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Multivariate Measures of Well-Being and an Analysis of Inequality in the Michigan Data

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We demonstrate a multidimensional approach for combining several indicators of well-being, including the traditional money-income indicators. This methodology avoids the difficult and much criticized task of computing imputed incomes for such indicators as net worth and schooling. Inequality in the proposed composite measures is computed using relative inequality indexes that permit simple analysis of both the contribution of each welfare indicator (and its factor components) and within and between components of total inequality when the population is grouped by income levels, age, gender, or any other criteria. The analysis is performed on U.S. data using the Michigan Survey of Income Dynamics.

KEY WORDS: Information theory; Generalized entropy; Schooling; Housing; Income.

1. INTRODUCTION

Economic welfare and its distribution across the population of an economy are unquestionably of crucial importance to a full understanding of the impact of politically and secularly induced economic change. There is general agreement among economists that the traditional money-income measures are inadequate and more comprehensive measures of economic status are needed. In this article, we provide a multidimensional analysis of a panel of families from the Michigan Survey of Income Dynamics to understand further how changing welfare factors have affected the distribution of U.S. economic welfare.

Serious attempts have been made to analyze distributional issues in a broader context than measured income approaches. Shorrocks (1983), Fei, Ranis, and Kuo (1978), Kakwani (1980), and Pyatt, Chen, and Fei (1980) presented factor-component analyses of income. The effect of combining welfare indicators such as wealth and net worth with income in composite measures of economic welfare was studied by Weisbrod and Hansen (1968), Murray (1964), and Projector and Weiss (1966, 1969). More recent discussion of this kind of approach is found in Maasoumi (1986), Atkinson and Bourguignon (1982), Kakwani (1984), and Rosen (1984).

One of the primary weaknesses in the previous work has been the need to use the imputation of income methodology. This methodology is of somewhat tenuous justification in most applied work. For example, Weisbrod and Hansen (1968) derived an annual lifetime annuity value of current net worth and aggregated this with non-asset money income. What is required for this exercise is a suitable interest rate applicable to all individuals and all assets and a life-cycle theory of the use of the wealth; see Projector and Weiss (1969) for a critical discussion. The Weisbrod–Hansen approach, however, does take the analysis beyond money-income analysis and is useful. Imputation of income to the net flow of housing services from homeowner equity is even more tenuous. As outlined by Kakwani (1984), this asset-generated stream of income is extremely important in measuring individual welfare, and this difficulty is, therefore, serious. This may well be compounded by the presence of bracketed house equity value data in surveys.

Following the developments by Maasoumi (1986) and Atkinson and Bourguignon (1982), we employ composite measures of well-being that combine any number of indicators in their original measured form without any conversions. In addition, our measures permit different valuations (weights) for different indicators, and admit substitution between them. Moreover, the available data may be based on indexed, categorized, or directly measured observations. Neither of these features may be generally found in such measures of well-being as those proposed by Weisbrod and Hansen (1968). The method of principal components (PC) proposed by Ram (1982) is also a special case of our approach. The methodology proposed here may also be used to study the inequality in aggregate measures of the factor components of income including the traditional linear sum of income components. Other theoretical and practical justifications for this multidimensional approach were discussed by Atkinson and Bourguignon (1982), Kolm (1977), and Maasoumi (1986).

In evaluating the inequality in the distribution of our composite welfare measures, two sets of somewhat related and familiar questions arise. The first relates to value judgments inevitably exercised at the theoretical level. Examples of this are the choice of the composite measure and its constituent variables, the choice of a particular inequality measure (i.e., welfare function), and the "utility" approach (interpretation) versus the "measurement" or consumption approach. The second set of questions arises at the level of implementation. Examples are the definition of such variables as income, the choice of the accounting unit (household, individual), if and how to adjust for family size, and the choice of time interval over which "welfare" is computed. For the latest debate about these questions see Kakwani (1984) and his interchange with Rosen (1984). In our computations we have been guided by what is feasible in practice and by our perception of the constructive outcome of such debates as cited previously. In addition, we recommend and offer a sensitivity analysis that may reveal which conclusions are robust with respect to changes in some of the underlying value judgments and definitions.

