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Toward a Framework for Time Use, Welfare, and Household-Centric Economic Measurement[1]

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Abstract: *What is meant by economic progress, and how should it be measured? The conventional answer is growth in real GDP over time or compared across countries, a monetary measure adjusted for the general rate of increase in prices. However, there is increasing interest in developing an alternative understanding of economic progress, particularly in the context of digitalization of the economy and the consequent significant changes Internet use is bringing about in production and household activity. This paper discusses one alternative approach, combining an extended utility framework considering time allocation over paid work, household work, leisure, and consumption with measures of objective or subjective well-being while engaging in different activities. Developing this wider economic welfare measure would require the collection of time use statistics as well as well-being data and direct survey evidence, such as the willingness to pay for leisure time. We advocate an experimental set of time and well-being accounts, with a particular focus on the digitally driven shifts in behavior.*

JEL codes: D11, D60, I31

Key words: Internet, time use, measurement, welfare, household

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1 *Introduction*

What is meant by economic progress, and how should it be measured? This question is conventionally answered by referring to growth in real GDP, either over time or compared across countries, a monetary measure adjusted for the general rate of increase in the price of goods and services. GDP was developed in a particular set of historical and geopolitical circumstances (Coyle, 2014; Schmelzer, 2016) and has long been subject to various critiques of its inadequacy as a welfare measure (for example, Waring, 1988; Costanza et al., 1997).[2]

Is. it possible to obtain an alternative economic welfare measure, and to what extent can it be expressed in monetary terms? In an economy that is four-fifths services rather than goods, with time to consume therefore inherent in the majority of economic activity, the utility of the different uses of time seems key to understanding economic welfare as well as productivity. As Steedman (2001) notes, people do not wake up thinking, "What shall I spend today?" but rather, "What shall I do today?"

These questions have become more urgent in a world in which, thanks to digitalization, the boundaries between leisure, unpaid household contributions to economy activity, and paid work have become more porous (Coyle, 2018). In particular, the Internet, the use of which is now frequent and pervasive in so many economies, has opened up novel economic possibilities that are changing the possibilities for consumption and leisure as well as market and household production with remarkable speed. Hulten and Nakamura (2017, 2018) have argued that GDP as currently measured is inadequate for measuring economic impacts on welfare in the context of digitalization. The question of what might replace it is particularly salient.

Digital technology has prompted significant shifts in the allocation of time, particularly since 2007 with the arrival of smartphones and mobile broadband access. In the U.S. and other OECD economies, Internet connectivity became saturated between 2007 — the year the iPhone was introduced — and 2015. People are spending increasing amounts of time online, thanks to pervasive access to fixed and mobile broadband, engaging in a range of activities from accessing entertainment to carrying out banking transactions, accessing government services, booking travel, locating rides, and much more.

Moreover, standard aggregate measures like GDP focus on transactions. However, in the Internet age, the marginal monetary price to consumers of many consumption goods, including many entertainment goods, is zero. This has occurred, at least in part, because the Internet has made the marginal cost of reproducing goods negligible. When marginal prices to the consumer are so low, time costs, rather than transaction prices, increasingly determine consumer choice.

Businesses as well as consumers are changing time allocation thanks to digital technology and the pervasive Internet. In the past decade, whole new business models such as digital matching platforms and cloud computing have emerged, in addition to the now-familiar extended supply chains in business enabled by information and communication technologies. Automation is enabling some activities to be undertaken much faster in a

[2] National accounts experts will know GDP was not intended to be a welfare measure; however, not only is it often used as a welfare measure in public and policy debate, it becomes one de facto as soon as nominal GDP is deflated by any constant-utility price index.

range of process innovations such as legal search, inventory management, financial transactions, and rapid changes in manufacturing production runs.

The debate about measurement of economic welfare has thus intensified, thanks to the obvious technology-driven changes under way in the economy as well as a broad dissatisfaction in many OECD countries with post-crisis economic progress. The significant changes over both longer and shorter periods in the allocation of time, described more fully below, suggest it should be taken seriously as a choice variable in assessing economic welfare. It makes sense to begin to think about a comprehensive framework for the measurement of welfare that includes all uses of time in market production, home production, user-generated content, consumption, and pure leisure time.

This paper first discusses previous approaches to a more satisfactory conception of economic welfare. We then turn to the allocation of time, describing the digitally driven changes in time use under way in advanced economies. We consider the contribution of different activities to economic well-being, including whether a monetary measure relating time use to well-being could be constructed. We review a range of methods that could contribute to a new measure of economic well-being. We end with a brief discussion of time use in production activities and the link to productivity. Our hope is that consideration of these alternative metrics can contribute to the development of a new consensus about measuring economic progress.

2 *A broader approach to economic welfare*

Many studies, both inside and outside economics, have aimed to broaden our understanding of welfare and its growth. Some have been rooted in the national accounts tradition but have aimed to include leisure and other production boundary adjustments to create a GDP-plus (for example, Nordhaus and Tobin, 1972; Jones and Klenow, 2016). Other approaches include psychological studies (Kahneman et al., 1999), sociological studies (Gershuny, 2000; Gershuny and Fisher, 2014), studies in the economics of the household (Becker, 1965; Juster et al., 1981; Steedman, 2001), economic studies of happiness or well-being (Easterlin, 1974; Stevenson and Wolfers, 2008; Clark et al., 2018), efforts to measure the value of free goods (Brynjolfsson et al., 2018; Nakamura et al., 2018), and efforts to measure national economic welfare taking account of time use (Krueger et al., 2009a).

A particular milestone in seeking a more holistic picture of economic welfare was the Stiglitz report (Stiglitz et al., 2010) underlining the limitations of GDP. Its challenge was taken up by organizations such as the OECD and the European Commission in their "GDP and Beyond" agenda, giving such efforts growing policy salience.[3] The importance of distribution in welfare assessments has also become more prominent recently (for example, Aitken and Weale, 2018). Heys (2018) has suggested considering different approaches to measuring economic progress on a spectrum of distance from standard GDP measures.

