of scale on the separability assumption can be illustrated with a very simple model. Suppose there is one purely private good exhibiting no economies of scale, and a second good which is purely public within the household. Suppose that the household maximizes a welfare function $U[u^A(q_1^A, \quad q_2), u^C(q_1^C, \quad q_2)]$, subject to the constraint that $p_1(q_1^A+q_1^C)+p_2q_2=X$, where $u^A(\cdot)$ and $u^C(\cdot)$ are the adults' and children's utility functions defined over the quantities each group consumes of goods 1 and 2, and X is total household outlay. It is easy to show that while the household of the adults alone would set the marginal rate of substitution between goods 1 and 2 equal to p_2/p_1, in the with-children household (because of the well-known "sum of the MRS's" rule for public goods) the adults' MRS will be set equal to $(p_2/p_1)-(u_2^C/u_1^C)$, where u_i^C is the partial derivative of the children's utility function with respect to good i. While the household utility function "looks" separable (being comprised of sub-functions for each group), the presence of economies of scale in the form of a pure public good means that the addition of children has price as well as income effects on the adults' consumption. This is illustrated in Figure 1. Suppose that the household budget constraint is represented by line AB, so that in the absence of children the adults would choose a bundle on that line. If the presence of children has only income effects on adults' consumption, the addition of children will cause a parallel inwards shift of the adults' budget constraint (line CD). If good 2 is public, however, the adults' budget constraint will have a flatter slope, like line EF. Measured in reference to any single reference indifference curve of the adult, the adults in the with-children household will consume a higher q_2 and a lesser q_1 (point a) than the adults alone (point b). Public goods are implicitly "cheaper" because they raise $U[\cdot]$ through both arguments. If the quantity of good 1 consumed by the adults (q_1^A) were identified as our hypothetical Rothbarth "adult good," then (assuming normality of good 1) this substitution away from q_1 in the adults' consumption would lead to overestimation of the amount of income needed to restore the adults to the pre-children welfare level. Of course, in a more general model, we do not know the degree to which adult goods may be complementary to goods with high economies of scale, and so cannot say definitively in what direction the bias would lie.

This simple model can also be used to illustrate how estimates of "negative" consumption might come about. Suppose we were lucky enough to identify the indifference curve which truly makes the adults-with-children as well off as the

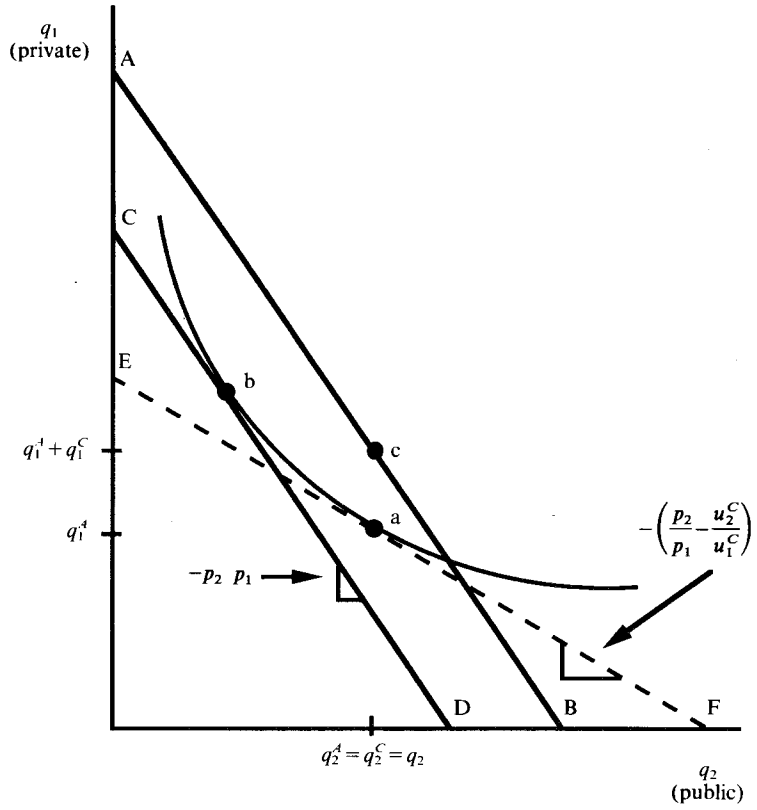

Figure 1. Implicit Price Effects of Public Good on Adults' Consumption

adults alone. (Perhaps substitution effects conflict and cancel out.) When we add the children's consumption of the private good to the with-children adults' consumption of the private good (remembering that the adults and children consume the same q_2 units of the public good), total household consumption of good 1 may still fall below the level of the equal-welfare childless adults' consumption of the good. Such a case is illustrated by point c in Figure 1. A misplaced assumption of separability would attribute the equal-welfare childless adults' consumption level (the vertical distance to point b) to the with-children adults, and subtract this from total household consumption of good 1 (the vertical distance to point c) to get "negative consumption" for the children (the distance to c minus the distance to b).