The plan of this article is as follows. Section 2 introduces the notation, the composite welfare measures, and an information-theoretic justification for its different functional forms. Section 3 presents the inequality measures and their properties, particularly in the multidimensional context. Section 4 presents our data and definitions for three indicators—income, housing, and schooling—and explains our computational decisions. The Michigan data are analyzed for four age groups in three different years (1968, 1975, and 1979). Interesting trends and life-cycle effects are noted in measured inequality in the composite welfare measures as well as in each of its three constituent indicators.

2. MULTIVARIATE MEASURES OF WELL-BEING

The idea that different indicators of economic welfare are distributed very differently has been supported in many studies (e.g., Lydall and Lansing 1959; Projector and Weiss 1966; Taussig 1973, 1976). Without this diversity in distributions there would be no need for a multidimensional measure. Indeed, our measures of multivariate welfare also depend on this diversity. Weisbrod and Hansen's (1968) composite measures may still be computed (even with identical distributions), however, for use in *absolute* welfare measurements and in the study of consumer (producer) behavior. When such diversity exists, we seek a composite (scalar) measure that is a function of the welfare indicators of concern to an analyst. The solution to this problem is similar to that of the index-number problem in that the choice of any particular index must be guided by its intended use. In our present study, we are concerned with measuring the *relative* inequality in the distribution of the composite measure, and thus we will propose indexes with distributions that most closely represent the *distributional information* in each of their constituent variables.

Formally, let X_{if} be the amount of attribute f ($f \in [1, M]$) received by the individual consuming unit i ($i \in [1, N]$). It follows that the "welfare-share matrix," x, has a typical element given by $x_{if} = X_{if}/\sum_{j=1}^{N} X_{jf}$. Define the composite measure of welfare by $S_i = h_i(X_{i1}, \ldots, X_{iM})$, where h_i is to be determined according to a suitable criterion that minimizes the distance between the distribution $S^* = (S_1^*, \ldots, S_N^*)$, $S_i^* = S_i/\sum_{k=1}^{N} S_k$, and the M distributions $x_f = (x_{1f}, x_{2f}, \ldots, x_{Nf})$, $f = 1, \ldots, M$. Consider the following multivariate generalization of the ϕ-entropy measure of divergence for our problem:

$$D_\phi(S, x; \alpha) = \sum_{f=1}^{M} \alpha_f \left\{ \sum_{i=1}^{N} S_i^* \left[\left(\frac{S_i^*}{x_{if}} \right)^{\phi} - 1 \right] \Big/ \phi(\phi + 1) \right\}, \quad (1)$$

where α_f is the analyst's valuation (weight) for the fth variable. Note that $\phi = -1$ and 0 correspond to the (weighted sums of) directional Kullback–Leibler measures of distributional divergence. For instance,

$$D_0(\ ) = \sum_f \alpha_f \left(\sum_{i=1}^{N} S_i^* \log \frac{S_i^*}{x_{if}} \right). \quad (2)$$

The minima of (1)–(2) with respect to S_i are obtained at, respectively,

$$S_i \propto \left(\sum_f \delta_f x_{if}^{-\phi} \right)^{-1/\phi}, \qquad \phi \neq 0, -1, \quad (3)$$

and

$$S_i \propto \prod_{f=1}^{M} x_{if}^{\delta_f}, \qquad \delta_f = \alpha_f \Big/ \sum_{k=1}^{M} \alpha_k. \quad (4)$$