All of these frameworks are more controversial than the conventional national accounts, however, as there is no consensus about their theoretical foundation (Coyle, 2017). We

[3] https://ec.europa.eu/eurostat/web/gdp-and-beyond

consider here whether two alternative approaches might be combined to produce a monetary or cardinal welfare measure.

One is rooted in the measurement of economic activity, utility being measured through ex post choices made by individuals. This is typically extended to a utility framework, through a labor-leisure model of the sort developed by Gary Becker (1965) and others in which, in its simplest form, the average utility of leisure time is estimated by the average productivity of work, so total utility is equal to the wage times work plus nonwork hours. This can be made more complex in a variety of dimensions, including adding household production and consumption (Becker, 1965; Varian, 2009), time to consume (DeSerpa, 1971; Steedman, 2001), housing (Dotsey et al., 2014), intra-household bargaining (Cherchye et al., 2012), the Internet (Goolsbee and Klenow, 2006), and age (Deaton, 2018). Put another way, in these approaches wages provide a price for time use that enables monetary measurement of nonwage time use. Utility experienced during production (both paid and household) is usually ignored but is, at least theoretically, an important dimension. In some economic models of this kind, a shadow price can be attached that produces a monetary estimate of utility similar to the concept underlying cost-of-living measures of inflation and real output. In a service-based and Internet-based economy, the utility of time spent in consumption as well as production seems a particularly important dimension to consider.

Less closely linked to monetary utility measures are happiness or well-being studies, including the measure of "objective" utility that Kahneman (1999) defines as the integral of instantaneous utility experienced over all hours. For example, subjects may be queried at random times during the day as to what they are doing and how they are feeling as they do it. These measures, averaged over time, represent "objective" utility. This objective utility is differentiated from subjective utility, which is the retrospective recall of the enjoyability of past events. Alternatively, subjects may be asked to write down afterward what they spent their time doing and how they were feeling at the time.

Both approaches require consideration of people's use of their time, the ultimate scarce resource. We suggest that linking them offers a better approach to the measurement of economic welfare as digitalization of the economy transforms the time people are spending in different activities to which they attach different degrees of well-being.

3 *Why we should take the time resource constraint seriously*

The current changes in people's allocation of time due to digital technology are occurring in the context of major secular trends. In U.S. data, there has been a significant increase in leisure time over the five decades leading up to the early 2000s, with substitutions away from market production for men and from home production for women, whose market labor increased over the same period (Aguiar and Hurst, 2007, 2016). The distribution of this increase was uneven, with a bigger increase in leisure time (and a bigger decrease in hours of market work) for lower-income individuals than for those in high-income occupations. Gershuny (2013, 2018) notes that market production has been falling as a proportion of time use, while home production and, in most OECD countries, leisure have been increasing, albeit leveling off in some rich countries in the most recent decades. The

long-term trend has been for hours of both market work and home production to decline, reflecting increasing productivity due to automation in both categories of production.[4]

In terms of consumption and leisure, there has been an increase in the time allocated to activities that are digitally mediated, such as use of social media, online search, and entertainment. Nakamura et al. (2018) estimate that user-generated content rose from less than one hour per week to nearly five hours per week from 2006 to 2016.[5] Aguiar et al. (2018) document a large increase in hours devoted to computer gaming over the Internet by young men in the U.S., accompanied by a decrease in paid work hours and an increase in reported well-being. In the UK, time spent online doubled between 2011 and 2018, reaching 24 hours in every week, with large majorities of adults accessing online services such as maps, social media, and government services as well as entertainment, and engaging in leisure, work-related, and home production activities online.[6] These partly substitute for other forms of consumption, not only for the usual economic reasons of price and quality changes but also because the time people have available for consumption and leisure activities cannot increase without limit but is constrained by the need for market work (to earn income) and for home production.

Although economic theory typically ignores the time required to consume goods and services, the fact that the time available is limited to 24 hours a day (less sleep) is the ultimate binding constraint in the economy — and in life. Indeed, it is an identity: All the time available will be "spent" in some way. Recognizing that it takes time to consume anything (but especially services) implies considering the economic welfare of consumers' joint expenditure of time and goods. This includes shopping time; after all, shops are clustered in high streets and malls to economize on "unproductive" time costs of shopping, and the department store and the supermarket were key time-saving process innovations in retail. It also includes travel time to places of entertainment or service delivery as well as the consumption time.

Becker (1965) goes some way toward this approach by including time as a reified input into home and market production functions. Consumption is modeled as the consumption of commodities, whose inputs may include paid goods and services and consumption time. His account explains the secular decline in hours of market work in terms of the "luxury" character of time-intensive goods. Since then, there have been several formulations in which consumers derive utility from joint combinations of time and expenditure. Rosen (1981) describes consumption as a joint expenditure of time and money as a foundation for "superstar" effects in some markets for services or leisure goods. Goolsbee and Klenow (2006) and Varian (2009) use time costs of Internet usage and for Internet search, respectively, to evaluate consumer surplus gains when marginal dollar costs are zero.

4 *Time use choice margins*

Becker's (1965) canonical model concerning the allocation of household time between market and home production refers to the time needed for the consumption of services as well as their production, and hence the scope for "productivity" gains in consumption

[4] https://ourworldindata.org/working-hours

[5] Market production in 2016 was just over 25 hours per week and home production 24 hours per week according to the American Time Use Survey, which does not count user-generated content as home production.

[6] https://www.ofcom.org.uk/__data/assets/pdf_file/0022/117256/CMR-2018-narrative-report.pdf

(Hulten and Nakamura, 2017). Technological advances in different domains can result in substitutions across the production boundary between home and market. Technological advances in domestic appliances shifted work from household to market. The digitalization of services such as travel accommodations and finance is shifting activity in the other direction. The former will have flattered measured productivity figures while the latter will have depressed them (Coyle, 2018).

