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# IS GDP BECOMING OBSOLETE? THE "BEYOND GDP" DEBATE

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An earlier version of this paper originally appeared in July 2022 with the same title and working paper number. The current version is significantly expanded with additional material from the wellbeing literature, but the core conceptual framework is essentially the same. Our earlier papers in this area include Hulten and Nakamura (2018, 2022). The opinions expressed are our own and not those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System, the National Bureau of Economic Research, or any other organization with which we are affiliated.

At least one co-author has disclosed additional relationships of potential relevance for this research. Further information is available online at http://www.nber.org/papers/w30196

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**ABSTRACT**

GDP is a closely watched indicator of the current health of the economy and an indispensable tool of economic policy. It is not, however, a persuasive indicator of individual wellbeing or collective economic progress. There have been calls to refocus or replace GDP with a metric that better reflects the welfare dimension. In response, the U.S. agency responsible for the GDP accounts recently launched a “GDP and Beyond” program. This is by no means an easy undertaking, given the subjective and idiosyncratic nature of much of individual wellbeing. Indeed, some sources of wellbeing may prove impossible to measure accurately. This paper joins the Beyond GDP effort by extending the standard utility maximization model of economic theory to include those non-GDP sources of wellbeing for which a monetary value can be established using a willingness-to-pay approach. We have termed our measure expanded GDP (EGDP) in our previous work, and the current paper extends that framework to include a welfare-adjusted stock of wealth, derived using the same general approach used to obtain EGDP. This welfare-expanded stock is useful for issues involving the sustainability of wellbeing over time. Finally, we propose a way of connecting GDP and the large literature on happiness and collective wellbeing by incorporating a survey-based subjective index of perceived wellbeing into the conventional ordinal utility framework. Our conclusion is that both the GDP and wellbeing metrics are important but address different questions: the size of the economy on one hand and true extent of economic progress on the other.

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## I. GDP and Its Challenges: An Overview[2]

America entered the Great Depression lacking an organized national statistical system with which to track the aggregate economy and to inform economic policy. By 1933, 25% of the workforce was unemployed, up from around 3% four years earlier. There was a partial recovery, but the rate went up again to 20% in 1938 before falling to as low as 1.2 % during World War II. There were no official estimates of Gross Domestic Product at the start of the Depression with which to guide the policy response, but this began to change by the mid-1930s. The National Income and Product (GDP) Accounts, in their more-or-less current form, were finally published in the late 1940s, thus establishing an internally consistent and ongoing data framework for informing economic policy, while also enabling the growth of a large empirical literature on longer-term sources of economic growth.[3] In view of the economic crises of recent years, it is clear that the national accounts are still as important as ever. How can the size of the "Okun Gap" resulting from the financial crisis of 2008 and its aftermath be determined without an estimate of GDP? How can an appropriate response to price inflation be formulated in the absence of reliable price statistics? How can current trends in employment and labor-force participation be understood without knowing the role of labor in production, or supply-chain disruptions without information about the industrial structure of the economy?

The development of these accounts was called "One of the Great Inventions of the 20th Century" by Paul Samuelson and William Nordhaus.[4] This praise applies as well to the development of the international dimension of the national GDP accounts, in the form of the United Nation's System of National as well as the advent of the purchasing-power parity

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[2] We thank Daniel Benjamin and Ori Heffetz for their helpful comments on an earlier draft, as well as Steven Landefeld and Dylan Rassier, and the participants at the October 14, 2021, seminar at the Bureau of Economic Analysis. Marshall Reinsdorf also provided valuable comments and insights. We thank, as well, the participants in the October 27, 2022, LSE Wellbeing Seminar (jointly organized by the Department of Psychological and Behavioural Science at the London School of Economics and the Centre for Economic Performance), and especially Christian Krekel and Richard Layard for their comments. Remaining errors and interpretations are our own and not those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System, or any other organization with which we are affiliated.

[3] For an historical perspective on the early evolution of the U.S. GDP accounts, see Carson (1975).

[4] The quote by Samuelson and Nordhaus is cited in J. Steven Landefeld, "GDP: One of the Great Inventions of the 20th Century," *Survey of Current Business*, January 2000.

adjustments to international GDP. An enormous amount of effort and resources have been devoted over the years to realizing these "inventions."

Yet, GDP has also attracted substantial criticism in recent years. The leading example is perhaps the 2009 report by the International Commission on the Measurement of Economic Performance and Social Progress, *Mismeasuring Our Lives: Why GDP Doesn't Add Up*, co-authored by Stiglitz, Sen, and Fitoussi. They argue that "there appears to be an increasing gap between the information contained in aggregate GDP data and what counts for common people's wellbeing (Stiglitz et al., page 12)." This argument has been taken up by the Bureau of Economic Analysis, the agency responsible for the national accounts and GDP, in a new initiative *"GDP and Beyond*". This new initiative was announced in the Survey of Current Business *(*Bohman (2020)): "Recently, BEA launched a Bureau-wide initiative to expand our official statistics beyond conventional measures of economic growth by highlighting aspects of economic well-being and sustainability." The same issue of the *Survey of Current Business* also includes an important article by Landefeld et al. (2020) that provides a taxonomy of the various options for the Beyond GDP project and references to the extensive literature.

A number of other economists have also questioned the relevance of the GDP concept.[5] Nordhaus and Tobin titled their 1973 paper, *"Is Growth Obsolete?*", in which they construct a measure of economic welfare. Coyle (2014) remarked that the GDP accounts were designed for an earlier economic environment, and Jones and Klenow start their 2016 paper with the statement that "As many economists have noted, GDP is a flawed measure of economic welfare." The large literature and active debate about the role of GDP growth in promoting climate change and diminishing biodiversity (Dasgupta (2021)) is another facet of the welfare critique of measured GDP.

The Stiglitz-Sen-Fitoussi report advocates "working towards the development of a statistical system that complements the measures of economic activity by measures centered

[5] Interest in the measurement of wellbeing is by no means a relatively recent event. The 2020 Survey *of Current Business* article by Landefeld et al. (2020) includes a table titled "Timeline of Research on Economic Well-Being and Extensions to the National Accounts" that lists 17 entries dating back to the 1700s and ending in 2018 (it includes the Stiglitz et al. report and has many other important references). Indeed, BEA has been active in recent years in improving the U.S. national accounts with such developments as the Integrated Macroeconomic Accounts and the capitalization of intangible capital.

on individual well-being and by measures that capture sustainability." This is the goal of this paper as well, but it is a goal that is hard to attain. Bridging the gap between a comprehensive welfare-based aggregate and conventional GDP must contend, among other things, with the fact that many aspects of wellbeing lie outside (and, in some cases, well outside) the reach of monetary metrics like GDP, or, what Pigou (1920) termed the "measuring rod of money." Many of these aspects of wellbeing are subjective and idiosyncratic, and some involve value judgments. Moreover, there is no one measure that commands a consensus. Settling on a "measuring rod of wellbeing" that commands a consensus has proved difficult despite the great effort and attention it has been given and the many resulting candidates.

Any proposed measuring rod of wellbeing also faces the problem of how (indeed, whether) it can be connected to GDP, the logical starting point of a movement Beyond GDP (and of this paper). Our first efforts in this direction were to build outward from the existing GDP accounts and their underlying economic theory to include sources of utility and disutility tied to GDP goods but not captured by GDP itself (Hulten and Nakamura (2018, 2020)), Our modification of the conventional GDP model to include these "spillovers" started with the standard general equilibrium model of utility maximization and extended this model to incorporate Lancaster's "New Approach to Consumer Theory"(1966a). The distinguishing feature of the Lancaster framework is that it introduces separate "consumption technology" that can shift over time, thus creating a gap between conventional production-oriented GDP and the associated wellbeing to the consumer. Our previous work showed that in many cases this gap can be measured using the compensating/equivalent variation approach. The result is a monetary metric of the value of the additional utility that can be added to conventional resource-based GDP to arrive at a welfare-oriented measure we term Expanded GDP (EGDP).

