APPRAISAL OF DIFFERENT METHODS OF ESTIMATING EQUIVALENCE SCALES AND THEIR RESULTS

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This paper discusses the problems encountered in constructing equivalence scales of the relative incomes required to enable families of different sizes or in different circumstances to enjoy the same standard of living. Theoretical problems and limitations of various methods are discussed, and examples of empirical results are presented.

1. INTRODUCTION

Equivalence scales are intended to measure the relative incomes which are needed to enable families of different size, or in different circumstances, to enjoy the same standard of living. They are useful in various contexts: for assessing and comparing changes in real income, the distribution of income, the impact of taxes and of social security benefits, and so on. The estimation of equivalence scales involves many difficulties, both conceptual and practical, and various methods have been tried.

Although, in theory, equivalence scales can be derived by laying down objective standards of what different households "need" and then determining the cost of achieving these standards (e.g., Rowntree [1], Booth [2]), they have usually been derived by empirical analysis of expenditure patterns, using data from surveys of household budgets (e.g., U.K. Family Expenditure Surveys [3, 4]). Despite the well-known problems concerning the accuracy of the survey data, they do reflect the actual behaviour of consumers and avoid the use of arbitrary standards. Studies of consumer behaviour do not, of course, take account of the non-material "satisfactions" which a married couple, for instance, may derive from having children (cf. Edward F. Denison [5]).

2. CRITIQUE OF PROPORTIONATE APPROACH

Attempts have been made to construct equivalence scales on the basis of expenditure on a given commodity or group of commodities as a proportion of income. The results of some of these attempts, and the results obtained by other methods, are listed in the Appendix. The main bases for constructing equivalence scales using the proportional approach can be summarized as follows:

(*a*) *Expenditure on Food*

Scales based on food expenditure are numerous,[1] and derive from the work of Engel who, in 1857, had observed "the proportion of the outgo (total

[1]Cf. Seneca and Taussig [6], where this method is used in assessing the horizontal equity of personal income taxation.

expenditure) used for food, other things being equal, is the best measure of the material standard of living of a population". [7] It is by now a well-known fact that expenditure on food as a proportion of total expenditure (or income) decreases as a household's income increases.

(*b*) *Expenditure on "Necessities" other than Food*

Scales have also been constructed based on the proportion of a household's expenditure on other "necessities" such as housing, heating and lighting, and clothing, separately or in combination with food. Expenditure on these "necessities" as a proportion of total expenditure (or income) also decreases as a household's income increases.

(*c*) *Expenditure on "Luxuries"*

Corresponding scales can be constructed, based on the proportion of total expenditure going on "luxuries," with varying coverage.

(*d*) *Total Consumers' Expenditure/Savings*

It has also been observed that the proportion of total consumers' expenditure to income falls as income rises; or, putting it the other way round, that the proportion of savings to income rises as income rises. Further scales have thus been estimated from the proportion of income going on consumer goods and services (or on savings).

Engel, the founding-father of this whole subject, considered that the proportion of the total expenditure of a household which is spent on food is a good indicator of the material standard of living of the household. This was based on the observed decline which took place in the proportionate expenditure on food as income increased, and provides a numerical method of comparing the standards of living of households *of the same composition* (without taking account of possessions, investments, etc). But, where two households differ in composition, this indicator loses its intuitive appeal. Consider, for example, the case of a married couple having their first child. If, at the same time, the couple receives an increase in income which enables them (while distributing their new total income between themselves and their child as they think best) to retain their own previous material standard of living, their new total income can be regarded as "equivalent" to their income when childless. It seems unlikely, however, that the proportion spent on food would remain unchanged. The variety of goods available to the adults is greatly in excess of that competing for the allocation of income/expenditure on behalf of the child (whatever its age); and, at least for very young children, food expenditure is likely to bulk larger than it does for adults. Therefore the proportion of the income "allocated" to the child that is spent on food is likely to be greater and possibly much greater than the proportion of the remaining income spent on food for the couple themselves. Hence the proportion of the couple's new total "equivalent" income that is spent on food will be greater than the proportion of their former income. Because food as a proportion of total expenditure decreases as income increases, use of these

proportions would imply that the couple with a child had a lower standard of living, and that a further increase in income would be necessary for "equivalence" with their childless state. The proportionate approach applied to food thus apparently overstates the level of income required for "equivalence" in material standards of living, by families with compared with those without children.

