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Measuring Real Income with Leisure and Household Production

William Nordhaus

5.1 Different Approaches to Evaluating Time Use

5.1.1 The Central Role of Time in Augmented Accounting

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 marketplace. Moreover, although we do not yet have economic accounts that incorporate the use of time, it is plausible that the economic value of time is the most important single nonmarket input, and perhaps also nonmarket output.

I will consider three issues relating to the use of time in this chapter. 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? Third, do measures of emotions have the property of "interpersonal cardinality" that is required to construct quantitative social indicators?

To begin with, it is worth reflecting on the importance of time use for nonmarket economic activity. Nonmarket 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 nonmarket and market labor, capital services, and material inputs. By far the largest inputs for nonmarket activity are labor (time). Indeed, virtually the entire value added of the nonmarket sectors comes from time inputs, while most of the nontime inputs are purchased in the market economy.

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Consider the cost of home production (such as doing the laundry). The total value of such activities consists of the value of purchased market inputs (soap, washing machines, electricity, and the like) plus the value of the time spent in the activities. For example, doing the family laundry might have a total cost of $21, of which $20 (one hour × $20 per hour) is the value of the time, while one dollar is the cost of the soap and washing-machine services. Virtually all the nonmarket inputs are likely to be time.

The same story holds for virtually every nonmarket activity: the major nonmarket input is labor. The one important exception might be the inputs of nonmarket 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 nonmarket 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 (BLS) 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.

5.1.2 Two Approaches to Quantitative Indicators on Time Use

In developing quantitative social indicators to integrate time use, we can consider two fundamentally different approaches. The first approach would be to use the methodology of national economic accounting. This approach, which has been considered in the literature on augmented and nonmarket accounts, would add the consumption and production of time to the accounts. To implement this strategy, we would need to develop a set of prices or values to weight the time consumptions, after which time could be added to apples and pears using the standard methodology of economic accounts. As I will indicate in the first part of this chapter, while this approach would conform to standards of national economic accounting, the data requirements are both theoretically and practically far beyond what is currently available.

A second approach, which has developed along a parallel track with an entirely different approach to valuation, is in the spirit of emotions re-

1. A review of the BLS time-use survey is available at http://www.bls.gov/tus/.
2. The Web page containing a description is available at http://www.timeuse.org/ahtus/.

search. This would include overall measures of emotions, such as happiness and misery; it might also attach emotions to particular activities, such as unemployment or the time spent watching television. This approach was pioneered by F. Thomas Juster and is followed in the study by Alan B. Krueger et al. (hereafter KKSSS).[3] This strategy uses a completely different approach to measuring the values associated with time uses—one based on surveys or other psychometric measurements. The second part of this chapter addresses the potential for use of hedonic psychology and emotions research in constructing quantitative social indicators.

5.2 Time Accounts Using the Approach of National Economic Accounting

This section examines the incorporation of time use into the standard national economic accounts. It derives equilibrium conditions for consumer behavior with market and nonmarket consumption, along with process or intrinsic values of time in different activities. (Process values and intrinsic values are terms that are used to represent the preference value of the time itself rather than the things produced by time.) Using a standard index-number approach, we show 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 nonmarket 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 growth rates in market and nonmarket 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.

5.2.1 Consumer Preferences and Equilibrium Conditions

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, to work at home and produce home goods, and to use time to enjoy leisure or nonwork activities. In general, we separate time used in home production from leisure by the definition that the time used in home production can be substituted for the time of others (such as washing dishes), while the activities in leisure cannot be produced by others (such as playing golf).