While it is easy to outline in theory the way in which implicit price substitution effects due to economies of scale invalidate the assumption of separability, the question of whether such effects are important is an empirical one. It could be that all goods are affected fairly evenly by economies of scale, in which case implicit prices would not change much. Or it could be that even if implicit prices change, parental preferences are such that compensated price elasticities are close to zero (i.e. indifference curves are close to being right-angle), and hence there is little behavioral consequence. If either (or both) of these patterns have empirical

support, the result that children have primarily income effects on their parents' consumption would hold in spite of the presence of economies of scale. One could admit the presence of economies of scale, but simply adjust equivalence scales or allocations derived from a Rothbarth approach for their presence through a single multiplicative, after-the-fact adjustment. Such an approach, which allows for income effects of scale economies but not for substitution effects, is suggested (but not followed) by Lazear and Michael (1986, 1988). What empirical evidence exists, however, suggests that economies of scale effect consumption of various goods in an uneven fashion, suggestive of substantial implicit relative price changes. Lazear and Michael (1980) found, in their estimation of reduced form equations on U.S. data, that factors that altered implicit prices in four-person families ranged from 1.04 to 2.37. Nelson (1988), in empirical estimation of a demand system on U.S. data, found that scaling market prices by factors ranging from 0.50 to 1.48 explained the demands of two-adult households in terms of the demand patterns of single adult households. Of the five goods included in that study, shelter was found to have the highest degree of economies of scale, and transportation the least. Empirical work on compensated price elasticities also rarely suggests the existence of right-angle indifference curves. For example, unpublished tables from the empirical work of Nelson (1988), show compensated own-price elasticities for five goods of -0.6 to -1.2, and compensated cross-price elasticities of 0.07 to 0.50, estimated on data for childless households. If implicit relative prices change and the adults respond, the presence of such substitution effects invalidates the separability assumption on which the Rothbarth method is based.

Other suggestions for allowing for economies of scale while still using the Rothbarth method have been made. Lazear and Michael (1986, 1988) "allocate" public goods in the same ratio as private goods by implicitly assuming perfect substitutibility of public and private goods.[5] Gronau (1988) suggests that one might redefine the question to identify adult welfare with only the adults' consumption of *private* goods, with an additional assumption that parents consumption of private and public goods are separable. This might be a sensible approach if private goods can be clearly separated from public goods, and public goods are a relatively unimportant part of household consumption. However, if one agrees that, for example, the categories of shelter, transportation, recreation, household furnishings, and fuel and utilities are ones in which there may be substantial economies of scale, one can see from Table 1 that such goods are not of minor importance empirically. These categories make up 57 percent of the average household budget.

The assumption of separability used by Gronau to justify use of identifiable adult goods as measures of adult welfare, when consistently applied to item-by-item analysis of adults' and children's shares of household consumption, yields a pattern of allocation which includes some "negative consumption" by children as well as non-zero consumption by children of adult goods. The existence of household public goods invalidates the separability assumption in theory.

[5]The consumption value of the *full* amount of the public goods is expressed in terms of the private goods using the ratio of their *marginal* utilities.

Empirical evidence tends to suggest that biases in results drawn from the Rothbarth method are more than just a minor theoretical possibility.

