MEASURING SOCIAL WELFARE IN THE NATIONAL ACCOUNTS

by

Dale W. Jorgenson, Harvard University

and

Daniel T. Slesnick, University of Texas, Austin

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1. Introduction.

At the Conference on Research in Income and Wealth in 2004, Jorgenson, J. Steven Landefeld, William D. Nordhaus, and their co-authors proposed *A New Architecture for the U.S. National Accounts*.[2] In 2008 the new architecture was endorsed by the Advisory Committee on Measuring Innovation in the 21st Century Economy to the U.S. Secretary of Commerce, Carlos Guttierez:[3]

> The proposed new 'architecture' for the NIPAs [U.S. National Income and Product Accounts] would consist of a set of income statements, balance sheets, flow of funds statements, and productivity estimates for the entire economy and by sector that are more accurate and internally consistent.[4]

The initial step in implementing the new architecture was the development of the Integrated Macroeconomic Accounts for the United States by BEA and the Board of Governors of the Federal Reserve System (FRB).[5] These accounts combine a measure of national saving from the income statements and balance sheets that comprise the FRB's

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[2] Dale W. Jorgenson, J. Steven Landefeld, and William D. Nordhaus (2006), eds., *A New Architecture for the U.S. National Accounts*, Chicago, University of Chicago Press.
[3] Advisory Committee on Measuring Innovation in the 21st Century Economy (2008), *Innovation Measurement: Tracking the State of Innovation in the 21st Century Economy,* Washington, DC, Department of Commerce, January.
[4] The Advisory Committee on Measuring Innovation in the 21st Century Economy (2008), p. 8.
[5] Albert M. Teplin, Rochelle Antoniewicz, Susan Hume McIntosh, Michael Palumbo, Genevieve Solomon, Charles Ian Mead, Karin Moses, and Brent Moulton (2006), "Integrated Macroeconomic Accounts for the United States: Draft SNA-USA," in Dale W. Jorgenson, J. Steven Landefeld, and William D. Nordhaus (2006), eds., pp. 471-540. For current data from the Integrated Macroeconomic Accounts, see: http://www.bea.gov/national/nipaweb/Ni_FedBeaSna/Index.asp.

Flow of Funds Accounts with saving from the NIPAs, defined as the difference between income and consumption. We use consumption from the Integrated Macroeconomic Accounts in constructing measures of social welfare for the U.S. national accounts.[6]

Our measure of potential social welfare is based on personal consumption expenditures. The actual level of social welfare also depends on the distribution of consumption over the population. We refer to our measure of actual social welfare as the standard of living, while inequality depends on the discrepancy between potential and actual social welfare. Our measures of the cost and standard of living and inequality[7] are consistent with the NIPAs and the Integrated Macroeconomic Accounts.

In response to the recommendations of the Advisory Committee on Innovation, the Bureau of Economic Analysis (BEA) and the Bureau of Labor Statistics (BLS) produced an Integrated Production Account in May 2009, linking multifactor productivity with the NIPAs.[8] This was a critical step in implementing the new architecture.[9] The omission of productivity statistics from the NIPAs and the United Nations' System of National Accounts (SNA) had been a serious barrier to application of the national accounts in assessing the sources of economic growth. Estimates of productivity are also essential for projecting potential economic growth.[10]

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[6] For more details see Dale W. Jorgenson (1990), "Aggregate Consumer Behavior and the Measurement of Social Welfare," *Econometrica,* Vol. 58, No. 5, September, pp. 1007-1040, and Daniel T. Slesnick (1998), "Empirical Approaches to the Measurement of Welfare," *Journal of Economic Literature,* Vol. 36, No. 4, December, pp. 2108-2165.

[7] See Dale W. Jorgenson (1997), *Measuring Social Welfare,* Cambridge, The MIT Press, and Daniel T. Slesnick (2001), *Consumption and Social Welfare: Living Standards and Their Distribution in the United States,* Cambridge, Cambridge University Press.

[8] Michael Harper, Brent Moulton, Steven Rosenthal, and David Wasshausen (2009). "Integrated GDP-Productivity Accounts." *American Economic Review* Vol. 99, No. 2, May, pp. 74-79. For current data from the Integrated Production Account, see: http://www.bea.gov/national/integrated_prod.htm

[9] For a more detailed discussion, Dale W. Jorgenson (2011), "Innovation and Productivity Growth: T. W. Schultz Lecture," *American Journal of Agricultural Economics,* Vol. 93, Issue 2, April, pp. 276-296.

[10] See: Dale W. Jorgenson, Mun S. Ho, and Kevin J. Stiroh (2008), "A Retrospective Look at the U.S. Productivity Growth Resurgence." *Journal of Economic Perspectives*, Vol. 22, No. 2, Spring, pp. 3-24

In September 2009 Joseph E. Stiglitz, Amartya Sen, and Jean-Paul Fitoussi presented *The Report by the Commission on the Measurement of Economic Performance and Social Progress* to the former President of France, Nicolas Sarkozy.[11] The *Report* called for a shift in the focus of economic measurement from production toward "people's well-being". The *Report* contained twelve specific recommendations, including the use of consumption, income, and wealth, rather than production, for this purpose.[12] The recommendations of the Commission are complementary to those of the nearly contemporaneous 2008 SNA (2009) which includes consumption, income, and wealth, but does not provide a welfare interpretation.[13]

The new architecture for the U.S. national accounts makes it possible to avoid confusing the measurement of production and welfare, a key concern of the Stiglitz-Sen-Fitoussi Report. By augmenting consumption with its distribution over the population, it is possible to incorporate detailed measures of the cost and standard of living and inequality into the national accounts. Similarly, by augmenting the national accounts to include both GDP and gross domestic income (GDI), it is possible to include measures of productivity in the national accounts, as pointed out in Chapter 20 of the 2008 SNA.

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[11] Stiglitz, Joseph E., Amartya Sen, and Jean-Paul Fitoussi (2010) , *Mismeasuring Our Lives: Why GDP Doesn't Add Up,* New York, the New Press. For more detail on the Commission and its reports, see: http://www.stiglitz-sen-fitoussi.fr/en/index.htm.

[12] A more technical presentation of issues in the measurement of welfare or "social well-being" is given in Marc Fleurbaey (2009), "Beyond the GDP: The Quest for Measures of Social Welfare," *Journal of Economic Literature, Vol*. 47, No. 4, December, pp. 1029-1075. This is partly based on Fleurbaey's report to the Commission. For more details see: http://www.stiglitz-sen-fitoussi.fr/documents/Individual_Well-Being_and_Social_Welfare.pdf. Fleurbaey's own proposal for welfare measurement is presented in Marc Fleurbaey and Francois Maniquet, *A Theory of Fairness and Social Welfare*, Cambridge, UK, Cambridge University Press, 2011.

[13] For a discussion of the implications of the Stiglitz-Sen-Fitoussi report for the U.S. national accounts, see: J. Steven Landefeld, Brent Moulton, Joel D. Platt, and Shaunda M. Villones (2010), "GDP and Beyond: Measuring Economic Progress and Sustainability," *Survey of Current Business,* Vol. 90, No. 4, April, pp. 12-25.

In this paper we focus on the measurement of social welfare within the new architecture for the U.S. national accounts. In Section 2 we introduce measures of individual and social welfare. The key feature of our measures of individual welfare is that they are cardinal and interpersonally comparable. We aggregate these measures of individual welfare by means of a social welfare function. In Section 3 we present money measures of individual and social welfare suitable for the national accounts. For this purpose we employ individual and social expenditure functions to provide money metrics of individual and social welfare.

Our measures of individual welfare incorporate three types of information. We use total expenditure as a measure of the size of the household budget. We express the family's consumption in constant prices. We then divide real consumption by a measure of household size. Finally, we express individual welfare as a logarithm of real consumption per capita, so that increments of individual welfare are equal to proportional increases in consumption. All of these features are common to measures of individual welfare employed in the literature on consumer behavior.

We combine measures of individual welfare into a measure of social welfare. We consider a class of social welfare functions that augments the mean of individual welfare with a measure of dispersion. This class includes the utilitarian social welfare functions based on average social welfare and often used in policy evaluations. Allowing for dispersion makes it possible to give additional weight to equity considerations. It is important to emphasize that the validity of social welfare evaluations depends on normative conditions, as well as empirical information from studies of consumer behavior.

In Section 4 we present the empirical counterparts of individual and social expenditure functions, exploiting an econometric model of aggregate consumer behavior described in greater detail in the Appendix. In Section 5 we summarize the new architecture and update the estimates for the key accounting magnitudes presented by Jorgenson (2009).[14] We link our measures of welfare to personal consumption expenditures, a component of net domestic expenditures in the Domestic Income and Expenditures Account.

In Section 6 we present measures of the cost and standard of living and inequality within the national accounts. We incorporate distributional information into the measurement of inequality and the standard of living. The Consumer Price Index produced by BLS can be interpreted as a measure of the cost of living. The Bureau of the Census generates official statistics on the standard of living, poverty, and inequality. However, none of these measures is integrated with the national accounts.

While our welfare measures are consistent with the 2008 SNA and the Stiglitz-Sen-Fitoussi Report, we emphasize links to the NIPAs and the Integrated Macroeconomic Accounts for the U.S. In Section 7 we discuss possible extensions of the national accounts to include non-market activities. Examples of non-market activities are the accumulation of human capital and the enhancement of environmental quality.

We conclude by recommending that national statistical agencies experiment with the incorporation of distributional information into the national accounts, beginning with a satellite system that presents a number of alternatives. The availability of properly constructed welfare measures would help to address concerns about the misuse of

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[14] Dale W. Jorgenson (2009), "A New Architecture for the U.S. National Accounts," *Review of Income and Wealth*, Vol. 55, No. 1, pp. 1-42.

aggregates like the GDP as surrogate measures of welfare. However, there appears to be little justification or support for treating welfare measures as a substitute for the economic aggregates that appear in the core accounts. We demonstrate that these aggregates are essential for the incorporation of measures of social welfare into the national accounts.

2. Measuring Individual and Social Welfare.

Despite the exclusion of social welfare from systems of national accounts, welfare measurement is well-established in both economic theory and economic statistics.[15] However, it is important to recognize that the economic theory of social choice is surrounded by a dense thicket of negative results. These "impossibility theorems" demonstrate the limitations of many of the approaches to welfare measurement proposed in the literature.

A crucial turning point in the theory of social choice occurred with Sen's (1970) magisterial *Collective Choice and Social Welfare.*[16] Sen greatly broadened the scope of welfare measurements by mapping out the alternatives to the traditional assumptions of ordinal measures of individual welfare that are not comparable among individuals. This led to an explosion of research on "possibility theorems" during the following decade. This new research on social choice established the existence of many feasible approaches to the measurement of individual and social welfare.[17]

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[15] The measurement of economic welfare is discussed by Dale W. Jorgenson (1997b), *Measuring Social Welfare,* Cambridge, The MIT Press, and Daniel T. Slesnick (2001), *Consumption and Social Welfare: Living Standards and Their Distribution in the United States,* Cambridge, Cambridge University Press.
[16] Amartya K. Sen (1970), *Collective Choice and Social Welfare*, San Francisco, Holden-Day.
[17] For a summary of this literature and many new results, including the framework used for our social welfare measures, see: Kevin W. S. Roberts (1980), "Possibility Theorems with Interpersonally Comparable Welfare Levels," *Review of Economic Studies*, Vol. 47, No. 147, January, pp. 409-420.

Economic statisticians have long had an arms-length relationship with the theory of social choice. This is not surprising, since many of the best-established statistics for measuring inequality require the construction of a social welfare function that theorists had shown to be impossible. Fortunately, the introduction of measures of inequality based on social welfare functions by Anthony B. Atkinson and Serge C. Kolm[18] was given a rigorous foundation in the possibility theory for social welfare measurement summarized by Roberts (1980).

Following the elaboration of new conceptual possibilities for welfare measurement, we developed an econometric methodology required to eliminate the gap between the theory of social choice and the measures of welfare used in economic statistics. We presented the results in a series of papers on the cost and standard of living, inequality, and poverty.[19] Our approach to welfare measurement is summarized in Jorgenson's (1990) Presidential Address to the Econometric Society, Slesnick's (1998) survey article in the *Journal of Economic Literature,* and Slesnick's (2001) book.