This paper continues in this direction by extending the EGDP framework to include an intertemporal dimension. This dimension is needed in order to address the sustainability of wellbeing issue that is of central importance for environmental concerns. It does so by introducing the Lancaster consumption technology into the conventional cost-based measurement of capital stock and wealth. The result is an alternative metric we call "E-wealth" that is the intertemporal counterpart of EGDP.

The paper's second contribution is a synthesis that attempts to reconcile GDP (and EGDP) with the large literature on the measurement of individual happiness and life satisfaction. It does so by reframing the standard ordinal utility model in a way that permits the inclusion of a numerical rating of overall self-perceived personal wellbeing. The significance of this addition to the Beyond GDP debate is that there are now two independent, but connected, metrics of economic progress: one denominated in monetary units and the other a numerical index of aggregate wellbeing. The large literature on happiness indexes is a resource we can tap into in search of a suitable index for this purpose.

This comparison helps address the bottom-line question of whether or not perceived social wellbeing has increased more or less rapidly than GDP. There are reasons to believe that it has grown faster, summarized in our earlier work which indicates that there are products whose contribution to welfare exceeds their contribution as recorded in GDP. However, there are also reasons to think that welfare growth has not kept pace with measured GDP, due, for example, to negative environmental externalities.

The main thrust of this paper is theoretical, and its goal is to develop a conceptual infrastructure to inform the data and accounting dimensions of the move beyond GDP (getting the data "right" is a non-trivial part of this move).[6] The paper offers no new empirical results but it does point to some of the many theoretical difficulties faced by an attempt to implement both the EGDP and the even more challenging wellbeing-happiness framework. We end by concluding that GDP and wellbeing are complements, not substitutes, whose metrics address different aspects of aggregate economic activity. Both are important and should, in principle, form part of any valid assessment of economic and social progress. However, given core GDP's operational importance for the conduct of economic

[6] In his 1994 Presidential Address to the American Economic Association, Zvi Griliches observed that economists "do not put enough emphasis on the value of data and data collection in our training of graduate students and in the reward structure of our profession. It is the preparation skill of the chef that catches the professional eye, not the quality of the materials in the meal, or the effort that went into procuring them."The focus of our paper is on the "ingredients" needed for a move beyond current GDP, and thus we do not attempt to summarize the sizeable analytical literature that focuses on the estimation of wellbeing in relation to GDP.

policy and its widespread familiarity and general acceptance by the public, its "headline" status should not be disturbed. Estimates of EGDP and the happiness index could, however, reasonably be assigned to wellbeing-oriented satellite accounts attached to the core.

## II. GDP: Conceptions and Misconceptions

A. Real GDP is often treated as though it were a single homogenous variable representing the total product of an economy, something you might purchase in a store. Nominal-price GDP is, in fact, a statistic built up from the data in a large number of tables, and real GDP is the estimate obtained mostly by controlling for price-level changes using a price deflation procedure. GDP is meant to be an indicator of the volume of economic activity, but that does not mean that it necessarily refers to a specific set of goods and services, nor that it is an exact measure of the entire scope of economic activity.

The diagram shown in Figure 1 describes the interconnected flows of inputs and output in a perfectly competitive economy that is closed to international trade. We do this to simplify the exposition of the basic issues of the beyond GDP debate. The generalization to an economy that is open to foreign trade does not change the essential mechanisms we wish to describe (more on this point in a section that follows):

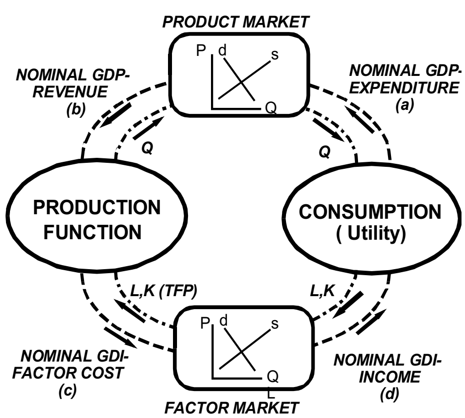


FIGURE 1

The figure indicates that there are, in fact, four different ways that a nominal "GDP" could in theory be approached. These four alternatives are shown in the circular flow structure of Figure 1, which provides a convenient organizing framework for the exposition of the link between theory and accounting practice. The alternatives in the figure include:

*(a)* the expenditure on the goods and services acquired;

*(b)* the payments received by the producers or owners of these goods and services;

*(c)* the cost to the producer of acquiring the labor and capital needed to produce this output;

*(d)* the income accruing to labor and capital.

Each of these flows reveals a different yet interconnected aspect of the economy.

The counter-clockwise flow around the outer edge of the figure is valued in nominal prices: quadrant *(a)* is a flow of payments into the product market from consumers, while *(b)* is a flow out of that market to producers. The flows are simply transfers and are thus equal (in principle, if not in practice) and, together, they constitute nominal-price GDP. The cost of production *(c)* is a flow into the factor market, and *(d)* is a flow out of that market to the owners of labor and capital; since the flows are ultimately (after some intermediation) transfers occurring within the factor and financial markets, they are also equal. Together, they constitute nominal GDI.

Two economic transformations also take place in the circular flows. First, the inputs of labor and capital acquired by producers are transformed into output, and the revenue from the sale of output *(b)* pays for the cost *(c)*, and they are thus equal. Secondly, income from *(d)* is used to purchase goods in the product market (via *(a)*) which are transformed into welfare according to the choices and expenditures made in light of the utility function. Income thus equals expenditures (including saving). Thus, the four elements *(a)* through *(d)* that constitute GDP and GDI are, in principle, equal. The overall result is the Frank Knight circular flow model of national income accounting (Patinkin (1973)).

The clockwise inner flows in quadrants *(c)* and *(b)* of the circular flow diagram refer to the real (constant price) quantity of inputs and real aggregate output. The quantities of labor and capital are linked to real output via the prevailing technology and its level of productivity. Similarly, the income obtained from the inputs in quadrant *(d)* is transformed into the welfare obtained from the purchase and consumption of real output $Q(a)$.

B. From Accounting to Analysis. The nominal-price flows in the four quadrants of Figure 1 can be formalized in an algebraic form by the following equation, shown here for the aggregate economy:

$$(1a) \quad GDP_t = P^Q{}_t Q_t = (P^L{}_t L_t + P^K{}_t K_t) = GDI_t.$$

The quantity of output is the $Q_t$ of Figure 1, whose price is $P^Q{}_t$; the two input quantities are, as before, $L$ and $K$, with prices $P^L{}_t$ (the wage rate) and $P^K{}_t$ (the gross return to capital, or Jorgensonian user cost of capital). GDP is the value of the product $P^Q{}_t Q_t$ and GDI is the gross income accruing to the two inputs $(P^L{}_t L_t + P^K{}_t K_t)$, all in year $t$.

The equality of nominal price GDP and GDI in equation *(1a)* holds in this economy when the two are valued in the current product and factor prices prevailing in each year. During periods of rising product prices, the welfare content of the expenditure for good $Q_t$ is eroded as the purchasing power of money declines, and each dollar of GDP buys fewer goods. Thus, it is usual in accounting practice to present an alternative measure of "real" GDP that corrects for inflation by expressing the nominal amount in the constant prices of a base-year (e.g., of $t=0$). The price deflation procedure results (in theory) in $GDP_{t,0} = P^Q{}_0 Q_t$. In other words, nominal GDP = $P^Q{}_t Q_t$ is multiplied by the price deflator $P^Q{}_0/P^Q{}_t$.