In the simple form of Becker's model, households combine time and market goods to produce basic commodities Z_i for i=(1,….. m):

$$Z_i = f_i (x_i, T_i), \quad (1)$$

where the x_i are market goods (including capital services of durable goods) and T_i is a vector of time inputs; the partial derivatives of Z_i with respect to both inputs are non-negative. Rewriting the production functions,

$$T_i = t_i Z_i \quad (2)$$

$$X_i = b_i Z_i.$$

The t_i and b_i are vectors giving the time and market goods inputs per unit of Z_i. Households combine the inputs via these household production functions to maximize utility.

$$U = U (Z_1, \ldots. Z_m) \quad (3)$$

in the usual way, subject to budget constraint, where Z is the bound on resources Z and g is the expenditure function:

$$g (Z_1, \ldots Z_m) = Z. \quad (4)$$

The expenditure function includes expenditure on both market goods and time; these are not independent because time can be converted into more market goods by spending more time at work and less in consumption. There is therefore a single constraint

$$\Sigma p_i x_i + \Sigma T_i \overline{w} = V + T\overline{w}, \quad (5)$$

where the p_i are the prices of the market goods, $\overline{w}$ is a vector of wages paid for hours of work, T is the fixed time endowment, and V is other income. Substituting in the production functions, (5) can be written as

$$\Sigma (p_i b_i + T_i \overline{w}) Z_i = V + T\overline{w}. \quad (6)$$

The full price of the goods consists of the sum of the prices of the market goods and time used in production, with an associated allocation of time across the production boundary.

As Juster et al. (1981) point out, on the usual assumption of time separability (3) can be interpreted as a sum of utility flows over time. That is, we can think of utility as a set of activities taking place over time, with different goods and services being consumed at different points in time. This stream of utilities subsumes the expenditure of time and of market and household produced goods at each point in time. The utility experienced during all activities — paid production, household production, and leisure — would then be important.

Under this approach, the utility or disutility of work (both paid work and household production) naturally comes to the fore. In the simplified Becker (1965) analysis, the utility or disutility experienced during market labor is assumed implicitly to be zero,

which allows the estimation of the marginal utility of time outside of market labor to be equal to the wage. This may no longer be true in a more elaborated model. As a consequence, the valuation of leisure — as a marginal choice between paid work and leisure — need not be equal to the wage but rather the wage plus the utility (or minus the disutility) experienced at work.

An alternative modeling approach is taken by Hulten and Nakamura (2018), who in addition wish to take into account the possibility that the household consumption function is not time invariant and that, indeed, the Internet and information-generating and aggregating technologies influence utility directly, not just through time and goods. They point out that additional volume and precision of information lead to better consumption choices, so the ongoing advance of knowledge and its availability to the consumer (accelerated by the mobile Internet) improve the consumption value of purchased products even when the production processes are unchanged. Moreover, in the consumption of expert services, the advance of knowledge implies that these services are better; yet it is difficult to measure this improvement, particularly in real time. As the consumption of services entails the cooperation of the consumer with the producer, the information available to the consumer is often determinative of the value of these services. This requires an expansion of the basic commodity production function to include (unpriced) information flows (y_i) such that

$$Z_i = f_i (x_i, y_i, T_i), \tag{7}$$

where increased information flows raise the expected utility of the commodity bundles.

In either case — changing utility of work or changing utility of consumption — the relationship between work and leisure comes into flux. And the relationship between money earnings and time changes as well. As De Vries (1994) argues, similar changes (increasing the marginal utility of money income) helped explain the direction of household activity to paid work and consumption of marketed products in a demand-side structural shift parallel to the supply-side technological innovations of the Industrial Revolution.[7] Improvements in household technologies in the 1950s and 1960s likely also led to a similar shift.

Steedman (2001) offers another alternative, incorporating time to consume into the standard utility maximizing framework, subject to money and time budget constraints, but omitting home production. The two budget constraints are

$$p.x \leq E + w.h, \tag{8}$$

where p, x, w, and h are vectors of money prices, market goods, wages, and hours worked, respectively, and E is a money endowment; and

$$h + (x/r) + l \equiv T, \tag{9}$$

where r is the rate of conversion between market goods and time to consumer (assumed to be fixed), l is hours of leisure, and T is again the fixed time endowment. Utility is defined over units of time; for some tractability, Steedman assumes a quadratic form. In this model, there is thus a three-dimensional production possibility frontier between consumption of market goods, leisure, and work hours. Non-satiation will not hold thanks to the time constraint (as it is an identity, where the money budget constraint is a weak

[7] In his seminal 1965 article, Becker raised the question of how changes in consumption time and working time productivity might be reflected in trends over time in hours of work.

inequality). The model, among other things, also introduces the possibility that, in a fixed period of time, more time allocated to a particular activity may reduce its marginal utility and that consumption of different commodities occurs at different speeds. These imply some nonstandard results. For example, inferior goods will exist: When income rises, the consumer will substitute expenditure in money for expenditure in time, switching from less expensive but more time-intensive goods. Taking account of time may thus take us into a world of Giffen goods and Veblen goods. There may also be discontinuous jumps in quantities in response to small changes in prices or income. Some of Steedman's results can appear in a life cycle model that embeds habit formation, such as in Stigler and Becker (1977).

One could think of combining all of the time use choice margins into a formal utility optimization model, but as Steedman's work suggests, this would be algebraically complex and would not result in the kind of "well-behaved" analytical solutions to which economists are accustomed. We do not therefore pursue this approach.

5 *Direct consideration of well-being in time spent*

Digitalization is causing relative price changes in terms of time as well as money and could be expected to lead not only to shifts in expenditure and consumption patterns but also to changes at the work/leisure/home production margins. There have been obvious changes in the time/money combinations involved in the purchase and consumption of some services. For example, time saved walking to the bank and standing in line may be used in watching a video online. More time may be spent taking and looking at smartphone photos, at negligible cost, or creating and uploading songs written for pleasure at home, and less on dining out. Perhaps there is less home cooking and more ordering food though delivery apps.