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 hedo-

3. See Juster (1985) and Krueger et al. (chapter 1 of this volume).

nics that follow.) The variable 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.

$$W_{i,t} = U(c^m_{i,t}, c^{nm}_{i,t}, B^m_{i,t}, h^m_{i,t}, B^{nm}_{i,t}, h^{nm}_{i,t}, B^l_{i,t}, h^l_{i,t}), \tag{1}$$

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 nonwork time, $B^m_{i,t}$ = technological change in market time, $B^{nm}_{i,t}$ = technological change in nonmarket time, and $B^l_{i,t}$ = 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 is also novel in allowing for the possibility of technological change that makes time spent more or less pleasant. This specification recognizes that leisure time is generally an input into a technology that produces the desired experience. For example, listening to music involves not only time but also complementary inputs such as equipment, space, background noise, and performance quality. Some time may be experienced as unpleasant (such as in dental surgery), but these are nowhere as unpleasant as surgery before anesthetics. 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 nonmarket time more productive (e.g., by using machines rather than washing by hand), but technologies can also 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 in equation (1) is not separable over activities. Most work on estimating the process value of time, going back to Juster and continuing with KKSSS, assumes that the preference function is to be separable across different time uses.[4] This assumption has been viewed as inappropriate and incompatible with empirical evidence in preference theory for many decades and is especially objectionable for time use (we discuss this point further next).[5]

The consumer has three constraints: an income constraint relating to market consumption, a home production function relating to home work and home consumption, and a time budget. The analysis uses a skeletal model that strips away inessential elements. The first constraint is that market consumption equals a fixed element (fringe benefits plus property income plus net transfers) plus market hours multiplied by the marginal wage:

$$c^m_{i,t} = I_{i,t} + w^m_{i,t} h^m_{i,t}. \tag{2}$$

4. Ibid.
5. See Stigler (1950).

We simplify the analysis by assuming that there are no lump-sum elements and that marginal compensation is proportional to the average productivity of market labor for that individual, $w^m_{i,t} = A^m_{i,t}$, so:

$$c^m_{i,t} = A^m_{i,t} h^m_{i,t}. \tag{3}$$

Home production is given by the home production function:

$$c^{nm}_{i,t} = A^{nm}_{i,t} h^{nm}_{i,t}, \tag{4}$$

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

Finally, we have the time budget constraint:

$$\bar{h}_{i,t} = h^m_{i,t} + h^{nm}_{i,t} + h^l_{i,t}. \tag{5}$$

Total time is $\bar{h}_{i,t}$.

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. In the balance of this discussion, we suppress the *i* subscript where it is unnecessary.

$$\frac{\partial U}{\partial h^m_t} = w_t + B^m_t \pi_{3,t} - B^l_t \pi_{5,t} = 0. \tag{6}$$

$$\frac{\partial U}{\partial h^{nm}_t} = \pi_{2,t} A^{nm}_t + B^{nm}_t \pi_{4,t} - B^l_t \pi_{5,t} = 0. \tag{7}$$

For notational convenience, $\pi_{k,t} = U_{k,t}/U_{1,t}$ is the marginal rate of substitution between the *k*th argument of the preference function in equation (1) and market consumption; $U_{k,t} = \partial U/\partial x_k$ is the derivative of U with respect to the *k*th elements; and the marginal rates of substitution are time dated to recognize that the marginal preferences change over time.

Equation (6) states that the marginal preference value of leisure should equal the net value of an hour in the market in producing goods. Equation (7) states that the marginal preference value of leisure should equal the net 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. Most analyses of time use assume that the marginal preference value of work is equal in the market and at home and further assume a homogeneous output. From these assumptions, we get the standard condition that the productivity of home production equals the marginal post-tax wage. There are also many 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.

5.2.2 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 the 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.[6]

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.[7] We begin by transforming the preference function in equation (1) into an index of real whole income for individual i at time t:

$$R_t = R(c_t^m, c_t^{nm}, B_t^m h_t^m, B_t^{nm} h_t^{nm}, B_t^l h_t^l). \tag{8}$$

The function R is an ordinal transformation of U such that, along the equilibrium path, R is locally homothetic. This implies that the rate of growth of real income is measured as:

$$\begin{aligned} g(R_t) = {} & s(c_t^m)g(c_t^m) + s(c_t^{nm})g(c_t^{nm}) + s(h_t^m)g(B_t^m h_t^m) \\ & + s(h_t^{nm})g(B_t^{nm} h_t^{nm}) + s(h_t^l)g(B_t^l h_t^l). \end{aligned} \tag{9}$$

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 $s(x_{k,t}) = \pi_{k,t} x_{k,t} / \Sigma_{k=1}^{5} \pi_{k,t} x_{k,t}$. In this expression, $x_{k,t}$ is the kth element; $\pi_{k,t} = R_{k,t}/R_{1,t} = U_{k,t}/U_{1,t}$ 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 $k = 5$ represent market consumption, nonmarket consumption, market time, nonmarket time, and leisure time.