The concept of "real" GDI is more complicated. In common usage, real *income* is commonly taken to mean income corrected for its purchasing power. This is essentially the wellbeing associated with the income emerging from the factor markets that flows to the consumer in quadrant *(d)*. It is also the meaning used by BEA for its "Inflation-adjusted measure of disposable personal income" account, where deflation is done using the personal consumption expenditure price index. There are a lot more complexities, but in our simplified version of the gross income framework, this amounts to $GDI_{t,0} = (P^Q{}_0/P^Q{}_t)(P^L{}_t L_t + P^K{}_t K_t)$; since nominal GDP in each year equals nominal GDI in that year, a general GDP price deflator can be applied to GDI to control for the purchasing power of income.

However, there is also a second concept of inflation-corrected GDI in the flows in quadrant *(c)*: real factor cost. Recalling equation *(1a)*, GDI itself is defined in nominal prices as the current cost to producers of acquiring the inputs of labor and capital, or $(P^L{}_t L_t + P^K{}_t K_t)$. Inflation affects both wages and capital prices (actual or implicit) and thus increases the cost of production. Using an input price index to correct for factor price inflation results in $(P^L{}_0L_t+P^K{}_0K_t)$. The key result, here, is that real GDP in this sense is not equal to real GDI in its form of factor cost:

$$(1b) \quad GDP_{0,t} = (P^X{}_0X_t + P^Y{}_0Y_t) \neq (P^L{}_0L_t + P^K{}_0K_t) = RFC_{0,t}\,.$$

This inequality has an important implication: the wedge between $GDP_{0,t}$ and $RFC_{0,t}$ in the price dual of the Solow Residual measure of total factor productivity (TFP). TFP is a measure of the increase in output per unit total input which, in the Solow-Jorgenson-Griliches framework, is based on the shift in the aggregate production function relating labor and capital to output ($Q = e^{\lambda}F(L,K)$), where $\lambda$ is the rate of TFP growth.

C. The circular flow formulation and the associated equations also have important implications for the Beyond-GDP project. First, the implied measure of aggregate economic activity in the circular flow diagram is seen to be *both* a measure of wellbeing and of the cost of production. Real GDP versus wellbeing is therefore not an "either-or" matter. Indeed, the goods of quadrant *(a)* include expenditures for many of the basic necessities of life. The issue for the Beyond GDP movement is therefore *not* whether wellbeing should be introduced into the national accounts, but how much additional wellbeing is missed by the current GDP metric, and how it might be measured.

Second, the connectivity of the four quadrants of the diagram means that any change made in one quadrant must be accommodated by a change in the others if current national accounting practice, with its separate cost and product sides, is to be preserved. Thus, any change contemplated in a reform of GDP must also find its way into nominal GDI (and *vice versa*). What does moving beyond GDP mean for GDI? This is a question that needs to be confronted when proposing additions or subtractions to the current GDP flows to arrive at a new version of GDP accounting structure that better reflects wellbeing.[7]

[7] The problem in moving beyond current GDP is complicated by the presence of intermediate inputs and outputs. Intermediate products are those goods that are produced for delivery to other industries as inputs into their production. Steel production delivered to the auto industry is an example. Because they are both inputs and outputs, the volume of their net production is zero. As a result, the GDP goods entering the product market from quadrant *(b)* are deliveries to final demand and not total output. A similar netting-out process occurs on the input side of the circular flow diagram, leaving the primary factor inputs of labor and capital in the factor markets (as, for example, in Hulten (1978)).

Third, the equality of the monetary flows in the four quadrants of Figure 1 do not make explicit provision for beyond-GDP sources of utility or wellbeing add-ons of the sort envisioned by the Beyond GDP movement. Where in the circular flow of payments do these additions fit? Indeed, many of the non-GDP sources of wellbeing are not even susceptible to the Pigovian measuring rod of money. The question then is how the different non-monetary and monetary measuring rods are to be fitted together into a new "architecture" that better portrays the true extent of aggregate wellbeing. This is where our paper makes its conceptual contribution by offering a way of augmenting the circular-flow accounting model to allow for additional sources of wellbeing.

## III. The Neoclassical Theory of GDP

A. The data flows tracked in Figure 1 are more than just a large double-entry accounting exercise that reflects the aggregate structure of a closed economy. They arise from the supply and demand decisions of producers and consumers, so it is therefore not surprising that they can be linked to a simple general equilibrium model of the economy. Indeed, the accounting equation *(1a)* can be derived from the conventional theory of utility maximization subject to a constraint. The link between theory and national income accounting practice was elaborated in the contributions of Christensen and Jorgenson (1969, 1970), and it is the conceptual basis for the "New Architecture" of the accounts put forward by Jorgenson and Landefeld (2006). This body of work establishes a linkage that provides conceptual consistency between theory and observation (following the Koopmans (1947) injunction against measurement without theory). Theory also provides a framework that guides and constrains what is to be included in the corresponding GDP accounts, a role that becomes even more important when considering how to revise the existing accounts to better represent economic wellbeing. Without such a guide, going Beyond GDP may involve going beyond the conventional corpus of economic theory.

Figure 2 below provides a convenient organizing framework for the exposition of the link between theory and accounting practice. In order to facilitate graphical intuition, we focus on the case of two goods, *X* and *Y*, and two inputs, *L* and *K*, and two consumers with identical ordinal utility functions, *U(X,Y)*.[8] The common utility function is

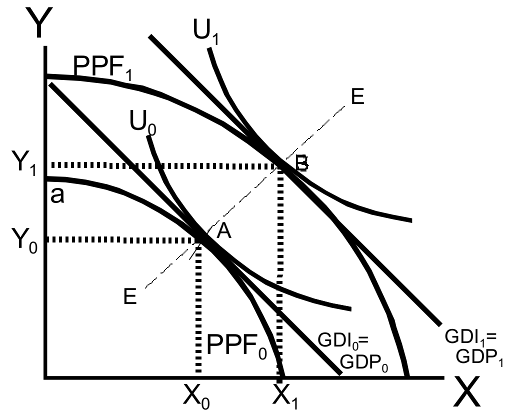


FIGURE 2

maximized subject to a constraint on how much can be produced in any year, represented by the production possibility frontier *F(X,Y;L,K,t)*. This production frontier transforms the given amount of labor and capital available in each year via the prevailing technology into the products available for consumption or use. The *t* term in the production function is a time-shift variable allowing for autonomous changes (denoted above by $\lambda$ in the single output case) in the production possibility frontier in each year due to changes in the productivity with which inputs are used in the production of output.

The point *A* is the point of tangency between $PPF_0$ and the highest indifference curve, $U_0$, of the ordinal utility function *U(X,Y)*. It thus simultaneously represents the highest level of utility that can be achieved consistent with remaining on the constraint imposed by the $PPF_0$, and the highest attainable level of GDI. It is also the market equilibrium of the conventional theory of the two person/two-good economy operating under conditions of perfect competition, where supply equals demand for both goods. In this textbook case, the slope of $PPF_0$ at *A*, the marginal rate of transformation (MRT) between *X* and *Y*, equals the slope of $U_0$, the marginal rate of substitution). The MRT is also the ratio of the marginal costs of *X* and *Y*, and the slope of the MRS is the ratio of the marginal utilities. The slopes

[8] See the 1957 article by Francis Bator, "The simple analytics of welfare maximization," for a summary exposition of this model**.**

are equal in this textbook case, bringing marginal cost into balance with the marginal utilities.

Since *A* is a competitive equilibrium with the MRT and MRS are equal, the equality defines the price ratio $P_X/P_Y$, which is also the slope of the mutual tangent line at *A*. The tangent line has the form $P_X X + P_Y Y$, which, in view of the accounting equation *(1a)*, equals GDP. The connection between the equilibrium price and marginal utility again emphasizes the welfare dimension of GDP. Similarly, the connection between price and the marginal cost of producing the quantities of *X* and *Y* at *A* indicates the cost dimension. Moreover, this cost is related to factor income under constant returns to scale in production when labor and capital are paid the value of their marginal products, in which case cost equals $P_L L+P_K K$. Constant returns also imply that $P_Q Q = P_L L+P_K K$, confirming that GDI equals GDP, as in equation *(1a)* of the preceding section. The tangent line in Figure 2 again establishes a link between theory and accounting.

