Time Use, Productivity, and Household-centric Measurement of Welfare in the Digital Economy

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Abstract

There is substantial interest in developing a broader understanding of economic progress than the standard indicator, real GDP, not least because digital technology is significantly changing both production within the GDP boundary and household activity outside the boundary. Market and household production and leisure now all involve substantial time online. This article describes a measurement framework that would encompass extended utility combining time allocation — over working for pay, producing at home, and leisure — with monetary measures of objective or subjective well-being during each activity and new ways of measuring productivity in digitalized activities. Implementation would require time use statistics in addition to well-being data and direct survey evidence on the shadow price of time. We advocate an experimental set of time and well-being accounts and discuss their data requirements.

Although widely used as shorthand for economic progress, the limitations of Gross Domestic Product (GDP) are well-known (Coyle, 2014). Digital technology is exacerbating GDP's shortcomings on both the production and expenditure sides of the national accounts, as it is significantly changing both production processes and household activity. A change and increase in the use of time is the distinctive feature of

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digitalization, pointing to the need to consider the role of time — the only resource in truly fixed supply — in understanding economic progress. In addition to enabling process efficiencies and new business models in production, digitalization greatly enhances private production's reach into the activity of household production and consumption, so to measure its total impact, a fuller measure of output is required.

On the production side, digital technologies are routinizing a growing swathe of service sector activities, such as analyzing legal documents, monitoring financial transactions for fraud, transcription, or writing standard reports, much as automation previously transformed manufacturing. This points toward faster processing time as an important productivity metric for such activities. In the case of other services, however, such as intensive-care nursing or childcare, the need for quality or focused interaction is more important and could point to a slower time to produce as the correct metric of both productivity and consumer welfare.

On the household consumption side, GDP primarily measures monetary transactions, equating inputs to outputs in nominal terms. The household inputs it counts are predominantly paid work hours, while utility is considered as household monetary expenditures on consumption goods. An alternative perspective is Becker's (1965) full income model, where all household hours are considered as inputs, and utility is a function of both time spent and monetary expenditures on goods. In this perspective, household work and leisure time are both inputs into the production of household utility, such that utility is a function of a household consumption technology. Alternatively, one can hew more closely to the notion that GDP is a production concept and include both paid work and household work as production. This perspective dates from the important work of Margaret Reid (1934), who argued for inclusion of household work in overall measures of production. This leads to a full income perspective that has been developed by, among others, Bridgman (2016), who has led its incorporation into a Household Production satellite account of the U.S. and other national income accounts.

The use of digital technology in activities such as online banking and retail is shifting some activities into the household side of the production boundary (Coyle, 2019). Production and consumption are further linked as the automation of routine activities may imply a changing bundle of activities in which slow thinking — as discussed in Kahneman (2011) — is growing in importance. Productivity metrics based on real GDP are often considered to be distinct from questions of measurement of economic welfare or well-being. However, as they require a constant-utility price index to calculate real output terms, they embed an implicit economic welfare framework; but it does not account for either time-savings or quality-time. In this article we consider the scope to consider time spent as an appropriate metric for the digital economy, looking through the lenses of both production and productivity and household activity, consumption and welfare. We propose some additions to statistics that would enable monitoring of productivity and welfare through the lens of time.

This article proceeds in section one with our fundamental framework, in which household well-being is considered to encompass utility throughout the day, Gary Becker's 'full income' approach. In section two, we focus on how digitalization has influenced production and the boundaries between production and consumption. Section three addresses the measurement of well-being and the difficulties of alternative means to assess growth, well-being, the shadow value of time, and well-being while at paid work. In section four we outline the way forward, highlighting the key issues to be addressed as economists and statistical offices grapple with the measurement and meaning of productivity.

Time to Consume

For many digital goods and services, the marginal monetary price of consumption is often zero, but time and attention are required. In both the United States and the UK the average person is estimated to spend the equivalent of about 24 hours, the equivalent of a full day, a week online. This makes a full-income perspective on consumption increasingly relevant as digital activity reaches deeper into our lives. This may be either because consumption is paid for with a barter transaction, as in Nakamura *et al.* (2018), or because consumption products are part of a subscription bundle. When this is true, as Goolsbee and Klenow (2006) point out, then the relevant cost that the consumer faces in choosing what and how much to consume is the shadow value of time.[2] Competition in many digital markets is competition for consumers' attention to advertising (Anderson and Peitz, 2019). Additionally, digitally-produced consumption goods, such as social media and product ratings, are increasingly produced with time contributed by households as well as firms.

