Measuring Real Income with Leisure and Household Production

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Abstract

The present paper examines several issues involved in expanding national economic accounts and social indicators to include the "consumption" of time. The first part examines this question in the context of the concepts of the standard national economic accounts. It derives equilibrium conditions for consumer behavior with market and non-market consumption along with intrinsic values of time in different activities. Using a standard index-number approach, it shows that a full set of accounts has data requirements that are far beyond those that are currently or prospectively available, with problems particularly arising for the valuation of time and for measuring technological change for non-market consumption and use of time. However, in a simplified case, the paper shows that the growth of real income can be approximated by a weighted average of productivity growths in market and non-market productivity and that the valuation of hours drops out of the formula. The second part of the paper examines the role of social indicators using the approach of hedonic psychology to value time in different activities. It raises several conceptual problems with this approach. One problem is that the "time-slice" approach of hedonic psychology has difficulties in measuring the equilibrium (marginal) valuations, while the approach of total valuation raises deep issues about where the natural "zero" of consumption lies. A second problem arises because of the non-storable nature of time, while a third arises because of simultaneous activities, both of which imply that the hedonic valuations are likely to be inaccurate. A fourth difficulty arises because the valuations in hedonic psychology rely upon additive separability of the utility function, whereas both standard economic theory and a variety of results from psychological experiments indicate that there are deep and pervasive patterns of intertemporal and intratemporal complementarity and substitution among different activities. A final concern with using the hedonic approach as a social indicator is that the hedonic measures do not meet the standards for a measurable variable – having a natural zero and a well-defined unit of increment – that are required to construct a meaningful index that can be aggregated across persons and time.

I. <u>The Central Role of Time in Augmented Accounting</u>

Our economic accounts center primarily on market transactions. But much of economic activity, and in all likelihood much of economic welfare, depends upon activities outside of the market place. Moreover, although we do not yet have a set of economic accounts that incorporates the use of time, it is plausible that the economic value of time is the most important single non-market input, and perhaps also non-market output.

I will consider two issues relating to the use of time in this note. First, how might we integrate time into our economic accounts? Second, are attempts to use hedonic psychology likely to be a fruitful way of valuing time in our economic accounts?

To begin with, it is worth reflecting on the importance of time use for non-market economic activity. Non-market activity consists of activities like education, recreation and other uses of leisure time, babysitting, home production of laundry and similar services, and work-related activities like commuting. The inputs into these activities consist of non-market and market labor, capital services, and material inputs. By far the largest component of non-market activity is labor (time). Indeed, virtually the entire value added of the non-market sectors comes from time inputs, while most of the non-time inputs are actually purchased in the market economy.

Consider the value of home production (such as doing the laundry) or recreation (such as golfing). The total value of such activities consists of the value of purchased market inputs (soap, washing machines, golf balls, and golf clubs) plus the value of the time spent in the activities. For example, doing the family laundry might have total value of $21, of which $20 (1 hour × $20 per hour) is the value of the time, while $1 is the cost of the soap and washing-machine services. Whatever the relative values, virtually all the non-market inputs are likely to be time.

The same story holds for virtually every non-market activity: the major non-market input is labor. The one important exception might be the inputs of non-market environmental capital (clean air, clean water, public beaches) that enter into recreation and health activities. These examples suggest that measuring and valuing time use may be the most important single component of non-market accounts.

Up to recently, the United States had been particularly laggard with respect to generating comprehensive and periodic time-use statistics. Fortunately, beginning in 2003, the Bureau of Labor Statistics began the collection of a large time-use survey for the United States (the American Time Use Survey, or ATUS).[1] In the latest survey year, 2006, this survey interviewed 13,000 households annually from the out-rotating panel of the Current Population Survey. It is currently the only time-use survey in the world to be conducted on a continuous basis. The ATUS will be an important addition to the U.S. statistical system and a crucial ingredient in the future construction of augmented accounts. In addition, there are now harmonized historical data on time use, such as the American Heritage Time Use Study (AHTUS).[2] The time of time-use studies has arrived.

II. Consumer Preferences and Equilibrium Conditions

This section examines the incorporation of time use into the standard national economic accounts. It derives equilibrium conditions for consumer behavior with market and non-market consumption along with intrinsic values of time in different activities. Using a standard index-number approach, it shows that a full set of accounts has data requirements that are far beyond those that are currently or prospectively available, with problems particularly arising for the valuation of time and for measuring technological change for non-market consumption and use of time. However, in a simplified case, we show that the growth of real income can be approximated by a weighted average of productivity growths in market and non-market productivity and that the valuation of hours drops out of the formula. We examine the case of a representative consumer. Further difficult issues, such as aggregation of diverse individuals or households, are discussed briefly.

A. Consumer Preferences and Equilibrium Conditions

1. *Individual decisions*

[1] A review of the BLS time-use survey is contained at http://www.bls.gov/atus/home.htm .

[2] The web page containing a description is at http://www.timeuse.org/ahtus/

I begin with a standard analysis of how consumers allocate their time and choose consumption. For this purpose, I assume that preferences are time-separable and examine the *ith* consumer deciding at time *t*. The consumer can choose to work in the market and buy market goods; work at home and produce home goods; and use time to enjoy leisure or non-work activities.