III. The Barten Method and Evidence on the Exogeneity of Goods-Specific Scales

Barten (1964) proposed incorporating demographic variation into "family" utility functions by dividing the quantity consumed of each good $i (i = 1, \ldots, n)$ by a function $m_i(a)$, where a is a vector describing household composition:

$$u = v\left[\frac{q_1}{m_1(a)}, \frac{q_2}{m_2(a)}, \ldots, \frac{q_n}{m_n(a)}\right].$$

While Barten was primarily interested in finding a way to estimate price elasticities from cross-sectional data, and not with intra-household allocation, Deaton and Muellbauer and others have interpreted $v[\cdot]$ as the parents' utility function over their own consumption and have given the q_i/m_i terms the interpretation of "the consumption of good i that actually reaches the parents when an amount q_i is purchased for the family as a whole" (Deaton and Muellbauer, 1986). That is, m_i is equal to one if children do not consume the good (or if the good is perfectly public), equal to two if parents get one-half of total household purchases, etc. The m_i are assumed to be exogenous—i.e. independent of quantities consumed, prices, and income (Muellbauer, 1974). The model can be rewritten as the maximization of utility defined over quantities $q_i^A = q_i/m_i(a)$ which have effective prices of $p_i^* = p_i m_i(a)$. From this form comes the interpretation that "the presence of children alters the effective prices of parental consumption" (Deaton and Muellbauer, p. 736).

But are the m_i terms really exogenous? Assuming that the m_i terms are constant in the face of income and price changes is the same as assuming that the ratio of childrens' to adults' consumption of each good i, q_i^C/q_i^A, does not vary with prices or income.[6] This in turn implies strong assumptions about the elasticities of substitution among goods and also that q_i^C and q_i^A share the same income elasticity (Gronau, 1988, p. 1199).

These implications can be made slightly weaker by modifying the Barten formulation to include "fixed costs," in what Deaton and Muellbaeur call the "Gorman-Barten" model. In this case the cost function can be written as

$$x = c[u, p_1 m_1(a), p_2 m_2(a), \ldots, p_n m_n(a)] + \sum p_i b_i(a)$$

where u is the adults' utility and the $b_i(a)$ are fixed costs for good i associated with household composition a. With the addition of fixed cost terms, strict proportionality of adult and child consumption levels of each good, and hence common income elasticities, are no longer implied. What is still assumed, however, is that *at the margin* the ratio of adult to child consumption must be constant. That is, once "fixed costs" have been allowed for, changes in adult consumption

[6]Note that since $1/m_i = q_i^A/q_i$ is the proportion of consumption which reaches the adults, $m_i = q_i/q_i^A = 1 + (q_i^C/q_i^A)$.

TABLE 2

ESTIMATED INCOME ELASTICITIES OF CLOTHING EXPENDITURES

	Lazear and Michael (1988)	Nelson (1989)	Moulton and Nelson (1989)
Girls	0.36	1.01	0.92
Boys	0.26	1.03	0.76
Women	0.73	1.76	1.54
Men	0.69	2.01	1.54

due to changes in prices or income must be accompanied by strictly proportional changes in children's consumption.

Ample empirical evidence exists that for at least one category of goods such income elasticities are decidedly different. Because adults' clothing and children's clothing are often recorded separately in household expenditure surveys, it is possible to estimate separate income elasticities. Table 2 contains estimates of income elasticities of clothing evaluated at the sample means for girls, boys, women and men from three recent empirical studies using United States Consumer Expenditure Survey data.[7] In each case the income elasticities for parents are estimated to be 50 to 100 percent higher than those for children. Adults appear to consume a larger share of total clothing expenditure as income rises. If $1/m_i$ is to be interpreted as the factor by which it is determined what proportion of total household expenditure on clothing "actually reaches the parents when an amount q_i is purchased for the family as a whole," it should therefore rise as income rises.

The story is the same even if fixed costs are allowed. Instead of comparing income elasticities, one can determine if the ratio of children's to adults' consumption is constant at the margin. Calculations using equations from Moulton and Nelson (1989) suggest that this is not the case. At the mean household expenditure level less one standard deviation, an income increase which causes expenditure on a mother to rise by one dollar would generate an additional expenditure of \$0.72 on clothing for her daughter. At mean total expenditure, the daughter would get \$0.54 to the mother's dollar, and at the mean plus one standard deviation the daughter would get \$0.47 of clothing for an additional dollar spent on the mother. The assumption of a constant ratio of adult to child consumption at the margin is therefore put into question.