Equations (3) and (4) will be recognized as the constant elasticity of substitution and the Cobb–Douglas functions, popular utility functions in economic literature. The function $S_i = \sum_f \delta_f x_{if}$ will be the "ideal index" if $D_\phi(\cdot)$ is adopted with $\phi = -1$. The traditional expenditure-income approach is therefore a special case of our more general approach. This can be seen by replacing δ_f with prices of various commodities (attributes) in the linear function obtained at $\phi = -1$. As may be verified, these ideal functional forms are independent of whether we work with S_i as a function of the shares, x_{if}, or the absolute levels, X_{if} (see Maasoumi 1986). Rather simple generalizations of (1) that lead to ideal composite indexes allowing variable elasticity of substitution between the welfare attributes rather than the constant levels dictated by (3)–(4) are under investigation. In practice the analyst's valuation of individual welfare is revealed by his choice of α_f as well as the levels of substituion. For the type of welfare variables we have in mind (often nontraded and difficult to monetize), reliable estimation of such parameters is not reasonably anticipated. Consequently, we caution against interpreting our composite indexes as the individual's *actual* utility function.

3. MEASURES OF INEQUALITY

The Gini index of inequality is the most well known and widely used measure in empirical studies. The recent influence of developments in the axiomatic approach to measures of inequality and the desire for less ambiguous decompositions of inequality into constituent and population subgroups is focusing attention on a new class of inequality measures known as the *generalized entropy* (GE) (see Bourguignon 1979; Shorrocks 1980). GE contains most of the well-known measures, including both of Theil's information measures of inequality, the coefficient of variation, and other measures that are ordinally equivalent to the family proposed by Atkinson (1970).

In our numerical investigations, we use both of Theil's measures, defined as follows for S_i:

$$I_0(S) = \sum_{i=1}^{N} S_i^* \log(S_i^*/p_i), \tag{5}$$

$$I_{-1}(S) = \sum_{i=1}^{N} p_i \log(p_i/S_i^*). \tag{6}$$

When the population share of the ith household (unit), p_i, is the same for all households $(1/N)$ this becomes

$$I_{-1}(S) = -\log N - (1/N) \sum_i \log S_i^*. \tag{7}$$

We have chosen (5)–(6) as our inequality measures, since (a) these two measures, particularly (6), possess the least ambiguous and most meaningful additive decomposability properties that we know of (see Foster 1983; Shorrocks 1980); (b) they satisfy the three "fundamental welfare requirements" of homogeneity, symmetry, and the Pigou–Dalton principle of transfers; (c) they are more clearly reflective of the impact of demographic and income-share changes within and between the population groups than such measures as Gini (see the Sec. 4 comparisons); and (d) these measures are clearly revealing of the contribution of each welfare variable to multidimensional inequality.

This last point may be seen from the following decompositions:

$$I_0(S) = \sum_{f=1}^{M} C_f I_0(x_f) - D_{-1}^*, \qquad \sum_f C_f = 1, \tag{8}$$

$$I_{-1}(S) = \sum_{f=1}^{M} \delta_f I_{-1}(x_f) - D_0^*, \tag{9}$$

where $I_{-\gamma}(x_f)$ is the inequality in the fth variable and D_ϕ^* is the minimum of D_ϕ obtained at $S_i = \sum_f \delta_f x_{if}$ for $\phi = -1$, and at $S_i = \prod_{f=1}^{M} x_{if}^{\delta_f}$ for $\phi = 0$ (see Maasoumi 1986). Note that D_0^* and D_{-1}^* are also decomposable and may be interpreted as "measures of fit" in the sense of criteria (1)–(2).

4. NUMERICAL DEMONSTRATION BASED ON A SAMPLE FROM THE MICHIGAN PANEL DATA

In this section we report the results of experiments conducted using several different values for ϕ and δ_f [Eqs. (3)–(4)], three inequality measures (including the Gini), and three welfare variables or attributes. Inequality in the distribution of each of these attributes as well as of their aggregates (S_i) are reported for the years 1968, 1975, and 1979. To pick up age differences and the life-cycle effects that are generally regarded as important in analyzing inequality, we considered four distinct age groups delineated by the age of household head—30 and below, 31–44, 45–65, and over 65. Our unit of measurement is the "household" (see Kakwani 1984), and household attributes are adjusted for family size by simply dividing by the number of individuals in the household (for income) and by the number of living spouses (for schooling); see Kakwani (1984) and Rosen's (1984) comments on that article. The difficulties with the choice of unit and with adjusting for family size are well known. Our reading of this literature suggests that the important issue is to be explicit about which distribution is being analyzed in the study.

