A Multi-dimensional Measure of Economic Well-Being for the U.S.: The Material Condition Index October 2013

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Abstract
When measuring economic well-being, a decision first needs to be made regarding what is to be measured and then second, how. Focusing on one dimension of economic well-being may provide an incomplete picture of the economic well-being of individuals and households. A recent call for the integration and multi-dimensional measurement of income, consumption and wealth has been published by the OECD (2013a), building on the recommendations of Stiglitz, Sen, and Fitoussi (2009). The OECD report notes that multi-dimensional measurement is a new field of statistics; the report describes several measures within this new field. One of these is a central tendency measure penalized for dispersion in the distributions of the dimensions under consideration. This particular measure draws on the work by Ruiz (2011) with a mapping of income, consumption, and wealth into a single index, the Material Condition Index (MCI). The purpose of the current study is to determine whether it is feasible to operationalize the Ruiz method using U.S. data. In this study, we apply the Ruiz method and test whether the joint distribution of income, consumption, and wealth produces a different picture of economic well-being than any of the three dimensions alone. Data from the 2009 quarter two through 2012 quarter one U.S. Consumer Expenditure Interview Survey are used. Our results suggest that the method can be applied to U.S. data but only under a certain assumption, that income, consumption, and wealth must be positive. Such a restriction limits the applicability of the method; future research will investigate relaxing this assumption. However, aside from this restriction, we find that the MCI provides a more complete picture of economic well-being than any of the three dimensions of economic well-being alone.

Key words: Income distribution, expenditures distribution, wealth distribution, joint distributions, economic well-being,

1. Introduction

In the past several years, various studies and reports have highlighted the need for further development in the integrated analysis of household income, consumption and wealth data at the level of individual households. Among these include the following: the first and second editions of the Canberra Group Handbook (2001, UNECE 2011); the Final Report of the 17th International Conference of Labour Statisticians (ILO 2004); the report by the Commission on the Measurement of Economic Performance and Social Progress, established by the French Presidency (Stiglitz et al., 2009); and reports by the OECD Expert Group on Micro Statistics on Household Income, Consumption and Wealth (ICW) reports (OECD 2013a,b).

The OECD Expert Group report, *Framework for Statistics on the Distribution of Household Income, Consumption and Wealth* (ICW Framework) (OECD 2013a), includes recommendations for defining, consistently and in an integrated framework, household income, consumption, and wealth. Recommendations are also made for the

collection of these data and methods for analyses. Among the methods are multi-dimensional analyses of income, consumption and wealth at the micro-level, including the use of composite measures that combine all three dimensions into a single statistic. One option for the production of a single statistic, incorporating these three dimensions, is a measure that combines central tendency and dispersion. For this index, a central tendency measure is penalized for dispersion in the distributions of the dimensions under consideration. This measure builds on work by Ruiz (2011), who refers to the measure as the Material Condition Index (MCI).

The MCI jointly considers three dimensions of economic well-being in a multi-dimensional, inequality-sensitive framework. Ruiz developed his measure by building upon original work of Foster et al. (2005) on composite measures of well-being and Alkire and Foster (2010) in their work on the inequality-adjusted Human Development Index (HDI). As noted by Ruiz, the MCI is based on the level of each dimension of economic well-being and two distinct forms of inequality: the spread of the distribution for each dimension, and the statistical dependence between dimensions. Ruiz suggested that this methodology is well-suited for dimensions with the same units of measurement, and so is specifically appealing for the measurement of households' financial conditions. Ruiz used a French household survey that records income, consumption, and wealth, and found that the use of the MCI, as a measure of households' material living standards, provides a very different picture from one solely using income, both on the equity and the efficiency side, and at the aggregate and the microeconomic level.

The purpose of the current research is to test the feasibility of applying the Ruiz method to analyze the economic well-being of people in the U.S. Data from the U.S. Consumer Expenditure (CE) Interview Survey from 2009 quarter two through 2012 quarter one are analyzed. We compare results from the multidimensional framework to one based on each of the dimensions alone. Our results show that income and consumption are only part of the story and that accounting for these together, along with wealth, provides for a more complete assessment of households' economic and material well-being. These results are dependent on the data, definitions of income, consumption, and wealth, and an assumption regarding the data specification, i.e., the restriction that values be positive. Future research will address a relaxation of this assumption.

In the next section of this paper the MCI is described. This is followed by a section in which income, consumption, and wealth are defined, following the ICW Framework (OECD 2013a) as closely as possible, along with the data source. The next section includes the results, and then the final section concludes.