3. Possible Biases Introduced

The above example shows how the technique of using equal proportions spent on food to measure equivalent standards of living introduces an upward bias into the equivalence scale values for families with children (in scales where a single adult or a childless married couple is taken as the standard household type). In the case of savings, which increase as income increases, the equal proportion technique introduces an upward bias where families regard savings on behalf of adults as more important than savings on behalf of children, and a downward bias in the reverse case. In general, an upward bias must be introduced if the equal proportion technique is based on any good, or group of goods (or on total savings) if (i) it is a more important constituent of a child's budget than an adult's and (ii) it is individually or collectively regarded as a "necessity" rather than a "luxury" in the sense that the proportion of income or total expenditure devoted to it declines as income rises; and vice versa.[2] The following table summarizes the direction of the bias introduced in different cases. In addition, where the equal proportion method uses commodities which are subject to economies of scale, and are also "necessities," it will tend to produce a downward bias.

Direction of Bias introduced into Equivalence Scale by use of Equal Proportion Method

Of the total income/expenditure devoted to adults/children, the proportion spent on X (or saved) is higher for: \ As income increases proportion spent on X (or saved):	Decreases	Increases
(a) Adults	Downward	Upward
(b) Children	Upward	Downward

The equal proportion technique is not without its usefulness since no scale satisfactory for all purposes is likely to be obtained using one basis only; and the investigation of economies of scale and of reasonable assumptions about the relative importance of expenditure in total or on individual commodities, or of

[2]Brown and Deaton [8] have recently provided a mathematical demonstration, within a utility framework, of the invalidity of the proportional technique.

savings, on behalf of adults or children, might enable the direction and size of possible biases to be anticipated. It would then be possible to specify a range of income within which the "true" equivalence scale value would be found, and by the exercise of judgment about the likely bias involved in the use of different commodities, this range could gradually be narrowed.

4. Empirical Evidence

In the Appendix, scales 4, 5 and 6 are based on the equal proportion techniques (4 and 5 on food expenditure, 6 on savings) and although the estimates are based on different data, collected in different places and at different times and therefore not strictly comparable, the relativities for the food scales are slightly larger than the relativities for the savings scale. The scales in the Appendix based on total expenditure (scales 7, 8 and 9) have lower relativities for households with children than scales based on the proportion of food in total expenditure; although, admittedly, they are not all directly comparable, these scales provisionally bear out the argument that food scales based on the equal proportion method bias the scale upwards.

5. Theoretical Limitations and Problems in Constructing Scales

The following paragraphs discuss generally other theoretical limitations and some of the statistical and econometric problems encountered in the construction of equivalence scales.

Firstly, there are "economies of scale." One meaning given to this term is that the margin for absorbing additional members with little increase in expenditure is greater the higher the standard of living and income of a household. For example, a family with a large house may have room for an additional member, while a poorer family would be forced to find larger and more expensive accommodation. A further example of such "economies of scale due to level of income" is the economy in the purchase of seasonal foods which the wealthier household with a deep freeze unit can afford. The other interpretation of "economies of scale" relates to households of different size and may be termed "economies due to sharing." Prais and Houthakker (1955) [9] pointed out the possibility that of two households with a given level of income per person, the larger household may, as a result of economies of scale due to sharing, enjoy a higher standard of living than the smaller household. While there is some scope for "economies of scale due to sharing" in expenditure on food, e.g., discounts on bulk purchases (which also applies in the "economies of scale due to level of income" sense), lower cost per person in the preparation of food, and less wastage, the scope is probably much greater for certain non-food items, particularly housing and fuel, and possibly clothing, which may be passed down from older to younger children. Equivalence scales based on total consumers' expenditure may, therefore, well reflect "economies of scale due to sharing" to a greater extent than those based on expenditure on food alone. Scales based on a commodity or commodities with significant economies due to sharing will have lower relativities than scales based on commodities without such economies. This may partly explain the different

relativities obtained in equivalence scales calculated for different commodities or groups of commodities, or savings. The direction and intensity of the biases introduced into the relativities by the differing economies of scale which exist for different commodities might be separately investigated using a similar approach to that indicated in Sections 2 and 3.