The population and "income" shares of our age groups in 1968 approximate those in all of the U.S. population, as given by Boskin, Kotlikoff, and Knetter (1985). We *randomly* selected 276 households (10%) from the random households in the 1968 file of the Michigan Panel Study of Income Dynamics, with about $\frac{2}{3}$ between the ages of 31–65 and $\frac{1}{3}$ in the other two age groups. It is this same sample of individuals that is analyzed in 1975 and 1979, so the effects of age (time), experience, and asset accumulation are at least partially captured; we defer to the interchange of Kakwani (1984) on these very points.

Our first chosen attribute is annual nominal income. This was defined to include wages and salaries, business income, and such things as asset income and transfer payments to the household. In the Michigan Panel Study this is referred to as gross taxable income plus transfers to the household. The second attribute of interest to us was net housing equity. Although actual dollar values are typically reported for *most years,* we chose to measure this variable as a bracketed or grouped variable. This was done because, although we believe the responses were roughly correct, they relied on the respondent to guess at a market value when in fact the actual market value is unknown. Although it is possible in this study to have real-estate-appraised values assigned to panel members, such additional data collection is quite costly. We are more confident that the actual equity is within the assigned bracket than we are in the point estimate of the respondent. Once our housing variable is a bracketed variable, we can take the midpoint, a weighted average of the original data, or a qualitative index as our house-equity variable. Using the original data presents an error-in-variables problem, whereas using the midpoint results in a loss of information problem, as does using a qualitative index. For the purpose of this analysis we decided on the qualitative index to represent subjective differences in welfare based on housing equity. The use of either midpoints or indexes will understate housing inequality, because within-bracket inequalities will go unmeasured. We defined 10 equity brackets for each year, starting from no equity and going up by $5,000 increments to the highest bracket for 1968 ($45,000 and more). These brackets were represented by a scale (index) from 1 to 10. We used the home ownership price component of the consumer price index to inflate these categories so that, for instance, the largest category in 1979 was a net equity of $105,000 or more. Housing was chosen because it is widely regarded as the most influential factor component of wealth affecting welfare.

The third and final attribute analyzed here is the average schooling of spouses (if two), categorized by half-year increments ($\frac{1}{2}$ to 17 years). Using categorized or grouped data entails a potential loss of distributional information. But recovery of this information usually requires degrees of accuracy in both reporting and data measurement that are not reasonably expected. The inequality of bracketed schooling or housing is likely to be an underestimate, but this is not a problem in itself so long as the distribution being measured is clearly specified. Schooling was chosen in our study because it is widely regarded as another important asset (human capital) affecting welfare, both in its income-generating role as productivity-improving capital and as a source of a stream of consumption. Imputing a dollar-income value to schooling requires having more knowledge about the individuals than was available. It is also thought that individuals invest in education at earlier stages of their lives and forego current income for the expected returns to schooling (income and otherwise); see Mincer (1958) and Rosen (1977). We think that it is desirable to have aggregate measures of welfare that, like our S_i, allow for substitution and unequal valuation of different welfare variables. The subjective decisions that must be made here by the analyst deserve close scrutiny. Toward this end, we analyze the sensitivity of our results and present them.