2. The Material Condition Index MCI

The Material Condition Index is based on the calculation of generalized means extended to a multi-dimensional framework, by use of a nested structure. In the one-dimensional case, assuming $(x_1,\ldots, x_n)$ is the distribution of income, for example, over n units of observations, the generalized mean of curvature q of this distribution is simply given by the following formula:

$$\mu_q(x_1,...,x_n) = \left[\frac{1}{n}\sum_{i=1}^{n} x_i^q\right]^{\frac{1}{q}} \forall q \neq 0 \qquad (1)$$

$$= \prod_{i=1}^{n} x_i^{\frac{1}{n}} \text{ for q = 0}$$

When $q = 1$ the generalized mean reduces to the arithmetic mean; when $q = 0$, this case is the geometric mean and when $q = -1$, the harmonic mean. As q increases, greater emphasis is put on the upper tail of the distribution. Conversely, when q decreases, greater weight is placed on the lower tail. In the case of observing levels of inequality, q can be referred to as a measure of inequality aversion. The generalized mean using a single dimension, with a curvature parameter, was proposed by Atkinson (1970) as a measure of economic well-being; the Atkinson framework discounts mean income by a measure of the spread in the income distribution according to a utilitarian welfare concept. As with the Atkinson measure, for the MCI, the q parameter discounts the mean well-being dimension level by a measure of the spread of the distribution.

Ruiz notes that generalized means are useful tools as they consider the whole distribution of a given variable or variables and may place continuously greater weights on lower incomes or consumption, for example, as q diminishes. As a result, one can lower the influence of the upper part of the distribution while at the same time not completely ignoring values just above a threshold. The index proposed by Ruiz is a multidimensional generalization of the Atkinson's measure. However, the multi-dimensional nature of the MCI builds upon the work of Foster et al. (2005) in his study of composite measure of well-being.

In a multi-dimensional framework, there are two ways of aggregating a distribution matrix. The first is to aggregate across the units (as in the one dimensional case), and then across the dimensions. The second way is to aggregate first across dimensions, thus generating for each unit an overall level of achievement across dimensions; we refer to these as individual MCIs. Elements of this vector, the individual MCIs, are then aggregated into a single number across individuals. The first way favors the dimensional perspective (eliminating the units point of view in the first step), while the second emphasizes the units. Following the terminology established by Kolm (1977), the first way can thus be seen as a specific or dimensional aggregation procedure (S-aggregation), while the second as an individualistic aggregation procedure (I-aggregation).

A simple assumption is made in the production of MCI based on income, consumption, and wealth in the study by Ruiz and in this study: that there is equal weighting regarding the importance of income, consumption, and wealth. Equal weighting is assumed when all three dimensions are used due to a lack of guidance regarding which dimension is more or less important in assessing economic or material well-being. Weighting of dimensions is a long standing issue in multi-dimensional analyses. The specification of the MCI, as presented below, allows for different weights to be applied to the dimensions. For example, zero weights are placed on wealth when the MCI is produced using consumption and income only.

The Material Condition Index is based on generalized means extended to a multi-dimensional framework, specifically a nested generalized mean. The formulas below are given for the I-aggregation:

$$W^I(X) = \left[\frac{1}{n} \sum_{i=1}^{n} \left[\left[\frac{1}{m} \sum_{j=1}^{m} \left(x_i^j \right)^r \right]^{\frac{1}{r}} \right]^q \right]^{\frac{1}{q}} \quad \forall q < 1, \forall r < 1, q \neq 0, r \neq 0 \qquad (2)$$

$$= \prod_{i=1}^{n} \left[\prod_{j=1}^{m} \left(x_i^j \right)^{\frac{1}{m}} \right]^{\frac{1}{n}} \text{ for } q = 0 \text{ and } r = 0$$

$$= \left[\frac{1}{n} \sum_{i=1}^{n} \left[\prod_{j=1}^{m} \left(x_i^j \right)^{\frac{1}{m}} \right]^q \right]^{\frac{1}{q}} \quad \forall q < 1, \; q \neq 0 \text{ and } r = 0$$

$$= \prod_{i=1}^{n} \left[\left[\frac{1}{m} \sum_{j=1}^{m} \left(x_i^j \right)^r \right]^{\frac{1}{r}} \right]^{\frac{1}{n}} \text{ for } q = 0 \text{ and } \forall r < 1, \; r \neq 0$$

The formulas below are given for the S-aggregation:

$$W^S(X) = \left[\frac{1}{m} \sum_{j=1}^{m} \left[\left[\frac{1}{n} \sum_{i=1}^{n} \left(x_i^j \right)^q \right]^{\frac{1}{q}} \right]^r \right]^{\frac{1}{r}} \quad \forall q < 1, \forall r < 1, q \neq 0, r \neq 0 \qquad (3)$$

$$= \prod_{i=1}^{m} \left[\prod_{j=1}^{n} \left(x_i^j \right)^{\frac{1}{n}} \right]^{\frac{1}{m}} \text{ for } q = 0 \text{ and } r = 0$$

$$= \left[\frac{1}{m} \sum_{i=1}^{m} \left[\prod_{j=1}^{n} \left(x_i^j \right)^{\frac{1}{n}} \right]^q \right]^{\frac{1}{q}} \quad \forall q < 1, \; q \neq 0 \text{ and } r = 0$$

$$= \prod_{i=1}^{m} \left[\left[\frac{1}{n} \sum_{j=1}^{n} \left(x_i^j \right)^r \right]^{\frac{1}{r}} \right]^{\frac{1}{m}} \text{ for } q = 0 \text{ and } \forall r < 1, \; r \neq 0$$

For both the I- and S-aggregations, q has the same interpretation as in the one dimensional case, expressing the concern for inter-individual inequality over all the dimensions, while r penalizes for the unbalancement in achievements between dimensions for each individual (what can be denominated as “intra-individual” inequality).

