Towards a Framework for Time Use, Welfare and Household-centric Economic Measurement

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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 money metric adjusted for the general rate of increase in prices. However, there is increasing interest in developing an alternative, holistic picture of the interaction between individuals and the economy to obtain a deeper 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 measure of economic progress, 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 a money metric growth rate for 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

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 money metric adjusted for the general rate of increase in the price of goods and services. The GDP growth approach was developed in a particular set of historical and geo-political circumstances (Coyle 2014, Schmelzer 2016), and has long been subject to various critiques of its inadequacy as a welfare measure (for example, Costanza 1997, Waring 1988). Can economists and national accountants develop a methodology that permits a more direct attack on the measurement of welfare within the framework of the national accounts?

Is it possible to obtain an alternative, holistic picture of the interaction between individuals and the economy to obtain a deeper understanding of economic progress? And to what extent can we present this as a growth rate, expressed in some kind of money metric? 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, whose use is now frequent and pervasive in so many economies, has opened up novel economic possibilities that have changed both for-profit business models and

[1] University of Cambridge and Federal Reserve Bank of Philadelphia respectively. These are our opinions and not those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System. We are grateful to Penny Mealy, Charles Hulten, Solomon Tarlin, and participants in a workshop in economic welfare at the Economic Statistics Centre of Excellence for their comments.

household production dramatically. 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?'

The scope for novel economic possibilities involving changing time use has increased with remarkable speed. The current changes are occurring in the context of major secular trends. In US data, there has been a significant increase in leisure time over the five decades to the early 2000s, with substitutions away from market production for men and 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 bigger decrease in hours of market work) for lower income individuals than for those in high income occupations. Gershuny (2013) notes that market production has been falling as a proportion of time use, while home production and, in most OECD countries, leisure, has been increasing. 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.[2]

More recently, digital technology has prompted significant shifts in the allocation of time, particularly since 2007 with the arrival of smartphones and mobile broadband access. The mobile Internet saturated in the US and other OECD economies between 2007 – the year the iPhone was introduced – and 2015. Nakamura, Samuels and Soloveichik (2018) estimate that user-generated content (UGC) rose from less than 1 hour per week to nearly 5 hours per week from 2006 to 2016 (market production in 2016 was just over 25 hrs per week and home production 24 hours per week according to the American Time Use Survey (ATUS), which does not count UGC as home production). Aguiar et al (2018) document a large increase in hours devoted to computer gaming over the Internet by young men in the US, accompanied by a decrease in work hours and an increase in reported wellbeing. 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.[3] Consumers are thus spending increasing amounts of time connecting to the Internet, 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.

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 range of process innovations such as legal search, inventory management, financial transactions and rapid changes in manufacturing production runs. The substitutions being brought about by digital technologies will occur within and across the economic boundaries conventionally drawn between activities: consumption/leisure, market production, home production.

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

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

The significant changes over both longer and shorter periods suggest the allocation of time should be taken seriously as a choice variable in assessing economic welfare. The question is especially salient now thanks to the impact of digital technologies.

This paper first discusses previous approaches to a more holistic conception of economic welfare. We then turn to the allocation of time , describing the digitally-driven changes in time use currently under way in advanced economies. After discussing the perspective time use provides on productivity, we turn to the contribution of different activities to economic well-being, including whether a money metric 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. Our hope is that we can bring these alternative metrics to a new consensus about economic measurement.

A wider picture of economic welfare

A milestone in seeking a more holistic picture of economic welfare was the Stiglitz report (Stiglitz, et al, 2010) advocating that economic statistics seek to move beyond GDP. This challenge was taken up by organizations such as the OECD and the European Commission in their 'GDP and Beyond' agenda.[4]

The debate about measurement of economic welfare has since intensified, due to both the obvious technology-driven changes under way in the economy, and a broad dissatisfaction in many OECD countries with post-crisis economic progress. 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. It thus makes sense to begin to think about a comprehensive framework for the measurement of welfare that includes all uses of time, whether in market production, home production, user-generated content, consumption, and pure leisure time.