Note that for globally homothetic U functions, R is uniquely defined. Moreover, this procedure assumes that U is a smooth function. If the U function is not globally homothetic, R will depend upon the path of consumption and prices. This property is shared with all superlative indices.

There are different alternatives to aggregating indices over individual consumers to construct a social index. The usual index, following Robert Pollak, uses the approach of the plutocratic index in which each (real) dollar

6. The approach utilized here follows the standard approach to the development of indices of real income and expenditures. See, for example, Diewert (1987).

7. See Becker (1965).

is equally weighted.[8] This then yields a growth rate in the total or national index that is simply the sum of the individual indices, where the individual indices are weighted by each individual's share of total consumption. We will omit this step for brevity, and because it adds nothing important in the current context.

5.2.3 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 United States since 2003. We have no reasonably accurate measures of home consumption. Furthermore, we have no measures at all of the marginal rates of substitution between time and market consumption (the $\pi_{k,t}$). And we have no measures of any of the technological variables outside the marketplace (the B_t^k). In other words, any attempt to measure whole income is doomed to fail for lack of critical data.

5.2.4 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 $B_t^k = 1$ for all k. Second, we assume that it is possible to measure the productivity of nonmarket work. We denote variables with dots over them as time derivatives, then rewrite equation (9) as:

$$\dot{R} = \dot{c}_t^m + \pi_{cnm,t}\,\dot{c}_t^{nm} + \pi_{hm,t}\dot{h}_t^m + \pi_{hnm,t}\dot{h}_t^{nm} + \pi_{hl,t}\,\dot{h}_t^l. \tag{10}$$

We take the time derivatives of equations (3) and (4), obtaining:

$$\dot{c}_t^m = \dot{w}_t h_t^m + w_t \dot{h}_t^m, \tag{11}$$

$$\dot{c}_t^{nm} = \dot{A}_t^{nm} h_t^{nm} + A_t^{nm} \dot{h}_t^{nm}. \tag{12}$$

Substituting these into equation (10) yields

$$\dot{R}_t = \dot{w}_t h_t^m + \pi_{cnm,t} \dot{A}_t^{nm} h_t^{nm} + \Psi_t, \tag{13}$$

where

$$\Psi_t = \dot{h}_t^m (w_t^m + \pi_{hm,t}) + \dot{h}_t^{nm} (\pi_{cnm,t}\, A_t^{nm} + \pi_{hnm,t}) + \pi_{hl,t}\,\dot{h}_t^l.$$

8. The concepts are discussed in Pollak (1998).

From the first-order conditions in equations (6) and (7) and the time budget constraint in equation (4), we have $\Psi_t = 0$, which reduces the expression in equation (13) to

$$\dot{R}_t = \dot{w}_t h_t^m + \pi_{cnm,t} \dot{A}_t^{nm} h_t^{nm}. \tag{14}$$

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 nonmarket consumption. Substituting from equation (4) that the growth in market income is $\dot{w}_t^m / w_t^m = \dot{A}_t^m / A_t^m$, this implies that the growth in real income is:

$$g(R_t) = \dot{R}_t / R_t = g(A_t^m)\sigma(c_t^m) + g(A_t^{nm})\sigma(c_t^{nm}), \tag{15}$$

where $g(A_t^m)$ and $g(A_t^{nm})$ are the rates of productivity growth in the market and the nonmarket consumption sectors, and the weights are the shares of the two items in whole consumption, $\sigma(c_t^m) = c_t^m / (c_t^m + \pi_t^{nm} c_t^{nm})$ and $\sigma(c_t^{nm}) = \pi_t^{nm} c_t^{nm} / (c_t^m + \pi_t^{nm} c_t^{nm})$.