A key presupposition of standard measures of inflation and productivity is that the utility of a precisely defined market good remains fixed from period to period. But, as Hulten and Nakamura (2020) point out, the utility of a market good to the consumer is not fixed but is affected by changes in household consumption technology. If the household consumption technology is fixed, then the purchase of a given good today has the same effect on utility as the purchase of that good in the previous period. However, digitalization changes the expected utility of goods. For example, pricing doctor visits or semester hours as if they were constant quality does not take into account improvements in the scientific know-how of the doctors and professors. Similarly, online restaurant ratings and reviews may improve a consumer's ability to better match their tastes to dining options. Enhanced information raises utility without changing the good provided or its supply cost. Indeed, any increase in the precision of a consumer's actionable information raises expected utility.

Furthermore, network externalities change the user value of social media,

2 Rosen (1981) argues that the shadow price of time is a crucial cost in all leisure activities with important implications for the incomes of 'superstar' artists and other entertainment workers.

ecommerce platforms, and so on, over time (Schreyer, 2021). The expected utility of any network good rises as it is more widely adopted, although the good does not change. In these examples, the price change also reflects changes in the quality of the good.

A full-income perspective can help account for such considerations arising from digitalization. One difference between GDP and full income is that the former involves only arm's length, monetary transactions, albeit progressively adding non-market transactions (imputed rent for owner-occupied housing, financial intermediation services indirectly measured, a growing range of intangible investments), whereas full income includes the shadow value of all household time and is thus substantially larger. Another way of describing the difference is that full income takes utility seriously: utility maximization should combine all these choice margins: the individual's choices of market hours, home production hours, leisure, and commodities, subject to the time identity and the usual monetary budget constraint (Steedman, 2001). That is, it measures the full experience of an economic agent during the day, including time spent at paid work, at unpaid household work, and at leisure. Either way, it offers a more complete approach than GDP to economic welfare. One can think of a spectrum from real GDP to full (market plus non-market) income to broad economic welfare as full income plus well-being or quality of life (Heys *et al.*, 2019; Bucknall, Heys, and Taylor, 2021).

When it comes to valuation of full income, there are two main perspectives with very different empirical implications. One, due to Becker, is to view the shadow value of unpaid time as equal to the market wage of the worker, on the grounds that this represents the opportunity cost of leisure or of household work. This is the approach used by the UK's Office for National Statistics in its household production satellite accounts. Another is to view the shadow value of time as equal to the market price of household chores, where the price of household chores is the wage rate of household workers, the route adopted by the US Bureau of Economic Analysis in its satellite accounts. These two perspectives produce very different results, as pointed out in Bridgman (2016), particularly as in recent decades the wage rate of household workers has fallen relative to the average wage.

Yet neither of these two approaches can be seen as bounds on the true value of full income. One reason is that the value of leisure or household work time might exceed the market wage. The monetary wage is only one of the possible gains from paid labour. Paid labour may have intrinsic value of various kinds, including the pleasantness of the task, the meaning of work, or on-the-job learning. Conversely, the wage may also overstate the value of time if the task is unpleasant, the work is viewed as unsavory, or depletes one's human capital. Similarly, hiring a worker to perform household chores may have intrinsic costs or benefits to the employer beyond the wage paid. Households may choose to employ a household worker because they experience social benefits beyond the household chores, such as companionship.

These considerations suggest several possible approaches to estimating

economy-wide full income. One is to delve more deeply into self-reports of well-being, to measure the utility economic agents derive from alternative activities on both sides of the production boundary and in leisure. Time use studies with subjective modules are available across a variety of countries and time periods. Ultimately, these might lead to direct monetary evaluations of subjective states. A second approach is to look to self-reports of choices of different possible activities, with economists increasingly looking to surveys to understand time allocation, especially when monetary compensation for behavior changes is included in experiments to ensure incentive compatibility as in Brynjolfsson, Colis, and Eggers (2019). And a third approach is to use parametric models with econometric measurement, which require an estimate of the shadow value of time for households. Ultimately, estimates from these methods need to be combined in a meta-analysis.