Econometric models of consumer behavior have long been used in measuring individual welfare.[20] The challenge we faced was to extend this approach to social welfare by comparing levels of welfare among individuals and aggregating over them. Our solution of this problem was to exploit the approach for exact aggregation over

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Fleurbaey and Maniquet (2011) have proposed an approach to welfare measurement that retains the traditional assumptions.

[18] Anthony B. Atkinson (1970), "On the Measurement of Inequality," *Journal of Economic Theory,* Vol. 2, No. 3, September, pp. 244-263. Serge C. Kolm (1969), "The Optimal Production of Social Justice," in Julius Margolis and Henri Guitton, eds., *Public Economics,* London, Macmillan, pp. 145-200.

[19] These papers are collected in Dale W. Jorgenson (1997b).

[20] See Angus Deaton and John Muellbauer (1980b), *Economics and Consumer Behavior,* Cambridge, UK, Cambridge University Press, Chapter 9, pp. 214-240, and Slesnick (1998).

systems of individual demand functions to obtain an econometric model of aggregate demand introduced by Jorgenson, Lawrence Lau and Thomas Stoker (1982).[21]

Jorgenson, Lau, and Stoker showed how to recover the models of individual demand that underlie their model of aggregate demand. In Jorgenson and Slesnick (1983, 1984) we showed how to derive cardinal measures of individual welfare that are interpersonally comparable from these models of individual demand. We introduced the normative assumptions employed by Roberts (1980) and aggregated our measures of individual welfare by means of a social welfare function.

Our final step was to convert individual and social welfare into money measures appropriate for the national accounts, using the individual expenditure function introduced by Lionel McKenzie (1957) and the social expenditure function originated by Robert Pollak (1981).[22] We used these tools in developing a "dashboard" of detailed measures of social welfare, as later recommended by Stiglitz, Sen, and Fitoussi (2010). We also developed measures of welfare for groups within the population and showed how to aggregate them into overall measures of social welfare.

Our empirical research used individual observations on households from the Consumer Expenditure Survey (CEX), conducted by BLS on a quarterly basis since 1980.[23] An important empirical limitation of consumer expenditure surveys and the CEX, in particular, is that observations are available for households and not for individuals. To

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[21] Dale W. Jorgenson, Lawrence J. Lau, and Thomas M. Stoker, "The Transcendental Logarithmic Model of Aggregate Consumer Behavior," in Robert L. Basmann and George Rhodes (1982), eds., *Advances in Econometrics,* Vol. 1, Greenwich, CT, JAI Press, pp. 97-238. This paper is included in Dale W. Jorgenson (1997a), *Aggregate Consumer Behavior,* Cambridge, The MIT Press, pp. 203-356.

[22] Lionel W. McKenzie (1957), "Demand Theory without a Utility Index," *Review of Economic Studies*, Vol. 24, No. 65, June, pp. 185-189. Robert A. Pollak (1981), "The Social Cost of Living Index," *Journal of Public Economics*, Vol. 15, No. 3, June, pp. 311-336.

[23] The most recent public use data set available for the CEX is for 2010. In 2009 BLS launched the Gemini Project to improve the quality of data reported on the survey. For details on important limitations of the current CEX see: http://www.bls.gov/cex/geminiproject.htm

generate interpersonal comparisons based on households, we employed a long-established concept in economic statistics, household equivalence scales.[24]

The concept of household equivalence scales has been used to establish family needs for income support programs and, more specifically, to assess the cost of additional children. We derived household equivalence scales econometrically from household expenditure functions.[25] These household equivalence scales, like traditional scales, depend on the demographic characteristics of households. Unlike traditional scales, these household equivalence scales also incorporate prices for the commodities purchased by the household.

The introduction of household equivalence scales into the measurement of social welfare bridged the gap between the economic theory and economic statistics. The conceptual basis for this link was established by Arthur Lewbel (1989) in a fundamental paper on the economic theory of household equivalence scales.[26] Lewbel began by clarifying the role of exact aggregation over individual households in deriving cardinal measures of individual welfare that are interpersonally comparable.

Lewbel demonstrated that household equivalence scales can be identified under the assumptions that these scales are independent of household welfare, depending only on household characteristics and prices. These are precisely the assumption employed in

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[24] See Dale W. Jorgenson and Daniel T. Slesnick (1987), "Aggregate Consumer Behavior and Household Equivalence Scales," *Journal of Business and Economic Statistics*, Vol. 5, No. 2, April, pp. 219-232. This paper is included in Dale W. Jorgenson (1997b). Alternative approaches to household equivalence scales are summarized by Slesnick (2001), pp. 88-121.

[25] This approach to modeling household behavior was originated by Anton P. Barten (1964), "Family Composition, Prices, and Expenditure Patterns," in Peter Hart, Gareth Mills, and John D. Whitaker, eds., *Econometric Analysis for Economic Planning: 16th Symposium of the Colston Society,* London, Butterworth, pp. 277-292.

[26] Arthur Lewbel (1989), "Household Equivalence Scales and Welfare Comparisons," *Journal of Public Economics*, Vol. 39, No. 3, August, pp. 377-391. See for more details: Marc Fleurbaey and Peter J. Hammond (2004), "Interpersonally Comparable Utility," Ch. 21 in Salvador Barbera, Peter J. Hammond, and Christian Seidl, eds., *Handbook of Utility Theory: Extensions*, Heidelberg, Springer, pp. 1179-1285.

our household equivalence scales. Using the possibility theorems summarized by Roberts (1980), Lewbel combined these household equivalence scales with cardinal measures of individual welfare to satisfy the requirements imposed by the theory of social choice, using our approach as a key illustration.

Aggregation over individuals is obviously the key to social welfare measurement. It is straightforward to incorporate the restrictions on individual consumer behavior required for exact aggregation. The necessary framework is provided by the theory of household behavior of Gary S. Becker, Pollak, and Paul A. Samuelson.[27] However, this is beyond the scope of the traditional theory of individual behavior.

Our cardinal and interpersonally comparable measures of individual welfare fit neatly into the framework of the theory of social choice. This has opened up the possibility of a rigorous approach to both individual and social welfare measurement that successfully exploits econometric methods for modeling consumer behavior. However, official measures of the cost and standard of living and inequality in the U.S. have been unaffected by this theoretical and econometric framework for welfare measurement.[28]

3. Money Measures of Individual and Social Welfare.

In this section we present money measures of individual and social welfare suitable for incorporation into the national accounts. Our measures of individual welfare are based on the preference orderings of individual consumers. We represent these

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[27] See Gary S. Becker (1981), *A Treatise on the Family,* Cambridge, Harvard University Press, Pollak (1981), and Paul A. Samuelson (1956), "Social Indifference Curves," *Quarterly Journal of Economics*, Vol. 70, No. 1, February, pp. 1-22.

[28] New supplemental measures of poverty based on income have been proposed by the Bureau of the Census (2011). See: http://www.census.gov/hhes/povmeas/ These are based on a 1995 report by the National Academy of Sciences. See Constance Citro and Robert Michael (1995), eds., *Measuring Poverty: A New Approach*, National Academies Press.

orderings by means of real-valued individual welfare functions. Our measure of social welfare is based on preferences over social states by all individuals. We represent a social ordering by means of a real-valued social welfare function, defined on the distribution of individual welfare over the population.

To represent preferences in a form suitable for measuring individual welfare, we take households as consuming units. We assume that expenditures on individual commodities are allocated to maximize a household welfare function. As a consequence, the household behaves in the same way as an individual maximizing a utility function, as demonstrated by Samuelson (1956) and Pollak (1981). We treat households as individuals in measuring social welfare. All subsequent references to individuals are to households considered as consuming units.

To provide a money measure of individual welfare we represent preferences by means of an individual expenditure function, using the following notation:

p_n – price of the n*th* commodity, assumed to be the same for all consuming units.

$p = (p_1, p_2, \ldots, p_N)$ – vector of prices of all commodities.

x_{nk} – quantity of the n*th* commodity consumed by the k*th* consuming unit $(n = 1,2, \ldots, N; k = 1,2, \ldots, K)$.

$x_k = (x_{1k}, x_{2k}, \ldots, x_{Nk})$ – vector of quantities of all commodities consumed by the k*th* consuming unit $(k = 1,2, \ldots, K)$.

$M_k = \sum_{n=1}^{N} p_n x_{nk}$ – total expenditure of the k*th* consuming unit $(k = 1,2, \ldots, K)$.

A_k – vector of attributes of the k*th* consuming unit $(k = 1,2, \ldots, K)$.

The *individual expenditure function* gives the minimum total expenditure M_k required for the k*th* consuming unit to achieve the welfare level W_k given the prices

$p\,(k = 1, 2, \ldots, K)$. More formally, the individual expenditure function $M_k(p, W_k, A_k)$ is defined by:

$$M_k(p, W_k, A_k) = \min\left\{M_k = \sum_{n=1}^{N} p_n x_{nk} : W_k(x_k, A_k) \geq W_k\right\}.$$

(1)

For a given price system we can translate individual welfare into monetary terms by evaluating the individual expenditure function. Individual welfare W_k is the maximum attainable at total expenditure M_k. This level of expenditure is a money measure of individual welfare at the current price system p.

We employ the individual welfare function and the individual expenditure function to construct measures of the household standard of living and its cost. We illustrate these concepts geometrically in Figure 1. This figure represents the indifference map for a consuming unit with expenditure function $M_k(p, W_k, A_k)$. For simplicity we consider the case of two commodities $(N = 2)$. Consumer equilibrium in the base period is represented by the point A. The corresponding level of individual expenditure $M_k(p^0, W_k^0, A_k)$, divided by the price of the second commodity p_2^0, is given on the vertical axis. This level provides a representation of individual expenditure in terms of units of the second commodity.

Consumer equilibrium in the current period is represented by the point C. To translate the corresponding level of welfare W_k^1 into total expenditure at the prices of the base period, we evaluate the individual expenditure function (1) at this level of welfare and the base period price system p^0. The resulting level of total expenditure $M_k(p^0, W_k^1, A_k)$ corresponds to consumer equilibrium at the point B. The quantity index given by the ratio between levels of total expenditure $M_k(p^0, W_k^1, A_k)$ and M_k^0. is a measure of the household standard of living. The price index given by the ratio between levels of total expenditure M_k^1 and $M_k(p^0, W_k^1, A_k)$ is a measure of the household cost of living.

Under the Pareto principle a social state represents an improvement over an alternative state if all consuming units are as well off as under the alternative and at least one unit is better off. The Pareto principle provides a partial ordering of social states. This ordering is invariant with respect to monotone increasing transformations of individual welfare that differ among consuming units. Only welfare comparisons that are ordinal and non-comparable among consuming units are required for application of the Pareto principle. The measures of household standard and cost of living we have described are based on comparisons of this type.

The money measure of individual welfare provided by the expenditure function (1) is a monotone increasing transformation of individual welfare. This transformation depends on the prices faced by the individual consuming unit and on the attributes of the individual. Considered as a measure of individual welfare in its own right this measure provides all the information about preferences required for applications of the Pareto principle. To obtain a complete ordering of social states we next introduce a social welfare function.

We consider orderings over the set of social states and the set of real-valued individual welfare functions. To describe these social orderings in greater detail we introduce the following notation:

x – matrix with N by K elements $\{x_{nk}\}$ describing social state.

$u = (W_1, W_2, \ldots, W_k)$ – vector of individual welfare functions of all K consuming units.

To represent social orderings in a form suitable for measuring social welfare we consider a class of social welfare functions $W(u, x)$ incorporating a notion of horizontal equity. In particular, we require that two individuals with identical individual welfare enter the social welfare functions in the same way. We also incorporate a notion of vertical equity by requiring that the social welfare functions are equity-regarding in the sense of Hammond (1977). This imposes a version of Dalton's (1920) principle of transfers: A transfer from a household with a higher welfare level to a household with a lower welfare level that does not reverse their relative positions must increase the level of social welfare.[29]

To provide a money measure of individual welfare, we express individual welfare in terms of total expenditure. Similarly, we can express social welfare in terms of aggregate expenditure. For this purpose we introduce the *social expenditure function,* defined as the minimum level of total expenditure, $M = \sum_{k=1}^{K} M_k$, required to attain a given level of social welfare, say W, at a specified price system p.[6] More formally, the social expenditure function $M(p, W)$ is defined by

$$M(p, W) = \min\left\{M = \sum_{k=1}^{K} M_k : W(u, x) \geq W\right\}.$$

(2)

[29] Hugh Dalton (1920), "The Measurement of the Inequality of Income," *Economic Journal,* Vol 30, No. 119, September, pp. 361-384, and Peter J. Hammond (1977), "Dual Interpersonal Comparisons of Utility and the Economics of Income Distribution," *Journal of Public Economics*, Vol. 7, No. 1, February, pp. 51-71.