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 equation (15) are proportional to h^m and h_t^{nm} which yields:

$$g(R_t) = g(A_t^m)\left(\frac{h_t^m}{h_t^m + h_t^{nm}}\right) + g(A_t^{nm})\left(\frac{h_t^{nm}}{h_t^m + h_t^{nm}}\right). \tag{16}$$

Equations (15) and (16) are the fundamental results. The simpler expression in equation (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 nonmarket time is a key ingredient in economic welfare. The important and nonintuitive 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 equation (15) and equation (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 equations (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 nonmarket work were approximately the same from 2003 to 2006 (3.5 hours per day for market work versus 3.8 hours per day for nonmarket work). This indicates that the welfare significance of productivity growth in nonmarket 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.

5.2.5 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

$$W_t = U_{cm}(c_t^m) + U_{cnm}(c_t^{nm}) + U_{hm}(h_t^m) + U_{hnm}(h_t^{nm}) + U_{hl}(h_t^l). \tag{17}$$

The U functions in equation (17) are separable preference functions for each of the time elements in equation (1) (note that this is a simplification and should not be used in practice). We define the net marginal preference value of an hour of market work, home work, and leisure, respectively, as

$$N(h^m) = U_{cm}'(c_t^m)w_t + U_{hm}'(h_t^m),$$

$$N(h^{nm}) = U_{cnm}'(c_t^{nm})\,A_t + U_{hnm}'(h_t^{nm}),$$

$$MU(h^l) = U_{hl}'(h^l).$$

The equilibrium conditions are then

$$N(h^m) = N(h^{nm}) = MU(h^l). \tag{18}$$

Figure 5.1 shows a Jevons stick diagram for the allocation of time using separable utility and only two activities, market work and leisure. The downward sloping line shows the net marginal preference value of market work, while the upward sloping line shows the marginal preference value of leisure, with leisure measured leftward from the right axis. At the equilibrium, E, the net marginal preference value of market work is equalized to the marginal preference value of leisure time, with market work being the segment WE and leisure time being the segment EZ.

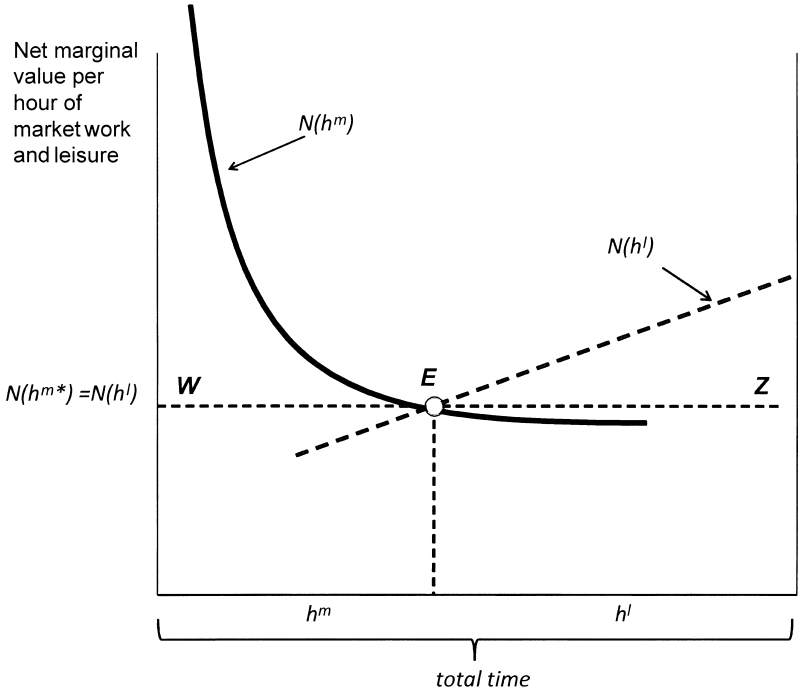

Fig. 5.1 Time-use equilibrium

5.3 Valuation Using Direct Measurement via Hedonic Psychology

5.3.1 What Are We Attempting to Measure?

The first part of this analysis examined the development of quantitative valuation of time use using the standard approach of national economic accounting and determined that the standard account appears to have excessively demanding requirements for valuation. We now examine the potential of the techniques of emotions research and hedonic psychology to value time in different activities and to develop quantitative social indicators.