The base methodology for the measurement of 'real' GDP is to first create nominal GDP accounting for all monetary transactions (plus some imputations) in the economy, and then to deflate it using period-to-period changes in prices of well-defined products. The theoretical rationale is that the deflation methodology approximates the use of an expenditure function (measuring the cost in today's prices of purchasing last period's utility). Thus deflated GDP is a constant-utility construct.

To consider how to develop alternative measures of nominal and real (constant-utility) full income, we begin with subjective utility (Kahneman, 1999) as the sum of (time-separable) utility over time, $\sum_t U(t)$ (Juster, Courant, and Dow, 1981). In Becker's (1965) simplest full income model, utility is consumption of household commodities, which are created using market goods combined with time needed for preparation and consumption. This time is evaluated by the market wage in his model. Households combine time and market goods to produce basic commodities and combine the inputs via household production functions to maximize utility. Their 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 budget constraint and 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 by the household across the production boundary.[3]

Full income can therefore be considered as the sum of money-metric utility over

3 An additional output of activity is learning (and its inverse, human capital obsolescence). Stigler and Becker (1977) emphasize the intertemporal impact of consumption on the utility of future consumption. Note that learning is an investment activity, whose stream of returns may appear as increases in the productivity of work (both at home and for pay) and in the productivity of leisure time. It has long been recognized that homes and consumer durables are investments that provide a stream of consumption services. There are many additional investment activities, including, but not limited to, home improvement, health care, household innovation, and the raising of children. These investment activities occur over the life cycle and have important impacts on the shadow value of time. It is unclear if these ultimately need to be included in total factor productivity measures, but they have important intergenerational impacts.

time. This stream of utilities subsumes the expenditure of time and of market and household produced goods at each point in time. Indeed, this is the standard form of the utility function used in the economics literature in general and the literature on home production in particular. Measurement of 'real' full income requires inferences about the shadow value of time in all activities measured in the same money-metric. During marketed work and household work, this utility captures the intrinsic enjoyment (or its dislike) associated with the activities of production, including the meaning attached to the activity (such as self-expression). Under this approach the utility or disutility of work (both paid work and household production) naturally comes to the fore. In the simplified Becker analysis, the utility or disutility experienced during market labour is assumed implicitly to be zero, which allows the estimation of the marginal utility of time outside of market labour to be equal to the wage. But if this is not the case, 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.

The shadow value of time is affected by digitalization. The potential for digitization to influence the utility of consumption, and thus the ultimate productivity of economic activity is modeled directly by Hulten and Nakamura (2017), who take into account the possibility that the household production function is not time invariant, but rather that the Internet and information-generating and aggregating technologies influence utility directly, not just through time and goods. For the additional volume and precision of information leads to better consumption choices, so the ongoing advance of knowledge and its availability to the consumer 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. 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.

In either case — changing utility of work or changing utility of consumption — the relationship between work and leisure come into dynamic flux. And the relationship between money earnings and time changes as well. As De Vries (1994) argues, similar changes (in the opposite direction, increasing the marginal utility of money income) previously 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. Improvements in household technologies in the 1950s and 1960s likely also led to a similar shift.

A key question is whether the market wage is the correct shadow value of time. Becker's simplifications ignore the portion of utility experienced directly during household and wage labour production. Moreover, by identifying the shadow value of time with the average wage, it ignores the complications due the constraint of a standard workweek causing the marginal value of labour to diverge from its aver-

age value. Nevertheless, this framework is more likely to capture a full picture of economic welfare in a digital economy with its zero price goods (Brynjolfsson, Colis, and Eggers, 2019), increased involvement of the household in the economy outside of wage labour (Coyle, 2019), and rapid advances in the application of information (Hulten and Nakamura, 2020). Hulten and Nakamura (2020) and Nakamura, Samuels, and Soloveichik (2018) provide evidence that production measures of output growth may be an order of magnitude smaller than welfare measures for specific innovations. We return below to the question of measurement of full income.

Time to Produce

Time use also offers a distinctive lens on production and productivity, as digital technology is changing production time as well as consumer time. There is no material product in some three quarters or more of economic activity now, yet our productivity intuitions relate to material goods transacted monetarily. From the productivity perspective, digital technologies and the pervasive internet mean there are some significant process innovations under way in terms of the time required to produce, and the production boundary.