Engel curve relationships where consumption of a given commodity is a function of income are the foundation on which income elasticities have been estimated. The estimation of equivalence scales has generally been an essential part of obtaining more precise estimates of such elasticities, by introducing household composition as a further explanatory variable. Cramer [10] shows that accurate estimation of the income elasticities, as indicated in the following paragraphs, depends on the imposition of some fairly restrictive *a priori* conditions concerning "economies of scale."

The introduction of a household composition variable creates statistical problems in the estimation of income elasticities.

1. *Bias*—If household composition is not treated as a separate independent variable, the strong correlation between income and household composition (due to characteristics in our social structure which are partly coincidental, e.g., one or two adult households, composed mainly of the young or the old, have substantially lower incomes than the rest of the adult population, and partly consequential in that a higher income may lead to an increase in the size of a family) would violate the major assumption of regression analysis, i.e., that the explanatory variable(s) and the disturbance term are unrelated, and cause simple least squares estimates of the elasticity to be biased.

2. *Efficiency*—Multiple regression, treating household composition as a separate variable, yields estimates of the income and household composition elasticities with very large variances owing to multicollinearity among the explanatory variables (the estimation problem). Improvement of the precision of these estimates depends on the imposition of an *a priori* condition restricting the joint variation of the estimates of the elasticities, the most common being that they should sum to unity. In effect this implies that for a particular commodity, expenditure is a constant proportion of total income or expenditure, irrespective of family size, providing that income keeps in step with the household composition variable, i.e., that households have no economies or diseconomies of scale. Cramer's household composition variable will not fully reflect any economies or diseconomies of scale due to sharing because the weight (based on age and sex) for a particular individual in the household is the same irrespective of the numbers already present in the household. The income elasticity is estimated for each commodity by a regression of consumption, divided by the appropriate values of the household composition variable, on income divided by the same values, the values being chosen according to the requirement that a single "per equivalent adult" Engel curve can apply to all sizes of household. Although the household composition variable is generally defined as a weighted sum of the values for each individual in a household (the weights, normalized by giving a value of unity to the adult male or twice this value to a married couple, being the equivalent adult or household scales), the only sound argument in favour of a particular scale is whether or not it satisfies the restrictive condition imposed (e.g., that elasticities

should sum to unity). Equivalence scales based on the condition that households have no economies or diseconomies of scale, in the sense used by Cramer, will be inappropriate for commodities where this condition does not apply.

6. Critique of Income/Expenditure Relationships Approach

Three approaches based on income/expenditure relationships are considered here:

(*a*) *The Equivalence Scale as a Weighted Sum of Specific Commodity Scales*

Sydenstricker and King [11] were the first to envisage the possibility of extending the technique of incorporating household composition as a variable in Engel curve relationships between expenditure on particular commodities and income to expenditure in general, by weighting the specific equivalence scales for particular commodities by the average expenditure on these commodities. Severe estimation problems are involved. Prais and Houthakker [9], having demonstrated the desirability of this approach, were unable to resolve all the problems of applying it. More recently Singh and Nagar [12] have presented an iterative procedure which appears to overcome the major problems.

(*b*) *An Equivalence Scale based on Differential Expenditure on Selected Commodities*

The method originally used by Nicholson [13] attempts to separate commodities which are consumed *exclusively* by adults and for which the specific equivalence scale values for children could reasonably be expected to be zero. It provides the necessary restriction for identification, thus overcoming the estimation problems encountered by Prais and Houthakker, and enables equivalence scales covering all income to be estimated. Cramer [10] argues that this approach, which depends on finding a selection of commodities which are (i) strongly correlated with income and (ii) consumed exclusively by adults, provides the "only valid" solution to the problem of indeterminacy. One drawback of this method is that some of the items which are consumed exclusively by adults (e.g., alcoholic drink, tobacco) are not usually recorded accurately. Another drawback is that tastes can change with age, a good reason for taking account of the ages of adults in the formulation of equivalence scales, For example, as a woman gets older she may be inclined to ignore current fashions and spend less on clothes. But, if only because there is no definitive solution, this method certainly merits further study—using recent data, finer subdivisions of expenditure than are normally used, and alternative selections of commodities that are consumed largely or, exclusively by adults (or exclusively by children).