We begin with the determinants of consumer choice as represented by a standard ordinal preference function. (I call this a "preference function" instead of a "utility function" to reserve the latter for the psychological hedonics below.) *W* is an ordinal index that represents more preferred combinations of bundles as higher values, while *U* is a standard preference function for individual *i* at time *t*.

$$(1) \qquad W_{i,t} = U\left(c^{m}_{i,t},\ c^{nm}_{i,t}, B^{m}_{i,t}h^{m}_{i,t}, B^{nm}_{i,t}h^{nm}_{i,t},\ B^{l}_{i,t}h^{l}_{i,t} \right)$$

where

$c^{m}_{i,t}$ = market consumption,

$c^{nm}_{i,t}$ = home consumption,

$h^{m}_{i,t}$ = market hours,

$h^{nm}_{i,t}$ = home work hours,

$h^{l}_{i,t}$ = leisure and non - work time,

$B^{m}_{i,t}$ = technological change in market time

$B^{nm}_{i,t}$ = technological change in non - market time,

$B^{l}_{i,t}$ = technological change in leisure.

This formulation is unusual in the literature on time use in specifically incorporating a "process value" or "intrinsic value" of time. It also is novel in allowing for the possibility of technological change that makes time spent more or less pleasant. Some examples would be the development of technologies that make work more pleasant (such as ventilation or air conditioning of factories), that make home work more pleasant (such as dishwashers), and that make leisure more pleasant (such as improved television sets). The point is that technologies can make non-market time more productive (by using machines rather than hand washing), but also technologies can make the experiences themselves more preferred. Of course, as in the case of air travel or airline food, time spent can also become more unpleasant.

Note that the preference function is not separable over activities. Most work on estimating the process value of time, going back to Thomas Juster and continuing with Alan Krueger et al., assumes that the preference function is to be separable across different time uses.[3] This assumption has been viewed as inappropriate and incompatible with empirical evidence in preference theory for many decades.[4]

The consumer has three constraints: an income constraint determining market consumption, a home production function relating home work and home consumption, and a time budget. The first is that market consumption equals a fixed element (fringe benefits plus property income plus net transfers) plus market hours times the marginal wage:

(2) $$c^{m}_{i,t} = I_{i,t} + w^{m}_{i,t}\, h^{m}_{i,t}$$

We simplify this analysis by assuming that marginal compensation is proportional to the average productivity of market labor for that individual, $A^{m}_{i,t}$, so:

(3) $$c^{m}_{i,t} = A^{m}_{i,t}\, h^{m}_{i,t}$$

Home production is given by the home production function:

(4) $$c^{nm}_{i,t} = A^{nm}_{i,t} h^{nm}_{i,t}$$

where $A^{nm}_{i,t}$ is the productivity of per hour worked of home production.

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[3] F. Thomas Juster, "Preferences for Work and Leisure," in F.T. Juster and F.P. Stafford, eds., *Time, Goods, and Well-being*. Ann Arbor, MI, University of Michigan, 1985, pp. 333-51; Alan B. Krueger, Daniel Kahneman, David Schkade, Norbert Schwarz, and Arthur A. Stone, "National Time Accounting: The Currency of Life," paper presented at the National Bureau of Economic Research, Time Use Conference, December 7-8, 2007.

[4] George Stigler, "The Development of Utility Theory. I," *The Journal of Political Economy*, vol. 58, no. 4, August 1950, pp. 307-327.

Finally, we have the time budget constraint:

(5) $$1 = h_{i,t}^{m} + h_{i,t}^{nm} + h_{i,t}^{l}$$

We index total time to unity.

We assume that preferences and resources are intertemporally separable. This assumption is purely for expositional convenience and does not change the measurements or analysis. Maximizing the preference function subject to the budget constraints yields the following two first-order conditions:

(6) $$\frac{\partial U}{\partial h_{i,t}^{m}} = U_{1,t} w_{i,t} + B_{i,t}^{m} U_{3,t} - B_{i,t}^{l} U_{5,t} = 0$$

(7) $$\frac{\partial U}{\partial h_{i,t}^{nm}} = U_{2,t} A_{i,t}^{nm} + B_{i,t}^{nm} U_{4,t} - B_{i,t}^{l} U_{5,t} = 0$$

For notational convenience, we denote $\partial U / \partial x_{k,t} = U_{k,t}$, where k is the kth argument of the preference function in (1), and these elements are time dated to recognize that the marginal preferences change over time.

Equation (6) states that the marginal preference value of leisure should equal to the value of an hour in the market in producing goods. Equation (7) states that the marginal preference value of leisure should equal the value of an hour of home work in producing home goods.

These conditions differ from standard practice in one major respect: Each equilibrium condition recognizes that there may be process or intrinsic values of time in different activities (market work and home work) and that these values therefore need to be netted out in the calculation. In the usual case where the marginal preference value of work is equal in the market and at home and there is a homogeneous output, we get the standard condition that the productivity of home production equals the marginal post-tax wage. There are also lots of unobservable variables in this approach, which will come back to haunt us when we attempt to construct an empirical measure reflecting the underlying preference function.

b. Measuring Real Income with Apples, Pears, and Hours

We now consider the question of how to measure real income when we include the "consumption of time" along with consumption of goods and services – we want to add apples, pears, and hours, so to speak. In developing an index in the absence of complete data, the equilibrium conditions are necessary for developing the theory behind economic accounting that includes time. [5]

In this section, we are interested in devising a measure of "real income" that is the analog of real income in the theory of income and prices. The concept underlying the approach is Becker's concept of "whole income."[6] We begin with a measure of real income of individual *i* at time *t*, $R_{i,t}$, that contains all consumption and time uses.

$$(8) \qquad R_{i,t} = \Re\left(c^{m}_{i,t},\, c^{nm}_{i,t}, B^{m}_{i,t}h^{m}_{i,t}, B^{nm}_{i,t}h^{nm}_{i,t},\, B^{l}_{i,t}h^{l}_{i,t} \right)$$