For both paid labour 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 labour we obtain many products we cannot produce ourselves or would take us excessive amounts of time to produce. This is one of the meanings of Adam Smith's pin factory, 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." Moreover, in a primitive society (such as Robinson Crusoe's) Adam Smith says, "Labour was the first price — the original purchase-money that was paid for all things."[4]

Digitalization of more service sectors such as law and accountancy or parts of medicine (tele-health, scrutiny of scans, etc.) is now under way and could in principle be expected to improve productivity through speeding up activities currently done by humans. This is similar to the automation of routine tasks in manufacturing. There is as yet little indication that conventionally measured productivity in many services is improving due to the adoption of digital technologies, and indeed some digitally-intensive services such as computer software have been notably poor productivity performers (Coyle and Chung, 2022). However, the measurement challenges when it comes to service sector productivity are considerable, as there is often no standard unit of volume and adjusting for quality is daunting: the quan-

4 These citations can be found in Ricardo (1819), 12-13 in the section of the Principles where he discusses his differences with Smith over the theory of value.

Table 1: A Time-based Perspective on Production, Consumption and Leisure

	Market production	Home production	Leisure/consumption
Routine	Routine manufacturing	Cleaning, driving; domestic robots, self-driving cars may automate some activities	Daily run, personal care, eating (largely non-automatable because inalienable although some market purchases possible eg nail bars, hairdryers)
	Routine services		
	Examples: payroll processing, checkouts, tax preparation		
	Increasingly: medicine, law, accountancy etc		
Non-routine	Medicine, legal, consultancy;	Cooking, gardening (may also be purchased in the market)	Cooking, gardening (inherently enjoyable for some people)
	Travel agency, banking;	(Increasingly) Travel agency, banking;	
	Non-routine manufacturing;	Creative activities eg vlogs, open source software (some people will seek to monetize these)	Creative activities eg vlogs, open source software (done for enjoyment)
	Car repair, driving, plumbing, decorating;		
		Car repair, driving, plumbing, decorating (may also be purchased in the market)	Theatre, concerts, sport, socializing, eating out

Source: developed by authors.

tity of software produced is not measured by any physical metric such as gigabytes, and its quality is unobservable until much later, if at all.

At the same time, some productivity gains made by companies through automating services have simply transferred time input requirements to households. Examples include the use of call centres which require customers to spend more time navigating menus to access the service they need, or automated checkout machines which have largely substituted unpaid household labour for paid store workers. This has been described as a 'time tax' (Lowry, 2021). On the other hand, some transfers of market activities to the household sector through digitalization, such as the shift to online banking or booking travel, has saved people queueing time or increased the variety and quality of the service.

Table 1 indicates how one might categorize these shifts. The first vertical division is the conventional production boundary between GDP and household production, and the second is the boundary between household productive activities and leisure/consumption time; while the horizontal division distinguishes been routine activities which are progressively being digitally automated and non-routine activities.

In the case of routine activities, welfare gains result from digital enabling the activities to be carried out more quickly. For example, 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 much faster than previously. This is a process innovation enabling the firm to reduce costs; customers should get a better (faster) service, and perhaps pay less for it as well (although this is complicated by information asymmetries and mark-ups). There will be general equilibrium effects too, through ac-

countancy and legal process as an intermediate input to other sectors, and through the shifting tasks, pay and employment of lawyers and accountants (which could decline, like drivers of horse-drawn carriages, or increase, like bank employees (in the aggregate) in the face of ATMs, depending on changes in demand for the sectors' services). The process innovations under way in such sectors are unlikely to be captured directly in GDP and conventional productivity calculations, as this would require a quality adjustment to the sector deflators to turn the time-saving improvements into output metrics. The fact that the process innovations enabled by digital technology manifest as time saved, rather than any other reduced input per unit of output, means they are not captured when the time to produce is omitted from the calculation.

In addition, some routine activities are crossing the production boundary — writing wills is one example, formerly involving lawyers, but now more likely a form downloaded off the internet. Travel agency is an example of a non-routine activity partially crossing from market to home production. Coyle (2019) argues that 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) have become significant. Shifts between market activity and household activity may change the time required for a given output in subtle ways. For instance, self-service gasoline stations may require some work on the part of the driver, but also less waiting for the gas station attendant. Internet shopping implies time saved in traveling to the store, and not having to wait on a queue at the cash register, but may require more time returning disappointing purchases.