Using a different (and somewhat complicated) line of reasoning, Brown and Deaton [8] have recently argued, on the basis of a particular form of the utility function, that this method is liable to produce a downward bias. Though doubtless correct as a formal description of the properties of a particular function, their argument (which implies that the addition of children causes the adults' consump-

tion, of e.g., drink, to rise) lacks intuitive appeal. It also depends very much on the validity of the function; it assumes, as do other methods, that the utility function (or the family's scale of preferences) is unchanged by the addition of one or more children to the family. It thus seems to share the same drawback as the method based on goods consumed exclusively by adults. In general, the addition of children is almost bound to affect their parents' way of life and is therefore likely to alter their own scale of preferences; this is possibly the kernel of the whole problem.

(c) *Equivalence Scales Based on "Threshold Incomes"*

The paucity of equivalence scales based on all items and on non-food items, compared with those based on food, results mainly from the traditional concentration on Engel curve relationships, which have been largely concerned with food, as a basic necessity of life. It is also due partly to the poorer quality of information on non-food items and partly to the fact that for certain non-food items households have significant economies of scale in the "income level" and the "sharing" sense. An additional check on estimates of equivalent "standards of living" for households of different size might be to use the concept of "threshold incomes," i.e., average levels of income at which families of different composition are just able to afford to buy particular commodities (which can be designated "luxuries" on the basis of income elasticities obtained from analysis of household budgets). In 1971, two-thirds of U.K. households had refrigerators, and two-thirds washing machines, half at least one car and a third a telephone. A third of households also had full or partial central heating. These proportions do not necessarily indicate the order of purchase of these durables, and it is also possible that other items such as carpets, vacuum cleaners or even non-durables designated as "luxuries" would be more appropriate. The designation of a particular good as a "luxury" or otherwise would need to be independent of household size. Even if this were the case, it is unlikely that the "luxury" designation would be independent of life-cycle income.

7. Problems Caused by Different Age Structures of Households

Equivalence scales are generally more meaningful when based on a set of households with relatively homogeneous needs. Thus married couples of working age, with or without children, are a relatively homogeneous group of households, compared with one-adult households, which are relatively heterogeneous. This is a factor which causes particular difficulty when deriving equivalence scales which relate "retired" households and other households. Although it cannot be denied that the needs, tastes and patterns of expenditure of "retired" households differ from those of households with occupied members, a useful first approximation may be to treat "retired" and "occupied" households as having "needs" which, taking expenditure as a whole, are equal, as an alternative to the usual assumption that "retired" households have fewer needs. This is based on the assumption that there is a balance between those items the need for which increases with age e.g., general services, medical attention, heating, and such commodities as tea and

tobacco and those items the need for which decreases, e.g., food in general, clothing, cost of travel to work. Depending on the extent to which retired persons were interested (and perhaps benefited from "perks") or were bored when at work, their expenditure on leisure activities after retirement may have to increase or decrease to yield them the same degree of satisfaction as when they were working. As such households are, in the U.K., a large (and increasing) sector of the community, and account for a good deal of social services expenditure, further experiments may be needed. One possible line of enquiry is an analysis confined to a limited range of items selected because they provide retired households with the same degree of satisfaction as working households. Another might be to construct an equivalence scale using items which can be classified as "luxuries" (income elasticity of demand greater than 1) or as "necessities" (income elasticity of demand less than 1) for both retired and non-retired households. A further approach might be to look at the income, expenditure and living conditions, of families just before, and just after, they retire, to see to what extent they have had to make adjustments because of the fall in their income: this could be done by means of a special survey or by follow-up surveys on respondents in household budget surveys who had since retired. Another possibility might be to ask those about to retire what income they considered they would need to give them the same standard of living after retirement, and to ask those just retired what income they considered they would need to give them the same standard of living as they had before retirement.