This simplified representation of an economy in competitive general equilibrium embodies the assumption of perfect competition with no market distortions due to monopoly, regulation, non-neutral taxation, or some other source of an inefficient allocation of resources; there is also assumed to be no Okun gap between potential and actual GDP resulting from the business cycle. The real world, however, often intrudes on the niceties of macroeconomic theory.[9] Samuelson (1962) has called the simple aggregate neoclassical theory model a parable that "has considerable heuristic value in giving insights into the fundamentals" of complex issues and theory. This applies both to macroeconomic analysis and to national accounting frameworks.

It is also significant for the Beyond GDP debate that it is the maximization of *wellbeing*, as represented in Figure 2 by the conventional ordinal utility function, that is the

[9] When distortions do occur, they can cause the economy to locate at a suboptimal point on or inside the production possibility frontier. The indifference curve associated with this point then lies then below the maximal utility of point *A*. The flows of GDP and GDI in Figure 1 portray the aggregate economy as it is, inclusive of its distortions, while the theoretical general equilibrium at point *A* in Figure 2 portrays the outcome as it should be, and the two are no longer linked.

true objective of the analysis and *not* the maximization of GDP or GDI, as sometimes asserted.

B. The Figure 2 framework also provides valuable insights into the sources of economic growth. This growth is portrayed in the figure as a shift in the production possibility frontier from $PPF_0$ to $PPF_1$. This outward movement in the production function causes the equilibrium to shift from *A* to *B* along the expansion path of this economy, *EE,* and the utility function to increase from $U_0$ to $U_1$..[10]

The path-breaking paper by Solow (1957) shows that the growth in aggregate real GDI can be decomposed into three sources: growth in the labor force, growth in the stock of capital, and an increase in total factor productivity (TFP).[11] This growth decomposition is not portrayed directly in Figure 2, but is implicit in equation *(1a)* and the discussion of TFP that accompanies *(1b)*. The importance of this decomposition is evidenced by the large body of research it has enabled and by the fact that it has become an official program at the Bureau of Labor Statistics (the Multifactor Productive Program). At the same time, Solow himself points to the many restrictive assumptions and simplifications involved in his growth decomposition.[12]

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[10] Distortions due to regulation or taxes may cause a wedge between GDP and GDI lines during the shifting process (see Basu and Fernald (2002) and Baqaee and Farhi (2019)) and thus cause them to have different slopes. Why is this important for our model? GDP measures expenditure for goods and services and is tangent to an indifferent curve at a point, say A, in our figures. But GDI is measured as income/factor cost, and thus may not be equal to GDP at A and not tangent to the indifference curve). GDP and GDI are only equal in our model at the equilibrium optimum optimoram point that defines the highest level of wellbeing. In this case, willingness to pay doesn't yield an accurate estimate of the change in utility.

[11] The shift in the production frontier shown in Figure 2 is not the only way that a technical change can affect the supply side of the economy. A new type of good, call it *Z*, may arrive in the marketplace that has characteristics that have no close substitutes among existing goods, similar or otherwise (smart cell phones are one example, the Internet is another). When it arrives, it appears as a new dimensional axis in the goods space, and the production possibility frontier becomes $F(X,Y,Z;L,K,t)$. Technical change in this new goods framework is therefore no longer restricted to an innovation-induced shift in the existing production technology for the existing goods *X* and *Y*. Moreover, the increase GDP following the arrival of the new good is widely viewed as not being accurately recorded in GDP. We will not pursue this line of development further, since it does not add much clarity to the Beyond GDP focus of this paper. A good summary of the new goods problem can be found in the introduction to the 1997 CRIW conference volume *The Economics of New Goods*, edited by Timothy Bresnahan and Robert Gordon.

[12] Solow began his classic 1957 paper with "it takes something more than a 'willing suspension of disbelief' to talk seriously of the aggregate production function," and, in his 1987 Nobel Laureate Lecture, "I would be happy if you were to accept that [growth accounting results] point to a qualitative truth and give perhaps some

C. Figure 2 portrays the economic factors involved in the derivation of GDP and GDI and highlights the role of prices in linking costs and benefits. Expanding on this point, the figure can be read as a two-part invention, one defining economic *growth* in terms of the shift in the production possibility frontier, the other defining economic *progress* in terms of the compensating and equivalent variations associated with the shift in the utility function. As it now stands, the two are forced to be equal in Figure 2 at the equilibrium points *A* and *B* on the expansion path, so the relevance of the dichotomy between growth and progress is of limited use for the Beyond GDP debate. Where in this framework would the added utility beyond current GDP (or shortfall) be located? Where in Figures 1 and 2 is the starting point for a move beyond GDP? These are the questions that the remaining sections of this paper attempt to answer.[13]

But, before going there, a word about the open economy case is in order. In the closed economies portrayed in the figures of this paper, the optimal points (like *A* and *B* of Figure 2) are determined by the interplay of domestic supply and demand, and market prices adjust so that the two are equal and GDP and GDI are equalized. It the economy were open to international trade, on the other hand, goods made in one country can be bought or sold elsewhere around the world at the prevailing international prices. The resulting GDP price line and equilibrium points and prices are determined in international markets, thus allowing gains from trade to occur.

In this case, the highest attainable indifference curve, and the optimal equilibrium point (call it $B^*$, analogous to B in Figure 4), lies outside the domestic PPF, and the tangency point defining $B^*$ is located somewhere on the international price line. The open-economy gains from trade thus permit going beyond *B* on the domestic PPF to B*. However, this gain does not change the overall conclusions about Lancaster's consumption technology, since the additional utility arising from the Lancaster approach augments the utility associated with both $B^*$ and *B*. We will therefore continue to work with the closed economy case for its simplicity of exposition. The Lancaster's consumption technology approach to the Beyond GDP problem is described in greater detail in the following section.

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guide to orders of magnitude." This might be said of GDP and GDI. Indeed, Hulten (1973) shows that the theoretical conditions under which a unique measure of GDP exists are extremely restrictive.

## IV. Lancaster's "New Approach to Consumer Theory"

A. The significance of Kelvin Lancaster's path breaking paper for the Beyond GDP project cannot be overstated. His New Approach to Consumer Theory offers a new possibility for consumer welfare to increase without a corresponding increase in the production of goods and services. In this framework, both household production *and* consumption take place and are separate and distinct features of the model. GDP goods are acquired in the marketplace from their producers and used as an intermediate input that is combined with other items produced within the household. The result is treated as an input to a "consumption technology" that then transforms the household "inputs" into an "output" form that conveys the actual benefit.[14] The basic idea is then that utility depends on the characteristics of goods consumed and how efficiently they are used to extract the utility, not the quantity of the goods themselves as per the usual household production model. Lancaster uses the example of a meal: the meal at home is more than just the sum of the individual items of food consumed, but a complex interaction of various factors.[15] One of the key features of the consumption technology for the meal is the technique and the recipe used to select and combine a variety of the ingredients, as well as creating an ambience as well as a meal. Moreover, it is the characteristics of the transformed items that convey utility, not the original goods originating in GDP. A favorable shift in the efficiency of the consumption technology can therefore result in an increase in utility without an increase in the quantity of the inputs that define real GDP. This increase is exactly the kind of result needed for a movement Beyond GDP.

B. Adding the Lancaster consumption technology to the conventional GDP accounting framework is one of the two the main technical contributions of this paper. The addition

[14] The Lancaster shift effect can also be seen as an externality whose benefits accrue over and above the benefits of the "ingredients." This is certainly one way of thinking about the consumption technology, but it would seem to suggest that the shift is a by-product or side effect of the basic activity rather than part of the purpose.