These shifts are still evolving. In retail, for instance, there has been a progression from checkouts that use modest capital equipment (conveyor belts and scanners) and much paid labour time, to self-checkouts using more sophisticated capital equipment and unpaid labour time, to checkout-free stores such as Amazon is pioneering, with highly sophisticated physical and intangible capital and scant labour time. On the whole, it is likely that thanks to digitalization there is a net substitution from market to household time-using production such that the measured productivity of affected sectors is lower than in the counterfactual non-digital world. The failure to consider the time savings in production enabled by digital technologies means the measured productivity figures are at present detaching from 'true' contemporaneous productivity (Coyle, 2019).

In the non-routine cases, economic welfare results from the scope to spend more time to both produce and consume simultaneously a higher quality service (more personalized or tailored to individual need, for example). These are also services where the information gains to either consumer or producer will directly increase consumers' utility, as described in the previous section. Thus productivity and utility are inextricably linked.

There is also an overlap between utility derived from how people spend their time and the productivity of their paid activities, as employee satisfaction can improve productivity. For example, Isham, Mair, and Jackson (2020) conclude from a literature review that positive well-being states

increase productivity while negative ones are negatively correlated with productivity. A recent meta-analysis of 339 studies found a strong positive correlation between employee well-being, productivity and firm performance (Krekel, Ward, and De Neve, 2019). A number of different psychological mechanisms have been postulated, such as expectancy theories (the expectation of well-being elicits better performance, e.g. Schwab and Cummings, 1970) or that well-being prompts creativity or more positive attitudes (e.g. Baumeister *et al.* 2007). Oswald, Proto, and Sgroi (2015) found that well-being improvements increased productivity significantly in a lab-based task. Edmans (2011) found a link between reported employee well-being and stock market returns among US companies. Satisfied employees likely gain more utility from their workplaces than dissatisfied ones. This affects the shadow value of their time. An interesting question is whether having higher productivity creates happier workplaces or the reverse: what is the source of these gains?

Challenges in the Measurement of Well-being

We turn now to discussing some potential approaches to the measurement of full income and a time-based perspective on economic welfare, before concluding with the implications for statistical collection. The utility measures based on full income 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. Krueger *et al.* (2009) attempt to integrate aggregate time use figures with well-being results in a "National Time Accounting," calculating a national well-being index that tracks changes over time resulting from changing time use patterns among different population groups. They produce a measure that supplements conventional GDP figures but is not a monetary metric – although they argue a money metric is feasible.[5] How then might it be implemented?

Direct measurement of well-being in time spent

There is a large and growing literature on the measurement of the well-being derived from different activities (Frijters and Krekel, 2021). We argued that how people feel while working for pay, producing at home, or at leisure encompasses all the possibilities for well-being. For a real-terms measure, we can ask, just as we do with dollars, how much time would be required to achieve the same utility as in the previous period.

Indeed, time spent offers a potentially more equitable way of valuing non-market 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 overly represent rich

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

people's preferences). There is new interest in measuring standard GDP growth more democratically (e.g. Aitken and Weale, 2020). Asking people instead how much time they would be willing to spend could also provide more equitable valuations, as time endowments are equal. A democratic measure of full income might be built around time units. In this metric, productivity is directly expressed as an index which would rise inversely with the decline (or fall with the increase) in the time requirements of a given level of welfare.

In a money metric approach to the shadow value of time, to consider how to implement the well-being in time spent framework, we start as above by thinking about a world in which the shadow value of time is equal to the market wage, and hours are fully adjustable. Suppose that digitalization makes leisure time more valuable in well-being terms. It is possible that market hours worked could fall (if the income effect outweighs the substitution effect) and wages could rise as less labour were offered, raising its marginal productivity. Or the reverse could happen.

One way to capture these effects might be to ask participants directly for evaluations of their well-being during different activities, as is done in some time use surveys. Alternatively, we could ask participants to report their monetary valuations of different activities, in effect their consumer surplus. These types of studies have been used in cost-benefit analysis of government-provided free goods, so there is a well-developed literature (for example, Viscusi, 2018; Small, 2012). There has also been a recent literature on monetary valuation of free digital goods (e.g. Goolsbee and Klenow, 2006; Brynjolfsson, Collis, and Eggers, 2019; Coyle and Nguyen, 2020). Moreover, a series of papers have argued that recent increases in the availability of data on time use provide a robust path forward for the measurement of household production, using parametric modeling (Aguiar, Hurst, and Karabarbounis, 2012; Aguiar *et al.* 2021; and Aguiar and Hurst, 2007, 2016).