We consider four substitution (aggregation) levels, $\phi = (-2, -1, -\frac{1}{2}, 0)$. We also allow for three different sets of weights for income, housing equity, and schooling. These are equal weights $\alpha_f = \frac{1}{3}$ ($f = 1, 2, 3$);

Table 1. Theil's Second Measure, PC Weights, $\phi = 0$

Group	G(In)	I(In)[a]	I(H)[b]	I(Ed)[c]	I(S)	In[d] share	H share	Ed share	Sample size
1968									
All	.663	.484	.450	.340	.347	1	1	1	267
1st G	.708	.153	.024	.049	.035	.24	.14	.28	67
2nd G	.695	.171	.223	.048	.085	.29	.40	.35	90
3rd G	.653	.212	.193	.079	.087	.44	.41	.33	94
4th G	.706	.177	.119	.072	.058	.04	.05	.04	16
Between term		.303	.294	.279	.275	$\rho_{In,H}$	$\rho_{In,Ed}$	$\rho_{H,Ed}$	
Within term		.181	.156	.061	.072	.239	.308	.168	
PC weights		.351	.350	.298					
1975									
All	.627	.556	.483	.255	.335	1	1	1	
1st G	.678	.177	.236	.022	.068	.23	.24	.27	
2nd G	.651	.217	.278	.018	.082	.35	.37	.34	
3rd G	.599	.298	.254	.043	.104	.39	.34	.33	
4th G	.755	.114	.253	.046	.090	.03	.05	.05	
Between term		.326	.225	.225	.249	$\rho_{In,H}$	$\rho_{In,Ed}$	$\rho_{H,Ed}$	
Within term		.230	.258	.030	.086	.225	.371	.163	
PC weights		.36	.35	.29					
1979									
All	.635	.501	.458	.254	.328	1	1	1	
1st G	.669	.196	.211	.020	.081	.22	.25	.26	
2nd G	.627	.242	.280	.023	.095	.38	.35	.34	
3rd G	.640	.245	.191	.033	.094	.36	.34	.34	
4th G	.713	.147	.178	.037	.075	.04	.05	.05	
Between term		.275	.233	.227	.238	$\rho_{In,H}$	$\rho_{In,Ed}$	$\rho_{H,Ed}$	
Within term		.226	.225	.027	.090	.339	.411	.166	
PC weights		.355	.352	.294					

[a] *In* is income adjusted for family size (see text).
[b] *H* is categorized net equity in housing with 1 = no equity and 10 = highest equity bracket.
[c] *Ed* is average years of schooling for spouses categorized from $\frac{1}{2}$ to 17 in $\frac{1}{2}$-year increments.
[d] All shares are rounded only in reporting.

$\alpha = (\frac{1}{2}, \frac{1}{4}, \frac{1}{4})$ for income, housing, and schooling, respectively; and finally, a set of weights derived from the first PC of these three attributes [the normalized first characteristic vector of the matrix $x'x$, where $x = (x_{if})$ is the welfare matrix defined earlier]. See Ram (1982) and Maasoumi (1985) for a description of the PC method in this context. Note that these latter weights change with the data and hence are not the same for the three years considered here. But the change is rather small over time, and the weights given to income, housing, and schooling are always in that (descending) order.

The Gini measure of *income* inequality is also reported for the three years of this study. The decompositions that are available for this coefficient are not computed here, because they are not additive, not comparable with those reported in our tables, and not free from the ambiguities discussed by Shorrocks (1980). See Pyatt, Chen, and Fei (1980) and Silber (1986) for some otherwise useful decompositions of the Gini index.

In Table 1, Theil's second measure of inequality is reported for all of the variables including the welfare aggregate S, which (in this table) has the Cobb–Douglas form given in (4) and the PC weights indicated. Moreover, $G(In)$ represents the Gini measure of *income* inequality that has widely influenced the common perceptions of "inequality." Table 2 depicts the trend of inequality over time. It provides some evidence on the robustness of Theil's second measure of inequality in the aggregates (S_i). The sensitivity of $I(S)$ to changes in both the attributes' relative weights (α_f) and in the measures of aggregation (ϕ) is clearly brought out in Table 2. Moreover, readings in each row provide the trend line in welfare inequality from 1968 to 1979. Tables 3 and 4 have a format similar to Tables 1 and 2, respectively, with the measure of inequality being Theil's first. This provides a further test of robustness of inferences drawn from Tables 1 and 2.