A number of 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 (Nordhaus and Tobin 1972, Jones and Klenow 2017). Other approaches include psychological studies (Kahneman et al, 1999), sociological studies (Gershuny and Fisher 2014), studies in the economics of the household (Becker, 1965, Juster et al 1981, Steedman 2001), economic studies of happiness (Easterlin 1974, Stevenson and Wolfers 2008), and efforts to measure the value of free goods (Brynjolfsson et al, 2017, Nakamura et al, 2018) and to measure the welfare of nations (Krueger et al, 2009a). The importance of distribution in welfare assessments has also become more prominent (for example Aitken and Weale 2018). All of these approaches are more controversial than direct measures of output in the conventional national accounts framework as there is no consensus about the theoretical foundation. Heys (2018) has suggested considering different approaches to measuring economic progress on a spectrum of distance from standard GDP measures.

There are two sorts of approaches, which might be combined to produce a money metric welfare measure.

One approach is rooted in the measurement of market activity, utility being measured through ex post choices made by individuals. This is extended to a utility framework,

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

typically through a labor-leisure model of the sort developed by Becker 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, 2017). 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 an estimate of money-metric utility similar to the concept of money-metric utility that underlies 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 money-metric 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: the retrospective recall of the enjoyability of past events. Alternatively, a subject may be asked to write down afterwards what they spent their time doing and how they were feeling at the time.

What is notable is that both approaches require consideration of people's use of their time, the ultimate scarce resource, an issue to which we return below in suggesting how economic measurement and economic welfare may be better linked as digitalization of the economy transforms the time people are spending in different activities to which they attach different degrees of well-being.

Why we should take the time resource constraint seriously

In terms of consumption, 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. 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 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, but not explicitly modeling time to consume. 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 are time and expenditure. Rosen (1981) describes consumption as a joint expenditure of time and monetary expenditure as a foundation for "superstar" effects on producers. 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.

Changes in technology such as those clearly being brought about by digitalization are exactly the kind of changes causing relative price changes in terms of time as well as money, and could be expected to lead to shifts in expenditure and consumption patterns but also 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. 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 a switch to home delivery 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 interactions via a smartphone makes it particularly useful in periods when we are waiting. This may turn periods that would otherwise be ones of boredom and discontent into active leisure, in effect, creating leisure time out of thin air. Self-reports are one way to explore these dimensions. In principle, time use surveys can capture 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 cross-check these measures.

Absent new time use data, it is impossible to be sure about systematic aggregate changes, but Internet use has become pervasive. The way people spend their time has been changing substantially during the past decade. 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, enabling 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% of all people over the age of 14 in the 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.

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 information, provided that the information is actionable, increases the value of any economic activity, including consumption. Thus welfare may become disconnected from production, and GDP may become an inadequate measure of welfare. A number of characteristics of the Internet are important for changing economic activity. In particular, 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 and

encourages cooperation outside normal paid economic channels (Hulten and Nakamura 2018, Coyle, 2018).

If, in fact, our measures of economic progress, based as they are on deflating dollar transactions with indices of changes in the prices of marketed products and services, are no longer accurate measures of gains in economic welfare, then we need to turn to alternative measures of welfare. While we may not be able to estimate these alternative measures of output with the accuracy supposed to be a feature of real GDP statistics, we may be able to obtain some guide to the orders of magnitude of true economic welfare growth. 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.

The standard approach of 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. It is possible to imagine an ambitious extension of standard general equilibrium theory with utility based on the flow of consumption to include the extended time required for production (market and home) and consumption (with leisure and consumption as joint activities). It is not clear that this project, beyond our scope here, would have any of the general equilibrium characteristics we are familiar with.

An alternative approach is to consider directly 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 first 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 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 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.[5]

The links between activities in the different conventional economic categories and average well-being in undertaking them are not straightforward, however. Surveys such as the ATUS and others 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, childrearing, or entrepreneurship. One approach would be to consider such goals as an investment in both individual capital, or capability and social goods, contributing to others, or to the next generation.