For a given price system we can translate social welfare into monetary terms by evaluating the social expenditure function. To determine the level of social welfare we first evaluate the individual welfare functions $\{W_k\}$ for all consuming units at the price system p and the distribution of total expenditure $\{M_k\}$. We then evaluate the social welfare function $W(u, x)$. Finally, we express the level of social welfare in terms of the price system by means of the social expenditure function $M(p, W)$.

Second, we can decompose our money measure of social welfare into money measures of equity and efficiency. Equity reflects the gain in welfare from a more egalitarian distribution of total expenditure. Efficiency is the maximum level of social welfare that can be attained by redistributions of aggregate expenditure among individuals. Welfare losses associated with an inequitable distribution of total expenditure are eliminated by this maximization.

To define money measures of equity and efficiency we evaluate the social welfare function at the maximum that can be attained through lump-sum redistributions of aggregate expenditure, $M = \sum_{k=1}^{K} M_k$. The maximum level of social welfare potentially available is our measure of *efficiency*. Evaluating the social expenditure function at the potential level of welfare, we obtain aggregate expenditure M, our money measure of efficiency at the current price system p.

Given a money measure of efficiency, we can define a corresponding money measure of *equity* as the ratio between the money measure of actual social welfare $M(p, W)$ and the money measure of efficiency M. This measure of equity increases as the distribution of total expenditure approaches perfect equality. Using the social expenditure function, we can express our money measure of social welfare as the product of measures of efficiency and equity:

$$M(p, W) = M \cdot \left(\frac{M(p, W)}{M}\right).$$

(3)

The critical feature of this decomposition is that all three measures are expressed in terms of the same price system p .

The social welfare function and the social expenditure function can be employed in defining measures of the social standard of living and its cost. We illustrate these concepts geometrically in Figure 2. The figure represents the indifference map of a representative consumer with preferences corresponding to the social expenditure function $M(p, W)$. This concept of a representative consumer was proposed by Samuelson (1956) and Pollak (1981). The same concept underlies our model of the household as a consuming unit.

For simplicity we consider the case of two commodities $(N = 2)$, as before. Consumer equilibrium at the actual level of social welfare in the base period W^0 is represented by the point A . The corresponding level of aggregate expenditure $M(p^0, W^0)$, divided by the price of the second commodity p_2^0, is given on the vertical axis. This level provides a representation of aggregate expenditure in terms of units of the second commodity. Consumer equilibrium at the level of social welfare in the current period W^1 is represented by the point C . To translate the level of social welfare W^1 into aggregate expenditure at the prices of the base period, we evaluate the social expenditure function at this level of welfare and the base period price system p^0.

The resulting level of aggregate expenditure $M(p^0, W^1)$ corresponds to consumer equilibrium at the point C'. Aggregate expenditure M^0 is the value of the social expenditure function at the potential level of welfare in the base period, say W^2, expressed in terms of the base period price system p^0. This is the maximum level of welfare that can be attained by lump-sum redistributions of aggregate expenditure. The corresponding consumer equilibrium is represented by the point B.

Similarly, consumer equilibrium at the potential level of social welfare in the current period, say W^3, is presented by the point D. This is the maximum social welfare that can be attained through lump-sum redistributions of aggregate expenditure M^1 at current prices p^1. We can translate this level of social welfare into aggregate expenditure at the base period price system p^0 by evaluating the expenditure function $M(p^0, W^3)$ at the consumer equilibrium represented by the point D'.

The quantity index given by the ratio between levels of aggregate expenditure $M(p^0, W^0)$ and $M(p^0, W^1)$ is a measure of the *actual standard of living*. Similarly, the quantity index represented by the ratio of the levels of aggregate expenditure $M(p^0, W^3)$ and M^0 is the measure of the *potential standard of living*. The ratio of the actual to the potential standard of living is an index of equity. Finally, the price index given by the ratio between levels of expenditure M^1 and $M(p^0, W^3)$ is the measure of the social cost of living proposed by Pollak (1981).

4. Implementing Measures of Individual and Social Welfare.

Our next objective is to implement empirically the money measures of individual and social welfare presented in the previous section.[30] We require individual welfare functions that reflect the preference orderings of individual consuming units. For this purpose *we* employ an updated version of the econometric model of consumer behavior in the U.S. presented by Jorgenson and Slesnick (1987). [31] The model is described in the Appendix.

Our econometric model incorporates integrability restrictions that assure the existence of an indirect utility function. In the following section we construct indirect utility functions for all consuming units. Combining these utility functions with assumptions about horizontal and vertical equity, we develop numerical counterparts for the money measures of individual and social welfare in Figures 1 and 2.

Our system of aggregate demand functions is obtained by explicit aggregation over individual demand systems. Our model of individual demand incorporates cross-section data on quantities consumed, total expenditure, and attributes of households such as demographic characteristics. The aggregate quantities consumed depend on the attributes and total expenditure of individual consuming units through summary statistics of the joint distribution of total expenditure and attributes of individual households.

Exact aggregation is useful in simplifying the econometric modeling of aggregate consumer behavior. In fact, the special formulations of exact aggregation developed by William M. Gorman (1953) and Muellbauer (1975) were designed precisely for this

[30] Implementation of measures of individual and social welfare is discussed by Slesnick (2001), pp. 201-214.
[31] This model was updated by Slesnick (2001), p. 96.

purpose.[32] We exploit the exact aggregation restrictions in constructing cardinal measures of individual welfare and defining interpersonal comparability. We combine these measures of individual welfare with the assumptions on horizontal and vertical equity discussed below to measure social welfare.

To construct an econometric model based on exact aggregation we first represent individual preferences by means of an indirect utility function for each consuming unit, using the following notation:

$w_{nk} = \frac{p_n x_{nk}}{M_k}$ – expenditure share of the n*th* commodity in the budget of the k*th* consuming unit $(n = 1,2,\ldots,N; k = 1,2,\ldots,K)$.

$w_k = (w_{1k}, w_{2k}, \ldots, w_{Nk})$ – vector of expenditure shares for the k*th* consuming unit $(k = 1,2,\ldots,K)$.

$\ln \frac{p}{M_k} = \left(\ln \frac{p_1}{M_k}, \ln \frac{p_2}{M_k}, \ldots, \ln \frac{p_n}{M_k}\right)$ – vector of logarithms of ratios of prices to expenditure by the k*th* consuming unit $(k = 1,2,\ldots,K)$.

$\ln p = (\ln p_1, \ln p_2, \ldots, \ln p_n)$ – vector of logarithms of prices.

We assume that the *kth* consuming unit allocates expenditures in accord with the transcendental logarithmic or translog indirect utility function,[8] say V_k, where:

$$\ln v_k = G\left(\ln \frac{p'}{M_k}\alpha_p + \frac{1}{2}\ln \frac{p'}{M_k} B_{pp} \ln \frac{p}{M_k} + \ln \frac{p'}{M_k} B_{pA} A_k, A_k\right), (k = 1,2,\ldots,K).$$

(4)

In this representation the function G is a monotone increasing function of its first argument. The vector α_p and the matrices B_{pp} and B_{pA} are constant and the same for

[32] William M. Gorman (1953), "Community Preference Fields," *Econometrica*, Vol. 21, No. 1, January, pp. 63-80, and John Muellbauer (1976), "Community Preferences and the Representative Consumer," *Econometrica*, Vol. 44, No 44, No. 5, September, pp. 979-999.

all consuming units. In addition, the function G directly on the attribute vector A_k.[9] This form of the indirect utility function is ordinal and noncomparable among consuming units. Measurability and interpersonal comparability of individual preferences are not required in modeling consumer behavior.

The expenditure shares of the k*th* consuming unit can be derived by the logarithmic form of Roy's (1943) Identity[33]

$$w_{nk} = \frac{\frac{\partial \ln V_k}{\partial \ln\left(\frac{p_n}{M_k}\right)}}{\sum_{n=1}^{N} \frac{\partial \ln V_k}{\partial \ln\left(\frac{p_n}{M_k}\right)}}, (n = 1,2,\ldots,N; k = 1,2,\ldots,K) .$$

(5)

Applying this Identity to the translog indirect utility function (4), we obtain the system of individual expenditure shares

$$w_k = \frac{1}{D_k(p)}\left(\alpha_p + B_{pp} \ln \frac{p}{M_k} + B_{pA} A_k\right), (k = 1,2,\ldots,K) ,$$

(6)

where the denominators $\{D_k(p)\}$ take the form

$$D_k(p) = \iota'\alpha_p + \iota' B_{pp} \ln \frac{p}{M_k} + \iota' B_{pA} A_k, \qquad (k = 1,2,\ldots,K) ,$$

(7)

and ι is a vector of ones.

The individual expenditure shares are homogeneous of degree zero in the unknown parameters-α_p, B_{pp}, B_{pA}. By multiplying a given set of these parameters by a constant we obtain another set of parameters that generates the same system of individual

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[33] Rene Roy (1943), *De l'Utilite. Contribution a la Theorie du Choix,* Paris, Hermann & Cie.

budget shares. Accordingly, we can normalize the parameters without affecting observed patterns of individual expenditure allocation. We find it convenient to employ the normalization

$$i'\alpha_p = -1 \quad .$$

Under this restriction any change in the unknown parameters will be reflected in changes in individual expenditure patterns.

The conditions for exact aggregation are that the individual expenditure shares are linear in functions of the attributes $\{A_k\}$ and total expenditures $\{M_k\}$ for all consuming units.[34] These conditions will be satisfied if and only if the terms involving the attributes and expenditures do not appear in the denominators of the expressions for the individual expenditure shares, so that:

$$i'B_{pA} = 0 \quad ,$$

$$i'B_{pp}i = 0 \quad .$$

The exact aggregation restrictions imply that the denominators $\{D_k(p)\}$ reduce to:

$$D(p) = -1 + i'B_{pp}\ln p \quad ,$$

where the subscript k is no longer required, since the denominator is the same for all consuming units. Under these restrictions the individual expenditure shares can be written:

$$w_k = \frac{1}{D(p)}(\alpha_p + B_{pp}\ln p - B_{pp}i \cdot \ln M_k + B_{pA}A_k), (k = 1, 2, \ldots, K) \quad .$$

(8)

[34] Details are given by Jorgenson, Lau, and Stoker (1982), pp. 280-286.

The individual expenditure shares are linear in the logarithms of expenditures $\{\ln M_k\}$ and the attributes $\{A_k\}$, as required by exact aggregation.

To construct an econometric model of aggregate consumer behavior based on exact aggregation we obtain aggregate expenditure shares, say w, by multiplying individual expenditure shares (8) by expenditure for each consuming unit, adding over all consuming units, and dividing by aggregate expenditure, $M = \sum_{k=1}^{K} M_k$

$$w = \frac{\sum M_k w_k}{M}.$$

(9)

The aggregate expenditure shares can be re-written

$$w = \frac{1}{D(p)}\left(\alpha_p + B_{pp}\ln p - B_{pp}\iota\frac{\sum M_k \ln M_k}{M} + B_{pA}\frac{\sum M_k A_k}{M}\right).$$

(10)

Aggregate expenditure patterns depend on the distribution of expenditure over all consuming units through summary statistics of the joint distribution of expenditures and attributes- $\sum M_k \ln\frac{M_k}{M}$ and $\left\{\sum\frac{M_k A_k}{M}\right\}$. Under exact aggregation systems of individual expenditure shares (8) for consuming units with identical demographic characteristics can be recovered in one and only one way from the system of aggregate expenditure shares (10). In this section we define cardinal measures of individual welfare that are fully comparable among individuals in terms of these indirect utility functions.

Under exact aggregation and integrability the translog indirect utility function for the k*th* consuming unit V_k can be written:

$$\ln V_k = \ln p' \alpha_p + \frac{1}{2} \ln p' B_{pp} \ln p - D(p) \ln \left[\frac{M_k}{m_0(p, A_k)} \right], \qquad (k = 1, 2, \ldots, K) .$$

(11)

In this representation the function $m_0(p, A_k)$ is the *general household equivalence scale* and can be interpreted as the number of household equivalent members.