A challenging feature is that substitutions of this kind may be hard to pin down through time use studies. Mobile apps often work in the background, giving us reminders, instructions, messages, and information while we are doing other things. In particular, the availability of many possible actions via a smartphone makes it particularly useful in periods of downtime such as waiting or queuing. This may turn periods that would otherwise be ones of boredom and discontent into active leisure, in effect creating new leisure time out of thin air. Self-reports are one way to explore these dimensions. In principle, time use surveys can capture the primary and alternative activities people are engaged in at a given time, but this is clearly somewhat harder than ascertaining whether somebody is ironing and watching TV at the same time. But time itself, together with the wage, offers a way to crosscheck these measures.

Absent new time use data, it is impossible to be sure about systematic aggregate changes, but since the launch of the first smartphone in 2007, use of the mobile Internet has become an ever-present activity in many people's lives. This has enabled the rapid growth of new services, from social media to digital apps and platforms, as well as new channels of distribution and access. An estimated 80 percent of all people over the age of 14 in developed economies were connected to the mobile Internet, mostly by smartphones, by December 2016 (Evans, 2017). The available statistics indicate substantial growth in the

volumes of data transmitted over mobile and fixed networks during the past decade, with a doubling in mobile data usage in 37 countries in the year to December 2017 alone.[8]

As Hulten and Nakamura (2017) show, the ever-present Internet has an important impact on the nature of the transmission of information. The transmission of actionable information increases the value of any economic activity, including consumption. The fact that information can be transmitted over the Internet at close to zero marginal cost changes pricing practices in ways that make the measurement of economic growth difficult (Hulten and Nakamura, 2018; Coyle, 2018). Hulten and Nakamura (2018) and Nakamura et al. (2018) provide evidence that production measures of output growth may be an order of magnitude smaller than welfare measures for specific innovations.

In the standard approach, utility maximization ideally should combine all these choice margins: the consumer's choices of market hours, home production hours, leisure, and commodities, subject to the time identity and the usual budget constraint. However, as noted, this ambitious extension of standard theory with utility, depending also on the extended time required for production (market and home) and consumption (with leisure and consumption as joint activities), may not have any of the general equilibrium characteristics with which we are familiar (Steedman, 2001).

An alternative approach is to directly consider well-being in the dimension of time. There is a large and growing literature on the measurement of the well-being derived from different activities. Our basic proposition is that utility over time is equivalent to well-being. How we feel while working for pay, producing at home, or at leisure encompasses all our possibilities for well-being. Indeed, time spent offers a potentially more equitable way of valuing nonmarket goods. Asking people how much they would be willing to pay for something is always skewed by how much income they have (just as markets will overly represent rich people's preferences). But since time is the great leveler, asking people how much time they would be willing to spend could provide more equitable valuations.[9]

However, the links between activities in the different conventional economic categories and average well-being in undertaking them are not straightforward. There are several complexities.

First, surveys capture subjective reports of how respondents feel — emotions such as happiness or anxiety. This surely cannot be taken directly as a measurement of utility, as subjective contemporaneous feelings need to be supplemented by purpose for longer-term goals such as health, education, child rearing, or entrepreneurship. One possibility would be to consider such goals as an investment in individual capital, or capability and social goods, contributing to others, or to the next generation.

A further consideration is that well-being, on the Cantril scale, is measured relative to the best possible life. The best possible life changes over time due to economic innovation. That is, novel economic possibilities, such as greater longevity, deeper scientific understanding, tastier food, and more captivating entertainment, may change the definition of the best possible life.

Another caveat is that work can be enjoyable or not, depending on the job, and, even when intrinsic job satisfaction is low, there are benefits from the social attachments and status

[8] http://www.oecd.org/sti/broadband/broadband-statistics/

[9] This insight is due to Penny Mealy, in conversation.

that come with paid employment. There is evidence that the nonmonetary aspects of work are significant, and people seek intrinsic meaning in their paid work (Cassar and Meier, 2018). What's more, the (dis-)utility of work appears to be changing over time as the character of work changes, and there are also substantial variations between groups (Kaplan and Schulhofer-Wohl, 2018; see also Jahoda, 1981, on the "latent" value of work).

Some home production activities are similarly enjoyable and blend with consumption/leisure, while others are clearly "chores" (Gershuny and Fisher, 2014). Paid labor or household production can both be directly very enjoyable or welfare enhancing. In effect, paid labor or household production can tip over into leisure.

Finally, leisure can also be productive. While we are at leisure, we can come up with good ideas or upload content that others may enjoy and learn from. Sichel and von Hippel (2018) argue that household research and development is substantial relative to private research and development.

Despite the complexities — we return to some of these in more detail next — to a first approximation we might think that time reductions (holding output constant) in paid labor and home production — that is, in what we call "work" — are an improvement in welfare. Conversely, increases in time working (either in home production or for pay) given constant output are, in principle, welfare worsening. This is on the assumption that, either in home production or at work, the object being produced is the major purpose of that time. Thus, while one may enjoy washing dishes or writing essays, one would prefer to do these tasks in a shorter period of time rather than stretching out these episodes.

For leisure, the presumption is the opposite: To a first approximation, the more time allocated to it, the better. It is likely that for many activities there are diminishing returns. How much time one spends at a given activity depends on how rapidly the returns diminish. On the other hand, in general, more time spent at leisure suggests more enjoyment per unit of time for that activity. This is the hypothesis that underlies the Goolsbee and Klenow (2006) analysis of the Internet. Of course, unemployment is a bad (forced) "leisure" in that it restricts our ability to obtain the highly productive goods of the marketplace, which may force us back toward the less productive branches of home production. And this overall low level of productivity likely further lowers the enjoyment of leisure time, as we are denied the goods we are accustomed to consuming at leisure.