Calculation of the MCI relies on an arbitrary choice of sequencing and, depending on the choice of curvature parameters, may result in different outcomes based on the aggregation sequence. A desirable and convenient property for a multi-dimensional index is path-independency, i.e., aggregating either across dimensions, then across units or first across units then across dimensions yields the same results. A path independent framework is where $q = r$, so that the sequence of aggregation yields the same result. For path-dependency, there are trade-offs between the curvature restriction (q) of the index and its sensitively to an increase in the dimensions’ correlations r, where $q \neq r$.

Regarding the choice of path-independency versus path-dependency, one is more flexible than the other while the other is easier to implement when data are limited. When there is path-independence, the S-aggregation can be used to produce the MCI and the input data for the measure can be from different sources. For example, for the U.S., the income data could be from the Current Population Survey, consumption-based data from the CE, and wealth data from the Survey of Consumer Finances. Survey-specific generalized means for each dimension, with a penalty for inequality within each dimension, would be produced for the total population. Then these population inequality-penalized generalized means for each dimension would be aggregated into one index to form the MCI. In contrast, when all the data are available in a single survey and observed simultaneously, the interaction between dimensions can be accounted for at the individual level. As noted in the OECD report (2013a) and by Ruiz (2011), accounting for this interaction at the individual or household level is a primary goal of multi-dimensional analysis of economic well-being; thus the I-aggregation will always be preferable to the S-aggregation. Our calculations show results for both path-independency and path dependency.

For a discussion of the properties of the aggregation function, we refer the reader to Ruiz (2011). Ruiz lists the properties of the aggregation function, theorems, and proofs. The properties of the multidimensional measure are the same as those in the literature on welfare comparisons and inequality.

The first step in the construction of the MCI is to normalize the entries of the dimensions in order to have a ratio-scale measure of the dimensions, with the lowest value set to 0% achievement level and 100% as the highest level of achievement. Such normalization means that there is comparability across the dimensions so that a 50% achievement in one dimension is equal to 50% achievement in all others. Such normalizations are standard in multi-dimensional measures (see Anand and Sen, 1994, for a discussion of this as applied to the Human Development Index (HDI), and Anand and Sen, 2000, in their work on the income component of the HDI).[1] Since income, consumption, and wealth are all measured in the same underlying units, dollars, such a normalized scale adjustment makes sense. We followed the method used by Ruiz, for each value of income, consumption, and wealth we subtracted the lowest achievement possible, divided by the difference in the maximum and minimum achievements. It is to this normalized matrix of income, consumption, and wealth that the parameters q and r are applied.

The focus of the MCI is the individual, thus an adjustment is needed to account for the differing needs of adults and children when data are available only at the household level. For the analysis, income, wealth, and consumption data are adjusted to account for these differing needs within a household (consumer units in the case of the CE). We follow the approach used by Ruiz (2011) and use the modified OECD scale with the following values applied: 1.0 to the first adult; 0.5 to the second and each subsequent person aged 14 and over; and0.3 to each child aged younger than 14. Each consumer unit's income, consumption, and wealth are divided by the number of adult equivalents in the consumer

[1] When comparing normalized means across time or across countries, it is imperative to normalize by the highest and lowest achievements across the time periods or across the countries. For example, let's say income, consumption, and wealth double from one period to the next. The normalization applied would result in a normalized mean, in our case a MCI, for the second period that is twice as large as the normalized mean in the first period, thus reflecting the fact that the levels of income, consumption, and wealth are higher and thus economic well-being is higher.

unit. Distributions are based on the ranking of people in the population and in different demographic groups by their equivalized income, wealth, and consumption. The person population weights are calculated by multiplying the number of people within the consumer unit times the consumer unit population weight (CE variable FINLWT21). All results presented are person population weighted.

3. Variable Definitions and Data Source

For this study, we follow as closely as possible the ICW Framework (OECD 2013a) in defining household income, consumption and wealth. A key requirement of the ICW Framework is consistency in the way that income, consumption, and wealth are defined. For example, the consumption value of the flow of owner occupied housing services is defined as the rental equivalence of the unit, net implicit rental income from this housing is included in income, and net worth (property value minus debt) of this housing is included in wealth. While consistency in defining variables is important, there are instances when the data available do not support the desired definitions; we note these instances below. A description of the data source and challenges are also included in this section.

3.1 Adjusted Disposable Income

The ICW Framework recommends that adjusted disposal income be used as the income measure for economic well-being measurement (see chapter 4, OECD 2013a). Adjusted disposable income equals all income received minus current transfers paid plus social transfers in kind (STIK). Income received is defined as those receipts that are received on a regular and recurring basis and are therefore available to support consumption and other ongoing obligations. Included in income is the implicit net rental income from owned dwellings, owner-occupied and vacation homes and time shares. In addition, the implicit net rental income from owned consumer durables, own-produced domestic services, and other home production are to be included. Current transfers paid include payments such as direct taxes, fees or fines paid, employer and employee contributions to social insurance schemes, current transfers to non-profit organizations, and current transfers to other households, such as child support or alimony payments. Social transfers in kind are non-monetary social transfers that a person receives usually from the government (sometimes from a non profit institute) as services.