The general household equivalence scale takes the form:

$$\ln m_0 = \frac{1}{D(p)} \left[\ln m(A_k)' \alpha_p + \frac{1}{2} \ln m(A_k)' B_{pp} \ln m(A_k) + \ln m(A_k)' B_{pp} \ln p \right], \qquad (k = 1, 2, \ldots, K)$$

, (12)

where:

$$\ln m(A_k) = B_{pp}^{-1} B_{pA} A_k, \qquad (k = 1, 2, \ldots, K) .$$

(13)

We refer to the scales $\{m(A_k)\}$ as the *commodity-specific translog household equivalence scales.*[35]

Given the indirect utility function (11) for each consuming unit, we can express total expenditure as a function of prices, the general household equivalence scale, and the level of utility:

$$\ln M_k = \frac{1}{D(p)} \left[\ln p' \left(\alpha_p + \frac{1}{2} B_{pp} \ln p \right) - \ln V_k \right] + \ln m_0(p, A_k), \qquad (k = 1, 2, \ldots, K) .$$

(14)

We refer to this function as the *translog individual expenditure function.* The translog expenditure function gives the minimum level of expenditure required for the k*th* consuming unit to achieve the utility level V_k, given the prices p $(k = 1, 2, \ldots, K)$.

[35] Alternative approaches to household equivalence scales are summarized by Slesnick (2001), pp. 88-121.

The first step in measuring social welfare is to select representations of the individual welfare functions. We define individual welfare for the k*th* consuming unit, say $W_k\ (k = 1,2,\dots,K)$, as the logarithm of the translog indirect utility function (11)

$$W_k = \ln V_k = \ln p'\alpha_p + \frac{1}{2}\ln p' B_{pp} \ln p - D(p)\ln\left[\frac{M_k}{m_0(p, A_k)}\right], \qquad (k = 1,2,\dots,K).$$

(15)

It is important to emphasize that we have utilized the exact aggregation restrictions. These restrictions add precision to the information about individual preferences available from the indirect utility function.

At an intuitive level the appeal of our measures of individual welfare is that they incorporate three types of information that are relevant to welfare measurement. Total expenditure M_k corresponds to size of the household budget, while the number of household equivalent member $m_0(p, A_k)$ is an indicator of the size of consuming unit. The budget and the size of the household are combined in a "per capita" measure of total expenditure.

Transforming expenditure per capita logarithmically implies that increments in individual welfare correspond to proportional changes in the resources of the household. Prices faced by the household enter through a linear transformation that is the same for all consuming units. Household size also depends on prices since the preferences of household members are not necessarily identical.

More formally, individual welfare is a linear function of the logarithm of total expenditure per household equivalent member $\ln\left[\frac{M_k}{m_0(p, A_k)}\right]$ with an intercept and slope coefficient that depend only on prices $p(k = 1,2,\ldots,K)$. This property is invariant with respect to positive affine transformations that are the same for all consuming units, so that the individual welfare function provides a cardinal measure of individual welfare that is fully comparable among units. The incorporation of measures of individual welfare based on the individual welfare function into a social welfare function requires a normative judgment about horizontal equity among individuals. We assume that every individual should be treated symmetrically with any other individual having the same welfare function.[36]

To represent social orderings in a form suitable for measuring social welfare we consider the class of social welfare functions introduced by Jorgenson and Slesnick (1983):

$$W(u,x) = \ln \bar{V} - \gamma(x)\left[\frac{\sum_{k=1}^{K} m_0(p,A_k)\ln V_k - \ln \bar{V}^{-\rho}}{\sum_{k=1}^{K} m_0(p,A_k)}\right]^{-\frac{1}{\rho}}.$$

(16)

The first term in the social welfare functions (16) corresponds to an average of individual welfare levels over all consuming units:

$$\ln \bar{V} = \frac{\sum_{k=1}^{K} m_0(p,A_k)\ln V_k}{M_k} = \ln p'\left(\alpha_p + \frac{1}{2}B_{pp}\ln p\right) - D(p)\frac{\sum_{k=1}^{K} m_0(p,A_k)\ln\frac{M_k}{m_0(p,A_k)}}{\sum_{k=1}^{K} m_0(p,A_k)}.$$

The second term is a linear homogeneous function of deviations of levels of individual welfare from the average and is a measure of dispersion in individual welfare levels. These social welfare functions are invariant with respect to positive affine transformations and provide cardinal measures of social welfare.

[36] Lewbel (1989) suggested that this approach could also be employed for the AIDS system proposed by Deaton and Muellbauer (1980). Details are provided by Fleurbaey and Hammond (2004).

The parameter ρ determines the curvature of the social welfare function in the individual welfare functions $\{W_k(x)\}$. We refer to this parameter as the *degree of aversion to inequality*. By selecting an appropriate value of this parameter, we can incorporate ethical judgments about vertical equity into the social welfare function. The range of admissible values of ρ is from negative unity to negative infinity.

The measure of dispersion vanishes in the limiting case where the degree of aversion to inequality ρ is equal to negative infinity. The social welfare functions reduce to the utilitarian case, corresponding to averages of welfare levels over all consuming units. This limiting case gives the least possible weight to equity considerations. In the applications presented in the following section we take ρ to be negative unity in order to give the greatest weight to equity considerations.

At this point we have generated a class of social welfare functions capable of expressing the implications of a variety of ethical judgments. The Pareto principle requires that an increase in individual welfare must increase social welfare. This condition implies that the increase in the average level of individual welfare, must exceed the increase in the dispersion in individual welfare.

We assume that the function $\gamma(x)$ must take the maximum value consistent with the Pareto principle, so that:

$$\gamma(x) = \left\{ \frac{\sum_{k=1,j}^{K} m_0(p, A_k)}{\sum_{k=1}^{K} m_0(p, A_k)} \left[1 + \left[\frac{\sum_{k=1,j}^{K} m_0(p, A_k)}{m_0(p, A_k)} \right]^{-(\rho+1)} \right] \right\}^{\frac{1}{\rho}}$$

(17)

where:

$$m_j0\ (p, A_j) = \min{}_k\ [\ [m]\ _j0\ ]\ (p, A_k), \qquad (k = 1, 2, \ldots, K)\ .$$

This assumption gives maximum weight to the second term on (1.4.6), representing equity considerations.

It is important to emphasize that the validity of social welfare evaluations of economic policy depends on normative conditions, as well as empirical information about preferences from econometric studies of consumer behavior like that described in the Appendix. The intuition underlying the class of social welfare functions (16) is that we augment the mean of individual welfare with a measure of dispersion. This class includes the utilitarian social welfare functions based on average social welfare and frequently used in policy evaluation. Allowing for dispersion makes it possible to give additional weight to equity considerations.

In order to determine the form of the social expenditure function $M(p, W)$, we can maximize the social welfare function (1.4.6) for a fixed level of aggregate expenditure by equalizing total expenditure per household equivalent member $\left[\frac{M_k}{m_0(p, A_k)}\right]$ for all consuming units. For the translog indirect utility function the maximum value of social welfare for a given level of aggregate expenditure takes the form:

$$\ln \bar{V} = \ln p'\left(\alpha_p + \frac{1}{2} B_{pp} \ln p\right) - D(p) \ln \left[\frac{M}{\sum_{k=1}^{K} m_0(p, A_k)}\right].$$

(18)

As before, this is the maximum level of welfare that is potentially available and can be taken as a measure of efficiency. Note that this measure of efficiency does not depend on the value of the degree of aversion to inequality ρ .

If aggregate expenditure is distributed so as to equalize total expenditure per household equivalent member, the level of individual welfare is the same for all consuming units. For this distribution of total expenditure the social welfare function reduces to the average level of individual welfare $\ln \bar{V}$. The value of social welfare is obtained by evaluating the translog indirect utility function at total expenditure per household equivalent member $\frac{M}{\sum_{k=1}^{K} m_0(p, A_k)}$ for the economy as a whole. This is an algebraic representation of the preferences of the representative consumer depicted in Figure 2.

We can express aggregate expenditure as a function of the level of social welfare and prices:

$$\ln M(p, W) = \frac{1}{D(p)}\left[\ln p'\left(\alpha_p + \frac{1}{2}B_{pp}\ln p\right) - \right] + \ln\left[\sum_{k=1}^{K} m^0(p, A_k)\right].$$

(19)

The value of aggregate expenditure is obtained by evaluating the translog individual expenditure function (14) at the level of social welfare W and the number of household equivalent members $\sum_{k=1}^{K} m_0(p, A_k)$ for the economy as a whole. This is the form of the social expenditure function used in constructing the measures of the social standard of living and its cost represented in Figure 2.

5. Measuring Welfare in the U.S. National Accounts.

We turn next to the measurement of social welfare in the new architecture for the U.S. national accounts. The first issue to be addressed is, why incorporate welfare into the national accounts? The advantages stem from the accuracy and reliability of estimates carried out within a system of national accounts. The accounts incorporate the double-entry bookkeeping associated with systems of private accounts.

Each account in the new architecture is expressed in both current and constant prices, so that the benefits of double-entry bookkeeping are multiplied by a factor of two. This "quadruple entry" bookkeeping is characteristic of national accounting but is not usually employed in private accounting. Finally, the results can be reported with other estimates from the national accounts on a regular basis – annually, quarterly, or even monthly.

A second advantage of measuring welfare within the national accounts is the establishment of international standards like those that underlie the 2008 SNA. The resulting uniformity of methods for national accounting is essential for international comparability. Based on experience with the 2008 SNA and its predecessors, the incorporation of welfare measures into the national accounts will require lengthy international consultations. While the 2008 SNA rules out a welfare interpretation of the national accounts, systems of satellite accounts, such as environmental accounts, are often given a welfare interpretation.[37]

As an illustration, the World Bank's internationally comparable estimates of poverty and inequality are very valuable in comparing economic performance and social progress across countries.[38] These estimates are based on hundreds of micro-economic

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[37] See 2008 SNA, Ch. 2, pp. 12-13, and Ch. 29, pp. 534-538. This issue will be discussed in more detail below.

[38] See Shaohua Chen and Martin Ravallion (2010), "The Developing World is Poorer than We Thought, but No Less Successful in the Fight Against Poverty," *Quarterly Journal of Economics,* Vol. 125, No. 4, November, pp. 1577-1629. A recent summary is provided by Ravallion (2012), "More Relatively-Poor People in a Less Absolutely-Poor World," Nancy and Richard Ruggles Memorial Lecture, International Association for Research in Income and Wealth, Boston, MA, August. A critique of the World Bank's approach is given by Angus Deaton (2010), "Price Indexes, Inequality, and the Measurement of World Poverty," *American Economic Review*, Vol. 100, No. 1, March, pp. 5-34.

data sets for different countries providing information on income and consumption for individuals and households. The estimates also incorporate purchasing power comparisons of production in the World Bank's International Comparisons Project.[39]

In response to the Stiglitz-Sen-Fitoussi Report the OECD has established an International Expert Group chaired by the Australian Bureau of Statistics to develop new international standards and guidelines for micro-economic data. These data cover income, consumption and wealth for households and individuals. The OECD has established a second International Expert Group on Disparities in the National Accounts chaired by Eurostat to consider the role of distributional statistics in the national accounts.[40]

In August 2008, four years after the meeting of the Conference on Research in Income and Wealth devoted to the new architecture, Jorgenson presented an update of the prototype system of national accounts he had developed with Landefeld. The occasion was Jorgenson's Richard and Nancy Ruggles Memorial Lecture to the 30th General Conference of the International Association for Research on Income and Wealth.[41] Jorgenson linked the new architecture presented in Figure 3 to the Integrated Macroeconomic Accounts developed by the BEA and the FRB.

Jorgenson presented GDP as a measure of production and personal consumption expenditures as a measure of potential social welfare. He emphasized that consumption is a measure of the current flow of welfare. Saving, the second component of domestic

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[39] World Bank (2008), *Global Purchasing Power Parities and Real Expenditures: 2005 International Comparison Program,* Washington, DC, World Bank. See: http://siteresources.worldbank.org/ICPEXT/Resources/ICP_2011.html

[40] Marco Mira d'Ercole, Bob McColl, and Mindi Kindermann (2012), "Development of International Standards for Micro Statistics on Household Income, Consumption, and Wealth," 32nd General Conference, International Association for Research in Income and Wealth, Boston, MA, August.