We will be examining primarily growth rates of this index. As with all measures of real income or output, the function $\Re$ is assumed to be locally homothetic. Furthermore, we use market goods as the numéraire. The rate of growth of real income is measured as:

$$(9) \qquad g(R_{i,t}) = s(c^{m}_{i,t})g(c^{m}_{i,t}) + s(c^{nm}_{i,t})g(c^{nm}_{i,t}) + s(h^{m}_{i,t})g(B^{m}_{i,t}h^{m}_{i,t}) + s(h^{nm}_{i,t})g(B^{nm}_{i,t}h^{nm}_{i,t}) + s(h^{l}_{i,t})g(B^{l}_{i,t}h^{l}_{i,t})$$

In this equation, $g(\cdot)$ is the proportional rate of growth of the element and $s(\cdot)$ is the elasticity of the real income function with respect to that element. In a market context, the elasticities are the expenditure shares of each element in whole income using the market or preference prices of each element. The expenditure shares are defined as $s(x_{k,i,t}) = \pi_{k,i,t}x_{k,i,t} \Big/ \sum_{k=1}^{5} \pi_{k,i,t}x_{k,i,t}$. In this expression,

[5] The approach followed here follows the standard approach to the development of indexes of real income and expenditures. See for example W. Erwin Diewert, "Index Numbers," in J. Eatwell, M. Milgate and P. Newman, Eds., *The New Palgrave: A Dictionary of Economics,* Volume 2, Macmillan, London, 1987, pp. 767-780.

[6] Gary S. Becker, "A Theory of the Allocation of Time," *The Economic Journal*, Vol. 75, No. 299, Sept. 1965, pp. 493-517.

$x_{k,i,t}$ is the *kth* element, $\pi_{k,i,t} = \Re_{k,i,t} / \Re_{1,i,t} = U_{k,i,t} / U_{1,i,t}$ is the marginal rate of substitution between item *k* and market consumption; item *k* represents the *kth* element in the preference or real-income function; and subscripts k = 1 through 5 represent market consumption, non-market consumption, market time, non-market time, and leisure time.

We can take different approaches to construct a social index. The usual index, following Robert Pollak, uses the approach of the "plutocratic index" in which each (real) dollar is equally weighted.[7] This then yields a growth rate in the total or national index that is simply the sum of the individual indexes where the individual indexes are weighted by market consumption. We will omit this step for brevity and because it adds nothing of interest.

c. The fundamental measurement problem

Our theory now collides with a fundamental measurement difficulty. Our measure of the growth of real whole income requires measures of both the items in the preference function as well as the marginal preference values. Only one of these, market consumption, has comprehensive measures, although we now have reasonably complete measures of hours for the U.S. since 2003. We have no serious measures of home consumption. Furthermore, we have no measures at all of the marginal rates of substitution between time and market consumption (the $\pi_{k,i,t}$). And we have no measures of any of the technological variables outside the marketplace (the $B_{i,t}^{k}$). In other words, any attempt to measure whole income is doomed to failure for lack of critical data.

d. A simplified measure of income growth

We can develop a substitute for the ideal growth index with some further assumptions. First, we assume that there is no technological change in the technology of time use. In other words, the $B_{i,t}^{k}$ = 1 for all *k*. Second, we assume that it is possible to measure the productivity of non-market work. We then rewrite equation (9) as:

[7] The concepts are discussed in Robert A. Pollak, "The Consumer Price Index: A Research Agenda and Three Proposals," *The Journal of Economic Perspectives,* Vol. 12, No. 1 (Winter, 1998), pp. 69-78.

(10) $$\dot{R}_{i,t} = \dot{c}^{m}_{i,t} + \pi_{cnm,t}\dot{c}^{nm}_{i,t} + \pi_{hm,t}\dot{h}^{m}_{i,t} + \pi_{hnm,t}\dot{h}^{nm}_{i,t} + \pi_{hl,t}\dot{h}^{l}_{i,t}$$

We take the time derivatives of equations (2) and (3), obtaining:

(11) $$\dot{c}^{m}_{i,t} = \dot{w}_{i,t}\, h^{m}_{i,t} + w_{i,t}\, \dot{h}^{m}_{i,t}$$

(12) $$\dot{c}^{nm}_{i,t} = \dot{A}^{nm}_{i,t} h^{nm}_{i,t} + A^{nm}_{i,t} \dot{h}^{nm}_{i,t}$$

Substituting these into (10) yields

$$\dot{R}_{i,t} = \dot{w}_{i,t}\, h^{m}_{i,t} + \pi_{cnm,t}\dot{A}^{nm}_{i,t} h^{nm}_{i,t} + \Psi_{i,t}$$

where

$$\Psi_{i,t} = \dot{h}^{m}_{i,t}\left(w^{m}_{i,t} + \pi_{hm,t} \right) + \dot{h}^{nm}_{i,t}\left(\pi_{cnm,t} A^{nm}_{i,t} + \pi_{hnm,t} \right) + \pi_{hl,t}\, \dot{h}^{l}_{i,t}$$

From the first-order conditions in (6) and (7) and the time budget constraint in (4), we have $\Psi_{i,t} = 0$, which reduces the expression in (13) to

(14) $$\dot{R}_{i,t} = \dot{w}_{i,t}\, h^{m}_{i,t} + \pi_{cnm,t}\dot{A}^{nm}_{i,t} h^{nm}_{i,t}$$

We then make one further simplification. We take the shares in equation (9) to be the shares of whole consumption rather than whole income, where whole consumption is equal to market plus non-market consumption. Substituting from (4) that the growth in market income is $\dot{w}^{m}_{i,t}/w^{m}_{i,t} = \dot{A}^{m}_{i,t}/A^{m}_{i,t}$, this implies that the growth in real income is:

(15) $$g(R_{i,t}) = \dot{R}_{i,t}/R_{i,t} = g(A^{m}_{i,t})\sigma(c^{m}_{i,t}) + g(A^{nm}_{i,t})\sigma(c^{nm}_{i,t})$$

where $g(A^{m}_{i,t})$ and $g(A^{nm}_{i,t})$ are the rates of productivity growth in the market and the non-market consumption sectors, and the weights are the shares of the two items in whole consumption, $\sigma(c^{m}_{i,t}) = c^{m}_{i,t} \Big/ \left(c^{m}_{i,t} + \pi^{nm}_{i,t} c^{nm}_{i,t} \right)$ and $\sigma(c^{nm}_{i,t}) = \pi^{nm}_{i,t} c^{nm}_{i,t} \Big/ \left(c^{m}_{i,t} + \pi^{nm}_{i,t} c^{nm}_{i,t} \right)$.