The inferences that may be gleaned from Table 1 are as follows:

1. For the variable definitions used in this study, the "schooling" inequality is much smaller than for the other two variables. This is consistent with existing evidence and with the findings, based on the entire Michigan sample in Maasoumi and Nickelsburg (1984). The difference between the inequality values for income and our "housing" variable, however, may be smaller than the understatement of housing inequality caused by various data-bracketing methods.

Table 2. Sensitivity and Trend in Theil's II, I(S)

	$\alpha = (\frac{1}{3}, \frac{1}{3}, \frac{1}{3})$			$\alpha = (\frac{1}{2}, \frac{1}{4}, \frac{1}{4})$			PC weights		
Group	1968	1975	1979	1968	1975	1979	1968	1975	1979
$\phi = 0$									
All	.344	.326	.320	.362	.361	.349	.347	.335	.328
1	.035	.063	.075	.052	.075	.091	.035	.068	.081
2	.080	.075	.086	.092	.091	.108	.085	.082	.095
3	.085	.095	.087	.098	.126	.113	.087	.104	.094
4	.054	.085	.070	.074	.087	.081	.058	.090	.075
B	.275	.247	.237	.279	.262	.245	.275	.249	.238
W	.069	.79	.083	.083	.099	.104	.072	.086	.090
$\phi = -\frac{1}{2}$									
All	.346	.330	.322	.365	.365	.350	.350	.339	.330
1	.037	.063	.072	.055	.075	.088	.038	.068	.078
2	.082	.076	.089	.091	.091	.111	.086	.083	.097
3	.088	.094	.082	.104	.125	.107	.091	.103	.089
4	.055	.086	.069	.074	.087	.081	.059	.091	.075
B	.275	.250	.241	.280	.266	.248	.275	.252	.242
W	.071	.080	.081	.085	.099	.102	.075	.087	.088
$\phi = -1$									
All	.351	.334	.325	.369	.368	.352	.354	.343	.333
1	.039	.063	.070	.057	.075	.085	.040	.069	.076
2	.086	.079	.093	.092	.093	.113	.091	.086	.101
3	.094	.095	.080	.110	.125	.103	.097	.103	.087
4	.058	.087	.069	.073	.088	.080	.061	.093	.074
B	.275	.253	.244	.281	.269	.251	.276	.255	.245
W	.076	.081	.081	.090	.099	.101	.079	.088	.088
$\phi = -2$									
All	.360	.341	.331	.375	.371	.354	.364	.350	.339
1	.044	.065	.068	.060	.076	.080	.045	.071	.074
2	.094	.086	.101	.096	.097	.119	.099	.092	.109
3	.106	.097	.079	.119	.122	.098	.109	.104	.085
4	.064	.091	.068	.074	.091	.078	.067	.097	.073
B	.276	.253	.248	.281	.271	.255	.277	.259	.249
W	.084	.088	.083	.094	.100	.099	.087	.091	.090

Table 3. Theil's First Measure, Equal Weights, $\phi = -1$

	1968				1975				1979			
Group	I(S)	I(In)	I(H)	I(Ed)	I(S)	I(In)	I(H)	I(Ed)	I(S)	I(In)	I(H)	I(Ed)
All	.352	.485	.457	.336	.335	.549	.478	.252	.324	.486	.456	.252
1	.037	.139	.028	.046	.060	.176	.229	.020	.066	.183	.200	.018
2	.091	.170	.241	.046	.082	.227	.263	.018	.095	.235	.289	.021
3	.096	.227	.192	.072	.098	.270	.260	.038	.079	.215	.186	.030
4	.055	.165	.121	.068	.086	.109	.252	.043	.071	.157	.177	.035
B	.275	.303	.294	.279	.253	.326	.225	.225	.244	.275	.233	.227
W	.077	.182	.165	.056	.082	.223	.253	.027	.080	.211	.222	.025

2. The inequalities in income and housing increase noticeably between 1968 and 1975, but then decline to just above their 1968 levels in 1979. Inequality in schooling declines noticeably from 1968 to 1975 and stays about the same in 1979.