We would expect such self-evaluations of either kind to be changing as 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 as noted in the previous section.

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. The available statistics indicate substantial growth in the volumes of data transmitted over mobile and fixed networks during the past decade, with average mobile data usage in OECD countries more than doubling between 2017 and 2020 (http://www.oecd.org/sti/broadband/broadband-statistics/).

Substitutions of this kind may also be hard to pin down through existing time use studies, although these have started to be adapted to the digital age (East *et al.*, 2021). 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 the device particularly useful in periods of downtime such as waiting or queuing. This may turn periods that would otherwise be ones of boredom into active leisure, or home production, in effect creating newly valuable 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, although this is clearly somewhat harder than ascertaining whether somebody is ironing and watching TV at the same time. Time use statistics including the full array of digital activities are essential for understanding the digital economy.

Evaluating well-being

The evaluation of well-being is a core issue for our proposal, and there is a substantial literature on this question. Here we briefly review some of the key open questions for statistical approaches.

The contrast between asking a general question (as in Juster, 1985) and a specific retrospective time period question (as in Kahneman and Krueger, 2006) 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 *et al.* (2009) 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 *et al.* use 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. However, Krueger *et al.* present evidence that, on average, remembered feelings 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 could be made since the use of mobile devices for reporting may enable low-cost extensions of these surveys.

Extensive studies by behavioral economists and psychologists on decision-making suggest that we often follow rules of thumb rather than making explicit utility maximization decisions. How does this affect the welfare value of consumption revealed by purchases? Benjamin *et al.* (2012) asked individuals to choose between alternative bundles, such as having a lower rent (20 per cent of income) and a longer commute (45 minutes) or a higher rent (40 per cent of income) and a shorter commute (10 minutes). Moreover, they asked the same individuals whether they believed this choice would lead to higher life satisfaction, greater happiness with life as a whole, or greater felt happiness (subjective well-being). They found that there are systematic differences between the choices people say they would make and what would maximize these various definitions of happiness. They also found that higher life satisfaction is most aligned with choice, while subjective well-being is less so.

Another issue is whether a single dimensional measure such as happiness is the appropriate way to measure episodic utility. Krueger *et al.* (2009) 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 be placed in a single metric as Krueger *et al.* suggest? 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 the Cantril scale (that is, how they rate their lives currently on a scale of 0 to 10 with respect to the best possible life they could be leading?) To the extent that the Cantril scale can be related to log measures of income, it may be possible to apply meaningful monetary values to specific activities. In turn, we might be able to associate these feelings with actual expenditures. That is, when someone pays to attend a concert or for a meal, do their feelings line up with their expenditures? Or are the feelings we experience and report partly mediated by the size of our outlays? On the other hand, Kahneman and Deaton (2010) provide evidence that Cantril scale reports and emotional well-being scales are less well correlated with higher incomes, which would limit the value of this strategy. One possibility is to use stated preferences to predict out-of-sample behavioral consequences, as suggested by Bernheim *et al.* (2013). They advocate using econometric techniques to measure the extent to which revealed preferences are predicted by stated preferences.

To the extent we can reconcile the results of different methods, the more confidence we can have in them. But there are several additional challenges in implementing the measurement at an aggregate level of well-being across activities.

For one, subjective reports will differ across individuals. How an individual scores feelings will contain random elements, possibly both person-specific and time- or context-specific. One way to deal with this is to treat these reports as a dependent variable with proxies for true utility on the right hand side, as in Blanchflower and Oswald (2004).

Another caveat is that work can be enjoyable or not, yet even when intrinsic job satisfaction is low, there are benefits from the social attachments and status that come with paid employment. There is evidence that the non-monetary 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; Jahoda, 1981), on the "latent" value of work.

Some home production activities are similarly enjoyable and blend with consumption (including of leisure activities), while others are clearly "chores" (Gershuny and Fisher, 2014). Leisure can also be productive. While we are at leisure, we can come up with good ideas or upload con-

tent that others may enjoy and learn from: Sichel and von Hippel (2019) argue that household research and development is substantial relative to private research and development.