We can get a slightly more intuitive result if we simplify further. Assume that the marginal preference value of market work is equal to the marginal preference value of home work and that the marginal product of home work is equal to the marginal compensation of market work. These assumptions imply that the weights in (15) are proportional to h^m and h^{nm}, which yields:

$$(16) \qquad g(R_{i,t}) = g(A_{i,t}^{m})\left(\frac{h_{i,t}^{m}}{h_{i,t}^{m}+h_{i,t}^{nm}}\right)+g(A_{i,t}^{nm})\left(\frac{h_{i,t}^{nm}}{h_{i,t}^{m}+h_{i,t}^{nm}}\right)$$

Equations (15) and (16) are the fundamental results. The simpler expression in (16) states that the growth in real income is equal to the weighted growth of market and home productivity, where the weights are the relative importance of market time and home-work time. This is completely intuitive in emphasizing that the productivity of non-market time is a key ingredient in economic welfare. The important and non-intuitive result in equations (15) and (16) is that the valuation of hours can be eliminated from the equation for the growth of real income. Only the growth rates of productivity in the two consumption sectors, and their shares, enter into the growth equation.

The correct growth rate would be slightly different if we made different assumptions about differences in marginal preference values or relative productivities of home production, but equation (16) provides the basic intuition. Note that the only difference between (15) and (16) is the relative size of the weights.

The results depend upon strong assumptions, however. They require not only that the consumer equilibrium conditions in (6) and (7) hold, but also that there is no technological change in the enjoyment of time. While we might worry that these are unrealistic, it is hard to imagine any series of measurements that could shed much light on these issues.

How much does the growth in real income given in equation (16) differ from conventional measures? According to the ATUS, time devoted to market and non-market work were approximately the same in 2003-2006 (3.5 hours per day for market work v. 3.8 hours per day for non-market work). This indicates that the welfare significance of productivity growth in non-market work is of the same order of importance as productivity growth in market work. We have virtually no serious research on the relative importance of market productivity growth as compared to home productivity growth, so the relative importance of the two terms in the welfare equation (16) is currently unknown.

e. Graphical approach

We can show the results graphically as follows. To derive the graphical results, we simplify by assuming that the preference function is additively separable, so

$$(17) \qquad W_{i,t} = U_{cm}\left(c_{i,t}^{m}\right) + U_{cnm}\left(c_{i,t}^{nm}\right) + U_{hm}\left(h_{i,t}^{m}\right) + U_{hnm}\left(h_{i,t}^{nm}\right) + U_{hl}\left(h_{i,t}^{l}\right)$$

Define the net marginal preference value of an hour of market work, home work, and leisure, respectively, as

$$N\left(h^{m}\right) = U_{cm}'\left(c_{i,t}^{m}\right)w_{i,t} + U_{hm}'\left(h_{i,t}^{m}\right)$$
$$N\left(h^{nm}\right) = U_{cnm}'\left(c_{i,t}^{nm}\right)A_{i,t} + U_{hnm}'\left(h_{i,t}^{nm}\right)$$
$$MU\left(h^{l}\right) = U_{hl}'\left(h^{l}\right)$$

The equilibrium conditions are then

$$(18) \qquad N\left(h^{m}\right) = N\left(h^{nm}\right) = MU\left(h^{l}\right)$$

Figure 1 shows a Jevons stick diagram for the allocation of time using separable utility. The downward sloping lines show the net marginal preference value of market and home work, while the upward sloping line shows the marginal preference value of leisure, with leisure measured leftward from the right axis. At the standard equilibrium, the net marginal preference values of market and home work are equalized to the marginal preference value of leisure time, with market work being the segment ***AB***, home work being the segment ***BC***, and leisure time being the segment ***CD***.

III. Valuation Using Direct Measurement via Hedonic Psychology

The first part of this analysis examined incorporating time use using the standard approach of national economic accounting. We now examine the potential of developing social indicators using the approach of hedonic psychology to value time in different activities. While this approach has much appeal, particularly the possibility of obtaining direct measures of the stated value of different uses of time, there are several conceptual problems with this approach.

In this section, we begin with some introductory comments on the hedonic approach. We then review some of the difficulties. One problem is that the "time-slice" approach of hedonic psychology has difficulties in measuring the equilibrium (marginal) valuations, while the approach of total valuation raises deep issues about where the natural "zero" of consumption lies. A second problem arises because of the non-storable nature of time, while a third arises because of simultaneous activities, both of which imply that the valuations are likely to be inaccurate. A fourth difficulty arises because the valuations in hedonic psychology rely upon additive separability of the utility function, whereas both standard economic theory and a variety of results from psychological experiments indicate that there are deep and pervasive patterns of intertemporal and intratemporal complementarity and substitution among different activities. A final concern with using the hedonic approach as a social indicator is that the hedonic measures do not meet the standards for a measurable variable – having a natural zero and a well-defined unit of increment – that are required to construct a meaningful index that can be aggregated across persons and time.

a. Apples, pears, hours, and hedonic psychology

To construct a meaningful social indicator, it is necessary to aggregate quantities of hours in different activities of different people using some appropriate set of marginal valuations. In principle, this is no different from the apples and pears that are aggregated in the national income accounts. But we have no marginal valuations. We are stymied because of the lack of observable market-like behavior relating to time. (By "market-like behavior," I mean decisions in which the relative marginal preference values of different outcomes are revealed by decisions taken in the fact of realistic prices or costs, and ones where decision makers have incentives to reveal accurate and reliable information.)