[15] "A meal (treated as a single good) possesses nutritional characteristics but it also possesses aesthetic and social characteristics, and different meals will possess these characteristics in different relative proportions. Furthermore, a dinner party, a combination of two goods, a meal and a social setting, may possess nutritional, aesthetic, and perhaps intellectual characteristics different from the combination obtainable from a meal and a social gathering consumed separately" (Lancaster (1966a), page 133). Subjective factors like ambience, mood, and novelty matter, as well as knowing which foods, sauces, spices and beverages go well together.

provides a pathway for utility to increase (or decrease) beyond that already embodied in GDP and allows for the possibility that the standard of living may grow at a different rate than real GDP. Fortunately, incorporating the Lancaster consumption function into the structure of Figure 2 is analytically straight-forward. Where Figure 2 portrays the equilibrium solution to the conventional problem of maximizing utility $U(X_t, Y_t)$ subject to the technology constraint $F(X_t, Y_t, t)$, a simplified version of the Lancaster consumption technology can be brought into play by expanding the utility function so that it allows for a time shift of its own, $U(X_t, Y_t, t)$.

This addition changes the dynamics of the utility maximization problem by allowing a second effect to influence the outcome by making more effective use of the available income, or, in other words, by getting more "utility bang for the GDP buck." Thus, while maximal utility is constrained by the production frontier in Figure 2, this need not be the case when the utility function is also allowed to shift independently. This is the situation portrayed in Figure 3, which illustrates what happens when a shift in the consumption technology

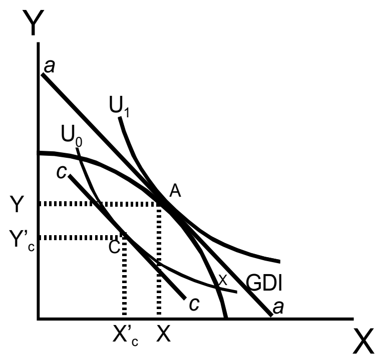


FIGURE 3

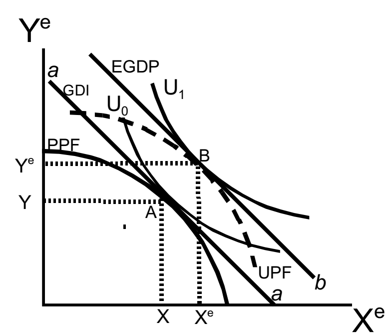


FIGURE 4

causes the utility function $U(X_t, Y_t, t)$ to shift outward by the factor $1+\theta$, and the indifference curves to shift inward.[16] The shift is shown here to apply equally to both $X$ and $Y$ (commodity neutral) for simplicity of exposition. The technology defining the production frontier, $F(X_t, Y_t, t)$, is held constant in the figure in order to isolate the utility effect. In other words, GDI is unchanged (the price line *aa* is designated here only by *GDI* for clarity of exposition, instead of *GDI = GDP* as in the preceding figure). The same amount of real

[16] This function $U(X_t, Y_t, t)$ is defined in a three-dimensional space whose axes are $X, Y$, and $U$. The indifference curves are projections of the three-dimensional utility function onto the two-dimensional product space, *XY*. An upward shift in the function thus leads to an inward shift in the latter.

GDP, $X$ and $Y$, thus supports a higher amount of wellbeing. This "bang for the buck" might also be called "utility-augmenting innovation" or, equally, "output-saving technical change".

How large a "bang" does the shift in the consumption technology produce in monetary term? The expenditure needed to support the old $U_0$ is represented by the line *cc* in the figure, which is assumed to be parallel to *aa* for illustrative purposes. Thus, at the point of tangency *C*, the required expenditure needed to attain the previous indifference curve is now only $P^X X_c + P^Y Y_c$, a saving of $V'$ due to the shift in utility:

$$(2) \qquad V' = (P^X X + P^Y Y) - (P^X X'_c + P^Y Y'_c)$$

The saving $V'$ provides a monetary value metric for measuring utility-augmenting innovation. In so doing, it provides a theoretical solution to the problem of incorporating additional sources of wellbeing into the conventional monetary framework of Figure 2.

C. Figure 4 is a variant of Figure 3 that clarifies the relation between GDI and welfare-adjusted GDP and leads to conventional compensating and equivalent variations that value the shift in utility. In Figure 4, an upward translation of the indifference curves now places $U_0$ tangent to the equilibrium point *A*, i.e., ($X$,Y), the point where it was prior to the shift in the consumption technology. In other words, the original competitive equilibrium prices and quantities (and GDI) are unchanged by the shift in utility to the indifference curve, $U_1$, which now lies beyond the production frontier, which is to say, beyond GDP and GDI. A new tangency point *B* is established on a notional price line *bb*.

This upward translation of the utility function also translates the units of measurement. Since the actual physical quantities of goods are unchanged, the values at *B* can be expressed in equivalent utility-loaded "efficiency" units, $X^e = (1+\theta)X$ and $Y^e = (1+\theta)Y$, where the $\theta$ (as before) is a parameter determining the shift in the consumption technology.[17]

[17] As an aside, it is worth noting that the consumption technology equation for good $X$, $X^e = (1+\theta) X$, has the same basic form as the quality change equation of standard price theory. However, this does not mean that the two concepts are equivalent. In the case of product quality change, many types of a good are subject to the development of progressively superior versions or models that embody new and superior capabilities (prime examples are computers and cellular telephones). If the $X$ is one such good, the equation $X^e = (1+\theta)X$ implies the superior version $X^e$ is equivalent to having more of the inferior version $X$ by a factor $(1+\theta)$. The important point, here, is that the new $X^e$ good and old $X$ are separate and distinctly different goods connected by the factor $\theta$, whose measurement is denominated in units of an index of quantity.

The utility-loaded "quantities," $X^e$ and $Y^e$, are located on a quasi-utility-possibility frontier *UFP* shown in the figure. The corresponding notional prices, $P^X$ and $P^{Ye}$, have the property that $P^{Xe} = P^X/(1+\theta)$ and $P^{Ye} = P^Y/(1+\theta)$. These equalities indicate that if output doubles in consumption efficiency units, the efficiency price must fall by half. Note that the nominal value of the good does not change when reported in efficiency units, leading to the equality $P^X X = P^{Xe} X^e$, and, similarly, $P^Y Y = P^{Ye} Y^e$. These equalities show that nominal GDP is left unchanged by the improvement in efficiency, implying that $P^{Xe}X^e + P^{Ye}Y^e = P^X X + P^Y Y$ .

What has changed is the difference between $[P^X(1+\theta)X + P^Y(1+\theta)Y]$ and $(P^X X + P^Y Y)$, the equilibrium valuations at the points *A* and *B*, on the price lines *aa* and *bb*. This difference is the compensating variation, *V*, which defines the willingness to pay for the additional utility $(1+\theta)$. In other words, the *V'* in Figure 3, is now repositioned relative to GDP to yield:

$$(3) \qquad V = [P^X(1+\theta)X + P^{Ya}(1+\theta)Y] - (P^X X + P^Y Y) = \theta(P^X X + P^Y Y)$$
$$= \theta\, GDP = \theta\, GDI.$$

The *V* in *(3)* captures the monetary effect of a $\theta$-shift in the consumption technology relative to GDI and is thus a potentially measurable metric for the unobserved $\theta$.

What does equation *(3)* mean for the measurement of GDP and GDI? *V* is a monetary measure of the change in welfare not associated with a change in GDI, and it can be added to GDP to arrive at an alternative expanded measure of GD*P*. We then use *(3)* to derive the following link between *expanded* GDP/EGDP and conventional GDI:

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The consumption technology case also has the same $X^e$ equation, but in this case, there is only one good and the *X* located at point *A* on the PPF, and its quantity remains unchanged at that point. What changes is the way *X* is used: new uses are discovered as a result of ingenuity, increased information, or by learning by doing, etc. The result is an outward shift in the consumption technology as $\theta$ increases and the utility generated by one unit of *X* increases by $(1+\theta)$. In this case, the measure of $\theta$ is logically denominated in units of an index of utility.