[41] Dale W. Jorgenson (2009).

expenditures, is a measure of current contributions to future welfare through consumption.[42]

Jorgenson's Ruggles Lecture focused primarily on integrating productivity measures into the national accounts.[43] The Domestic Income and Product Account is presented in Table 1. In the prototype system of national accounts this account is modeled after Jorgenson's Presidential Address to the American Economic Association.[44] Like the BEA-BLS Integrated Production Account, this conforms to the standards presented in the Schreyer's (2001) *OECD Productivity Manual.*

A key innovation in the new architecture for the U.S. national accounts is the inclusion of prices and quantities of capital services for all productive assets in the U.S. economy. The process that led to the 2008 SNA was formally initiated by the United Nations Statistical Commission in March 2004, almost simultaneously with development of the new architecture. Issues related to the measurement of capital were assigned to an Expert Group, designated Canberra II after the site of the initial meeting in Canberra, Australia.

The incorporation of the price and quantity of capital services into the 2008 SNA was recommended by the Canberra II Expert Group and approved by the United Nations

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[42] This interpretation has been developed by Paul A. Samuelson (1961), "The Evaluation of 'Social Income,'" in F. A. Lutz and D. C. Hague, eds., *The Theory of Capital,* London, Macmillan, pp.32-57. William D. Nordhaus and James Tobin (1973), "Is Growth Obsolete?" in Milton Moss, ed., The *Measurement of Economic and Social Performance*, Princeton, Princeton University Press, pp. 509-564., and Martin Weitzman (1976), "On the Welfare Significance of National Product in a Dynamic Economy," *Quarterly Journal of Economics*, Vol. 90, No.1, February, pp. 156-162, and Weitzman (2003), *Income, Wealth, and the Maximum Principle,* Cambridge, Harvard University Press.

[43] Issues in measuring productivity were considered by a Statistical Working Party of the OECD Industry Committee, headed by Edwin Dean, former Associate Commissioner for Productivity and Technology of BLS. The Working Party established international standards for productivity measurement at both aggregate and industry levels. The results are summarized in Paul Schreyer (2001), *Measuring Productivity*, Paris, Organisation for Economic Co-operation and Development.

[44] Dale W. Jorgenson (2001), "Information Technology and the U.S. Economy," *American Economic Review,* Vol. 91, No. 1, March, pp. 1-32.

Statistical Commission at its February-March 2007 meeting. Schreyer, then head of national accounts at the OECD, prepared an OECD Manual[45] on *Measuring Capital.* Schreyer's *Manual* provided detailed recommendations on methods for the construction of prices and quantities of capital services.

Estimates of capital services like those used in the new architecture were discussed in Chapter 20 of the 2008 SNA:

> By … associating estimates of capital services with the standard breakdown of value added, the contributions of both (labor) and capital to production can be portrayed in a form ready for use in the analysis of productivity in a way entirely consistent with the accounts of the SNA.[46]

Jorgenson concluded that the Domestic Income and Product Account of the new architecture for the U.S. national accounts is consistent with the 2008 SNA. The volume measure of input is a quantity index of capital and labor services, while the volume measure of output is a quantity index of investment and consumption goods. Productivity is the ratio of output to input.

The interpretation of output, input, and productivity requires the production possibility frontier introduced by Jorgenson (1966)[47]:

$$Y(I,C) = A\, X(K,L),$$

Gross Domestic Product in constant prices Y consists of outputs of investment goods I and consumption goods C. These products are produced from capital services K and labor

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[45] Paul Schreyer (2009), *Measuring Capital,* Paris, Organisation for Economic Co-operation and Development.
[46] 2008 SNA (2009), Ch. 20, p. 415.
[47] Dale W. Jorgenson, "The Embodiment Hypothesis," *Journal of Political Economy,* Vol. 74, No. 1, February, pp. 1-17.

services L. These factor services are components of Gross Domestic Income in constant prices X and are augmented by multifactor productivity A.

The key feature of the production possibility frontier is the explicit role for changes in the relative prices of investment and consumption outputs. The aggregate production function is a competing methodology, but there is no role for separate prices of investment and consumption goods. Under the assumption that product and factor markets are in competitive equilibrium, the share-weighted growth of outputs is the sum of the share-weighted growth of inputs and growth in multifactor productivity:

$$\overline{w}_I \Delta I + \overline{w}_C \Delta \ln C = \overline{v}_K \Delta \ln K + \overline{v}_L \Delta \ln L + \Delta \ln A ,$$

where w and v denote average shares of the outputs and inputs, respectively, in the value of GDP.

Table 3 presents accounts for the sources of U.S. economic growth during 1948–2010 and various sub-periods. For the period as a whole the contribution of capital services accounted for 51.6 percent of economic growth. Labor services contributed 31.6 percent, while multifactor productivity growth contributed only 19.0 percent. The first sub-period ends with the business cycle peak in 1973. After strong output and productivity growth in the 1950s, 1960s and early 1970s, the growth of GDP dropped from 3.95 percent from 1948-1973 to only 2.68 percent from 1973 through 1995.

A powerful resurgence in U.S. economic growth began in 1995 but ended abruptly in 2000 with the dot-com crash. U.S. economic growth surged to 4.14 percent during the period 1995–2000. This reflected the investment boom of the late 1990s, as businesses, households, and governments poured resources into plant and equipment, especially computers, software, and communications equipment. Between 1973–95 and

1995–2000 the contribution of capital input to U.S. economic growth jumped by 0.80 percentage points, accounting for more than half the increase in output growth of 1.45 percent. The contribution of labor input increased by a modest 0.17 percent, while multifactor productivity growth accelerated by 0.49 percent.

After the dot-com crash in 2000 GDP growth slowed to 2.87 percent per year and the relative importance of investment in information technology declined sharply. The contribution of capital services to economic growth dropped by 0.62 percent per year. The growth of multifactor productivity increased to 0.82 percent, while the contribution of labor input sank by more than a full percentage point to 0.24 percent per year. GDP growth plunged to only 0.94 percent during 2005-2010, a sub-period that includes the Great Recession of 2007-2009.

The results presented in Table 3 highlight the importance of the new architecture. In the absence of an integrated production account, like that published by BEA and BLS in 2009, the analysis of sources of economic growth would have had to rely on a mixture of estimates from different sources, combined with estimates of missing information, such as growth in labor input per hour worked. Different analysts could readily produce conflicting interpretations of events such as the spurt in productivity growth after 1995 and the collapse of output and productivity growth during the Great Recession.

The Domestic Income and Product Account of the new architecture has been disaggregated to the level of 65 industries by Jorgenson, Ho, and Samuels (2012a). This covers the period 1948-2010.[48] The methodology follows that of Jorgenson, Ho and

[48] Jorgenson, Ho, and Samuels (2012a), "Information Technology and U.S. Productivity Growth: Evidence from a Prototype Industry Production Account," in Matilde Mas and Robert Stehrer (2012), eds., *Industrial Productivity in Europe: Growth and Crisis,* Cheltenham, UK, Edward Elgar, pp. 35-64. See also: Dale W. Jorgenson, Mun S. Ho, Jon D. Samuels, (2012b), A Prototype Industry-Level Production Account for the

Stiroh (2005), and conforms to the international standards established in Schreyer's OECD *Productivity Manual*. Jorgenson and Schreyer (2012) have shown how to integrate the industry-level production account of Jorgenson, Ho, and Samuels (2012b) into the 2008 SNA.[49]

Industry-level production accounts based on the methodology of Jorgenson, Ho, and Stiroh (2005) have been incorporated into the national accounts in seven countries. The EU KLEMS project has developed systems of production accounts for the economies of 25 of the 27 European Union (EU) member states.[50] For major EU countries this project includes accounts for 72 industries, covering the period 1970-2005. The World KLEMS Initiative will extend the EU KLEMS framework to important developing and transition economies, including Argentina, Brazil, Chile, China, India, Indonesia, Mexico, Russia, Turkey, and Taiwan.[51]

We employ the Domestic Income and Expenditures Account presented in Table 2 in measuring individual and social welfare in the new architecture. The key accounting identity for the Domestic Income and Expenditures Account is that net income is equal to net expenditures. Net income includes gross income from sales of capital and labor services from the Domestic Income and Product Account, less depreciation. Net income also contains net receipts from the rest of the world, including taxes and transfers. Net

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United States, 1947-2010," presented to the Final Conference of the World Input-Output Database project, Groningen, the Netherlands, April 25. http://www.economics.harvard.edu/faculty/jorgenson/files/12_0425_WIOD.pdf.

[49] Dale W. Jorgenson and Paul Schreyer, "Industry Level Productivity Measurement and the 2008 System of National Accounts," *Review of Income and Wealth,* forthcoming. .

[50] The EU KLEMS project was completed on June 30, 2008. A summary of the findings is presented by Marcel P. Timmer, Robert Inklaar, Mary O'Mahony, and Bart van Ark (2010), *Economic Growth in Europe: A Comparative Industry Perspective*, Cambridge, Cambridge University Press, and Matilde Mas and Robert Stehrer (2012), eds., *Industrial Productivity in Europe: Growth and Crisis,* Cheltenham, UK, Edward Elgar. For current estimates see: www.euklems.net/.

[51] See: http://www.worldklems.net/

expenditures are the sum of personal consumption expenditures, government consumption expenditures, and net saving.[52]

Economic growth creates opportunities for both present and future consumption. These opportunities are generated by expansion in the supply of capital and labor services, augmented by changes in the level of living:

$$Z(C,S)=B\ W(L,N),$$

Net Domestic Expenditures in constant prices Z consist of consumption expenditures C and saving S, net of depreciation. These expenditures are generated by Net Incomes in constant prices W, comprising labor incomes L and property incomes N, also net of depreciation.

The level of living B must be carefully distinguished from multifactor productivity A. An increase in the level of living implies that for given supplies of the factor services that generate labor and property incomes, the U.S. economy generates greater opportunities for present and future consumption. The share-weighted growth of expenditures is the sum of the share-weighted growth of incomes and growth in the level of living:

$$\overline{w}_C \Delta \ln C + \overline{w}_S \Delta S = \overline{v}_L \Delta \ln L + \overline{v}_N \Delta \ln N + \Delta \ln B\ .$$

where w and v denote average value shares for expenditures and incomes, respectively.

Table 4 presents a decomposition of the uses of economic growth for the period 1948–2010. The growth rate of expenditures is a weighted average of growth rates of personal consumption expenditures, government consumption expenditures, and net saving. The contribution of each category of expenditures is

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[52] Jorgenson (2009), Table 3, p. 15, expresses the Domestic Income and Expenditures Account in terms of the U.S. National Income and Product Accounts.

the growth rate weighted by the relative share. Similarly, the contributions of labor and property incomes are the growth rates weighted by the relative shares. Growth in the level of living is the difference between growth rates of expenditures and incomes.

The growth of net expenditures largely reflects the pattern of output growth, but averaged 0.25 percent lower for the period 1948-2010. Strong growth in expenditures during the period 1948–73 was followed by a slowdown after 1973. A sharp revival occurred after 1995, followed by another slowdown after 2000 and a collapse after 2005. Personal consumption expenditures, our measure of potential welfare, greatly predominated as a source of growth in the net expenditures. The contribution of net saving added on 0.16 percent to growth of expenditures for the period as a whole, but this contribution declined sharply after 2000.

6. Standard of Living and Its Cost.

Our measure of potential social welfare is personal consumption expenditures from the Domestic Income and Expenditures Account of the new architecture, expressed in constant prices per household equivalent member. The new architecture employs measures of capital services like those discussed in the 2008 SNA in measuring the consumption of housing services and the services of consumers' durables. Actual social welfare also depends on the distribution of personal consumption expenditures over the population and provides our measure of the standard of living. The ratio of the nominal value of personal consumption expenditures to the value in constant prices provides our measure of the cost of living.

Our cross-section observations on consumption expenditures for each commodity group and demographic characteristics of individual households are from the Survey of Consumer Expenditures (CEX). [53] We combine data from the CEX with price information from the Consumer Price Index (CPI). Following Slesnick (2002) and Mary Kokoski, Patrick Cardiff, and Brent Moulton (1994),[54] we exploit the fact that the prices faced by households vary across regions of the United States as well as over time periods.

We focus on integration of distributional measures based on consumption into the national accounts.[55] Fisher, Johnson, and Smeeding (2012) provide a detailed survey of the recent literature on the measurement of inequality in consumption and income.[56] Their own estimates of inequality employ data from the CEX and cover the period 1984-2010. Other recent and comprehensive studies of welfare measurement based on the CEX include Attanasio, Hurst, and Pistaferri (2012) and Meyer and Sullivan (2009).[57]

Measurement of the standard of living and its cost are classic problems in the application of normative economics.[58] Measurement of the standard of living is the

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[53] Our measures of personal consumption expenditures and consumption at the micro-economic level are discussed in detail by Slesnick (2001), pp. 47-66, and Jorgenson and Slesnick (2008).