A further consideration is that well-being, in 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, as well as tastier food and more captivating entertainment, all may change the definition of the best possible life.

Thinking about how to interpret the allocation of time between paid labor, home production, and leisure, to a first approximation we might think that time reductions

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

(holding output constant) in paid labor and home production, that is, in what we call "work" is 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 in either 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. Varian's discussion of the value of search assumes that one would search more if search took less time.

A further 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 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 substantial variations between groups (Kaplan and Schulhofer-Wohl, 2018).

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 be directly very enjoyable or welfare enhancing. In effect, paid labor or household production can tip over into leisure if they are enjoyable. 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.

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, but 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 below. For now, it is important to note that it is *holding income constant* that reductions in time spent in either paid labor or household production are leisure- and welfare-enhancing. For unemployment may result in more time spent at leisure, but is not welfare enhancing. However, holding income constant implies *a money metric is required*. The utility measures that we propose are, at least potentially, provided with a quantitative money metric because of their connection to the consumption and production of goods. The next logical step is to consider whether a money metric could be applied to a time use and well-being approach, as a substitute for the habitual use of changes in GDP as the shorthand social welfare metric dominating policy debates. 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 money metric welfare measure, they argue that

such a welfare measure is possible.[6] In their attempt to integrate aggregate time use figures with well-being results in a 'National Time Accounting' they calculate a national well-being index which 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 money metric. We seek to draw the lines connecting potential money-metric valuations and personal consumption expenditures, on the one hand, and measures of consumer self-reports on feelings and on happiness, on the other.

Is it possible to assign shadow prices to these feelings, as Krueger et al suggest is possible, if not a step they were prepared to take? When Brynjolfsson et al (2018) ask about consumers' willingness to pay for online services that are unpriced, or what they would have to be paid to give up these services, they reopened this question of the extent to which consumers and households are able to put money-metric valuations on goods and services. Further evidence along the lines of Brynjolfsson et al (2018) could be obtained by asking survey participants directly about their shadow value of time. What would they be willing to pay for an extra day's vacation, provided their workload were reduced comparably? What would they have to be paid to work an extra day, assuming their workload were not thereby reduced? The answers to these questions could then be related their wage rates and the measured experienced utility of labor.

In an alternative approach, 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, the wage rate of employees, and also the case when neither wage rate is applicable.

Alpman et al (2018) take an alternative approach, using experienced well-being and time use surveys, combined with money metrics to directly estimate the monetary value of nonmarket activities. In essence, they scale money metric expenditures with estimates of experienced well-being, along the lines of Krueger et al, within a representative agent framework to estimate full 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-

[6] "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 2009a, p15.

being" valuations of non-market activities and then multiply these by total consumption expenditure to derive a money metric. This is an important first step in using experienced well being surveys to estimate the value of the shadow price of time.

The time use lens on productivity

Time use also offers a different lens on production and productivity. After all, what does 'productivity' mean when there is no product? From this perspective too, digital technologies and the pervasive internet mean there are some significant changes in time use and the implied 'true' productivity change under way at present.

For 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 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 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 Adam 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." (Smith, 1776, 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."[7]

Saving time on routine activities and being able to spend more time on non-routine activities, in order to improve quality, are intuitive meanings of productivity in different services. Table 1 indicates how one might think of productivity improvements from a time-metric perspective. The first vertical division in the Figure is the production boundary, and the second is the boundary between productive activities and leisure/consumption; while the horizontal division distinguishes been routine activities, which can readily be automated, and non-routine activities. In the former case, productivity and welfare gains result from technological innovations enabling the activities to be carried out more quickly. In the latter case, the gain results from the scope to spend more time and deliver a higher quality service (more personalized or tailored to individual need, for example).