Although the ICW Framework recommends that adjusted disposal income be used as the income measure for economic well-being measurement, not all of the information needed to create an ICW Framework disposable income variable is available in the CE. For example, the net rental income from owned dwellings can be created but not the implicit rent from durables and other home production. Regarding durables, vehicles, in particular, posed a problem for us. The CE Survey Interview collects an inventory of vehicles and information about the purchase of new vehicles, including loan information, and associated expenditures for vehicle use and maintenance of new and previously purchased vehicles. However, no information is available regarding the flow of services from owned vehicles; thus, a net rental income from the flow of services associated with vehicle ownership is not made. A requirement of the ICW Framework is that income, consumption and wealth be consistently defined. Given this requirement, the net implicit income, consumption, and net worth of vehicles are not included in our measures for this analysis. In addition, little information on social transfers in kind, with the exception Supplemental Nutrition Assistance Program (SNAP) payments, is available in the CE. Current transfers to be subtracted from income, such as income taxes, are limited to those

reported by consumer units. Reports of income taxes are generally of lower quality in the CE; plans are currently underway at the BLS to impute income taxes (see Paskiewicz 2013). Thus, for this analysis we use money income as our starting point, and then make subtractions to meet the OECD ICW Framework recommendation as closely as possible.

Adjusted disposable income used in this study is the combined money income of all consumer unit members (14 years of age or over) during the 12 months preceding the interview, plus the net rental income of owned housing and plus the cash value of SNAP payments minus current transfers. Transfers subtracted include reported income taxes, payments made to others outside the consumer unit for child support and alimony, cash support for non-consumer unit members, gifts to non-consumer unit members, contributions to charities and other organizations, churches, education institutions, political organizations, other contributions and cash, and deductions for Social Security.

It is critical to note that for this study, income is defined with only one of the social transfers available to eligible consumer units in the U.S., that being SNAP. Other social transfers in-kind would include Medicare and Medicaid, housing subsidies, school meals, energy assistance, etc. These other transfers in-kind also represent important policy tools that redistribute income. Had these items been included estimates of inequality of the income and consumption distributions likely would be much different from what is reported here. It is well known that STIK are very important to welfare analysis. In addition, better estimates of income taxes are also likely to alter the results of the distributional analysis. Further work should account for an expanded set of STIK and income taxes.

3.2 Wealth

The definition of wealth, or net worth, following the ICW Framework, is the value of all assets owned by a household less the value of all its liabilities at a particular point in time (see chapter 6, OECD 2013a). An asset is a store of value representing a benefit or series of benefits accruing to the economic owner by holding or using the entity over a period of time. Assets may be financial in nature or not. All liabilities are financial in nature.

For this study, using CE data, wealth is defined as total assets minus debt. Assets include the value of the following as of the fifth interview: current values of savings and checking accounts, current values of securities (stocks, bonds, or mutual funds), balances of money owed to the consumer unit, value of the insurance policies surrendered, and market value of owned primary residence, vacation homes, time shares. Liabilities are defined to include the following: balances owed on mortgage principal on an own dwelling occupied by the consumer unit, vacation homes, and times shares; and, money owed to other creditors, such as department stores, banks, credit unions, finance companies, insurance companies, doctors, dentists, and other medical practitioners. The current market values of owned dwellings and associated debt have been adjusted to reflect non-business use, and in the case of time shares, the amount of time that the consumer unit has access to the time share. Not included in assets are properties without housing. Although we have the market value and debt of unimproved land, we do not have a consumption flow value for the land. As noted in the adjusted disposable income section, we do not consider vehicles in our analysis.

3.3 Actual Final Consumption

The ICW Framework recommends that actual final consumption be the measure used for economic well-being analysis (see chapter 5, OECD 2013a). Actual final consumption is

defined as consumption expenditure plus the value of social transfers in kind provided by government and non-profit institutions. Actual final consumption expenditure is the value of goods and services used or paid for by a household to directly meet its needs. These goods and service are obtained: through the purchase of goods and services in the market; as in kind income from employers, from self-employment (through barter of goods and services produced by the household), or from property or other investments (e.g. portion of crop provided by share-farming tenant); from the household's own production of goods and services; or as transfers in kind from other households or from businesses, and as social transfers in kind provided by government and non-profit institutions. For services and non-durable goods, the expenditure made is assumed to be equal to consumption. For durable goods, those that can be used repeatedly over a period of time, it is the value of the flow of services from these that are included in consumption.

Using the CE Interview data, expenditures consist of the transaction costs, including excise and sales taxes, of goods and services acquired during the interview or recordkeeping period. Expenditure estimates include expenditures for gifts, but exclude purchases or portions of purchases directly assignable to business purposes. With the exception of owned dwellings, vehicles, and major appliances, the full cost of each purchase is recorded as the consumption value, even though full payment may not have been made at the date of purchase.