The need for equivalence scales to take account of the ages of members of the household has already been stressed. Scales which do not differentiate between the ages of children, but define the household type solely in terms of the number of adults and children will, on empirical evidence, generally be biased upwards. In U.K. surveys it has been observed that the average age of children in families increases as the number of children increases (e.g., where there is only one child the average age is about 6, compared with 8 where there are four or more children). Thus, assuming that "needs" increase with age, the equivalence scale values obtained as family size increases will reflect these increasing "needs" and will be greater than the values which would be expected for families with different numbers of children, but where the average age of children was the same. Whether or not this bias is important will depend on the use to which the scale is put. If it is used to determine relativities for different household types for use in social welfare programmes, it may be appropriate that the bias resulting from different age structures should be included.

8. Summary and Conclusions

Scales which measure the equivalent needs of households of different composition are useful in a wide variety of contexts—distribution and redistribution of income, studies of poverty, standards of living, long-term economic forecasting, etc.—not only at subsistence or modest income levels, but at all levels of welfare. The construction of equivalence scales involves a number of conceptual and other problems and various methods have been tried or suggested. The various methods raise difficulties of one kind or another: bias (upwards or

downwards) in the estimates of relativities based on proportionate expenditure; the treatment of economies of scale, and statistical problems in equivalence scales derived from Engel curve relationships between expenditure and income; and differences in tastes. A further difficulty is the lack of suitable data for the full utilization of methods which may help overcome some of these problems, or for any extension of the analysis to cover retired households and children by age. To be useful, a scale, or the basis on which it is constructed, need not satisfy every stringent theoretical condition which could be imposed. For some purposes complete accuracy or sensitivity to change may not be demanded, and if the degree and direction of any bias which a particular method introduces is known, it can to some extent be allowed for. For work on the redistribution of income for example, a roughly estimated scale may be sufficient. However, in work aimed at establishing relativities for state benefits (e.g., family allowances, supplementary benefits), greater accuracy and sensitivity are clearly essential.

Further work needs to be done on the estimation of equivalence scales using different methods, and on the application of the scales to studies involving comparisons between households of different composition.

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APPENDIX: EXAMPLES OF EQUIVALENCE SCALES

(Standardized Household of 2 Adults = 2.00)

Household Type	*Scales* (References below)								
Basis	[1] DA	[2] GA	[3] F†	[4] F	[5] F	[6] S	[7] E	[8] E	[9] E
One adult	—	—	1.05	1.08	1.20	1.39	—	—	1.28
Two adults	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Two adults, one child	2.75*	2.60[1]	2.84[2]	2.62	2.73[2]	2.55*	2.50	2.24	2.26
Two adults, two children	3.39*	2.99[1]	3.42[2]	3.10	3.33[3]	3.03*	2.80	—	2.50
Two adults, three children	3.93*	3.40[1]	3.89[2]	3.50	3.87[3]	3.45*	—	—	2.72
Two adults, four children	4.41*	3.82[1]	4.26[2]	3.87	4.40[3]	3.85*	—	—	2.94
Three adults	2.75*	—	3.05	—	—	2.55*	—	—	2.59
Three adults, one child	3.39*	—	3.89[2]	—	—	3.03*	—	—	—
Three adults, two children	3.93*	—	4.47[2]	—	—	3.45*	—	—	—
Four adults	3.39*	—	4.00	—	—	3.03*	—	—	3.11

The quotation of scale values to 2 decimal places facilitates comparison of the relative values but is not justified on the grounds of accuracy alone.

*Household composition only given by persons (unknown whether adults or children).

†Equivalent adult scale, interpolated values for ages of children, one adult = man, two adults = man, woman.

[1]Age, sex, order of children: boy 13, girl 8, child 6, child 4.

[2]Assumed to be same as above.

[3]Order of children: child 6–15, two children, eldest 6–15, three children, eldest 6–15, four children, eldest 6–15.

Basis of Scale

DA—Dietary Adequacy
GA—General Adequacy (Maintenance Budget)
F—Food Expenditure
S—Savings
E—Total Expenditure

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