Some examples in red text indicate changes due to digital innovations. These may save time (online banking versus walking to the bank and standing in line); some offer new ways of spending time (online entertainment and social media) and some involve time use exchanges (ordering a meal through an app saves my time but someone is still preparing it). In some cases the aggregate effects may be large. 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

[7] These citations can be found in Ricardo (1951), 12-13 in the part of the *Principles* where Ricardo discusses his differences with Smith over the theory of value.

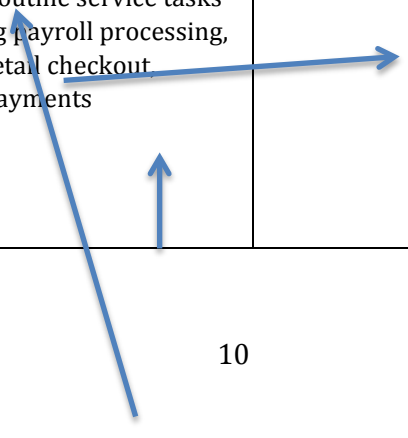
previously. This is a process innovation enabling the firm to reduce costs; customers should get a better (faster) service, and perhaps pay less for it as well. There will be general equilibrium effects too, through accountancy and legal process as an intermediate input to other sectors, and through 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 face of ATMs, depending on aggregate demand for the sectors' services).

The process innovations under way in such sectors are highly unlikely to be captured in GDP and conventional productivity calculations, as this would require a complex 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 required to produce is omitted from the calculation.

Furthermore, some routine activities are crossing the production boundary – writing wills is one example, formerly involving lawyers, 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 (2018) argues that one potentially significant substitution concerns 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 your 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. On the whole, however, it is likely that thanks to digitalization there is a net shift from market to household time-using production such that the measured productivity of affected sectors is lower than in the counterfactual non-digital world.

Table 1: A time-based approach to productivity

	Market production	**Home production**	**Consumption/leisure**
Routine activities Productivity increase equivalent to time saving	Routine manufacturing tasks Routine service tasks eg payroll processing, retail checkout payments	Cleaning Driving	Daily run Eating Personal care



	All liable to be automated	May be automated in future – domestic robots, self-driving cars (cf washing machines, microwaves)	Largely non-automatable because inalienable although routine (but cf safety razor)
Non-routine activities 'Productivity' increase equivalent to better quality, more customisation etc	Medicine Consultancy Legal services Elements of these being automated by digitalisation of routine tasks within them Travel agency Banking services Moving online and into home production – time saved in not going to high street Non-routine manufacturing Car repair, plumbing, decorating	Cooking Gardening Caring May also be purchased in the market Creating – vlogs, open source resources, craft activity, writing Car repair, plumbing, decorating Often purchased in the market	Cooking Gardening Inherently enjoyable for some people Cinema Sport Socialising, eating out Creating – vlogs, open source resources, craft activity, writing New online activities – digital enabling some of these to transform into home production or market production

Time use choice margins

Gary 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 (Hulten and Nakamura, 2017). His formal model, however, considers just

time for production, in the market and in the home. Technological advances in different domains can result in substitutions across the production boundary between home and market. Technical advances in domestic appliances shifted both from household to market. The digitalization of services such as travel and accommodation 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

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

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 maximise 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, and w´ is a vector of wages paid for hours of work, 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 all 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 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 leads to better consumption choices, so the ongoing advance of knowledge and its availability to the consumer (as 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 (particularly in real time) 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) 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.[8] Improvements in household technologies in the 1950s and 60s likely also led to a similar shift.

Steedman (2001) offers another alternative, incorporating time for consumption into the standard utility maximizing framework, subject to money and time budget constraints; but omitting home production. His model, among other things, adds in 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 non-standard results. For example, non-satiation may not hold thanks to the time constraint (as it is an identity, where the money budget constraint is a weak inequality.) Inferior goods will exist: when income rises, the consumer will substitute expenditure in money for expenditure in time, switching away from less expensive but more time intensive goods. Taking account of time may 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. 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 complex and would not result in the kind of 'well behaved' analytical solutions economists prefer. Some of Steedman's results can appear in a lifecycle model that embed habit-formation, such as in Stigler and Becker.