Finally, well-being, on the standard 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. This will affect the measurement of well-being over time.[6]

Despite these complexities, to a first approximation we might think that less time spent (holding output constant) in paid labour 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. 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.

Boerma and Karabarbounis (2019) draw the distinction between home work and leisure using the substitutability or complementarity of time in production — in home work, time is substitutable with market goods (think washing machines) while in leisure time is complementary with market goods.

Monetary measures of well-being: the shadow price of time

It is important to note that it is when holding income constant that reductions in time spent in either paid labour or household production are leisure- and welfare-enhancing. Holding income constant implies that a monetary measure is required.

The literature often assumes the shadow value of time is given by the wage rate. Are there other ways to assign monetary shadow prices to the feelings of well-being in different uses of time? There are several options. Essentially these correspond to the debate about the relationship between stated preference, stated feelings, and revealed preference measures. Economists place more weight on revealed preference measures, but a good deal of policy-oriented welfare analysis rests upon

6 The best possible life may also be affected by social and political factors, such as the emergence of new rights and freedoms. However, that is outside the scope of this discussion.

stated preferences as 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 in this example 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.

Self-reports of value of time are one route, asking survey participants directly about their shadow value of time, just as Brynjolfsson *et al.* (2018, 2019) and Coyle and Nguyen (2020) ask about the monetary value of different digital consumption/leisure activities. 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.

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 not stressful — the difference between the pay they would demand for this 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 standard use of hedonic wage regressions in order to isolate the marginal benefit or disbenefit of certain job characteristics as compared with average wages. This might help selecting between using the wage rate of the individual or the wage rate of the task performed as the relevant price.

Happiness reports are another approach. For although stated preference studies are widely used in environmental and cultural 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. While this scale is both 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 relatable to a cardinal, monetary measure of utility.[7]

Surveys could ask: 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 house-

7 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 per cent would choose their actual date, which contrasts with the Cantril ladder results indicating that well-being has remained flat over time.

hold chore (pay rates on some digital platforms would provide alternative evidence of this) or at what pay would individuals work an additional hour at their current jobs or at some benchmark alternative? The answers to such questions could then be related to their wage rates and the measured, experienced utility of labour.

In an alternative approach, not reliant on such 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 labour 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, say, 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 (Doepke and Zilibotti, 2019). Diewert, Fox, and Schreyer (2018) show how to estimate the shadow price of household production using the own-wage or the wage rate of potential employees, as well as the case when neither wage rate is applicable.

Alpman, Murtin, and Balestra (2018) take yet another approach, using experienced well-being and time use surveys combined with money measures to estimate directly the monetary value of non-market activities. In essence, they scale money expenditures with estimates of experienced well-being (along the lines of Krueger *et al.*, 2009) within a representative agent framework to estimate total income for a range of countries. Their approach is somewhat ad hoc. Yet they are able to link time use and well-being ratings to different activities to estimate the relative "well-being" valuations of non-market activities and then multiply these by total consumption expenditure to derive a monetary measure of welfare.

Intrinsic well-being at work

The question of how much enjoyment people can derive from work has nagged at economists since the studies that underlie Juster, Courant, and Dow (1981) first revealed how many people 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). The standard full-income approach 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. Rothwell and Crabtree (2019) provide survey evidence that job satisfaction beyond the wage is important to workers and correlates with reported well-being. The value of leisure depends then on both the wage the worker receives and how much intrinsic utility they obtain from that job. This may change over time as digitalization changes the character of many jobs, making some (data scientists) more satisfying and others (warehouse workers) far less so; it is possible

that the average utility of labour and its distribution as experienced have changed, 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).

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. The experience of the pandemic has also changed people's preferences over the jobs they hold (the so-called 'great resignation,' Cook, 2021), and the location and hours of work as compared with household production and leisure (Barrero, Bloom, and Davis, 2021).

An additional question raised by Cassar and Meier (2018) is whether the experienced utility measures that we use are adequate for capturing non-monetary incentives that may affect the shadow value of time. In particular, they argue that the meaningfulness of labour, particularly as captured in the mission or purpose of the work (for example, in the non-profit or arts sectors), has an important impact on the pay workers are willing to accept for a given task. A variety of empirical evidence in the human resource management literature bears on this question.

Equally, the utility people receive from different types of non-market 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, Courant, and Dow (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 Way Forward

The agenda of measuring broader economic welfare and productivity in terms of a money metric of the well-being afforded by different allocations of time, with digitally-driven re-allocations across the production boundary and the work/leisure boundary, must address open questions as discussed above in order to progress.