Not all the data for ICW Framework definition of consumption are available from the CE. The CE data are restricted primarily to purchases of goods and services on the market and from other consumer units. However, also collected are the values of employer-provided food and rent as pay and, implicitly, the value of SNAP benefits. It is that SNAP benefits are reflected in reported food expenditures. The service flows from owned housing are collected and valued as reported rental equivalence. Owned housing includes owner occupied units, time shares, and vacation properties. A select few categories of housing maintenance and repair expenditures are counted as consumption; these are limited to those that it is assumed renters have as well. The rental equivalence of owned housing is assumed to include the service flows from major household appliances since such appliances are often included in rental units. Other consumer durables are assumed to be valued at their expenditure value; no consumption values are added to the data to reflect the consumption of previously purchased consumer durables. Vehicles are the one exception to this treatment; as noted earlier, vehicles are not considered in our analysis. As for income, the actual final consumption measure used for this study does not meet the full recommendation of the ICW Framework.

3.4 Data Source and Challenges

Accounting for the relationship among income, consumption, and wealth at the individual or household level is a desirable goal of multidimensional measures of economic well-being such as the Material Condition Index. To meet this desired goal, a single source is needed to provide these data. The Consumer Expenditure Survey is the only U.S. federal survey that collects data on income and wealth and data that can be used to produce consumption estimates. The CE collects detailed data on an estimated 60 to 70 percent of total family expenditures (BLS 2013). In addition, global estimates are obtained for food and other selected items. These global estimates account for an additional 20 to 25 percent of total expenditures. Unique to the Diary are nonprescription drugs and medical supplies (primarily topicals and dressings), personal care products, and housekeeping supplies, which included postage. Data from 2009 quarter two through 2012 quarter one are used in the creation of the MCI for the U.S. This time period was selected due to the

availability of reported rental equivalence data from all owned housing. The CE has collected estimates of reported rental equivalence for owner occupied housing for many years. Beginning with 2008, data have been collected on the rental equivalence of vacation properties and time shares. The CE Division within the BLS, beginning with 2009 quarter two, has made available rental equivalence values for these properties that reflect adjustments for personal use (as opposed to business use). For the analysis, income, wealth, and consumption values were converted to 2011 dollars, using the All Items Consumer Price Index for Urban Consumers (CPI-U), before the MCIs were computed.

A requirement of this study is that an annual accounting of income and consumption is used and that the data refer to the same time period, with the stock of wealth valued at the end of this time period. The CE collects expenditure data every three months over five periods; each quarterly report of expenditures is for the previous three months. We use the data from the last four interviews to produce our measure of annual consumption. Income data are collected in interviews two and five but only the annual income reported in the fifth interview refers to the same time period as the sum of expenditures over the four quarters; thus, fifth quarter income is used. Stocks of assets and liabilities, needed for the wealth measure, are only collected in the fifth interview. Due to CE design for the collection of these data, we restrict our sample to consumer units who complete the last four quarterly interviews of the CE Survey Interview. To examine the MCI for different types of consumer units, we use the demographic characteristics recorded for the fifth interview.

All results in this study are population weighted and are based on the cross-section consumer unit weights provided in the CE internal data base for the fifth interview multiplied by the number of members in the consumer unit. A more appropriate weight would account for the fact that the study sample is restricted to consumer units with four complete interviews. Our final data set included information on 14,948 unique consumer units over the 2009 quarter two through 2012 quarter one interview time period.

To produce the MCI, Ruiz (2011) assumed there to be diminishing marginal returns from income and wealth. This means that the accumulation of income and wealth beyond a certain point does not enhance material well-being in a dollar to dollar way. To account for diminishing returns to income and wealth, Ruiz applied a log transformation to these variables but not to consumption. For our study, we also applied a log transformation to consumption to reflect our assumption that there are diminishing returns to consumption as well. The choice of a log transformation is only one of many that could have been made (see Anand et al., 2000). However, once our choice was made, it became is necessary that income, wealth, and consumption be positive. Ruiz dealt with negative and zero values by assigning bottom codes to the French data. Due to the extremes in wealth, Ruiz restricted wealth to financial wealth only and did not consider liabilities. In our case, we bottom recoded income and total wealth (financial plus non-financial assets minus liabilities) that were less than $1000 to equal $1000 and recoded wealth values greater than $2,000,000 to be equal to $2,000,000. There were two cases with negative consumption values; these were dropped. All other consumption values were greater than $1000 and so were not bottom recoded. We did not top recode income or consumption. The theory underlying the MCI supports the idea that values can only be zero or positive; this is because achievement in material conditions can only be zero or positive, it can never be negative.

In order to make the scale of income, consumption, and wealth comparable across dimensions, Ruiz applied a normalization to the values resulting in values between 0 and 1. For the normalization, the minimum or lowest level of achievement in the population, for example for income, was subtracted from the individual value of the achievement; this was then divided by the difference in the maximum and minimum achievable values in the dimension. We followed the same normalization in our study. However, the normalization used by Ruiz poses a challenge for log transformations when the difference in the lowest achievement and actual value equals 0, thus the numerator is zero in this case. To deal with this problem, we created a minimum achievable value that was $1 lower than the lowest reported value in our data. Another way to have dealt with this would have been to assume that the lowest achievement possible would be $0; then the difference between the bottom recoded value of $1000 and the lowest achievement possible would always be positive.

4. Results

The Material Condition Indexes (MCI) presented in this section are based on the normalizations of income, wealth, and consumption such that the lowest normalized value of each is 0 (actually just above 0) and the highest is 1. In the tables we show results by deciles of income as income is the usual measure used for economic well-being.