Some of these issues are considered further next. For now, it is important to note that it is when *holding income constant* that reductions in time spent in either paid labor or household production are leisure and welfare enhancing. (While unemployment may result in more time spent at leisure, it is not welfare enhancing.) However, holding income constant implies *a monetary measure is required*. The utility measures that we propose are, at least potentially, provided with a quantitative metric because of their connection to the consumption and production of goods. How far we can proceed down this road is above all an empirical question. Although Nordhaus (2009) argues that the data cannot exist to proceed along this path, Krueger et al. (2009b) deliver a spirited rejoinder. While Krueger et al. (2009a) opt not to proceed to the natural conclusion of a monetary welfare measure, they argue that it is feasible.[10] Instead, in their attempt to integrate aggregate

[10] "In principle it is possible to estimate the monetary price that people are willing to pay on the margin. … For example, the way workers trade off pay for a more or less pleasant job. … Alternatively, the amount that people are willing to spend on various types of vacations can be related to the flow of utility they receive. … Although it

time use figures with well-being results in a "National Time Accounting," they calculate a national well-being index that tracks changes over time resulting from changing time use patterns among different population groups. National Time Accounting of this kind produces a measure supplementing conventional GDP figures but is not a monetary metric. For the reason explained previously, we seek to draw the lines connecting potential monetary valuations and personal consumption expenditures, on the one hand, and measures of consumer self-reports on feelings and happiness, on the other.

Is it therefore possible to assign shadow prices to these feelings and thus to different uses of time? There are several options. Essentially these correspond to the broader debate about the relationship between stated preference, stated feelings, and revealed preference. Economists are inclined to place more weight on revealed preference measures, but a good deal of policy-oriented welfare analysis rests upon stated preferences as well as revealed preferences, with the former providing valuable additional evidence. An excellent example of this can be seen in Small's (2012) discussion of the valuation of travel time as a crucial input into any cost-benefit analysis of transportation policy. He discusses travelers' stated valuation of travel time costs and compares it to their preferences as revealed, for example, by econometric analyses of commuting time-rental tradeoffs. He points out that the evidence for the welfare impact of in-vehicle amenities is thin. Amenity questions will become even more salient as we realize the possibility of partially or totally self-driving cars. Reported measures of happiness or other feelings while driving may help bridge this gap.

One route would be to ask survey participants directly about their shadow value of time, just as Brynjolfsson et al. (2018) ask about the monetary value of different digital consumption/leisure activities (see also Coyle and Rogers De Waal, in progress). Such studies introduce monetary scales of utility in the evaluation of goods, asking how much subjects would be willing to pay for a given amenity (such as social media) or how much they would be willing to accept to do without the amenity.

However, although such contingent valuation studies are widely used in environmental economics, the more usual approaches to self-reports of utility in the context of the well-being literature are based on arbitrary scales. The best-known of these are the happiness studies, where subjects are asked to report, for example, in terms of the Cantril ladder, how they rate their lives currently on a scale of 0 to 10 with respect to the best possible life they could be leading. While this scale is clearly arbitrary, and context-specific, Deaton (2008) and Stevenson and Wolfers (2008) show that responses across countries are on average well approximated by a linear regression on log income per capita. So, self-reports of utility appear to be, at least in cross section, relatable to a cardinal, monetary measure of utility.[11]

It is true that the studies in Kahneman (1999) show that such self-reports are affected by many factors other than measured real income. But can self-reports be placed on a monetary scale? The self-reported monetary values reported by Brynjolfsson et al.

is possible … to put a dollar value on W in this framework, we shy away from this step …" (Krueger et al., 2009a, p. 15). See also Gershuny (2000), chapter 8.

[11] Because the frame for the Cantril ladder is "the best possible life," the definition of the best possible life evolves over time with new discoveries. It is less evident that these happiness measures correlate with measured real GDP over time. Benjamin et al. (2012) ask students whether they would choose to have been born about when they were (1990) or in 1950; 87 percent would choose their actual date, which contrasts with the Cantril ladder results indicating that well-being has remained flat over time.

(2018), based on willingness to pay/willingness to accept methodologies and thus related to compensating and equivalent variation, suggest that there may be some way to do so. Surveys could ask the following: What would people be willing to pay for an extra day's vacation, provided their workloads were reduced? What would they have to be paid to work an extra day, assuming their workloads were not reduced? What would they pay for someone else to perform a household chore or at what pay would individuals work an additional hour at their current jobs or at some benchmark alternative? The answers to these questions could then be related their wage rates and the measured, experienced utility of labor.

In an alternative approach not reliant on contingent valuation methods, Bridgman (2016) uses estimates of the replacement cost of household activities to derive a first version of a household production account. Since the average wage rate for household employees across types of work does not vary very much, we can easily approximate the value of household production if we assume that hired labor is a reasonably good substitute for home production. This approach assumes that the shadow price of time for highly paid workers can be equated to the wage rate of household employees. But if highly paid workers are deeply concerned about their children's education and/or enjoy their interactions with their children, then the shadow price of their time may be substantially higher. The former implies greater household production, but as investment, while the latter adds to consumption. Diewert et al. (2018) show how to estimate the shadow price of household production using the wage and the wage rate of employees as well as the case when neither wage rate is applicable.

Alpman et al. (2018) take yet another approach, using experienced well-being and time use surveys combined with money measures to estimate directly the monetary value of nonmarket activities. In essence, they scale money expenditures with estimates of experienced well-being (along the lines of Krueger et al., 2009a) within a representative agent framework to estimate total income for a range of countries. Their approach is somewhat ad hoc, not being derived from a full-blown theory of individual welfare. Yet they are able to link time use and well-being ratings to different activities to estimate the relative "well-being" valuations of nonmarket activities and then multiply these by total consumption expenditure to derive a monetary measure of welfare. This is an important first step in using experienced well-being surveys to estimate the value of the shadow price of time.