In summary, evidence from data from the United States suggests that the shares of total and marginal clothing expenditures which reach children decrease with household income, and the shares which reach adults increase. This implies that at least one of the Barten model m_i parameters is not exogenous. Once it is

[7]Lazear and Michael (1988, Chapter 3) use 1972–73 data and a regression of the level of clothing expenditure on demographic variables and the level of household before-tax income. Nelson (1989) uses 1984–85 data and a regression of the natural logarithm of clothing expenditure on demographics and the natural logarithm of total household consumption expenditure. Moulton and Nelson (1989) use 1984–85 data and a regression using the share of clothing expenditure in total household expenditure on the left-hand-side and, on the right-hand-side, demographics and the log of total household consumption.

allowed that these can change with income, the m_i parameters estimated with the Barten-form demand equations must be interpreted as being determined by the *outcome* of intra-household allocation decisions, not, as the Barten model holds, as the factors which *determine* household allocation.

IV. Conclusion

The purpose of this paper has been to clarify a debate about equivalence scales by presenting empirical evidence on the key assumptions of the popular Rothbarth and Barten methods of deriving scales. Evidence regarding the plausibility of the separability assumption in the Rothbarth method was drawn from a study of the implications of the method for the allocation of specific goods, and from empirical evidence on the possibility of implicit price effects due to household economies of scale. The existence of household economies of scale or public goods bring the question of whether it makes sense to try to "allocate" all of household consumption among household members to the fore. Both sources of evidence on the separability assumption cast doubt on its plausibility. Regarding the Barten model, studies of United States clothing demand reveal that both the total and marginal shares of clothing expenditures which go to adults tend to rise with income. The parameters of the Barten model which purport to determine intra-household distribution are hence endogenous, rather than exogenous as assumed. In spite of the elegance with which the Rothbarth and Barten models can be theoretically expressed, it is premature to assume that, on an empirical and practical level, such models generate estimated equivalence scales of any higher quality than those generated by more *ad hoc* and simpler methods.

Appendix

The first stage in Rothbarth model estimation is the computation of "equivalent income," defined as the income level which, if the model is correct, would give adults in a childless household the same welfare level as adults in a with-children reference household. The reference household is chosen to be a household with the with-children sample mean characteristics given in Table A1. Gronau suggests a method based on Ordinary Least Squares estimation of an equation of the form shown in the first column of Table A2. This is directly comparable with reported results in Gronau's work (1991, Table 3, Column 4), the only (relatively minor) differences being due to differences in the criteria used to select the sample. Following formulas developed in his paper for calculation of equivalent income yields $X^A = 7{,}524$.

Deaton and Muellbauer's suggestion (explained more fully in Deaton, Ruiz-Castillo, and Thomas, 1985) starts with a demand equation for adult goods of the Working-Leser share-log form. The first two columns of Table A3 show the results of such estimation, for two different definitions of "adult goods." One finds "equivalent income" by solving for the predicted share, and hence level,

TABLE A1

DESCRIPTIVE STATISTICS: 1972-73 U.S. CONSUMER EXPENDITURE SURVEY

	Childless Households	With-Children Households
Sample Means		
Husband's education	11.2	12.2
Wife's weeks of employment	25.7	16.1
Number of children ages		
Less than 2	—	0.23
2 to 5	—	0.57
6 to 15	—	1.06
Household size	2	3.86
Total annual consumption expenditures	$8,328	$9,738
Number of observations	2,327	2,930

TABLE A2

SELECTED REGRESSIONS, GRONAU'S FORM

	Adult Clothing	Food	Personal Care	Alcohol
Intercept	−285.0	901.7	44.8	−40.3
	(23.9)	(55.6)	(7.6)	(10.4)
Husband's education	11.9	−24.6	−2.2	0.99
	(1.9)	(4.5)	(0.61)	(0.83)
Wife's weeks of employment	1.66	−0.93	−0.01	0.27
	(0.33)	(0.77)	(0.11)	(0.14)
Total consumption expenditures	0.74	0.115	0.013	0.013
	(0.002)	(0.005)	(0.001)	(0.001)
Dummy for presence of children	65.6	−68.1	−42.7	32.1
	(35.8)	(83.0)	(11.5)	(15.6)
Dummy × husband's education	−4.21	8.9	1.62	−0.34
	(2.8)	(6.6)	(0.91)	(1.2)
Dummy × wife's weeks	−1.31	2.4	0.56	−0.21
	(0.46)	(1.1)	(0.15)	(0.20)
Dummy × total consumption	−0.016	0.017	−0.003	−0.005
	(0.002)	(0.006)	(0.001)	(0.001)
Adjusted R^2	0.39	0.29	0.14	0.08

Note: Dependent variable is level of expenditure. Standard errors are in parentheses.

of expenditure for the reference household, and then numerically solving for the level of expenditure X^A which would give a childless household the same demand for the adult good(s). For adult clothing, this yields $X^A = 7{,}655$; for the second definition of adult goods, $X^A = 7{,}966$.