In the absence of direct market-like measures of relative preferences, we might rely upon survey techniques. One approach, which has not been followed, would be a contingent valuation study of time. An alternative might be laboratory experiments where subject barter time with one another.

A new approach, which I will discuss in this section, uses the methodology of hedonic psychology. This is the science of directly measuring utility, happiness, emotions, or the emotional outcomes of consumption or other activities of everyday life.

The first challenge here is to find a measuring rod – a hedonimeter – to measure the pain or pleasure involved in different experiences. We can begin with the original discussion more than a century ago by F.Y. Edgeworth: [8]

> Imagine an ideally perfect instrument, a psychophysical machine, continually registering the height of pleasure experienced by an individual, exactly according to the verdict of consciousness, or rather diverging therefrom according to a *law of errors*. From moment to moment the hedonimeter varies; the delicate index now flickering with the flutter of the passions, now steadied by intellectual activity, low sunk whole hours in the neighborhood of zero, or momentarily springing up towards infinity. The continually indicated height is registered by photographic or other frictionless apparatus upon a uniformly moving vertical plane…. The integration must be extended from the present to the infinitely future time to constitute the end of pure egoism.…We have only to add another dimension expressing the number of sentients, and to integrate through all time and over all sentience, to constitute the end of pure utilitarianism.

Recent developments in hedonic psychology have launched a major research program to pursue Edgeworth's dream. As Kahneman, Diener, and Schwartz conclude in their overview of a compendium of studies in their edited volume, *Well-Being:*

> We are particularly hopeful that a scientific understanding of hedonic experience will allow for the development of valid hedonic indicators that reflect the pleasantness of life in the everyday experiences of people….To this end, we propose that nations should begin monitoring pleasure and pain through on-line experience recording among samples of respondents to complement existing social indicators, and to provide a more direct assessment of the final outcome about which people are most concerned.[9]

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[8] F.Y. Edgeworth, *Mathematical Psychics,* London, C. Kegal Paul & Co., 1881, p. 101-102.
[9] Daniel Kahneman, Ed Diener, and Norbert Schwartz, "Preface," in Daniel Kahneman, Ed Diener, and Norbert Schwartz, Eds., *Well-Being: The Foundations of Hedonic Psychology,* Russell Sage Foundation, New York, 1999, pp. xi-xii.

The study of Krueger, Kahneman, Schkade, Schwarz, and Stone is a major attempt to implement this research agenda with time-use data.[10]

Does this actually lead to a meaningful social index that can be used for the purpose of welfare analysis in the traditional economic sense? Economists have been taught to regard such an approach with the deepest suspicion. As Paul Samuelson summarized:[11]

> With ever fewer exceptions, modern economic theorists believe that … everything of interest and relevance in [the nonstochastic theory of consumer preference] can be expressed in purely *ordinal* terms.

I review two sets of difficulties that arise in using hedonic psychology to develop a social indicator constructed from time use. The first relates to measurement problems that arise particularly when time use is the activity on which emotions are attached. The second issue concerns whether the project of interpersonal comparison of hedonic measures is a meaningful activity.

b. Problems with time use as the hedonic commodity

Time use has some special problems for valuation with hedonic psychology, of which I discuss four.

1. *Difficulties in measuring marginal values*

The first issue arises when we attempt to put valuations on time in the context of "utility analysis" or "preference analysis." What are we attempting to measure with our hedonimeter? Are we trying to test whether the equilibrium conditions for utility maximization are met? Or, are we attempting to estimate the total surpluses of each activity (roughly, the total area under the different marginal preference value curves and above some arbitrary zero level of consumption)?

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[10] Alan B. Krueger, Daniel Kahneman, David Schkade, Norbert Schwarz, and Arthur A. Stone, "National Time Accounting: The Currency of Life," paper presented at the National Bureau of Economic Research, Time Use Conference, December 7-8, 2007.
[11] Paul A. Samuelson, "Probability, Utility, and the Independence Axiom," *Econometrica,* vol. 20, no. 4, Oct. 1952, pp. 670-678 at p. 670.

One interpretation is that the effort is attempting to verify the equilibrium conditions, which are the valuations in economic accounts. The problem here is that it is difficult to ensure that we are capturing equilibrium valuations in a slice-of-time sampling methodology, as in shown in Figure 2. The marginal values of time are shown as the heavy upper envelop of the marginal valuations of the three activities, traced out as the line ***ABCD.*** We also show three observations of time value as points *Obs m, Obs h,* and O*bs ℓ.* These are respectively observations of the intrinsic value of a slice of market time, home-work time, and leisure time.

Even in the situation where we have perfectly resolved the issues of how to measure process value – we have the perfect hedonimeter – we are almost certain to capture above-equilibrium slices of time. If we took the observations in Figure 2, we would conclude that home work is ranked first, leisure is ranked second, and market work is ranked third. The ranking would be subject to sampling error, and it is very unlikely that we would get a slice of any of the three activities at point ***C***, which is the point at which the values of the marginal hours are equalized.