[8] 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.

Self-reports: Money metric scales and arbitrary scales of happiness

A more direct approach is to consider direct measurement of economic well-being. Economic structural modeling can permit estimates of money-metric scales of utility, although these often rest on parametric assumptions which are necessarily simplified relative to the real world. That is, we can begin from the notion of utility. Brynjolfsson et al (2018) reintroduced money-metric scales of utility in the evaluation of goods, asking both how much subjects would be willing to pay for a given amenity (such as social media or a indoor plumbing) or how much they would be willing to accept to do without the amenity. Coyle and Rogers De Waal (2018) conducted a similar survey concerning willingness to accept doing without online services. The estimated monetary values can be sizeable.

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 self-reports 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. Thus self-reports of utility appear to be, at least in cross-section, relatable to a money-metric scale of utility.[9]

It is true that the studies in Kahneman (1999) show that such self-reports are affected by many other factors than measured real income. But can self-reports be placed on a money-metric scale? The self-reported money-metric utility values evoked by Brynjolfsson et al (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. We might, for example, query individuals on what they would pay for someone else to perform a household chore or at what pay would an individual work an additional hour at their current job or at some benchmark alternative.

The enjoyment of work

An important question is how much utility do employees 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

[9] Because the frame for the Cantril ladder is "the best possible life", it might be that 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 wellbeing has remained flat over time.

(Nakamura and Csikszentmihalyi 2002). As a first approximation, economists such as Becker have argued that the wage is an estimate of the value of leisure time and home production time. They argue 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 both on the wage the worker receives and how much utility the worker receives from that job. If the population is experiencing greater distress, as suggested by Case and Deaton (2017) and Deaton (2018), it is of value to explore how the work might be contributing to this. 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 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.

A further issue is that work can contribute to one's skills if it results in learning while doing. To this extent, work can raise one's human capital. This may be true for the early years of developing skills, while it may not be true of a dead end job, and is less true later in life. Thus part of the work-life quandary of a young educated parent is that their time at work is valuable not just for the current pay, but as part of a career path. This may further raise the shadow value of time relative to the wage.

Such questions are akin to asking for self-reports on the enjoyment experienced during different activities, such as at work, or driving in traffic, or while at leisure out of the home. Such questions are studied in Gershuny (2013) and Krueger (2009). 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 argues that what evidence there is supports the view that ex post diary studies have similar results to the real-time studies.

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 at a neutral job compared to their current job for an extra hour of work 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 hours flexibility, vacation time, meaningfulness, 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. These 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.

A crucial question is how, and to what extent, the resulting metrics are relatable to measures of real GDP, perhaps as extended by Nakamura et al (2018) or to alternative measures of money-metric utility such as those suggested by Hulten and Nakamura

(2018). An important question that might be answered is whether labor conditions as a whole have been stable in a given economy; is it 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, e.g., Bentel and Demougin (2010), The composition of labor has also changed, which could also change the utility of experienced labor, as argued by Kalplan and Schulhofer-Wohl (2018).

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 2, 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" given the ratings 8.02 in 1975 and 8.17 in 1981. The next less enjoyable category was "home entertainment." By contrast, cooking was rated 6.17 (1975) and 6.13 (1981), and television 5.93 (1975) and 6.00 (1981).

While it might be objected 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 process benefits from work and the intrinsic characteristics of the jobs a reflected by its occupational status." (Juster, 1985, 341,)

Krueger et al (2006) in the Princeton Affects and Time Survey asked respondents to record their happiness on a scale of zero to six, where zero meant not experiencing the feeling at all and six meant the feeling was very strong. This data is presented in Table 3. (They were asked the same question about feeling stressed, sad, interested, and pain.) In sharp contrast to the Juster 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 survey asked about general attitudes toward activities, while the Krueger survey asked about specific episodes in the previous day. However, if it is the case that employment has become substantially less pleasant then this would have first-order effects on money metric estimates of utility.