Before discussing different approaches, we begin with some definitions of different kinds of variables. Most functions in standard preference theory in economics are *individually ordinal.* This indicates that these functions can be transformed by a monotonic function and yield the same observable outcomes. In some economic applications, such as behavior toward risk, functions are *individually cardinal.* This indicates that the variable or function is unique up to a linear monotonic transformation for each person. Both are *individual* in the sense that there is no method by which levels can be compared across different individuals.

To serve as a quantitative social indicator, a function or variable must have a cardinal scale that is meaningfully defined across individuals. I will call this characteristic *interpersonally cardinal.* This means that the variable must have a uniquely defined zero and a well-defined unit of increment and that there must be a method to compare the values across individuals. This implies that the zero and the increment must be stable across time, people, and countries.[9] Consumption is an interpersonally cardinal variable because my personal consumption expenditures can be added to yours, as long as we respect the convention of using the same prices and commodities; consumption has a natural zero and a natural unit of increment, and these are comparable across individuals. Interpersonal cardinality has much tighter constraints than personal cardinality, which in turn is stricter than ordinality.[10]

The development of quantitative social indicators using measures of emotions—such as happiness using hedonic psychology—could take three potential paths. We can think of these as proceeding from least demanding to most demanding of the data and analytical constructs.

A first approach, which is the spirit of the macrohappiness studies, including the development of the U-index by KKSSS, has been to develop measures of the instantaneous or average flow of emotions such as happiness, pain, and the like. These are analogous to estimates of global mean temperature. They are measurements that are not attached to particular causes or activities. A significant body of research is devoted to this strategy, as is summarized by Kahneman, Diener, and Schwartz in their overview of a compendium of studies in their edited volume, *Well-Being:*[11]

> 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

9. This point can be illustrated with a simple example. Assume that we are interested in comparing the happiness of two groups, calculated as the average happiness of each group. (a) Under an ordinal measure, there is no meaningful way of taking averages of indices that simply provide greater than or less than rankings. We might make Pareto rankings, as is done in welfare economics, but these would continue to be ordinal measures. (b) Assume that the happiness scales are individually cardinal but not interpersonally cardinal across groups. The happiness measures of group A are (1, 7) for an average of 4, while those of group B are (2, 4) for an average of 3. Under the original scaling, group A is happier than group B. By individual cardinality, we can add, say, 5 to each value in group B and maintain all observable functions of the variable. After the rescaling, group B is happier than group A. (c) Finally, assume that the scale is interpersonally cardinal and can be transformed only by a common scale variable, k. Then the average value for A is always $k4$, which is always greater than group B's $k3$.

10. These definitions from economics differ from those used in other areas. In psychology, a cardinal scale is referred to as an interval scale. What is called interpersonally cardinal in this chapter is referred to as ratio measurement in psychology. The terminology in psychology originated with Stevens (1946). The related theory of measurement has, over the last half-century, sparked a fierce controversy in psychology with virtually no counterpart in economics.

11. See Kahneman, Diener, and Schwartz (1999, xi).

> 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.

The second approach attempts to attribute emotions to particular causes or activities. This is analogous to saying that global warming is due to the accumulation of greenhouse gases. This brand of emotions research associates well-being with attributes or activities such as inflation, unemployment, or per capita income. The KKSSS study, like the work of Thomas Juster and John Robinson before it, attempts to associate emotions with particular time-use activities. For example, the U-index of KKSSS relates to whether the maximum of the negative emotions exceeds the maximum of the positive emotions. The following discussion points to several difficulties that arise in attribution; for example, the studies assume separability of time values over time and activities.

The third approach, which imbeds the analysis in the framework of national economic accounts developed in the first part of this chapter, would aim to estimate the value of time as compared with other components of economic activity. The accounting framework values the time using the marginal rates of substitution or marginal values of time. This approach might be devoted to measuring the growth of whole income in equation (9). This method is the most demanding of the three because it requires estimating marginal valuations of time relative to other economic activities such as consumption of goods and services. It is possible that the psychometric approach could estimate the marginal rates of substitution, but this approach has not been pursued, partly because of lack of interest and partly because of lack of data.