Table 1 includes MCIs based on each dimension separately by deciles for the U.S. When only one dimension is being considered, only the *q* parameter comes into play. The assumption being made is that for economic well-being measurement, only one dimension of economic or material well-being is important. In our case, the MCI based on income alone has weights applied to consumption and to wealth that are equal to zero. The MCI based on consumption has income and wealth weights equal to zero. And, the MCI based on wealth has income and consumption weights equal to zero. The focus in this table is on the relative magnitude of the MCIs. The numbers in the tables do not have a direct interpretation but are to be considered relatively. For example, a MCI of 0.7 suggests a higher degree of overall achievement relative to a MCI of a value of 0.4 when both of the inequality parameters are set equal to one. When the inequality parameters are set to values less than one, a MCI of 0.5 would suggest a higher degree of overall achievement with a penalty for inequality within dimensions and between dimensions relative to a MCI of a value of 0.1.

In the tables, MCIs (which are the same as generalized means) are produced for different degrees of aversion to inequality. When *q=1* there is neutral aversion to inequality and the MCI is the same as the arithmetic mean. To try to explain this, let's look at Table 1 and the decile results for income. The MCI based on income when *q=1*, the arithmetic mean, for decile one is 0.24244 and for decile 10 it is 0.58639. This means that income in the top decile is on average 2.4 times that of incomes in the lowest decile. Overall, as one's aversion to inequality gets stronger (moving from a parameter value of 1 to -3 in our case), the MCI based on income alone (the generalized mean with a penalty for inequality in the income distribution) decreases and the effect of high incomes becomes less important and overall economic well-being falls for the population (from 0.42628 to 0.004218). This also means that with a strong aversion to inequality, small changes in low incomes will have a much larger impact on the generalized mean value than very large changes to middle and upper incomes.

Comparing the MCIs (generalized means) based on income, consumption, and wealth alone, higher achievement or economic well-being results are observed when measured by consumption as opposed to income. The MCIs are higher for consumption than they are for income for all levels of inequality aversion considered. The MCIs for wealth are quite high for individuals in the high income groups. In most cases, however, economic well-being across the population is lower when measured using wealth; this is due to the extreme inequality in wealth relative to that in income and consumption.

The remaining tables include results for the MCI that are based on the joint distribution of income, consumption, and wealth. Table 2 presents the MCIs overall and for each income decile using a path-independent measure ($q=r$). When q and r do not equal *1*, the generalized means for income, consumption and wealth are penalized for inequality in their distributions (inter-consumer unit inequality within each measure) and for unbalanced achievement across the distributions (intra-consumer unit inequality of the three measures). The stronger the penalties (i.e., more negative the parameter values), the greater is the aversion to inequality of income, consumption and wealth within and across consumer units, the lower the MCI values. Table 3 presents the MCIs overall and for each income decile assuming path-dependency; this is a test of whether the I- and S-aggregations produce the same or different results than when path independence is assumed. For Table 3 results, inequality between dimensions is held constant with the r parameter set equal to 0.5, while the inequality between individuals within each dimension is allowed to vary.

Table 1. Material Condition Index Based on Individual Dimensions, CE Interview 2009Q2-2012Q1, based on conversion to 2011 Dollars

	Income			Consumption			Wealth		
	Neutral	Medium	Strong	Neutral	Medium	Strong	Neutral	Medium	Strong
q=	1	-1	-3	1	-1	-3	1	-1	-3
Income Decile									
1	0.24244	0.12024	0.00196	0.40811	0.39419	0.37600	0.18068	0.07026	0.05138
2	0.32918	0.32870	0.32820	0.43566	0.42750	0.41944	0.22629	0.08151	0.05526
3	0.36644	0.36619	0.36595	0.46129	0.45361	0.44590	0.29460	0.10212	0.05994
4	0.39526	0.39512	0.39499	0.48305	0.47652	0.47002	0.34614	0.12873	0.07212
5	0.42065	0.42052	0.42039	0.49950	0.49265	0.48578	0.38436	0.15126	0.07999
6	0.44379	0.44370	0.44362	0.51170	0.50579	0.49989	0.39527	0.15864	0.08049
7	0.46679	0.46669	0.46659	0.52906	0.52347	0.51762	0.43024	0.17814	0.08499
8	0.49070	0.49059	0.49048	0.54564	0.54020	0.53472	0.46876	0.21146	0.09783
9	0.52100	0.52078	0.52056	0.56913	0.56328	0.55653	0.51362	0.24498	0.10601
10	0.58639	0.58336	0.58078	0.61902	0.61135	0.60369	0.61269	0.33816	0.13202
Total	0.42628	0.34405	0.004218	0.50623	0.49120	0.47368	0.38529	0.13450	0.070579

A comparison of values from Table 1 and Table 2 shows that the MCI under path-independency provides a different picture of consumer units' material well-being than for the case of consumption and wealth alone. For all levels of inequality aversion considered, the MCI levels are systematically lower than those for consumption alone (e.g., 0.07 points lower for the neutral case). This implies that consumption tends to provide an over-appreciation of average consumer units' material well-being relative to a measure based on the joint distribution of income, consumption, and wealth. For example, with $q=r=1$ the overall MCI is the simple average of the MCIs of the three components individually. Such a result implies that, on average, households have

relatively lower levels of economic or material well-being when measured in terms of levels of income and/or wealth compared to their well-being when measured in terms of consumption levels. This result is magnified when a penalization for inequality is applied to the levels of the dimensions to account for intra-dimensional and inter-dimensional inequality. When moving from a weaker to a stronger aversion to inequality, the decline in the MCI is larger than in the case of the generalized means of consumption alone. This indicates that the joint distribution of income and wealth is far more unequal than that of consumption alone. This result is similar to the finding of Ruiz (2011) when he compared MCIs based on income alone with a parameter *q=1* (the generalized income means) and the MCI under path-independence.