One response to this concern is that, as long as the marginal valuations are linear, the slices would provide unbiased estimates of the average marginal values. However, this implies that we are interested in total surplus or utility rather than equilibrium marginal utility from different uses of time. Attempting to measure total utility or total surplus falls into the conceptual morass called the "zero problem."[12] Suppose that we want to measure the total consumer surplus of water consumption in the national accounts. We then need to integrate the marginal surpluses between some "zero" level and current consumption. But what do we mean by zero? Is it literally zero water consumption (in which case consumer surplus is equal to the value of life itself)? Or is it the level of consumption in pre-industrial times? If the latter, should pre-industrial times relate to the 1700s, when water in the U.S. was plentiful? Or to the time when humans first crossed the Bering land bridge, when ice was plentiful but water was scarce? In time-use studies, should we consider the surplus of time spent breathing? If so, would this include the first minute as well as the marginal minute? If we attempt to measure total surpluses for necessities in too many areas with low "zeroes," we will undoubtedly find ourselves with multiple infinities of output and income.

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[12] See William Nordhaus, "Principles of National Accounting for Nonmarket Accounts," in Dale W. Jorgenson, J. Steven Landefeld, and William D. Nordhaus, Eds., *A New Architecture for the U.S. National Accounts,* Chicago, University of Chicago Press, 2006, pp. 143-160.

2. *Difficulties due to non-storability of time*

A second issue revolves around the fact that time is a non-storable commodity. In the analytical section above, we assumed that time could be allocated to different activities without regard to the time of day, week, or year. In reality, time is a heterogeneous commodity rather than a homogeneous lump that can be allocated continuously over tasks. For example, I have an implicit contract with Yale that I will teach intermediate macroeconomics from 11:35 to 12:50 on December 5, 2007. There is an important seminar going on at the same time, but I cannot both teach in one place and be in the seminar room at the same time. Some activities can be shifted over time, so that I can record the News Hour on my DVR and "move" it over time. But I cannot move my time over time.

If we consider time as a non-storable commodity, we would need to estimate the time-use stick diagrams for each slice of time. In this respect, time is like electricity, which also cannot be cheaply stored. We see a variation in hourly electricity prices often vary by a factor of 5 during the day and varied by a factor of 50 in 1999, and there is no reason why time prices should not vary greatly as well. For individuals facing rigid schedules (for work, school, meetings, and so forth), we could easily find that marginal valuations are all over the map depending on the extent of "time crunch" or "time glut."

Treatment of non-storable time will lead to substantial complications in the analysis. The activities need to be represented with the appropriate time-stamped constraints. For example, work must start at 8:30 am, and commuting must take place in the time just prior to the start of work. Peak time will have a higher shadow price. This implies that any activity that is observed during peak times must have a high valuation. By contrast, off-peak times will have a low valuation. We may see that something – like watching TV – occurs in off-peak times and conclude that this is a low-value activity, whereas the truth is that it is simply off-peak.

3. *Difficulties due to simultaneous uses of time*

A third issue involves the fact that time is very often devoted to multiple purposes. We frequently encounter people talking on their cell phone while walking; these are clearly two distinct and inseparable activities – communicating while traveling. We might be listening to the radio while driving to work. These are not isolated examples – simultaneous time use is pervasive.

Since little time-use research to date has been economic in its orientation, little attention has been given to the problem of joint production in time use. We can introduce simultaneous activities easily in the analytical apparatus of section II. Assume that there is no technological change in time use and that there are n different kinds of simultaneously enjoyed leisure time. Denote $U_{5,k,t}$ as the marginal preference value of the *kth* component of leisure time, where $U_{5,1,t}$ is the marginal preference value of the primary activity (perhaps measured by hedonic psychologists). The equilibrium condition in equation (6) for the simultaneous time uses becomes:

$$(19) \qquad U_{1,t} w_{i,t} + U_{3,t} = U_{5,1,t} + \sum_{k=2}^{n} U_{5,k,t}$$

This shows that if we identify only a single activity (activity $k = 1$), we might misestimate the marginal value of the hour. The general supposition is that we exclude many valuable non-market time-use activities, which would lead to biased estimates of the value of non-market time.

4. *Difficulties arising from non-separability of hedonic values*

A final issue is that the emotional effects of experiences have deep and potentially unfathomable patterns of substitution and complementarity. So when we observe someone who reports "eating and drinking," the reported pleasures and pains are likely to depend upon the context and history as well as companions and quality of the food. The following summary provides a cautionary note on the difficulties of attaching experiential values to different activities.[13]

- Sensory pleasure (especially culinary and sexual) is extremely context-dependent…
- Most sensory pleasure is experienced in the remembered or anticipated domains, as opposed to the on-line (experienced) domain….

[13] Paul Rozin, "Preadaptation and the Puzzles and Properties of Pleasure," in Daniel Kahneman, Ed Diener, and Norbert Schwartz, Eds., *Well-Being: The Foundations of Hedonic Psychology,* Russell Sage Foundation, New York, 1999, pp. 129.

- Combinations of sensory pleasures do not obey any simple, hedonic algebra….It is not clear what we would even want to say about the pleasure of listening to Beethoven while eating our favorite food (and having a massage)….
- There is a large effect of experience on sensory pleasure. Hedonic shifts and reversals are common.

Note particularly the difficulty of defining the pleasure of simultaneous activities such as eating and listening to music.

This finding is critical to the interpretation of time-use data. As noted above, most studies examining the value of time, including the Krueger et al. study, rely centrally on the assumption of separability of the preference function for different time uses. This assumption is clearly unwarranted on the basis of empirical studies of the psychology of sensory experiences. While additive utility was customary in the early years of the development of demand theory, it was ironically Edgeworth who "destroyed this pleasant simplicity and specificity" when he wrote the general non-separable utility function that we used in equation (1) and is now common currency in economics.[14]

c. Can emotions be aggregated?