3. $G(In)$ goes down in 1975 and up for 1979. This does not accord with any of the $I(In)$ reported in this study or those reported in Maasoumi and Nickelsburg (1984) or those in the extensive study of income inequality and mobility in Maasoumi and Zandvakili (1986) using all of the Michigan panel for every year of the study up to 1981. The last study employed several different definitions of income and several inequality measures in addition to Theil's two measures. It used an expanding interval over which incomes are measured starting with annual incomes. In Table 1, although "within-group" values for $G(In)$ are reported, they cannot be unambiguously attributed to the corresponding age groups. This can be done for both of Theil's measures, however, and is least ambiguous for Theil's second measure.

4. The between-group and the average within-group terms reported with Theil's measures are very informative. For instance, we see that the major percentage changes in income and housing inequalities are caused by changes *within* groups. In fact, by 1979, although inequality between age groups has declined, that within groups has increased on the average. This is quite plau-

Table 4. Sensitivity and Trend in Theil's I, I(S)

	$\alpha = (\frac{1}{3}, \frac{1}{3}, \frac{1}{3})$			$\alpha = (\frac{1}{2}, \frac{1}{4}, \frac{1}{4})$			PC weights		
Group	1968	1975	1979	1968	1975	1979	1968	1975	1979
$\phi = 0$									
All	.343	.327	.319	.361	.360	.345	.347	.336	.327
1	.032	.060	.071	.048	.071	.084	.033	.065	.076
2	.082	.077	.088	.094	.094	.109	.088	.084	.096
3	.084	.096	.084	.097	.123	.106	.087	.105	.091
4	.051	.085	.073	.068	.086	.086	.054	.091	.079
B	.275	.247	.237	.279	.262	.245	.275	.249	.238
W	.068	.080	.082	.082	.098	.100	.072	.087	.089
$\phi = -\frac{1}{2}$									
All	.347	.330	.321	.366	.366	.348	.351	.340	.329
1	.035	.059	.068	.051	.072	.082	.035	.065	.074
2	.086	.078	.091	.095	.096	.112	.092	.086	.099
3	.088	.097	.081	.106	.125	.104	.091	.105	.088
4	.052	.086	.072	.069	.086	.085	.056	.092	.078
B	.275	.250	.241	.280	.266	.248	.275	.252	.242
W	.072	.080	.080	.086	.100	.100	.076	.088	.087
$\phi = -1$									
All	.352	.335	.324	.372	.370	.351	.356	.345	.332
1	.037	.060	.066	.054	.072	.080	.038	.066	.072
2	.091	.082	.095	.098	.099	.116	.097	.089	.103
3	.096	.098	.079	.116	.127	.101	.099	.107	.086
4	.055	.086	.071	.070	.086	.084	.059	.093	.077
B	.275	.253	.244	.281	.269	.251	.276	.255	.245
W	.077	.082	.080	.091	.101	.100	.080	.090	.087
$\phi = -2$									
All	.364	.344	.331	.381	.375	.362	.369	.353	.339
1	.041	.063	.065	.056	.074	.076	.043	.068	.070
2	.102	.091	.105	.104	.106	.122	.108	.098	.112
3	.112	.102	.079	.131	.127	.098	.116	.110	.086
4	.062	.089	.070	.072	.088	.081	.065	.095	.075
B	.076	.256	.248	.281	.271	.262	.277	.259	.249
W	.088	.088	.083	.100	.104	.100	.092	.094	.090

sible, as our sample frame is one of an aging population. With the passage of time, age differences account for fewer of the differences in incomes and assets. Inequality in schooling declines steadily both between and within age groups. The decline in the within-group term, however, is relatively dramatic between 1968 and 1979.