When comparing the results for income alone from Table 1 with the MCI results in Table 2, it appears that income does almost as good a job at measuring material conditions as does the joint distribution of income, consumption, and wealth. Whether the joint defined MCI results are statistically significantly different from the results based on each dimension alone cannot currently be tested as we have no standard errors for the MCIs. The results by income deciles reveal differences that could not have been identified using income, consumption, or wealth alone. By moving along the inequality aversion line, consumption- and income-specific MCIs (generalized means) remain almost unchanged in Table 1, with the exception of the first decile for income. This means that there is strong homogeneity within deciles with regard to income and consumption. This is not the case for wealth alone. The combined result of these three underlying findings is evident in the MCI of Table 2. Here the MCI displays sizable reductions, suggesting that the structure of wealth in each income decile is not as homogeneous as that of consumption and income.

As noted earlier, a desirable and convenient property for a multi-dimensional index is path-independency, i.e., aggregating either across dimensions then across individuals in a population, or first across individuals then across dimensions yields the same results. When the *r* and *q* parameters are equal, the S- and I-aggregations produce the same MCIs. To test whether path independency holds, we move to the more general case, allowing *r* and *q* to differ; we refer to these measures as path-dependent.

Table 2. Material Condition Index Under Path-Independency

CE Interview 2009Q2-2012Q1, based on conversion to 2011 Dollars

Path Independence (q=r)

	Neutral	Medium	Strong
q=r	**1**	**-1**	**-3**
Income Decile			
1	0.27707	0.11959	0.00282
2	0.33038	0.16998	0.07952
3	0.37411	0.20369	0.08625
4	0.40815	0.24198	0.10368
5	0.43483	0.27226	0.11494
6	0.45025	0.28478	0.11570
7	0.47536	0.31034	0.12215
8	0.50170	0.34808	0.14044
9	0.53458	0.38573	0.15212
10	0.60604	0.47565	0.18901
Total	0.43927	0.24237	0.00608

Table 3 includes results for the path-dependent measures using the S-aggregation and I-aggregations with a constant penalization for the unbalanced dimensions within individuals, denoted by the *r* parameter, while *q* varies. In other words, there is a constant penalty, with *r=0.5*, placed on the data when the correlations between income, consumption, and wealth are not equal for individuals. For the S-aggregation, the *q* parameter is applied first to income, consumption, and wealth separately to penalize the within dimension inequality; thus, the first aggregation is across individuals units within each dimension. The next aggregation is across dimensions with a penalty applied to account for between-dimension inequality, again, denoted by the *r* parameter. For the I-aggregation, the *r* aversion to inequality parameter is applied to each dimension of income, consumption, and wealth within each individual to create something like an individual Material Condition Index. Then the joint distributions of the individual MCIs are aggregated through the application of the *q* parameter to account for differences between individuals of their specific MCI's. Hence, for the I-aggregation, the aggregation is first across dimensions and then across individuals.

As seen in Table 3, when moving to the general case, allowing *q* and *r* to vary, we see that the numerical results are not the same for the S- and I-aggregations. But, when no penalization is applied for inter-individual inequalities (*q=1*), the MCI displays almost identical results whatever the order of the aggregation. However, differences emerge when moving along the inequality aversion line. For example, under medium (*q=-1*) and strong aversion (*q=-3*), path independent measures display lower values of material well-being or achievement overall and for each income decile than do the path-dependent measures. The S-aggregation, with path dependence, displays higher values relative to those for the I-aggregation overall and for all but the first two income decile groups. In contrast, for France, Ruiz (2011) reported that the I-aggregation displayed the highest values, while measures using the S-aggregation were in-between the I-aggregation with path dependency and with path independency.