The ambitious program of hedonic psychology, as noted above, is to construct measures of pain and pleasure to complement existing social indicators. The goal might be to construct an index of NNH (net national happiness) to replace GDP. Indeed, the paper by Krueger et al. presents the tentative first steps toward just such an aggregate index (although their index is more like Net National Misery).

I will not digress onto the issue of whether such a measure would be a socially worthwhile social indicator, whether this view of human aspirations is too impoverished to be interesting, or the many paradoxes that arise in its interpretation.[15] Rather, I ask whether there any way that a social or aggregate index of happiness (or more generally of emotions) can be constructed that would be a meaningful social indicator. Is this even theoretically possible? I think not.

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[14] The quotation is from George Stigler, "The Development of Utility Theory. I," *The Journal of Political Economy*, vol. 58, no. 4, August 1950, pp. 307-327, at p. 322.

[15] These issues have been widely debated in philosophical discussions of utilitarianism, such as Amartya Sen and Bernard Williams, Eds., *Utilitarianism and Beyond,* Cambridge, UK, Cambridge University Press, 1982.

To serve as a social indicator, a variable must be a measurable variable. This means that it must have a uniquely defined zero and a well-defined unit of increment. Moreover, the zero and the increment must be stable across time and observations (people). Measurability is a stricter concept than cardinality, which is usually defined as unique up to a linear transformation. Consumption is a measurable variable because my personal consumption expenditures can be added to yours as long as we respect the convention of using the same prices. Consumption has a natural zero and a natural unit of change.

Assume for purposes of discussion that we have developed a perfect hedonimeter based on brain scanning, and further that we have made careful measurements that map the brain images to reported pain, pleasure, sadness, sweetness, and the other important aspects of reported emotions. Perhaps we can even calibrate the level of pain or frustration that would make me frown or grind my teeth. Would it make any sense to add these together or average these emotions?

I am inclined to the view that comparing or adding people's emotions is a meaningless exercise.[16] Because emotions are so contingent on history and context, the zero point will vary with time, mood, circumstances, genetics, and culture. So there is unlikely to be a natural zero point for happiness or other emotions. Similarly, it is difficult to conceive of a natural unit of increment for emotions. We cannot say how the incremental pleasure that Sam experiences in eating a cheeseburger compares with the incremental pain that Helen experiences when she has a flat tire. The measurability of temperature and consumption does not hold for emotions.[17]

We might suspect that emotions are not even cardinal but are ordinal in the sense of "more pain, less pain."We might suspect this because any index that we construct can be stretched by a monotonic transformation and provide the same

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[16] The argument that follows is hardly original with the present author. It goes back at least to Isaiah Berlin, "Utilitarianism" (unpublished, available at http://berlin.wolf.ox.ac.uk/lists/nachlass/index.htm).

[17] The proponents of hedonic psychology are sensitive to this issue and make a case for a natural zero point. The psychological evidence against a universal neutral point is reasonably compelling, however. For example, whether a blue light is perceived as blue or green or neither-blue-nor-green will depend upon what the person saw just before the blue light.

information. Can we really say that Sam's second cheeseburger makes him twice as happy as the first, rather than four times as happy or log(2) times as happy? Ordinal measures that are only unique up to a monotonic transformation are even less suitable for social indicators or aggregates than ones that are cardinal up to a linear transformation. Since the reported emotions can be mathematically "stretched" and maintain the property of more pleasant or less pleasant, we cannot construct either aggregate indexes of emotions over individuals, or even indexes of emotions over time of the same individual.

An example will illustrate the point. Constructing an index of aggregate pain or pleasure is similar to creating an index of the aggregate blueness of the Atlantic Ocean. I do not doubt that in some ideal world we can make measurements of the spatially averaged wavelength of the light coming off the Atlantic Ocean. Moreover, I do not doubt that we can in principle measure the physiological responses to particular wavelengths of light in different people. Moreover, we might even correlate these physiological responses with how people describe their experience, whether the ocean is "blue" or "deep blue" or "a beautiful blue." But it would make no sense to construct a national index of "Blueness of the Atlantic Ocean" that involved adding up how individuals on a particular day report the experience of looking at the Atlantic Ocean. Nor would it make sense to have an index of "Blueness" that would go up or down from day to day depending upon the weather, the seasons, and people's moods. Neither blue oceans nor blue moods constitute a meaningful index because they are not based on measurable variables.

We leave the last word to the philosopher who launched the utilitarian revolution, Jeremy Bentham. He expressed his own reservations about utility measurement as follows:[18]

> `Tis in vain to speak of adding quantities which after the addition will continue to be as distinct as they were before; one man's happiness will never be another man's happiness; a gain of one man is no gain to another; you may as well pretend to add 20 apples to 20 pears, which after you had done that could not be 40 of anything but 20 of each just as there was before.

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[18] Quoted in George Stigler, "The Development of Utility Theory. I," *The Journal of Political Economy*, vol. 58, no. 4, August 1950, pp. 307-327, at pp. 309-310.