[54] Daniel T. Slesnick (2002), "Prices and Regional Variations in Welfare," *Journal of Urban Economics*, Vol. 51, No.3, May, pp. 446-468, and Mary Kokoski, Patrick Cardiff, and Brent Moulton (1994), "Interarea Price Indices for Consumer Goods and Services: An Hedonic Approach Using CPI Data, BLS Working Paper 256, July.

[55] This is complementary to the work of Dennis Fixler and David Johnson (2012), "Accounting for the Distribution of Income in the U.S. National Accounts," 32nd General Conference, International Association for Research in Income and Wealth, Boston, MA, August. Fixler and Johnson consider the integration of income measures into the national accounts.

[56] See Jonathan Fisher, David Johnson,and Timothy Smeeding (2012), "Inequality of Income and Consumption: Measuring the Trends in Inequality from 1985-2010 for the Same Individuals," 32nd General Conference, International Association for Research in Income and Wealth, Boston, MA, August, pp. 6-9.

[57] See Orazio Attansio, Eric Hurst, and Luigi Pistaferri, "The Evolution of Income, Consumption, and Leisure Inequality in the U.S., 1980-2010," NBER Working Paper No. 17982, April, and Bruce Meyer and James Sullivan (2009), "Five Decades of Consumption and Income Poverty," NBER Working Paper No. 14827, March. This short list of references is far from exhaustive.

[58] Measurement of the standard of living and its cost is discussed by Dale W. Jorgenson and Daniel T. Slesnick (1983), "Individual and Social Cost-of-Living Indexes, " in W. Erwin Diewert and Claude Montmarquette (1983), eds., *Price Level Measurement,* Ottawa, Statistics Canada, pp. 241-323, and

objective of the approach to evaluating national income introduced by Hicks (1940) and discussed by Samuelson (1950).[59] John Chipman and James Moore have demonstrated that the compensation principle proposed by Hicks provides a valid indicator of social welfare only if preferences are identical and homothetic for all consuming units.[60] Sen (1976, 1979) has revived interest in this problem, applying rank-order weights to elements of the matrix x that describes the social state.[61] Hammond (1978) has shown that Sen's approach requires preferences of the type considered by Gorman (1953) for its validity.[62]

In this section we implement the approach to normative economics presented in Section 2. For this purpose we consider the problem of measuring the performance of the U.S. economy over the period 1948-2010. We introduce a quantity index of social welfare that can be interpreted as a measure of the standard of living. We define this index of social welfare, say Q_A, as the ratio of two levels of aggregate expenditure per capita

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Jorgenson and Slesnick (1990), "Inequality and the Standard of Living," *Journal of Econometrics,* Vol. 43, Nos. 1-2, January/February, pp. 103-120, and Slesnick (2001), pp. 67-121.

[59] See John R. Hicks (1940), "The Valuation of Social Income," *Economica*, N.S., Vol. 7, pp. 105-124, and Paul A. Samuelson (1950), "Evaluation of Real National Income," *Oxford Economic Papers*, N.S., Vol. 1, pp. 1-29.

[60] John S. Chipman and James C. Moore (1973), "Aggregate Demand, Real National Income, and the Compensation Principle," *International Economic Review*, Vol. 14, No. 1, February, pp. 153-181, and Chipman and Moore (1980), "Real National Income with Homothetic Preferences and a Fixed Distribution of Income," *Econometrica*, Vol. 48, No. 2, March pp. 401-422.

[61] Amartya K. Sen (1976), "Real National Income," *Review of Economic Studies,* Vol. 43, No. 133, February, pp. 19-40, and Sen (1979), "The Welfare Basis for Real Income Comparisons: A Survey," *Journal of Economic Literature,* Vol. 17, No. 1, March, pp. 1-45.

[62] Peter J. Hammond (1978), "Economic Welfare with Rank Order Price Weighting," *Review of Economic Studies,* Vol. 45, No. 2, June, pp. 381-384.

$$Q_A(p^0, W^0, W^1) = \frac{\frac{M(p^0, W^1)}{\sum_{k=1}^{K^1} m^0(p, A_k)}}{\frac{M(p^0, W^0)}{\sum_{k=1}^{K^0} m^0(p, A_k)}} .$$

(21)

The numerator of our quantity index of social welfare (21) is the aggregate expenditure per capita required to attain the current level of social welfare W^1 at the base period price system p^0. The denominator of the index (21) is the expenditure per capita required for the base period level of welfare W^0 at this price system. Our measure of the size of the population is the number of household equivalent members for society as a whole. The current number of households is K^1, while the base period number of households is K^0. The number of households varies over our sample period, 1948-2010, exceeding one hundred million by the end of the period.

We employ the social welfare function (16) and the translog social expenditure function (19) in implementing the index of social welfare (20). To obtain the base level of social welfare W^0, we evaluate the social welfare function at the base period price system p^0 and the base period distribution of total expenditure $\{M_k^0\}$. We express the current level of social welfare W^1 in terms of the social welfare function by replacing the base period price system and distribution of total expenditure with the current price system p^1 and the current distribution of total expenditure $\{M_k^1\}$. It is important to emphasize that the degree of aversion to inequality ρ is equal to negative unity, which gives maximum weight to equity considerations.

Using the social expenditure function, we express the quantity index of social welfare (20) in the form

$$\ln [Q_A(p^0, W^0, W^1) = \frac{1}{D(p^0)(W^0, W^1)} .$$

(22)

We refer to the index Q_A as the *translog social standard of living index.* If this index is greater than unity, actual social welfare has increased; otherwise, social welfare has remained the same or decreased.

Next, we decompose our quantity index of social welfare (22) into the product of an index of efficiency and an index of equity. For this purpose we first determine the maximum level of welfare, say W^8, that can be attained through lump-sum redistributions of aggregate total expenditure $M^1 = \sum M_k^1$. Expenditure must be distributed so as to equalize individual expenditure per capita, so that the social welfare function reduces to average individual welfare (18)

$$W^8 - \ln \bar{V}^1 - \ln p^{1'} \left(\alpha_p + \frac{1}{2} B_{pp} \ln p^1\right) - D(p^1) \ln \left[\frac{M^1}{\sum_{k=1}^{K^1} m_0(p_1, A_k)}\right] .$$

(23)

This is the maximum level of social welfare potentially available in the current period and is a measure of efficiency. This measure does not depend on the degree of aversion to inequality ρ , since the second term in the social welfare function (16) is identically equal to zero.

We define the quantity index of efficiency, say Q_E, as the ratio of two levels of aggregate expenditure per capita

$$Q_E(p^0, W^0, W^1) = \frac{\dfrac{M(p^0, W^1)}{\sum_{k=1}^{K^1} m_0(p^0, A_k)}}{\dfrac{M(p^0, W^0)}{\sum_{k=1}^{K^0} m_0(p^0, A_k)}} = \frac{\dfrac{M(p^0, W^1)}{\sum_{k=1}^{K^1} m_0(p, A_k)}}{\dfrac{M^0}{\sum_{k=1}^{K^0} m_0(p, A_k)}}, \qquad (24)$$

where M^0 is base period expenditure.

The numerator of our quantity index of efficiency (24) is the aggregate expenditure per capita required to attain the potential level of social welfare in the current period W^1 at the base period price system p^0. The denominator of our index is the expenditure per capita required to attain the potential level of welfare in the base period W^0 at this price system. The quantity index of efficiency (24) is the ratio of money measures of efficiency in the current period and the base period, both evaluated at the base period price system p^0. This index is independent of the degree of aversion to inequality ρ .

We express potential levels of social welfare in the base period W^0 and the current period W^1 in terms of average individual welfare (18). Using the social expenditure function, we express the quantity index of efficiency (24) in the form

$$\ln Q_E(p^0, W^0, W^1) = \frac{1}{D(p^0)(W^0 - W^1)} .$$

(25)

We refer to the index Q_E as the *translog efficiency index.* If this index is greater than unity, potential social welfare has increased; otherwise, potential welfare has remained the same or decreased.

Finally, we define a quantity index of equity, say Q_E as the ratio of the index of social welfare to the index of efficiency

$$Q_E = \frac{Q_A}{Q_F} = \frac{\dfrac{M(p^0, W^1)}{M(p^0, W^S)}}{\dfrac{M(p^0, W^0)}{M^0}} .$$

(26)

The numerator of our quantity index of equity (26) is a money measure of equity in the current period, evaluated at the base period price system p^0. Similarly, the denominator is the money measure of equity in the base period, evaluated at this same price system. These measures depend on the degree of aversion to inequality ρ .

Using the social expenditure function, we express the quantity index of equity (26) in the form

$$\ln Q_E(p^0, W^0, W^1, W^2, W^S) = \frac{1}{D(p^0)}[(W^0 - W^1) - (W^2, W^S)] .$$

(27)

We refer to the index Q_E as the *translog equity index*. If this index is greater than unity, equity has increased; otherwise, equity has remained the same or decreased.[63]

In Section 4 we have observed that the social welfare function (16) provides a cardinal measure of social welfare. Since the logarithms of translog indexes of the standard of living, efficiency, and equity are proportional to differences between values of the social welfare function, they also provide cardinal measures of social welfare. Similarly, growth rates of these indexes, defined in terms of differences between successive logarithms, are cardinal measures of changes in social welfare.

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[63] This approach to the measurement of inequality was introduced by Dale W. Jorgenson and Daniel T. Slesnick (1984), "Aggregate Consumer Behavior and the Measurement of Inequality," *Review of Economic Studies,* Vol. 51, No. 3, July, pp. 369-391, and is discussed by Jorgenson (1990), Jorgenson and Slesnick (1990), Daniel T. Slesnick (1994), "Consumption, Needs, and Inequality,"*International Economic Review,* Vol. 35, No. 3, August, pp.677-703, and Slesnick (2001), pp. 122-155.

To define a social cost-of-living index we first consider the ratio of nominal expenditure per capita, as follows

$$\ln \frac{\dfrac{M^1}{\sum_{k=1}^{K^1} m_0(p^1, A_k)}}{\dfrac{M^0}{\sum_{k=1}^{K^0} m_0(p^0, A_k)}} - \ln \frac{\dfrac{M(p^1, W^2)}{\sum_{k=1}^{K^1} m_0(p^1, A_k)}}{\dfrac{M(p^0, W^2)}{\sum_{k=1}^{0} m_0(p^0, A_k)}} . \qquad (28)$$

The base period level of aggregate expenditure M^0 is a money measure of potential social welfare, evaluated at base period prices p^0. Similarly, the current level of aggregate expenditure M^1 is a measure of potential welfare at current prices p^1.

Next, we decompose our index of nominal aggregate expenditure (28) into the product of an index of efficiency and a social cost-of-living index. We rewrite the nominal expenditure index (28) as follows;

$$\ln \frac{\dfrac{M^1}{\sum_{k=1}^{K^1} m_0(p^1, A_k)}}{\dfrac{M^0}{\sum_{k=1}^{0} m_0(p^0, A_k)}} = \ln Q_p + \ln P ,$$

where Q_p is the translog index of efficiency (25) and the index P is the translog social cost-of-living index introduced by Jorgenson and Slesnick (1983)

$$\ln P(p^1, p^0, W^R) - \ln M^1 - \frac{1}{D(p^0)}\left[\ln p^0(\alpha_p + B_{pp} \ln p^0) - W^R\right]$$

$$+ \ln \sum_{k=1}^{K^1} m_0(p^0, A_k) . \qquad (29)$$

To construct the translog social cost-of-living index we first determine the potential level of welfare W^S from average individual welfare (18). The social cost-of-living index is the ratio of the aggregate expenditure required to attain the potential level of welfare in the current period W^S at current prices p^1 to the expenditure required to attain this level of welfare at base period prices p^0. Since this index depends only on the potential level of social welfare W^s, it is independent of the degree of aversion to inequality ρ. If the translog social cost-of-living index is greater than unity and aggregate expenditure is constant, then social welfare is decreased by the change in prices.

As an illustration of the standard of living index Q_A in (21) and the cost-of-living index *P* in (29), we assess the impact of changes in the price system *p* and the distribution of total expenditure $\{M_k\}$ on the standard of living and its cost for the U.S. economy. We begin with personal consumption expenditures for the U.S. in nominal terms from Table 1. This is aggregate expenditure *M*, the sum of total expenditure over all U.S. households $\sum_{k=1}^{K} M_k$.