For reasons of space, the full set of 38 regressions used to infer goods-specific consumption of adults and children cannot be reported. The remaining columns of Table A2 and Table A3 report on a subset of these regressions, for one good that showed reasonable results in text Table 1 (food), one with implied negative consumption of children (personal care) and one with implied positive consump-

TABLE A3

SELECTED REGRESSIONS, DEATON AND MUELLBAUER'S FORM

	Adult Clothing	Adult Clothing, Alcohol, Tobacco	Food	Personal Care	Alcohol
Intercept	0.178	0.438	0.667	0.027	−0.003
	(0.076)	(0.099)	(0.199)	(0.030)	(0.037)
Ln (Per Capita Consumption) ($\times 10^{-3}$)	−44.9	−90.4	−36.1	−1.23	0.565
	(19.2)	(25.0)	(49.8)	(7.48)	(9.16)
Ln (Per Capita Consumption)^2 ($\times 10^{-3}$)	3.37	5.67	−1.85	−0.003	0.093
	(1.21)	(1.57)	(3.13)	(0.47)	(0.57)
Number ($\times 10^{-3}$) of children aged					
less than 2	−2.84	−7.32	−55.2	−5.85	0.035
	(1.50)	(1.94)	(3.88)	(0.58)	(0.71)
2 to 5	−2.82	−7.04	−18.9	−3.70	−0.071
	(0.90)	(1.17)	(2.34)	(0.35)	(0.43)
6 to 15	−5.51	−8.82	5.83	−0.79	−0.157
	(0.59)	(0.77)	(1.54)	(0.23)	(0.28)
Husband's education ($\times 10^{-3}$)	1.36	0.41	−3.45	−0.23	0.109
	(0.14)	(0.17)	(0.35)	(0.05)	(0.06)
Wife's Weeks of Employment ($\times 10^{-3}$)	0.17	0.14	−0.17	0.021	0.017
	(0.02)	(0.03)	(0 06)	(0.01)	(0.01)
Adjusted R^2	0.10	0.05	0.18	0.05	0.01

Note: Dependent variable is the share of the good (or group of goods) in total consumption. Standard errors are in parentheses.

tion by children of "adult goods" (alcohol). These equations were used to predict the mean level of consumption of each good for the reference household (by setting the variables equal to the with-children sample mean values given in Table A1) and for the similar but childless household whose welfare is presumably at the same level (by setting total consumption equal to the calculated X^A, education and employment equal to their with-children means, and the presence of children equal to zero). The difference is predicted mean children's consumption, under the assumption of separability.

Table A4 presents estimated standard errors for predicted means for certain goods for the Gronau form, and 95 percent confidence intervals on the assumption that errors are normally, independently, and identically distributed. While various aspects of the specification of the stochastic demand equations could be disputed (especially regarding likely heteroskedasticity in the error terms and possible endogeneity of total consumption), and the table of confidence intervals does not take into account covariances among the parameter estimates (as would a formal hypothesis test), the results give the impression that the peculiar results regarding children's consumption cannot be *completely* dismissed based on imprecision of the estimates alone. Previous works on equivalence scales generally ignore standard errors of the predictions entirely.

Complete information on selection of the sample, regressions, and calculations is available from the author upon request.

TABLE A4

95% CONFIDENCE INTERVALS FOR PREDICTED MEAN EXPENDITURES

	Predicted Mean	Standard Error	Lower Bound	Upper Bound
"Negative child consumption" goods				
Personal care				
with children	101	2.16	97	105
without children	112	2.98	106	118
Health insurance				
with children	207	4.21	199	215
without children	232	5.46	221	243
Dry cleaning				
with children	72	1.92	69	77
without children	78	2.48	73	83
Public education				
with children	16	1.92	12	20
without children	22	2.48	17	27
"Positive child consumption" goods				
Alcohol				
with children	86	2.94	80	92
without children	77	3.80	70	84
Tobacco				
with children	153	3.14	147	159
without children	140	4.07	132	148

Note: Gronau's form. OLS standard errors. Normality assumed.

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