The key underlying requirement is the need for more detailed and regular time use data, including digital activities. Other open questions concern;

- the concepts and measurement of well-being in different activities;
- measurement of of the shadow value of time in monetary terms;
- the distinction between routinizable and other activities as reflected in changing time allocations;
- the link between well-being in time at work and the quality/productivity of the work.

We have set out a series of questions about the linkages among measures of utility, consumption expenditures, and time allocation to work and leisure, and 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.

How should statistical agencies move forward on this agenda? There are two parts to our answer. First, statistical agencies need to consider new measures of output that better capture the utility impacts of the changing economy and time use. Many agencies already produce household accounts, such as the BEA and ONS. They could augment these with others such as the proposed retail satellite account that U.S statistical agencies are establishing under the leadership of the Bureau of labour Statistics. Time saving might be captured in the retail satellite account where we take into account the consumer's time spent shopping (including driving time, as suggested by Mandel, 2017) and spent checking out (as discussed above).

Second, statistical agencies need to broaden their regular collection practices to include the data they will need to support the regular updating of the experimental satellite accounts, so that they can eventually include the results in the main accounts. It may be that aggregate statistics evolve beyond the national accounts largely capturing transactions to move closer to welfare measurement and capturing more of the benefit of innovations. This would correspond to the impetus to go beyond real GDP to official GDP plus (Brynjolfsson *et al.*, 2019) or expanded GDP (Hulten and Nakamura, 2020) or a full spectrum from market activities to broad economic welfare (Heys *et al.*, 2019)

In addition, we want to move from measurement of shifting time allocations to money metrics. There is therefore a rich research agenda concerning the meaning of self-reports on different methodologies (with unbiased self-reports difficult to obtain and so challenging for official statistical production), the utility derived from different activities at leisure and at work, the best approach to applying a money metric, and the potential need for more than one dimension to measure economic welfare.

In addition to the digital transformation that has been our focus, these questions arise in the context of pandemic, ecological crisis and geopolitical conflict. Citizens are unsurprisingly asking questions about how official measures capture well-being changes. Health outcomes, in a world in which some countries' health care expenditures can exceed ten per cent of GDP, are an increasingly important part of measured real growth. At the same time, the relationship between such real expenditures and either direct health outcomes or well-being are not closely connected. Health outcomes, as the pandemic has shown, are the outcome of health shocks and of prior health expenditures and accumulated human capital. As a consequence, well-being may be worsened by health shocks, regardless of the efficacy of the health care system. Such shocks would, in principle, be registered as a decline in measures of full

income. These costs include excess deaths, millions of COVID and long COVID patients, and the psychological and educational tolls of isolation, fear, and disruption, as well as direct economic costs.

In addition, the unprecedented speed with which the pharmaceutical firms and governments were able to develop, trial, approve, and manufacture vaccines that are highly protective against the new coronavirus and its variants is a credit to advances in the world economy and evidence of its puissance. This appears to be allowing much of the world to return to more normal levels of activity, a feat that could be valued as worth trillions of dollars.

How should we incorporate these events into both the time series of GDP and full income? In current SNA practice, we generally do not see either the full, extraordinary costs of the pandemic or the extraordinary economic benefits from the innovative ideas, development and distribution of vaccines. The metrics include only the expenditures on the development of the vaccine made by pharmaceutical companies and governments, and then the costs of producing and distributing the vaccine, largely borne by governments.

The rise in global temperatures and other ecological impacts associated with climate change raise similar questions about how to develop a measure of well-being that incorporates all relevant considerations. For example, in the formulation developed by Partha Dasgupta (2021), nature impacts the economy as a set of assets or resources and also as a direct influence on the environment in which consumption and other economic activities take place.

Both types of challenge illustrate the growing wedge between standard national accounts measures, productivity and well-being, and further underline the case for new approaches to measurement. In GDP economists have constructed a measure based on expenditure and output, imperfectly adjusted through deflation to link to underlying utility. The effort to develop an improved measure of economic well-being, reflected in the growing attention paid to measurement issues, is unlikely to have as well-defined or uncontroversial a quantification as 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 and policymakers currently rely upon GDP and its components to answer this question. If there is an increasing gap 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 official statistics. 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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