6 *The enjoyment of work*

Earlier, we noted that one complexity in thinking about monetary welfare measures based on time use concerns the enjoyment people can derive from work. This question has nagged at economists since the studies that underlie Juster et al. (1981) first revealed how many workers value their work. This is consistent with the emphasis in the positive psychology literature on "flow," or satisfying absorption in a meaningful activity (Nakamura and Csikszentmihalyi, 2002). As a first approximation, economists such as Becker (1965) have argued that the hourly wage is the opportunity cost of an hour of leisure. This assumes that the work itself is neither pleasant nor unpleasant. But some people have jobs they enjoy quite a lot, while others report that they find their work relatively unpleasant. The value of leisure depends then on both the wage the worker receives and how much utility the worker receives from that job. This may depend on whether labor conditions as a whole have been stable in a given economy; it is possible

that the average utility of labor as experienced has changed, perhaps due to a change in the bargaining power of workers (as evidenced by declining labor share); see, for example, Bental and Demougin (2010). The composition of labor has also changed, which could also change the aggregate utility of experienced labor, as argued by Kaplan and Schulhofer-Wohl (2018).

Other changes may be occurring. If the population is experiencing greater distress, as suggested by Case and Deaton (2017) and Deaton (2018), it is of value to explore how paid work might be contributing to this. Equally, the utility people receive from different types of nonmarket production may vary; for example, Lerner and Tirole (2003) suggest that developers of open source software gain three types of utility: enjoyment from the activity, peer esteem, and future rewards in terms of pay and promotion in their career. Juster et al. (1981) and Juster and Stafford (1991) have argued that a more complete welfare accounting might include the underlying utility experience at both paid work and household production.

The evidence to date on the enjoyment of work is mixed. In the 1975 and 1981 surveys presented in Juster (1985), employed Americans were asked to record their level of enjoyment of 20 activities on a scale as bounded by 10 (enjoy a great deal) and 0 (don't enjoy at all), with 5 representing an activity to which the respondent was indifferent. As shown in Table 1, the activity "job" was given a mean score of 8.02 in 1975 and 7.79 in 1981. The next *more* enjoyable category was "going on trips, outings" with the ratings 8.24 in 1975 and 8.17 in 1981, while the next *less* enjoyable category was "home entertainment" with the ratings 7.76 (1975) and 7.54 (1981). By contrast, cooking was rated 6.17 (1975) and 6.13 (1981), and television 5.93 (1975) and 6.00 (1981).

While one might object that the high rating for paid work and the low ranking for household work reflects the wage received for the former, sorting the jobs by occupation results in "virtually no association between the process benefits from work and the intrinsic characteristics of the job as reflected by its occupational status" (Juster, 1985, p. 341).

Krueger et al. (2009a) in the Princeton Affect and Time Survey asked respondents to record their happiness on a scale of 0 to 6, where 0 meant not experiencing the feeling at all and 6 meant the feeling was very strong. These data are presented in Table 2. (They were asked the same question about feeling stress, sadness, interest, and pain.) In sharp contrast to the Juster (1985) studies, work was among the least enjoyable activities, well below all leisure time activities and quite similar to or worse than household production activities.

Whether this reflects differences in methodology between the two surveys or differences in the experience of work is unclear, as there are substantial differences in methodology. For example, the Juster (1985) survey asked about general attitudes toward activities, while the Krueger (2009a) survey asked about specific episodes in the previous day. However, if it is the case that employment has become substantially more, or less, pleasant, then this would have first-order effects on monetary estimates of utility.

7 *A research agenda*

If our suggestion that economic welfare could be measured by the well-being afforded by different allocations of time is to be progressed, there are several open questions, in

addition to the underlying issue of the need for more detailed and regular time use data, including digital activities. These concern the measurement of well-being and of the shadow value of time in monetary terms.

Issues in measuring well-being

The contrast between asking a general question (as Juster [1985] does) and a specific retrospective time period question (as Krueger [2006] does) is related to Kahneman's (1999) distinction between "objective" and "subjective" utility. For objective utility, we want to know how an experience feels in real time. It is evident that our recollection of the past may differ from our moment-to-moment feelings. Gershuny (2013) and Krueger (2009a) consider self-reports on the enjoyment experienced during different activities, such as at work, driving in traffic, or at leisure out of the home. Gershuny deploys mean activity enjoyment scales, while Krueger uses unhappiness indexes, measured as the proportion of time during the event when negative feelings are rated as strongest. Both are based on diary self-reports, as opposed to the expensive studies where individuals are asked to report in real time in response to random signals. However, Krueger et al. (2009a) present evidence that, on average, remembered feelings, as measured in their survey, are reflective of moment-to-moment feelings, as detected in surveys conducted with special devices for recording feelings at specific points in time. This is an ongoing area of study, and it is possible that progress can be made since the use of mobile devices for reporting may enable low-cost extensions of these surveys. Empirical evidence of this kind may also bring us closer to understanding how experienced utility at work and the wage rate are related to the shadow value of leisure.

Extensive studies on decision-making by behavioral economists and psychologists suggest that we often do not maximize utility when we make decisions but rather follow rules of thumb. How does this affect the welfare value of consumption revealed by purchasing decisions? Benjamin et al. (2012) asked individuals to choose between alternative scenarios, such as having a lower rent (20 percent of income) and a longer commute (45 minutes) or a higher rent (40 percent of income) and a shorter commute (10 minutes). Moreover, they asked the same individuals whether they believe this choice would lead to higher life satisfaction, greater happiness with life as a whole, or greater felt happiness (subjective well-being). They find that there are systematic differences between the choices people say they would make and what would maximize the various measures of happiness. They also find that higher life satisfaction is most aligned with choice, while subjective well-being is less so. And while some of the difference between choice and what would actually maximize happiness is explicable as a problem of self-control, self-control issues appear to explain only a minority of the differences.

In a follow-up study, Benjamin et al. (2014) looked at the same question — how does our choice relate to what would make us happiest on various definitions — in a real world context. They examine the residency training choices of medical graduates and ask how their choices would affect happiness and life satisfaction during residency as well as which would lead to the best possible life. They find that none of these three measures well explains people's choices and, in particular, that residency prestige and the desirability of the choice for the individual's partner had considerable additional weight. Thus, professional and social concerns — above and beyond what seems most desirable for the individual — are important in understanding choice.