5.3.2 Some Difficulties with the Hedonic Approach

Most of the measures developed in the three approaches previously described assume that the magnitudes are interpersonally cardinal. Economists have come to regard cardinal measures of utility with suspicion. As Paul Samuelson summarized:[12]

> 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 several issues that arise in the application of hedonic measurements in the construction of quantitative indicators, both generally and specifically as applied to time use. The fundamental problem can be easily summarized. Most measures in emotions research can best be described as ordinal, and few or none would seem to be interpersonally cardinal in the

12. See Samuelson (1952, 137).

sense previously defined. Statistical operations (such as averages over space or time) on ordinal variables are not invariant to monotonic transformations of the variables. Therefore, we will get different answers depending upon the scaling of our measures. This implies that these variables are not useful as quantitative social indicators.

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 indices of emotion or happiness? Are we trying to test whether the equilibrium conditions for utility maximization are met? Or, are we attempting to estimate the total or the average of the emotional values for each activity? (The total is the area under the different marginal value curves and above some zero level of time in figure 5.1).

We begin with the question of using hedonic measures to measure the equilibrium values of time, such as those that are needed for equations (5) and (6). (It should be emphasized that this has not been the objective of much of the psychometric literature.) This approach would be necessary to value the impact of policies or shocks that shift time use among different activities. The problem, as shown in figure 5.2, is that it is difficult to ensure that we are capturing equilibrium valuations in a slice-of-time sampling methodology. The value of a time slice will be given by the point on the net marginal value curves where the time slice is taken. We show four different slices: *A* and *B* are ones where market work is sampled, while *C* is one where leisure is sampled, and *E* is an hour that is just at the indifference point.

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. It is very unlikely that we would get a slice at exactly point *E*, which is the point at which the values of the marginal hours are equalized. While many studies do not attempt to measure the equilibrium value, these measures are the standard approach for evaluating policies or shocks that reallocate hours among different uses for individuals who are making purposive use of their time.

The Zero Problem for Total Utility

Many studies of happiness are concerned with measuring total or average value or utility from different uses of time. Attempting to measure total utility falls into the conceptual morass called the zero problem.[13] 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