To transform aggregate expenditure into a measure of the standard of living the first step is to express total expenditure in real terms, using the social cost-of-living index *P* in (29). We convert this to per capita terms by dividing by the number of household equivalent members $\sum_{k=1}^{K} m_0(p, A_k)$ of the U.S. population. This results in a measure of potential social welfare and is proportional to the translog efficiency index Q_P in (24).

The final step in constructing a measure of the U.S. standard of living is to transform real expenditure per capita by a measure of equity. For this purpose we multiply real expenditures per capital by the translog equity index Q_E in (26). The product of the equity index and real expenditure per capita is our standard of living index.

This is a measure of actual social welfare and is proportional to the translog social welfare index Q_A in (22).[64]

For the postwar period as a whole the average annual growth rate of real expenditure per capita, our measure of efficiency, is 2.46 percent, while the average growth rate of equity is 0.23 percent. Multiplying the two we obtain a measure of the standard of living with a growth rate of 2.69 percent. It is important to emphasize that we have selected a social welfare function that gives the greatest weight to equity considerations. In particular, we have selected values of $\gamma(x)$ and ρ that give maximum weight to the dispersion in individual welfare levels.

Growth in the standard of living peaked during 1948-1973 at 3.62 percent and then declined to around two percent after 1973. The revival in economic growth during the boom from 1995-2000 was largely offset by the sharp decline in equity. Inspection of the index of equity given in Table 5 reveals that all of the growth in equity occurred during the period 1948-1973. The growth of equity was a negative 0.10 percent during the slowdown in economic growth from 1973-1995 and dropped to a negative 0.71 percent during the investment boom of 1995-2000.

7. Conclusion.

In this paper we have presented money measures of the cost and standard of living and inequality. These are suitable for incorporation into the new architecture for the U.S. national accounts.[65] This process could begin with a satellite system for measuring social welfare that would include the two polar opposite social welfare functions that we have

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[64] For measures covering the years 1947-1985, see Jorgenson (1990) and Jorgenson and Slesnick (1990).
[65] Recommendations for the federal statistical programs are given by Jorgenson (1998) and Slesnick (2001), pp. 190-199.

considered. The social welfare function with degree of aversion to inequality ρ equal to negative unity gives maximum weight to equity considerations, while the utilitarian social welfare functions gives these considerations minimum weight.

The satellite system for measuring social welfare could include a breakdown of our measures of social welfare by dimensions that we have distinguished in modeling consumer behavior – family size, age of head, region, race, and urban vs. rural residence – as well as total expenditure or personal consumption expenditures per family. Using collections of data sets on consumption from sources such as the World Bank and the Luxembourg Income Study, together price data on consumption from sources like the World Bank's International Comparison Project, it would be possible to provide international comparisons for our measures of social welfare.[66]

The boundary of social welfare could be extended to include non-market goods and services. A comprehensive review of nonmarket accounts is provided by Katharine B. Abraham and Christopher Mackie (2005, 2006) and their co-authors.[67] This includes accounts for household production, investments in education and health, activities of nonprofit organizations and governments, and environmental assets and services.

Jorgenson and Slesnick (2008) have extended the model of consumer behavior presented in the Appendix to include the demand for leisure, as well as goods and

[66] See the following for data from the World Bank:
http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/EXTPA/0,,contentMDK:20202198~menuPK:435055~pagePK:148956~piPK:216618~theSitePK:430367,00.html
For data from the Luxembourg Income Study, see: http://www.lisdatacenter.org/.

[67] Abraham, Katherine G., and Christopher Mackie (2005), eds., *Beyond the Market: Designing Nonmarket Accounts for the United States.* Washington, DC, National Academies Press. A summary is provided by Abraham and Mackie (2006), in Jorgenson, Landefeld, and Nordhaus (2006), eds., pp. 161-192. The conceptual basis for nonmarket accounting is discussed by Nordhaus (2006), in Jorgenson, Landefeld and Nordhaus (2006), pp. 143-160.

services.[68] This concept of leisure includes the non-market time used for household production, investments in education and health, and volunteer activities. Leisure time based on the CEX could be included in measures of individual and social welfare like those we have presented for market goods and services.[69]

An official wealth account for the U.S. economy is currently unavailable. The next step in integrating the NIPAs with the Flow of Funds Accounts will be to extend the national balance sheet for the U.S. economy. The prototype system of national accounts generated by Jorgenson and Landefeld (2006) could incorporate balance sheets for the individual sectors identified in the Flow of Funds Accounts.

A wealth account is essential for measuring the accumulation of wealth to meet future financial needs for both public and private sectors, as well as assessing the levels of domestic and national saving and their composition. This could be used as the basis of intertemporal measures of individual and social welfare. For this purpose a representation of consumer behavior like that employed by Jorgenson and Slesnick (2008) would be required.

Our final conclusion is that distributional information should be incorporated into the national accounts. As maintained in the Stiglitz-Sen-Fitoussi Report, GDP is not a satisfactory measure of the standard of living. The same can be said of real personal consumption expenditures per household equivalent member, our measure of potential social welfare. Equity has been a relatively modest source of growth in the U.S. standard

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[68] Dale W. Jorgenson and Daniel T. Slesnick (2008), "Consumption and Labor Supply," *Journal of Econometrics,* Vol. 127, No. 1, September, pp. 326-335.
[69] See Alan B. Krueger (2009), *Measuring the Subjective Well-Being of Nations: National Accounts of Time Use and Well-Being,* Chicago, University of Chicago Press. Krueger (2009) and his co-authors have developed a more detailed system of National Time Accounting that includes both market and non-market uses of time, combined with evaluations based on measures of subjective well-being.

of living over the period 1948-2010, relative to efficiency. However, the growth of equity has fluctuated widely among sub-periods, as shown by the strong positive contribution of equity from 1948-1973 and the substantial negative contribution from 1995-2000.

Incorporating distributional information in the national accounts is a substantial departure from a long tradition in national accounting. This tradition, as reflected in SNA 2008, excludes normative judgments that are essential for interpreting distributional information. The traditional view is that economists have little to contribute to these judgments. As a consequence of the development of the economic theory of social choice and its many applications, many economists have become expert in bringing normative perspectives to bear on the evaluation of economic policy.

The strengths of the traditional approach to the national accounts can be preserved by including distributional information in a satellite system and presenting a number of alternatives. This may help to end the fruitless search for a substitute for well-established aggregates from the Production, Income and Expenditure, and Wealth accounts, such as the GDP, personal consumption expenditures, and national wealth. These are essential for developing and interpreting distributional information within the framework of systems of national accounts like the new architecture.

Appendix: Modeling Consumer Behavior.

The system of individual expenditure shares (6) can be fitted without requiring that it is generated from an indirect utility function of the form (4). We say that the system is *integrable* if it can be generated from such an indirect utility function. Since we utilize the indirect utility functions for all consuming units in measuring social welfare, we must impose conditions for integrability on the individual demand functions. A complete set of conditions for integrability[70] is the following:

1. Homogeneity. The individual expenditure shares are homogeneous of degree zero in prices and total expenditure.

We can write the individual expenditure shares in the for

$$w_k = \frac{1}{D(p)}\left(\alpha_p + B_{pp} \ln p - B_{pM} \ln M_k + B_{pA} A_k\right), (k = 1, 2, \ldots, K)$$,

where the vector of parameters β_{pM} is constant and the same for all consumer units. Homogeneity implies that this vector must satisfy the restrictions

$$\beta_{pM} = B_{pp}\,\iota$$

(A1)

Given the exact aggregation restrictions, there are $N - 1$ restrictions implied by homogeneity.

2. Summability. The sum of the individual expenditure shares over all commodity groups is equal to unity

$$\iota' w_k = 1, \qquad (k = 1, 2, \ldots, K)$$.

We can write the denominator $D(p)$ in (1.3.5) in the form

$$D = -1 + \beta_{Mp} \ln p$$,

where the vector of parameters β_{Mp}, is constant and the same for all commodity groups and all consuming units. Summability implies that this vector must satisfy the restrictions

$$\beta_{Mp} = \iota' B_{pp}$$.

(A2)

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[70]This set of conditions is based on the classic formulation of the theory of consumer behavior by John Chipman, Leonid Hurwicz, Marcel K. Richter, and Hugo Sonnenschein (1971). Details are presented by Jorgenson, Lau, and Stoker (1982), pp. 287-301.

Given the exact aggregation restrictions, there are $N - 1$ restrictions implied by summability.

3. Symmetry. The matrix of compensated own- and cross-price substitution effects must be symmetric.

If the system of individual expenditure shares can be generated from an indirect utility function of the form (4), a necessary and sufficient condition for symmetry is that the matrix B_{pp} must be symmetric. Without imposing this condition, we can write the individual expenditure shares in the form:

$$w_k = \frac{1}{D(p)}\left(\alpha_p + B_{pp}\ln\frac{p}{M_k} + B_{pA}A_k\right), \qquad (k = 1, 2, \ldots, K).$$

Symmetry implies that the matrix of parameters B_{pp} must satisfy the restrictions:

$$B_{pp} = B'_{pp} .$$

(A3)

The total number of symmetry restrictions is $\frac{1}{2}N(N-1)$.

4. Nonnegativity. The individual expenditure shares must be nonnegative.

By summability the individual expenditure shares sum to unity, so that we can write:

$$w_k \geq 0, \qquad (k = 1, 2, \ldots, K),$$

where $w_k \geq 0$ implies $w_{nk} \geq 0 (n = 1, 2, \ldots, N)$, and $w_k \neq 0$.

Since the translog indirect utility function is quadratic in the logarithms of prices, we can always choose the prices so that the individual expenditure shares violate the non-negativity conditions. Accordingly, we cannot impose restrictions on the parameters of the translog indirect utility functions that would imply non-negativity of the individual expenditure shares for all prices and total expenditure. Instead we consider restrictions on the parameters that imply monotonicity of the system of individual demand functions for all data points in our sample.

5. *Monotonicity.* The matrix of compensated own- and cross-price substitution effects must be non-positive definite.

We introduce the definition due to Martos (1969) of a *strictly merely positive subdefinite matrix*, namely, a real symmetric matrix S such that:

$$x'Sx < 0$$

implies $Sx > 0$ or $Sx < 0$.[71] A necessary and sufficient condition for monotonicity is either that the translog indirect utility function is homothetic or that B_{pp}^{-1} exists and is strictly merely positive subdefinite.

In implementing the econometric model of consumer behavior we divide consumer expenditures among five commodity groups. These groups are aggregates defined on a much more detailed classification of commodities, as described by Jorgenson, Slesnick, and Stoker (1987).[72] We assume that the indirect utility functions are homothetically separable in prices of the commodities within each group:

1. *Energy:* Expenditures on electricity, natural gas, heating oil, and gasoline.

2. *Food:* Expenditures on all food products, including tobacco and alcohol

3. *Consumer goods:* Expenditures on all other nondurable goods.

4. *Capital services:* The service flow from consumer durables and housing.

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[71] Bela Martos (1969), "Subdefinite Matrices and Quadratic Forms," *SIAM Journal of Applied Mathematics,* Vol. 17, No. 6, November, pp. 1215-1223.

[72] Dale W. Jorgenson, Daniel T. Slesnick, and Thomas M. Stoker (1987), "Two-Stage Budgeting and the Consumer Demand for Energy," in John R. Moroney (1987), ed., *Advances in the Economics of Energy and Resources,* Vol. 6, Greenwich, CT, JAI Press, pp. 125-162.

5. *Consumer services:* Expenditures on consumer services, such as car repairs, medical services, entertainment, and so on.

We employ the following demographic characteristics as attributes of individual households:

1. *Family size:* 1, 2, 3, 4, 5, 6, and 7 or more persons.

2. *Age of head:* 16-24, 25-34, 35-44, 45-54, 55-64, 65 and over.

3. *Region of residence:* Northeast, North Central, South, and West.

4. *Race:* White, nonwhite.

5. *Type of residence:* Urban, rural.

We treat expenditure shares for the five commodity groups as endogenous variables, so that we estimate four equations. As unknown parameters we have four elements of the vector α_p, four expenditure coefficients of the vector $B_{pp}\iota$, sixteen attribute coefficients for each of the four equations in the matrix B_{pA}, and ten price coefficients in the matrix B_{pp} which is constrained to be symmetric. The expenditure coefficients are sums of price coefficients in the corresponding equation, so that we have a total of 82 unknown parameters. Jorgenson and Slesnick (1987) estimated the complete model by pooling time-series and cross-section data.