Another issue is whether a single dimensional measure such as happiness is the appropriate way to measure episodic utility. Krueger et al. (2009a) use five dimensions

of feeling and combine them to distill an overall measure of time spent in unpleasantness; a time period is unpleasant when the strongest feeling experienced is negative (stressed, in pain, or sad, as opposed to happy or interested). This allows for the fact that, for example, an episode of work may contain more elements of pain or stress than, say, watching television. Can these multidimensional feelings in fact be placed in a single monetary metric as Krueger et al. suggest might be possible?

For that matter, are scaled self-reports associated with specific activities, whether single dimensional or multidimensional, in turn relatable to scaled self-reports of overall happiness, as in Cantril scales? To the extent that Cantril scales can be related to log measures of income, there is the possibility that meaningful monetary values can be applied to specific activities. In turn, we might then be able to associate these feelings with actual expenditures. That is, when someone pays to attend a rock concert or for a meal, do the feelings line up with their expenditures? Or are the feelings we experience and report partly mitigated by the size of our outlays?

One possibility is that we can use stated preferences to predict out-of-sample behavioral consequences, as argued by Bernheim et al. (2013). They advocate using econometric techniques to measure the extent to which revealed preferences are predicted by stated preferences. This may help us to understand the extent to which a given monetary measure reflects actual choices. On the other hand, we might believe that feelings — as revealed by feelings in time use studies — are more definitive of welfare. Either way, to the extent we can reconcile the results of different methods, the more confidence we can have in them.

Issues in measuring the shadow value of time

As discussed, we need a shadow price for time to construct a monetary measure. If we were to ask workers how much they would require to work an extra hour at a "neutral" job — one that, say, requires some concentration but is unstressful and easy — it is possible that the difference between the pay they would demand for an extra hour of work at a neutral job compared with their current job could be a metric of the utility cost (or benefit) of their work. Pay at the "neutral" job should reflect the true marginal value of leisure. This would be analogous to the use of hedonic wage regressions in order to isolate the marginal benefit or disbenefit of certain job characteristics, as compared with average wages, in the conventional approach.

Maestas et al. (2018) ask workers about their preferences for working conditions, such as flexibility in hours, vacation time, and meaningfulness of the work, and how much they would be willing to accept in pay reductions to change them. This enables them to discuss the extent to which working conditions exacerbate wage inequality. The answers will likely also reflect the shadow value of time. Mas and Pallais (2017) ask similar questions in the context of call centers, where they can also measure the revealed preferences of the workers.

An additional question raised by Cassar and Meier (2018) is whether the experienced utility measures that we use are adequate for capturing nonmonetary incentives that may affect the shadow value of time. In particular, they argue that the meaningfulness of labor, particularly as captured in the mission or purpose of the work, has an important impact on the pay workers are willing to accept for a given task. They point to a variety of empirical evidence in the human resource management literature that bears on this question. The willingness of better-paid workers to work longer hours may be due to the

meaningfulness of their labor as well as subsidiary factors such as autonomy, competences, and social relatedness. It may also be the case that child rearing, which is experienced as often being unpleasant, may have a "mission" attached to it that more than makes up for short-term disutility.

To the extent that happiness can be related to real income, and thus translated into a monetary metric, changes in happiness can be interpreted as equivalent to changes in real income. For example, Blanchflower and Oswald (2004) use 1972–1998 data from the U.S. to calculate that for males it would take some $60,000 (1990 dollars) to compensate them for being unemployed; that is, an unemployed male would be as happy as an employed male with similar income if given an additional $60,000. This probably cannot be interpreted as measuring the direct utility of employment in addition to the wage, as the status of being unemployed is different from being employed at "neutral utility" work (Frey, 2008, pp. 45–53). However, similar techniques might be used to interpret the sort of data presented in Krueger et al. (2009a) or Juster (1985), which could be more closely tied to a concept of "neutral" utility if these data could be related to the overall happiness of individuals. This is a conceivable complement to surveys that ask about the monetary value of the utility of work.

There is, finally, a wider question about time use as the foundation for an economic welfare metric. This is whether it points to consideration of a capabilities-based rather than utility-based approach to social welfare. Capabilities (Sen, 1982) refer to what people can *do* rather than what they can spend, although their possibilities for spending will constrain what they can do. In social welfare terms, it is not really the economic outputs themselves that concern us, and yet in GDP economists have constructed a measure based on expenditure and output, imperfectly adjusted through deflation to link to underlying utility. Our leisure and work activities are enhanced by our capabilities. But many of our capabilities are unexercised in a particular period of time or may never be exercised. To the extent that capabilities make us able to contemplate larger or more productive outcomes, they are reflected in our work activities. Social interaction, purpose, and capability may be alternative dimensions to how we are feeling. For example, having a "serious" conversation with someone may not be joy-filled, but it may be more valuable than joy. Having a purpose may require actions that provoke deep anxiety. However, this goes beyond our scope here.

8 *The time use lens on productivity*

Time use also offers a different lens on productivity as well as utility, and we offer a few comments, although the productivity question is outside our scope here. The spread of digital technologies and pervasive Internet use in production activities, from continuing automation of processes including in services to reorganization though the use of cloud computing or logistics networks, indicates significant changes in time use and the implied "true" productivity change under way at present.

In the case of both paid labor and home production, productivity, in the sense of minimizing the time required to produce a given outcome, is an important variable. In exchange for paid labor, we obtain products we cannot produce through home production or that would take excessive amounts of time to produce. There is an endogeneity between time and money: I can use my time to make money, which allows me to use my time in different ways, which then changes the tradeoff between spending time on making

money or not. This is one of the multiple meanings of Adam Smith's (1776) pin factory, in which we see how factory production of pins reduces the time required to produce a pin *vis à vis* home production of the same pin. And it is one of the senses in which Smith ascribes value: "The real price of every thing, what every thing really costs to the man who wants to acquire it, is the toil and trouble of acquiring it. What every thing is really worth to the man who has acquired it, and who wants to dispose of it, or exchange it for something else, is the toil and trouble which it can save to himself, and which it can impose on other people" (Book 1, Chapter 5). In a primitive society (such as Robinson Crusoe's) Smith says: "Labour was the first price—the original purchase-money that was paid for all things" (Book 1, Chapter 5).