The difference between the two cases can be seen in Figure 2, In the quality change case, the result is a shift in the PPF, since higher quality is equivalent to more when $X_{t+1} = (1+\theta)X_t$,; in the consumption technology case, the shift occurs in the indifference curve. However, it is also important to recognize the two cases are not mutually exclusive, and that there are cases in which both shifts can occur in response to the same innovation (e.g., computer assisted minimally invasive surgery). Both cases are important for accurate economic measurement, and any effort to incorporate the consumption technology into current measurement practice should not come at the expense of current programs to measure product quality change alone (as, for example, the Bureau of Labor Statistics price measurement program).

$$(4) \quad EGDP = [P^X(1+\theta)X + P^Y(1+\theta)Y] = V + (P^X X + P^Y Y)$$
$$= V + GDP = (1+\theta)\ GDP \ .$$

This formulation expresses in technical terms one of our main contributions to the Beyond GDP project. The *EGDP* defined in *(4)* clearly goes beyond *GDP* by the addition of the wellbeing metric *V*. It establishes that there are two valid concepts of aggregate economic performance, one anchored in the productivity of the resources on the PPF and the other in the realm of wellbeing. In addressing the question of whether aggregate economic activity should measure productivity or welfare, the EGDP framework of *(4)* allows both to be measured in an internally consistent way.

Can the consumption technology also shift inward? In this case, the inward shift could be interpreted as arising from a willingness to pay for *avoiding* or mitigating the harm associated with the consumption of certain goods such as climate change. There may also be a political economy dimension to the problem when externalities are involved, since the harm to be avoided arises from negative spillovers among agents, often not perceived by the individual agents themselves and thus not valued (as with air pollution from autos) that lower collective wellbeing.

D. Willingness-to-pay provides a Pigouvian measuring-rod-of-money solution to the problem of estimating the monetary value of the additional utility "top up" that goes beyond GDP. They are essentially the additional willingness to pay for the goods included in market GDP, which is itself an indicator of the willingness to pay for the goods that currently comprise GDP. However, while this "solution" may have a theoretical appeal, it is not so easy in practice.

A difficulty arises from the fact that the empirical literature approaches the estimation of willingness-to-pay metrics on a good-by-good basis and is thus uses a partial equilibrium approach. Applying this approach to good *X* in isolation holds constant the price and quantity of all other goods and thus ignores the possible substitution effects associated with a change in price of *X*. Unfortunately, it is very difficult for empirical studies to capture the full general equilibrium nature of the willingness-to-pay problem required by the *CV/EV* in Figure 4. This is unfortunate for the purpose at hand, because even when accurate partial equilibrium estimates of *X* and *Y* are available, the sum of the two partial equilibrium estimates does not necessarily result in the correct general equilibrium answer. Thus, adding them to GDP, even when they can be estimated accurately, does not in general yield the true EGDP. Moreover, many of the partial equilibrium estimates are based on hypothetical experiments that value specific goods without having to confront the tradeoffs implicit in a true budget constraint.

Another difficulty arises from the occasional nature of the partial equilibrium studies. The price and quantity transactions that flow around the circle in Figure 1 can be tapped to produce consistent estimates of GDP on the regular and timely schedule needed for national accounting. The same cannot be said of the willingness-to-pay estimates of $\theta$, which are not based on regular market flows, but instead must depend for the most part on non-market estimates from periodic studies and surveys.[18]

However, this does not mean that partial equilibrium estimates of willingness-to-pay $\theta$ are without value. While they are unlikely to be as accurate and timely as the more standard, transaction-based, GDP estimates, they have already shed valuable, if only periodic, light on areas in which the GDP accounts have problems (e.g., the potential magnitude of the willingness to pay for Internet applications that are offered without a direct charge).[19] This approach is also helpful in improving many other problem areas in real GDP, like those goods for which no reliable output price deflators are available and real output is valued at production cost (thus missing productivity change).

## V. Extension of the Consumption Technology to Include Wealth Accounting and Sustainability

A. The GDP model thus far presented treats each year as a separate accounting event, with each year having its own circular flow account. Successive years are, however, connected by

[18] These "administrative" points may seem somewhat pedestrian, but regularity and consistency over time are two of the most important features of the GDP accounts. They are needed in order to track the growth and fluctuations of real GDP and its components over time, which, in turn, are needed to assess the evolution of the economy. This point also applies to the assessment of the growth in wellbeing.

[19] The study by Brynjolfsson et al. (2019) of the partial equilibrium value of new goods in the Digital Economy is an exception. It does provide a time dimension, but it also illustrates the important point that, while the annual values may be quite large, their contribution to the growth of GDP may be small. Both matter for understanding the evolution of GDP and aggregate wellbeing.

capital stock formation. This connection involves additions to capital stock through investment and subtractions via depreciation and, when tracked and recorded over time, the result is the conventional wealth account of an economy.

Wealth accounting is an important part of an integrated set of national accounts, tracking, as it does, the future consumption potential of an economy. The standard theoretical model underlying these accounts involves maximizing an intertemporal utility function whose arguments are the annual flows of consumption over time, $U(C_1, C_2, C_3, \ldots)$, which can be simplified to an analytically more useful additive form as the discounted present value $\Sigma_t[U(C_t)/(1+i)^t]$, where $i$ is a constant rate of discount. This form of the intertemporal utility function is maximized subject to the constraints imposed by the technology available in each year, $Q_t = C_t + I_t = (1+\lambda)^t F(L_t, K_t)$, where $L_t$, is the amount of labor input, $\lambda$ is the rate of TFP growth, $K_t = I_t + (1-\delta) K_{t-1}$ is the capital accumulation process, and $K_0$ is the initial endowment of capital. The solution of this constrained optimization program is the optimal consumption path $(C^*_1, C^*_2, C^*_3, \ldots)$. In order to attain this path, current output is divided between current consumption and investment, which increases the future production of output (and thus future consumption).

B. Wealth and the Role of the Consumption Technology. In order to explore the role of the consumption technology (and its $\theta$) in the context of wealth maximization, it is first necessary to recast the intertemporal optimization problem in a way that links it to the *XY* framework of Figure 2. Figures 2 and 4 portray the optimal allocation of two goods, *X* and *Y*, at a single point in time, but this can be transformed, as per Hulten (1979), into the optimal allocation problem of an economy with single good at two points in time. In this formulation, consumption in the current period, $C_0$, replaces *X*, and consumption in the following period, $C_1$, replaces *Y*. Instead of the production possibility frontier, $F(X,Y)$, there is now an intertemporal production possibility frontier; instead of the utility function for *X* and *Y*, there is an intertemporal utility possibility frontier. The intertemporal production frontier represents the achievable combinations of consumption now and consumption later, given technology, inputs, capital accumulation, and the initial endowment of capital. The highest attainable level of utility is the indifference curve of the intertemporal utility function that is tangent to the intertemporal production possibilities (equivalent to the point *A* in Figure 2).