The contrast between asking a general question as Juster does and a specific retrospective time period question as Krueger does is related to Kahneman's 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. However, Krueger et al 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 on-going area of study, and it is possible that greater progress can be made since the use of mobile devices for reporting may enable low-cost extensions of these surveys. These may bring us closer to understanding how experienced utility at work and the wage rate are related to the shadow value of leisure.

An additional question is raised by Cassar and Meier (2018) as to whether 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 capture in the mission or purpose of the work has an important impact on

the pay that workers are willing to accept for a given task. They point to a variety of empirical evidence in the human resource management literature that bear 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 utility.

Another question is which sort of happiness individuals are maximizing when they make economic decisions? On what basis does one buy a new car or house, or decide what work to do? That there now exist courses on positive psychology, aimed at helping students to maximize their happiness, as well as extensive studies on decision-making carried out by behavioral economists and psychologists suggesting that we often do not maximize when we make decisions. How does this affect the welfare value of consumption, defined as purchasing decisions? Benjamin et al (2012) asked individuals to choose between alternative scenarios, such as would they rather have a lower rent (20% of income) and a longer commute (45 minutes) or a higher rent (40% of income and a shorter commute (10 minutes). Moreover, they ask 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 wellbeing). They find that there are systematic differences between the choices people 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 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 by various definitions – in a real world context. They examine the residency training choices of medical graduates and ask how their choices would affect happiness during residency, life satisfaction during residency and which would lead to the best possible life. They find that none of these three perfectly explain people's choices, and, in particular, that residency prestige and the desirability of the choice for the significant other had considerable additional weight. Thus professional and social concerns – above and beyond what seems most desirable for the individual – are important in understanding choice.

Can we read off happiness surveys the utility experienced while working? 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 Osward (2004) use 1972-1998 data from the US to calculate that for males it would take some $60,000 (1990s dollars) to compensate them for being unemployed, that is, that 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, 45-53). However, similar techniques might be used to interpret the sort of data in Krueger et al (2009) or Juster et al (1985) which can be more closely tied to a concept of "neutral" utility, if these data could be related to the overall happiness of individuals that can then

be interpreted in a money metric way. This is a conceivable complement to surveys that ask about the monetary value of the utility of work.

These episodic measures of utility may buttress our understanding derived from other measures of welfare. Currently, policy oriented welfare analysis rests upon stated preferences and revealed preferences. 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 moreover points out that the evidence on the welfare impact of amenities such as in-vehicle amenities and mobile communications and entertainment 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.

Another issue is whether a single dimensional measure such as happiness is the appropriate way to measure episodic utility. Krueger et al 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, pain, 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 money-metric as they suggest might be possible?

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 state preferences. This may help us to understand the extent to which a given money metric measures reflect actual choices. On the other hand, we might believe that feelings – as revealed by feelngs 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.

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, then 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 the expenditures? Or are the feelings we experience and report partly mitigated by the size of our outlays?

Finally, a wider question about time use as the foundation for an economic welfare metric 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 may be more valuable than joy. Having a purpose may require actions that provoke deep anxiety. However, this goes beyond our scope here.

The path ahead

We have laid out a series of research questions about the linkages among measure of utility, consumption expenditures, and time allocation to work and leisure. These research questions derive from the earlier seminal work on time use by Becker, 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 link from our evaluations of our activities, one by one, 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 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 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 wellbeing 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 a quantification 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? Macoeconomists 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 discuss economic policy issues meaningfully. However, national accountants would not be able to do this on their own. Developing meaningful estimates would require a sustained dialogue between government statisticians and the economics profession at large.

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Table 2. 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
Hone entrertainment	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 3. Happiness Ratings from Krueger et al (2008), 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	4.5
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/clean-up	4.02	4.02
Personal care	4.02	4.07
TV	3.91	4
Working	3.8	3.83
Medical care	3.64	3.76
Education	3.62	3.55
Housework	3.55	3.56
Adult care	3.54	3.5
Household management	3.5	3.7
All	4.13	4.13