Saving time on routine activities and being able to spend more time on nonroutine activities in order to improve quality are intuitive meanings of productivity in different services. In the case of routine activities, productivity and ultimately welfare gains result from technological innovations, enabling the activities to be carried out more quickly. In the nonroutine case, the gains result from the scope to spend more time and deliver a higher-quality service (more personalized or tailored to individual need, for example). Digital innovations are changing the time needed for different production activities. They may save time (online banking versus walking to the bank and standing in line), offer new ways of spending time (online entertainment and social media), or involve time use exchanges (ordering a meal through an app saves that person's time but someone else is still preparing it). In professional services such as accountancy and law, machine learning means routine tasks such as elements of audit or discovery can be automated and carried out faster than previously. This is a process innovation enabling the firm to reduce costs; customers should get better (faster) service, and perhaps pay less for it as well. There will be general equilibrium effects too, through accountancy and legal process as an intermediate input to other sectors, and through the shifting of tasks, pay, and employment of lawyers and accountants (which could decline, like drivers of horse-drawn carriages, or increase, like bank employees in the face of ATMs, depending on aggregate demand for the sectors' services). Furthermore, some routine activities are crossing the production boundary. Writing wills is one example, formerly involving lawyers and now more likely a form downloaded from the Internet. Booking travel is an example of a nonroutine activity partially crossing from market to home production. Coyle (2018) argues that one potentially significant substitution concern moves out of marketed activity into home production (such as switching from travel agents to booking trips online from home, or the production of free open source software). Shifts between market activity and household activity may change the time required for a given outcome in subtle ways. That is, self-service gasoline stations may require some work on the part of the driver but also less waiting for the gas station attendant to get to the car. Internet shopping implies time saved in traveling to the store and also not having to wait on a queue at the cash register but may require more time returning purchases whose characteristics are not as expected.

The process innovations affecting (home and market) production time under way may not be fully captured in GDP and conventional productivity calculations, as this would require a quality adjustment to the sector deflators to turn some qualitative time-saving improvements into quantity of output metrics. The fact that the process innovations enabled by digital technology manifest as time saved will likely reduce other input costs but will also improve the quality of the product or service.

9 The path ahead

We have laid out a series of questions about the linkages among measures of utility, consumption expenditures, and time allocation to work and leisure as well as about the measurement of the shadow value of time. These research questions derive from the earlier seminal work on time use by Becker, Gershuny, Kahneman, Juster, Krueger, and many others. This distinguished tradition is given new urgency not only by the current public debate about the inadequacy of conventional real GDP as a measure of economic welfare or progress but also by the evident significant changes in time use in both consumption and production processes due to digital innovation.

On the one hand, the unanswered questions relate to how our different activities relate to our overall evaluations of our current well-being. On the other hand, they link from these evaluations to money measures of work and consumption. Some of these questions may be answered by econometric studies, while others may be answered through survey methods. There is therefore a rich research agenda concerning the meaning of self-reports on different methodologies, the utility derived from different activities at leisure and at work, the best approach to applying a money metric, and indeed the potential need for more than one dimension to measure economic welfare. One thing that is already clear is the need for updated and more frequent time use surveys.

The effort to come up with an additional measure of economic well-being is unlikely to have as sharp or uncontroversial a quantification as our current measures of GDP until this research agenda is much further advanced. Agreement on measurement is more likely to come about if we examine economic well-being through multiple lenses and work toward an understanding about the most convincing ways to measure it.

How might this quantification be established as a long-term means of evaluating a national economy's contribution to the welfare of its residents? Macroeconomists currently rely upon GDP or some subset of its components to answer this question. If there is an increasing difference between the answer supplied by measures of GDP and measures based on welfare, then it may be that a measure of welfare should become part of the system of national accounts. Establishing this additional accounting may be crucial if economists are to be able to discuss economic policy issues meaningfully, in a context in which there is growing public questioning of whether real GDP growth is an adequate measure of broad economic progress. However, this task will require a sustained dialogue between government statisticians and the economics profession at large.

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Table 1. Basic Process Benefits (Juster, 1985)

Activity	1975 Score	1981 Score
Talking with children	9.16	8.98
Care of children	8.87	8.74
Trips with children	8.87	8.72
Games with children	8.62	8.24
Talking with friends	8.38	8.27
Going on trips, outings	8.24	8.17
Job	8.02	7.79
Home entertainment	7.76	7.54
Reading books, magazines	7.60	7.49
Going to church	7.23	7.28
Reading newspapers	7.17	7.10
Making things for house	6.78	6.47
Playing sports	6.76	6.23
Going to movies, plays	6.65	6.38
Gardening	6.55	6.27
Cooking	6.17	6.13
Television	5.93	6.00
Other shopping	5.69	5.30
Housing repairs and alterations	5.11	4.94
Work, school organizations	5.00	5.13
Grocery shopping	4.57	4.55
Cleaning house	4.22	4.18
Sleeping	NA	7.54
Eating at home	NA	7.46
Personal care	NA	7.38
Eating out	NA	7.33
Taking naps	NA	5.20
Caring for other children	NA	4.53

Table 2. Happiness Ratings from Krueger et al. (2009a), data from 2006		
Activity	**Happy (Raw)**	**Happy (after removing individual fixed effects)**
Sports/exercise	5.08	4.89
Religious	4.97	4.81
Socializing	4.74	4.68
Child care	4.63	4.59
Eating/drinking	4.57	4.49
Telephone	4.47	4.50
Relaxing/leisure	4.34	4.35
Lawn/garden	4.23	4.21
Volunteer	4.22	4.28
Shopping	4.11	4.15
Travel	4.05	4.06
Food prep/cleanup	4.02	4.02
Personal care	4.02	4.07
TV	3.91	4.00
Working	3.80	3.83
Medical care	3.64	3.76
Education	3.62	3.55
Housework	3.55	3.56
Adult care	3.54	3.50
Household management	3.50	3.70
All	4.13	4.13