13. See Nordhaus (2006).

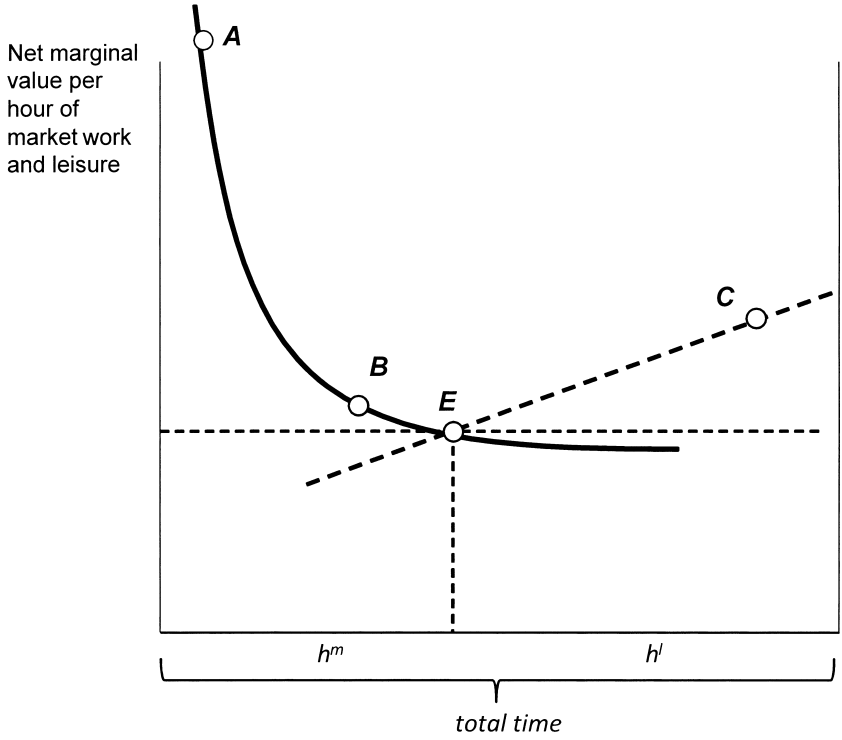

Fig. 5.2 Valuation with the time-slice methodology

to the value of life itself)? Or is it the level of consumption in preindustrial times? If the latter, should preindustrial times relate to the 1700s, when water in the United States 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 the value of time.

Difficulties Due to Nonstorability of Time

While some studies of happiness and time use might limit themselves to pure measurement, virtually every study goes on to attribute well-being to particular activities or other determinants. The KKSSS study, for example, associates the U-index with different time-use activities.

The next set of issues revolves around the difficulties of attributing time to particular time-use activities because of an oversimplified set of assump-

tions. One concern revolves around the fact that time is a nonstorable commodity. In the previous analytical section, 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 University that I will teach intermediate macroeconomics from 11:35 AM to 12:50 PM on a particular day. 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 *News Hour* on my DVR and move it over time. But I cannot move my time over time.

If we consider time as a nonstorable 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 wide variations in hourly electricity prices, 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 nonstorable 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 times 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 occurring in off-peak periods.

Difficulties Due to Simultaneous Uses of Time

A similar difficulty in attributing well-being to activities arises because 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 5.2. Assume that there is no technological change in time use and that there are n different kinds of simultaneously enjoyed leisure time. Denote $\pi_{5,k,t}$ as the marginal preference value of the kth component of leisure time, where $\pi_{5,1,t}$ 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:

$$w_t + \pi_{3,t} = \pi_{5,1,t} + \sum_{k=2}^{n} \pi_{5,k,t}. \tag{19}$$

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 nonmarket time-use activities, which would lead to biased estimates of the value of nonmarket time.

Difficulties Arising from Nonseparability of Hedonic Values

A final issue relating to separability—which can be thought of as the general case involving time separability and activity separability—is that the emotional effects of experiences have deep and potentially unfathomable patterns of substitution and complementarity. So here again, attempting to attribute emotions to particular activities may prove impossible.

For example, 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 by Rozin provides a cautionary note on the difficulties of attaching experiential values to different activities:[14]

- 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.
- 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 in particular 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 previously noted, most studies examining the value of time, including the KKSSS 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 standard in the early years of the development of demand theory, it was Edgeworth—an early proponent of psychometric studies—who "destroyed this pleasant simplicity and specificity" when he wrote the general nonseparable utility function that we used in equation (1) and that is now common currency in economics.[15]

14. See Rozin (1999).
15. The quotation is from Stigler (1950, 322).

It will be useful to recall why additive utility functions fell out of favor in economics. To begin with, they were seen to be an unnecessary restriction. Moreover, on careful examination, we see complements and substitutes everywhere—such as left shoes and right shoes for the former, or beef and chicken for the latter. Addictions are examples of strong intertemporal complementarities that are well established in economics and psychology. People are often embarrassed about eating alone in a restaurant, while Robert Putnam has classified the activity of bowling alone as symptomatic of the decline of social capital. While understanding dependences over time, space, and activities is a challenging task for time-use research, measuring these relationships will be necessary for the accurate attribution of emotions to particular activities.

5.3.3 The Lack of Interpersonal Cardinality

The ambitious program of hedonic psychology is to construct measures of pain and pleasure to complement existing quantitative social indicators. Can an index of happiness (or misery, or more generally of emotions) be constructed that would be a meaningful social indicator? Is this even theoretically possible? I think not.[16]

The basic difficulty is that measures of emotions are conceptually individually ordinal, while interpersonal cardinality is needed to qualify as a meaningful quantitative social indicator. Assume for purposes of discussion that we have developed a perfect hedonimeter based on brain scanning, and further that we have accurate techniques to map how brain images correspond to reported pain, pleasure, sadness, sweetness, or other features 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 to average these emotions?