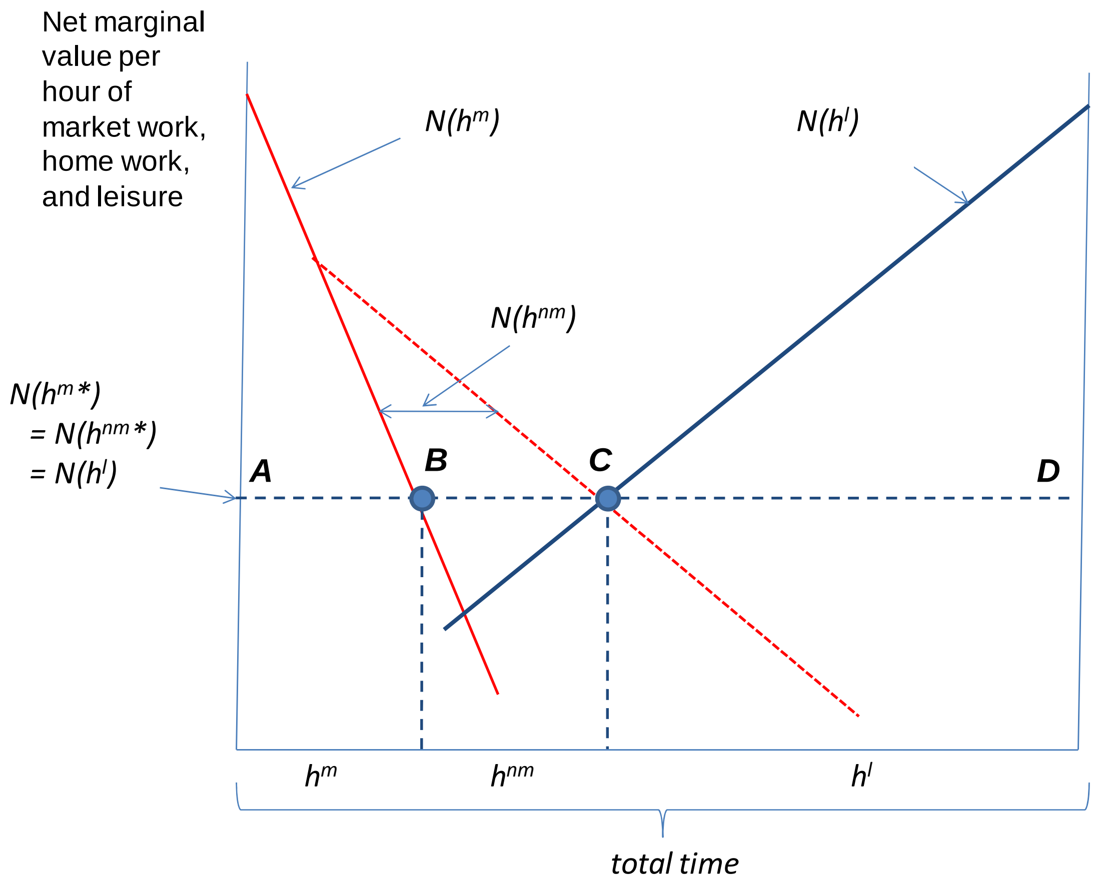

Figure 1. Time Use Equilibrium

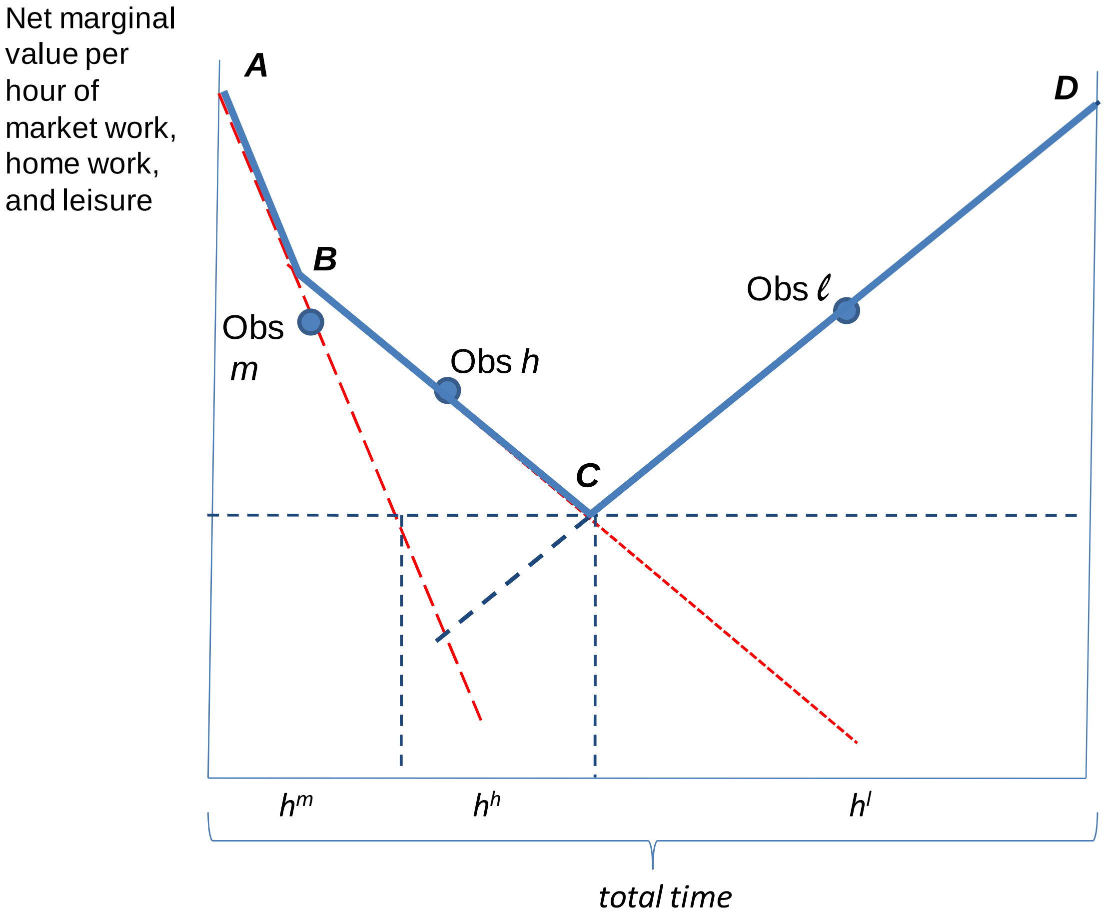

Figure 2. Valuation of time using the time-slice methodology