The tangency between the intertemporal production and utility functions also defines the maximum attainable value of wealth associated with the optimal consumption path. Where we had the maximal $P^X X + P^Y Y$, the intertemporal analogue is now $P^C{}_0 C^*{}_0 + P^C{}_1 C^*{}_1$. This is shown in the first equality of the following wealth equation

$$(5) \qquad W_0 = \Sigma_t P^C{}_t C^*{}_t = \Sigma_t C^*{}_t /(1+i)^t = P^I{}_0 K_0 + H_0.$$

The second equality follows because the price of $C_0$, $P^C{}_0$, can be normalized to a value of one since it can be taken as the numeraire in this one good world, while the price of the good in a later period, $P^C{}_1$, is $1/(1+i)$, where $i$ is the rate of interest/time preference. Thus, where GDP is the sum of the price times quantity of $X$ and $Y$, the analogous wealth is the sum of the normalized price times quantity of $C^*{}_0$ and $C^*{}_1$, or $C^*{}_0 + C^*{}_1/(1+i)$, in the two-period version of *(5)*. The third equality in *(5)*, $P^I{}_0 K_0 + H_0$, is the wealth analogue of the GDI term in *(1b)*, $P^L L + P^K K$. The $H_0$ here is the discounted present value of the stream of future wages, and $K_0$ is again the endowment of capital at the start of the period (in theory, it represents many different types of capital, including not only tangible structures and equipment, but also intangible and environmental assets).[20]

C. Given the importance of the link between GDP and EGDP in this paper, it is worth noting that equation *(5)* can be easily modified to include a consumption technology. This is accomplished in principle, as before, by adding a time shift variable to the utility function. Assuming, for simplicity of exposition, a constant rate of change of $\theta$, this leads to $(1+\theta)^t C_t$ in place of $C_t$ in the intertemporal utility function and in *(5)*. The latter results in a version of consumer wealth that parallels the transition from GDP to EGDP:

$$(6) \qquad EW_0 = \Sigma_t[(1+\theta)^t C^*{}_t]/(1+i)^t ,$$

[20] The study by Abraham (2010) provides a good overview of the issues surrounding the human capital term, $H_0$, and shows that different approaches give very different estimates. It might also be noted that $H_0$ grows over time not only because of labor force growth, but also because of increased investments in health and education.

(A more general version would make the individual $\theta$ a function of time). This Expanded Wealth adjusts for changes in the efficiency of consumption over time and allows for improvement in future living standards from this source of innovation.

The wealth analogy of the difference between GDP and EGDP can be taken further. Where before we had $EGDP = (1+\theta)GDP = (1+\theta)GDI$, the parallel "Beyond Wealth" relation is

$$(7) \qquad EW_0 = \{\Sigma_t[(1+\theta)/(1+i)]^t\} W_0$$

The annual $(1+\theta)$ is here replaced by its accumulated present value, $\Sigma_t[(1+\theta)/(1+i)]^t$. This formulation allows for innovations that expand the intertemporal utility possibility frontier and thus have far-reaching effects.

However, while *(7)* indicates that E-wealth expands the conventional cost-based wealth to arrive at a welfare measure, it is not intended as a replacement for conventional wealth but, instead, as a complement that addresses different questions (as with GDP and EGDP). Conventional wealth is useful for issues involving the utilization and allocation of existing capacity, for problems involving the intertemporal allocation of resources (e.g., investment in future productive capacity), and for estimating the sources of growth of the economy. It is also an indicator of the concentration of the ownership and control of an economy's productive capacity. The welfare-based measure indicates the true extent of wellbeing when the adjustment is made for the utility not included in GDP.

D. Wealth, Capital, and the Sustainability of Wellbeing. There is a large literature on the question of whether prevailing economic trends are sustainable into the future, dating back to at least Malthus. The issue has been actively discussed in recent years, particularly with respect to climate change and environmental pollution, but also with a stress on natural resource and ecological sustainability (see, for example, the report by Dasgupta (2021) on biodiversity). Stiglitz et al. stress the need to bring the issue of economic sustainability into the Beyond GDP sphere of issues and Recommendation 3 of their Report emphasizes, in their words, that "Measures of wealth are central to measuring sustainability." A reasonable working definition of sustainability might well be a time-path of annual wealth stocks (or wealth per capita), and the associated consumption paths, which do not trend downward over time or collapse.

There are many approaches to the sustainability problem, and the E-wealth model of the preceding section contributes yet another. That model identifies two concepts of wealth that are relevant to the problem: cost-based wealth stock $W_t$ and welfare-expanded wealth, $EW_t$. They reveal different ways that the path of future wellbeing can he unsustainable, even though they are connected by the time path of the $\theta$ as per equation *(7)*, where $EW = \{\Sigma_t[(1+\theta)/(1+ i)]^t\} W$.

First, the time path of cost-based $W$ may not be sustainable due to factors not necessarily related to damage to the environment. How might this happen? A heedless disregard for the consumption of future generations, who are not present to protect their interests, may lead to inadequate current investment. On the other hand, this seemingly heedless behavior may reflect the (possibly correct) belief that productivity (the $\lambda$ implicit in *(5)*) may make future generations so much richer than an increase in current consumption may be warranted.

Second, sustainability may fail because of environmental factors, even if the time path of cost-based wealth can be sustained. The problem, occurs when the degradation of the environment causes the path of $\theta$ in *(7)* to be sufficiently negative that the time path of E-wealth, $EW$, trends downward, despite an upward trend in the optimal path associated with $W$. Thus, what appears to be sustainability under the conventional definition of wealth is now seen to be unsustainable when, in effect, $(1-\theta)^t$ drags the economy down. The situation in which the $\theta$ declines over time may accelerate this process. The bottom line is that the conventional definition of wealth is not a sufficient statistic for determining the sustainability of wellbeing (one of the points of the Dasgupta (2021) report).

## VI. Some Historical Perspectives on the Consumption Technology and $\theta$

A. The consumption technology described in this paper has been introduced in general theoretical terms and the shift in that technology treated as a black box. Thus, it is important to recognize that the abstract $\theta$ is very much alive and well in the real world. The historical record since the start of the Industrial Revolution suggests that the extra-GDP effects of the consumption technology have been very large in the areas of health care and information development and transmission. The associated contributions to wellbeing may thus go well beyond the benefits attributed to them by the GDP metric alone, as the following "case studies" suggest.

B. The world of 1820 lacked effective medical treatments for many, if not most, serious afflictions. As Gawande (2012) put it: "over the past two centuries, surgery has become radically more effective ... [with] changes that have proved central to the development of mankind's abilities to heal the sick." Effective anesthesia was a game changer in the practice of surgery, allowing surgeries that involved more lengthy procedures to be performed. It was also a game-changer for patient comfort and wellbeing.

The realization in the 19th Century that infections were caused by germs also led to a major advance in medical practice. The simple expedient of having the attending surgeons wash their hands and clean their instruments prior to a surgical intervention was an important, and virtually costless, innovation over the prevailing practice. Gawande points to Semmelweiss, who "had found that hand washing by birth attendants eliminated puerperal sepsis, the leading cause of maternal death".

The development of antiseptics and antibiotics was another medical game-changer for both clinical and patient outcomes. The importance of the antibiotics revolution is highlighted by David Landes (1998), who starts his book *"The Wealth and Poverty of Nations"* with an account of how Nathan Rothschild, "probably the richest man in the world, at least in liquid assets," died from an infection that might easily have been treated with modern antibiotics. Not even the richest of people could buy an outcome readily available today despite what was clearly an enormous willingness to pay.

The development of antibiotics clearly provided utility benefits beyond the pure clinical outcomes embodied in GDP, since, for example, it reduced the need for amputation and the pain and life-change that it implies, and the painful practice of cauterizing a wound. Antibiotics have also freed communities from some of the fearsome epidemic diseases of history.

The prevention of disease through vaccination is another area where the welfare gains are huge and ultimately achievable at a minimal resource cost. The development of vaccines brought once fearsome diseases like smallpox, diphtheria, tetanus, yellow fever, and polio more or less under control, with enormous increases in human wellbeing. They also have important spillover effects that benefit entire populations. The spillover effects of a successful vaccine are considerably greater than its consequences for GDP alone, as important as that may be. The isolation associated with epidemics can be very disruptive of normal lifestyles and daily routines, and the anxiety and sorrows and other psychological costs imposed on individuals are very large.

The computer revolution has also enhanced the revolution in medicine, in another way, with important breakthroughs, for example, in the advent of minimally-invasive and arthroscopic surgery. Minimally invasive surgical techniques have, for example, have led to significant decreases in recovery times and increases in patient comfort. These benefits accrue to the consumer-patient and occur over and beyond the amount spent on the procedures themselves. And anyone who has experienced older forms of cardiovascular surgery will appreciate the comfort factor.