It makes no sense to use such measures of emotions as quantitative social indicators because they are not interpersonally cardinal. We point to three difficulties in existing approaches.[17] To begin with, it seems unlikely that we can define a condition that would represent an unambiguous zero or neutral emotional state (other than being dead, which is not appealing in this context). Because emotions are so contingent, the zero point will vary with mood, circumstances, genetics, context, history, and culture. Therefore, there is unlikely to be a natural zero point for happiness, misery, pain, or other emotions.

Secondly, it is difficult to conceive of a natural unit of increment for emo-

16. I do not discuss here whether such measures would be worthwhile social indicators, whether this view of human aspirations is too impoverished to be interesting, or the many paradoxes that arise in its interpretation. These issues have been widely debated in philosophical discussions of utilitarianism, such as in Sen and Williams (1982).

17. The discussion that follows is hardly original with the present author. It goes back at least to Isaiah Berlin, "Utilitarianism" [1937?].

tions that would apply across people. We cannot say how the incremental pleasure that Sam experiences in eating a "delicious" cheeseburger compares with the incremental pain that Helen experiences when she has a "bad" headache.[18] Therefore, it is difficult to see how the increment of emotions can be calibrated across different individuals.

Third, many if not all measures of emotions do not have the characteristic of cardinality; rather, they are ordinal in the sense that a state is identified as being "more painful" or "happier." These are ordinal measures because any numerical index that we construct based on the reported emotions can be stretched by a monotonic transformation and provide the same 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? Moreover, they are likely to be individually ordinal in the sense that we can stretch Sam's cardinal emotion scale arbitrarily relative to Helen's. Since the individual-reported emotions can be each mathematically stretched or transformed and maintain the property of more pleasant or less pleasant, the increment and level of any aggregate index will be arbitrary depending upon what individual transformations are applied. This implies that we cannot generally construct either aggregate indices of emotions over individuals or even indices of emotions over time of the same individual in a way that meaningfully represents the changes of individuals.

An example will illustrate the point. Constructing an index of aggregate pain or pleasure is similar to creating an aggregate index of the blueness of the Danube River. I do not doubt that in some ideal world we can make measurements of the spatially averaged wavelength of the light coming off the water. We might be able to measure the physiological responses to particular wavelengths of light in different people. Moreover, we could potentially correlate these physiological responses with how people describe their experience: whether the river is "blue" or "deep blue," or even so pleasurable as to inspire a song about "the beautiful blue Danube." However, it would make no sense to construct a national index of "Blueness of the Danube River" that involved adding up how individuals on a particular day report the experience of looking at the Danube River. Nor would it make sense to have an index of "Blueness" that would go up or down from day to day depending upon unemployment, inflation, or per capita income. Neither blue rivers nor blue moods constitute a meaningful index of emotions because they are not based on interpersonally cardinal variables.

The force of these criticisms will differ depending upon the exact details of the index that is created. The most problematical indices are ones that attempt to attribute differences in happiness over time and people to par-

18. 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.

ticular causes. These would appear to suffer from many of the criticisms discussed here.

The U-index of KKSSS would appear to avoid the difficulties of some happiness indices by its creation of an ordinal index. But, their procedure simply pushes the difficulty into the background. To illustrate their procedure, we can simplify by assuming that we measure a pain subindex, P, and a happiness subindex, H. Then construct a net misery index, M, which equals one if $P > H$ and equals zero if $H > P$. While this looks ordinal, it actually makes very strong assumptions about the subindices. This approach is equivalent to assuming that there are interpersonally cardinal subindices in an underlying preference function, $U(P,H)$. The subindices assume interpersonal cardinality in the sense that the zeros must be the equivalent for each subindex (that is, $U[0,H] = U[P,0]$ for all P and H), and that the utility increments must be equal for each numerical increment for each emotion (i.e., $\partial U/\partial H = \partial U/\partial P$ for every point of the function where $P = U$). Even with these strong assumptions, there is no reason to assume that the U-indices would be interpersonally comparable, either across persons or over time for individuals.

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:[19]

> '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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19. Quoted in Stigler (1950, 309–10).

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