Table 3. Material Condition Index Under Different Aggregations
Unbalanced between dimensions is penalized with r=0.5 in each case
CE Interview 2009Q2-2012Q1, based on conversion to 2011 Dollars

	S-Aggregation			I-Aggregation		
	Neutral	Medium	Strong	Neutral	Medium	Strong
q=	1	-1	-3	1	-1	-3
Income Decile						
1	0.25949	0.21441	0.18435	0.25484	0.22832	0.20594
2	0.31269	0.27160	0.23693	0.30944	0.28509	0.26733
3	0.35461	0.32944	0.30597	0.35584	0.32713	0.30327
4	0.38906	0.37271	0.35701	0.39207	0.36344	0.33713
5	0.41653	0.40509	0.39394	0.42045	0.39227	0.36435
6	0.43276	0.42147	0.41016	0.43627	0.40968	0.38209
7	0.45832	0.45008	0.44180	0.46236	0.43613	0.40726
8	0.48602	0.48087	0.47570	0.49029	0.46588	0.43734
9	0.52002	0.51703	0.51406	0.52456	0.50062	0.47025
10	0.59347	0.59299	0.59253	0.59833	0.57559	0.54474
Total	0.41550	0.40228	0.38948	0.42446	0.37231	0.31836

An additional set of MCIs were produced that are based on income and consumption only. This was done because of our concern with the restrictions that we had to place on the wealth data for the previously produced results. As noted earlier, we recoded wealth values that were less than $1,000 to equal $1,000. In our original look at the data, we found that 14 percent of consumer units in our sample had negative net worth while an additional 10 percent had zero net worth; 5 percent had values between $0 and $1,000. These results revealed a multidimensional measure that accounts only for income and consumption, and not wealth, will lead one to assume a more optimistic view of material conditions or economic achievement in the U.S., for the time period under study, than will one based on the joint distribution of income, consumption, and wealth together.

5. Conclusions

In this study, the OECD ICW Framework was used to define income, consumption, and wealth using available data from U.S. Consumer Expenditure Survey, Interview Component. Data from consumer units participating in four consecutive interviews during the 2009 quarter two to the 2012 quarter one time period were used for the analysis. Following the method developed by Ruiz (2011), joint distributions of income, consumption, and wealth were produced with results shown as Material Condition Indexes. The sensitivity of aversions to inequality on the indexes was studied. Findings suggest that consumption is more equally distributed across individuals in the population, and represents higher levels of economic well-being than do income or wealth in the U.S. for the time period under study. In general, using consumption alone overestimates the material well-being of consumers relative to a measure that considers the joint distribution of income, consumption, and wealth. However, the results for income alone, compared to the MCI, show little difference in economic well-being.

The results from the analysis are sensitive to the definitions of income, consumption and wealth used. Future analyses will include the flow of services from owned vehicles in the consumption measure and a net income flow for these services for income. For a consistent wealth measure, the net worth of vehicles owned, after accounting for vehicle loan debt, will be developed. Future analyses will also be based on a better adjusted disposable income measure, one that is based on a simulation of taxes. The sensitivity of the results to other normalizations and to the treatment of negative and zero values for income, consumption, and wealth will also be studied. And finally, longitudinal weights will be developed that account for attrition in response across the four interviews.

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References

Alkire, S., and J. Foster, (2010), "Designing the Inequality-Adjusted Human Development Index (HDI)", Working Paper No. 37, Oxford Poverty and Human Development Initiative, Oxford University.

Anand, S. and A.K. Sen (1994), "Human Development Index: Methodology and Measurement," Occasional Papers, Human Development Report Office, http://hdr.undp.org/en/reports/global/hdr1994/papers/oc12.pdf

Anand, S. and A.K. Sen (2000), "The Income Component of the Human Development Index," *Journal of Human Development*, 1, 83-106.

Atkinson, A. B., (1970), "On the Measurement of Inequality", *Journal of Economic Theory*, 2, 244-263.

Bureau of Labor Statistics (2013), "Chapter 16.Consumer Expenditures and Income,," *BLS Handbook of Method*, http://stats.bls.gov/opub/hom/pdf/homch16.pdf

Canberra Group (2001), *Expert Group on Household Income Statistics: Final Report and Recommendations*. Ottawa.

Chakravarty, S. R., (1990), *Ethical Social Index Numbers*, Springer-Verlag, Heidelberg.

Foster, J. E., L. F. Lopez-Calva, and M. Székely, 2005, "Measuring the Distribution of Human Development: Methodology and an Application to Mexico", *Journal of Human Development*, 6, 5-29.

ILO (2004), Resolution 1: Resolution Concerning Household Income and Expenditure Statistics, adopted at the 17th International Conference of Labour Statisticians, December. Geneva.

Kolm, S-C. (1977), "Multidimensional Egalitarianisms", Quarterly *Journal of Economics*, 91, 1-13.

OECD (2013a), *Framework for Statistics on the Distribution of Household Income, Consumption and Wealth*, OECD Publishing, Paris, draft document.

OECD (2013b), *Guidelines for Micro Statistics on Household Wealth*, Report of the OECD Expert Group on Household Income, Consumption and Wealth Statistics, Paris, draft document.

Paszkiewicz, Laura and Leann Weyl (2013), "Implementation of NBER's TAXSIM in the CE – how do the estimates measure up?" presentation prepared for the Joint Statistical Meetings, Montreal, Canada, available from Paszkiewicz at the U.S. Bureau of Labor Statistics.

Ruiz, N. (2011), Measuring the joint distribution of income, consumption and wealth using nested Atkinson measures, OECD Statistics Directorate Working Paper no. 40, 2011.

Stiglitz, J. E., A. Sen, and J-P. Fitoussi (2009), Report by the Commission on the Measurement of Economic Performance and Social Progress, CMEPSP.

UNECE (2011), *The Canberra Group Handbook on Household Income Statistics*, Second Edition. ECE/CES/11. Geneva.