5. Results in inferences 2 and 4 make it clear why inequality measurement in any single attribute would be misleading as an *overall* measure. For instance, the increase in income inequality between 1968 and 1975 is neither evident in nor tempered by the decrease in schooling inequality. Given that income and education have the highest correlation of any two of our attributes (see $\rho_{In,Ed}$ values), an overall measure that is capable of reflecting their interrelation as well as any relative valuations we wish to give to these welfare variables is desirable. In Table 1, $I(S)$ provides this balanced view of overall inequality using a Cobb–Douglas aggregate measure ($\phi = 0$) and the PC weights (valuations) for the three variables. According to $I(S)$, overall inequality has declined slightly but steadily. This decline is entirely accounted for by the decline in the inequality *between* the age groups. In fact, within-group inequality has been on the rise over time.

Are the preceding results sensitive to the particular weights or the aggregation function chosen for Table 1? We believe Table 2 provides strong evidence that the preceding conclusions are robust with respect to α and ϕ. We find that inequality increases uniformly with decreasing values of ϕ. The between-group inequality is remarkably robust to changes in both ϕ and α. The increase in the within-group inequality is, therefore, the cause of increase in inequality as ϕ declines. $I(S)$ declines over time, as does its between-group component, but its within-group component increases over time.

We conclude that, although age difference explains less of the overall inequality over time, between-group inequality is still clearly the dominant (better than 2:1) component of inequality. These conclusions were confirmed in a study of the entire Michigan sample (Maasoumi and Nickelsburg 1984).

Are the preceding conclusions sensitive to the choice of the inequality measure? Tables 3 and 4 domonstrate that the preceding conclusions are confirmed when Theil's first measure is employed. Indeed, except for very slight differences in some within-group inequalities, Tables 2 and 4 contain almost identical entries. Maasoumi and Zandvakili (1986) and Zandvakili (1987) considered only income inequality but measured with several other inequality measures belonging to the GE family of measures mentioned in Section 3. They find that different measures generally provide the same pattern of changes and relative magnitudes as those exhibited by Theil's measures. We conclude that the general inferences outlined previously are invariant with respect to the choice of the inequality measure within the GE family. It is worth recalling that GE also contains the coefficient of variation and a member that closely approximates the Gini index (see Kuga 1979). The latter result suggests that $G(S)$, although not additively decomposable, will provide the same *overall* picture *in relative terms* as is given in Tables 2 and 4.

5. CONCLUSION

We have reported a decomposition of inequality in three important welfare variables and in the distributions of several aggregated measures of welfare. Both the decompositions and our chosen measures of inequality are more informative than the existing measures and much more successfully reflect the important and substantial demographic and distributive changes that have occurred in the United States in the last two decades. These changes were decumented by Boskin et al. (1985) from the Current Population Surveys.

We recommend a sensitivity analysis at least as extensive as we have provided whenever robust inferences on inequality and its movements are desired. This is needed because there is an inescapable role played by the *analyst's* subjective valuations of different welfare variables and his assessment of their interactions. Our results formally trace the rather unambiguous consequences of these value judgments as, for instance, a comparison of $I(I_n)$ and $I(S)$ demonstrates. Income, I_n, is an "aggregate" that assigns zero weights to nonmarket welfare-generating aspects of housing, schooling, and other variables and makes no allowance for the compensating effects of other attributes. S, on the other hand, moves in the right direction by assigning nonzero weights to other variables. We have aimed at demonstrating that further studies based on larger sets of variables, other functional forms for S, and fuller samples or population surveys are warranted. Although formation of general social impressions about overall "equality" may be better informed with as large a number of variables as practicable, many specific policy-oriented studies can be based on a small set of relevant variables.

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