Provided that the parameters of the model of aggregate expenditures are identified, these parameters could be estimated from aggregate data alone. A necessary condition for identification is that the number of free parameters in the aggregate model must be less than the total number of instruments, assuming that no multicollinearity exists among the instruments. This condition would require a very large number of instruments to identify all the unknown parameters from our model for aggregate expenditures. Accordingly, we employ methods of estimation based on individual observations and make use of the variation in prices over time and across regions to identify the unknown parameters.

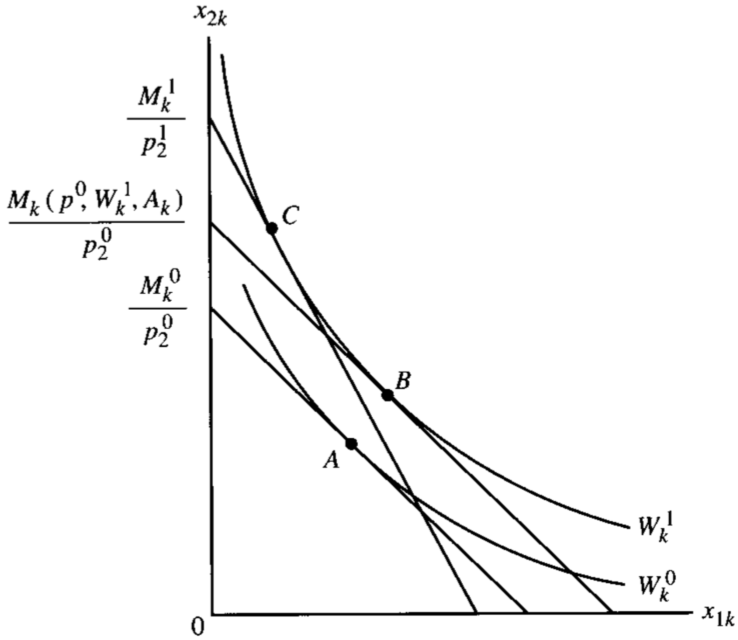

Figure 1: Household standard of living and its cost.

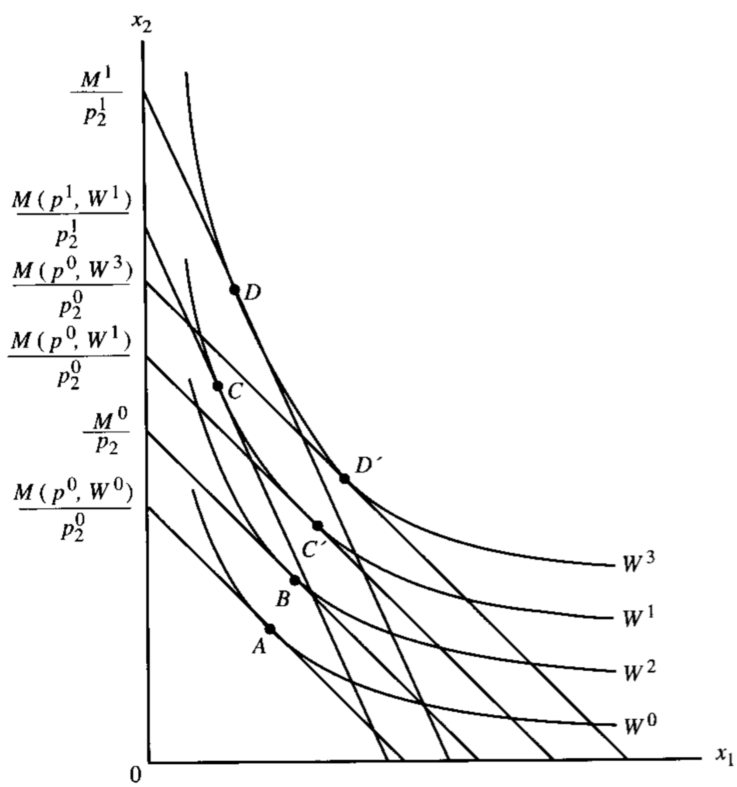

Figure 2: Social standard of living and its cost.

Figure 3: New Architecture for an Expanded and Integrated Set of National Accounts for the United States

1. PRODUCTION

Gross Domestic Product Equals

Gross Domestic Factor Outlay

2. DOMESTIC RECEIPTS AND EXPENDITURES

Domestic Receipts Equal

Domestic Expenditure

3. FOREIGN TRANSACTION CURRENT ACCOUNT

Receipts from Rest of World Equal

Payments to Rest of World and

Balance on Current Account

4. DOMESTIC CAPITAL ACCOUNT

Gross Domestic Capital Formation Equals

Gross Domestic Savings

5. FOREIGN TRANSACTION CAPITAL ACCOUNT

Balance on Current Account Equals

Payments to Rest of the World and

Net Lending or Borrowing

6. DOMESTIC BALANCE SHEET

Domestic Wealth Equals

Domestic Tangible Assets and

U.S. Net International Position

7. U.S. INTERNATIONAL POSITION

U.S.-Owned Assets Abroad Equal

Foreign-Owned Assets in U.S. and

U.S. Net International Position

Table 1: Production Account, 2010

Output

Line		Product	Source	Total
1		GDP (NIPA)	NIPA 1.1.5 line 1	14,526.5
2	+	Services of consumers' durables	our imputation	1,396.6
3	+	Services of household land (net of BEA estimate)	our imputation	174.6
4	+	Services of durables held by institutions	our imputation	49.9
5	+	Services of durables, structures, land, and inventories held by government	our imputation	500.4
6	+	Private land investment	our imputation	0.0
7	+	Government land and inventory investment	our imputation	-62.6
8	-	General government consumption of fixed capital	NIPA 3.10.5 line 5	278.6
9	-	Government enterprise consumption of fixed capital	NIPA 3.1 line 38 - 3.10.5 line 5	55.4
10	-	Federal taxes on production and imports	NIPA 3.2 line 4	101.5
11	-	Federal current transfer receipts from business	NIPA 3.2 line 16	48.7
12	-	S&L taxes on production and imports	NIPA 3.3 line 6	952.6
13	-	S&L current transfer receipts fom business	NIPA 3.3 line 18	50.3
14	+	Capital stock tax	-	0.0
15	+	MV tax	NIPA 3.5 line 28	9.1
16	+	Property taxes	NIPA 3.3 line 8	430.6
17	+	Severance, special assessments, and other taxes	NIPA 3.5 line 29,30,31	74.5
18	+	Subsidies	NIPA 3.1 line 25	57.3
19	-	Current surplus of government enterprises	NIPA 3.1 line 14	-15.7
20	=	Gross domestic product		15,685.5

Factor Outlay

Line		Income	Source	Total
1	+	Consumption of fixed capital	NIPA 5.1 line 13	1,874.9
2	+	Statistical discrepancy	NIPA 5.1 line 26	0.8
3	+	Services of consumers' durables	our imputation	1,396.6
4	+	Services of household land (net of BEA estimate)	our imputation	174.6
5	+	Services of durables held by institutions	our imputation	49.9
6	+	Services of durables, structures, land, and inventories held by government	our imputation	500.4
7	+	National Income Adjustment for Land Investment	our imputation	-62.7
8	-	General government consumption of fixed capital	NIPA 3.10.5 line 5	278.6
9	-	Government enterprise consumption of fixed capital	NIPA 3.1 line 38 - 3.10.5 line 5	55.4
10	+	National income	NIPA 1.7.5 line 16	12,840.1
11	-	ROW income	NIPA 1.7.5 line 2-3	189.4
12	-	Sales tax	Product Account	638.9
13	+	Subsidies	NIPA 3.1 line 25	57.3
14	-	Current surplus of government enterprises	NIPA 3.1 line 14	-15.7
15	=	Gross domestic income		15,685.4

Table 2: Domestic Receipts and Expenditures, 2010

Receipts

Line	Income	Source	Total
1	+ Gross income	Product Account	15,685.4
2	+ Production taxes	Product Account	638.9
3	- Subsidies	NIPA 3.1 line 25	57.3
4	+ Current surplus of government enterprises	NIPA 3.1 line 14	-15.7
5	= Gross domestic income at market prices		16,251.3
6	+ Income receipts from the rest of the world	NIPA 1.7.5 line 2	702.9
7	- Income payments to the rest of the world	NIPA 1.7.5 line 3	513.5
8	- Current taxes and transfers to the rest of the world (net)	NIPA 4.1 line 25	151.6
9	= Gross income		16,289.1
10	- Depreciation	our imputation	2,776.3
11	= Net income		13,512.8

Expenditures

Line	Expenditures	Source	Total
1	+ Personal consumption expenditures		10,781.1
2	PCE nondurable goods (NIPA)	NIPA 2.3.5 line 6	2,301.5
3	PCE services (NIPA)	NIPA 2.3.5 line 13	6,858.5
4	PCE services less space rental value of inst building and nonfarm dwellings	our imputation	5,729.2
5	Services of consumers' durables	our imputation	1,396.6
6	Services of structures and land	our imputation	1,303.9
7	Services of durables held by institutions	our imputation	49.9
8	+ Government consumption expenditures		2,663.9
9	Government consumption nondurable goods	NIPA 3.10.5 line 8	271.1
10	Government intermediate purchases, durable goods	NIPA 3.10.5 line 7	75.6
11	Government consumption services total		369.1
12	Government consumption services	NIPA 3.10.5 line 9	758.1
13	Less sales to other sectors	NIPA 3.10.5 line 11	389.0
14	Services of durables, structures, land, and inventories held by government	our imputation	500.4
15	Less government enterprise consumption of fixed capital	NIPA 3.1 line 38 - 3.10.5 line 5	55.4
16	Government compensation of employees exluding force account labor	NIPA 3.10.5 line 4-10	1,503.1
17	+ Gross national saving and statistical discrepancy	Capital Account	2,844.0
	- Depreciation	our imputation	2,776.3
18	= Net domestic expenditures		13,512.8

Table 3: Contributions to Output Growth, 1948-2010

Average Annual Growth Rates

Output	1948-2010	1948-1973	1973-1995	1995-2000	2000-2005	2005-2010
Gross Domestic Product	3.18	3.95	2.68	4.14	2.87	0.94
Contribution of Consumption	2.29	2.79	1.96	2.33	2.26	1.27
Contribution of Investment	0.89	1.16	0.72	1.81	0.61	-0.33
Input and Productivity	**1948-2010**	**1948-1973**	**1973-1995**	**1995-2000**	**2000-2005**	**2005-2010**
Gross Domestic Factor Outlay	2.59	2.93	2.52	3.49	2.05	1.07
Contribution of Capital Services	1.64	1.88	1.40	2.20	1.58	1.05
Contribution of Labor Services	0.95	1.06	1.12	1.29	0.24	0.03
Multifactor Productivity	0.59	1.02	0.16	0.65	0.83	-0.14

Table 4: Contributions to Growth of Net Expenditures, 1948-2010

Average Annual Growth Rates

Receipts	1948-2010	1948-1973	1973-1995	1995-2000	2000-2005	2005-2010
Domestic Receipts	2.24	2.70	2.15	3.02	1.14	0.68
Contribution of Labor Income	1.08	1.19	1.29	1.48	0.28	0.02
Contribution of Net Property Income	1.16	1.51	0.86	1.54	0.86	0.66
Level of Living	0.74	1.03	0.56	0.90	1.17	-0.46

Expenditures	1948-2010	1948-1973	1973-1995	1995-2000	2000-2005	2005-2010
Net Expenditures	2.99	3.73	2.71	3.91	2.31	0.23
Contribution of Consumption	2.82	3.34	2.44	3.34	2.72	1.50
Contribution of Personal Consumption	2.36	2.69	2.07	3.12	2.45	1.12
Contribution of Government Consumption	0.46	0.65	0.37	0.21	0.27	0.37
Contribution of Net Saving	0.16	0.39	0.27	0.57	-0.42	-1.27

Table 5: Measures of Social Welfare, 1948-2006

Average Annual Growth Rates

	1948-2006	1948-1973	1973-1995	1995-2000	2000-2006
Standard of Living	2.69	3.62	2.02	1.94	1.94
Efficiency	2.46	2.83	2.11	2.64	2.08
Equity	0.23	0.79	-0.10	-0.71	-0.14