Finally, mention should be made of the substitution of drug therapies for surgical intervention or hospitalization. Low-dose aspirin is a good example. It lowers the risk of heart disease and stroke at very little cost compared to the clinical problems it deters. Moreover, the statin anti-cholesterol drugs, which also treat cardiovascular problems, have outsized benefits. In addition to the clinical benefits, they have positive effects on the quality of life (e.g., diet) beyond the reduced probability of serious afflictions.

C. We have gone into great detail about the advances in medical technology because they speak to the question posed at the start of this section: is the consumption technology a real phenomenon or simply a theoretical construct? The examples cited above show that it is very real indeed as it pertains to medical care. The Information Revolution presents another set of examples of the importance of the consumption technology. In their book *How Google Works*, Schmidt and Rosenberg (2014) argue that the world has entered an era in which "the internet has made information free, copious, and ubiquitous" to the consumer. The onset of the "Internet Age," was remarkably rapid. A survey by the U.S. Census Bureau (2014) found that the fraction of U.S. households with a computer at home rose from about one-quarter in 1993 to more than three-quarters in 2012. Other studies cited in Hulten and Nakamura (2021) found that the share of adults who use at least one social media site increased from less than one-tenth in 2005 to two-thirds in 2015, and market penetration of smart phones more than doubled from 35 percent to 77 between 2011 and 2016.

The impact of the Internet Age on peoples' lives has been enormous. Nowhere is this better illustrated than in the institution of marriage. A study by Cacioppo et al. (2013) reported that more than a third of new marriages originated from an on-line meeting, while a 2019 study by Rosenfeld et al. reported 39% of heterosexual couples met their partner online, up from 22% in 2009. These impacts have affected peoples' lives in ways that are not counted in GDP.

While on-line dating and friendships are important benefits of the new Internet Age, they are only part of the full "free, copious, and ubiquitous" available information as a result of the information revolution. There is a phenomenal amount of information literally at one's fingertips and available as the need arises. The information ranges over many areas, and is accessed through search engines, on-line encyclopedias and dictionaries, and GPS maps indicating traffic, best routes, nearest hospitals, gas stations, and places to eat (to name some of the major areas). And it is available on a portable device that fits in a pocket. The cell phone itself is a masterpiece of technical innovation: it is a telephone, camera, music player, video player, personal organizer, and Internet access point.

The value of this readily available information and communication accrues directly to the consumer in various ways, but in general it allows them to make more informed decisions about how to spend their income. It also allows people to communicate with their friends. This is the "bang for the buck" described in the preceding sections as a shift in the consumption technology. There is, of course, a resource cost – the cost of the cell phones and other equipment, the cost of subscriptions and access fees, and direct fees for some content.[21] However, the cost that finds its way into GDP is relatively small: according to BEA estimates for 2019, the "Data processing, internet publishing, and other information

[21] This note also discusses some of the issues associated with household inputs to the production of social media and data (see also Coyle and Nakamura (2022)).

services" share of GDP is 1.2%, or around $270 billion; the share of the "Broadcasting and Telecommunications" (excluding broadcasting less Internet) is 1.6%, and the "Computer and electronic products" is 1.4%. This is not a large footprint for a revolution in consumer benefits, which Hulten and Nakamura (2021) put at $100 billion to more than $1 trillion in their review of the existing studies. But, while the benefits may not appear large when compared to a total GDP of around $21 trillion in 2020, they do appear large when compared to the total input cost of the "free" Internet apps, which Nakamura et al. (2018) estimate to have been $103 billion in 2015. This evidence suggests that significant gains have accrued to consumers beyond what appears in GDP.

This brief review of the potential size of $\theta$ has focused on the positive side of this parameter. However, not all the impacts of the Information Revolution are positive. The negatives include harassment or unwanted messages, and, in addition to these issues, there are the much noted problems of disinformation and privacy. There are also substantial mental health concerns. Twenge et al. (2019) found that people who spend more time on social media and less direct time with others are more likely to be depressed. A 2023 CDC report, "Youth Risk Behavior Survey: Data Summary and Trends Report, 2011-2021," found that 20% of the female respondents (and 16% of all respondents) experienced "electronic bullying." It also reported that the percentage of high school students that experienced "persistent feelings of sadness or hopelessness" rose from 28% in 2011 to 37% in 2019, just before the Covid pandemic, and then to 42% in 2021." In commenting on the CDC findings, Haidt (2023) focused on the rise between 2011 and 2019 in a piece titled "Social Media is a Major Cause of the Mental Illness Epidemic in Teen Girls. Here's the Evidence." The 2023 report of the Surgeon General about the current loneliness epidemic in the U.S. ("Our Epidemic of Loneliness and Isolation"), amplifies on these concerns.

There are also other powerful forces on the negative side of the ledger. The footprint of humanity has weighed heavily on the environment and left a large mark, creating negative externalities associated with damage to the environment. However, so much has been written recently (e.g., Dasgupta (2021) and the various U.N. IPCC reports), and so much attention has been given to it that we will not go into detail here.

## VII. Happiness Indexes and Wellbeing Indicators

A. The EGDP approach set out in the preceding sections offers one way of reaching beyond GDP to get to a measure of wellbeing, while at the same time, retaining a conceptual link to the conventional GDP accounts and the standard utility maximization model. Implementation to date has largely relied on surveys of the self-reported willingness to pay for selected GDP goods whose benefits extend beyond the market amount actually paid.[22] Since the survey approach works (at least conceptually) for the estimation of the $\theta$'s required for EGDP, it seems like a natural way of approaching the larger problem of developing a more comprehensive self-reported index of overall personal wellbeing.

The self-reported survey approach is well established in the literature on happiness. Unlike the piecemeal approach of each individual EGDP's $\theta$ surveys, a general happiness survey aims to produce an overall assessment of a country's sense of wellbeing. This expanded scope is an advantage for the broader Beyond GDP goals, but there is another difference between the two that is a major disadvantage. The individual $\theta$ surveys are based on a willingness-to-pay approach that provides an objective money-denominated metric, while the indexes of self-assessed happiness or wellbeing are highly subjective and raise questions about comparability across people, time, place, and cultural traditions. Moreover, there is no current consensus about the appropriate unit of measurement of happiness, no accepted yardstick of wellbeing. The utilitarian philosophers and their followers had proposed the "util" as a viable unit of wellbeing, and along with it came a cardinal utility function with its cardinal indifference curves. The util was largely notional and non-observable and was abandoned in favor of the ordinal utility approach of Figure 2, which was sufficient for the task of determining the economic equilibrium point $A$ of a utility maximizing economy.

Introducing an index of subjective wellbeing into Figure 2 via the self-reported happiness survey approach opens another path for moving beyond GDP besides EGDP. One version of the self-reported survey method asks respondents to rate the degree of their happiness (or other indicator of their wellbeing or life-satisfaction) on a numerical scale like 0 to 10. The results are averaged to obtain an aggregate index (which we will call $H$). The

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22 Brynjolfsson et al. (2019) is a leading example.

numerical ranking scale is not fully cardinal, but it does produce a numerical hierarchy of revealed happiness states whose growth rates over time can be compared to the survey results from the willingness-to-pay $\theta$ surveys.

The *H* index must be fitted into the theoretical structure on Figures 2 and 4 in order to permit a more technically rigorous comparison of *H* and $\theta$. Since *H* is an index of subjective wellbeing, this requires a reinterpretation of the ordinal indifference curves to one that permits a quasi-cardinal interpretation. Then, under this alternative interpretation, an *H* index can in principle be associated with each equilibrium point of tangency (like *A*) and thereby assigns that index value to the entire indifference curve. The renumbering of the indifference curves does not change the location of the equilibrium point *A*. Moreover, each point on the growth path *EE* of the economy (like *A* and *B* in Figure 2) receives an *H* index score. The points on *EE* are thus associated with both the value of GDP (and its relative price ratio) and an *H* index score. In addition, since Figure 2 portrays the situation in which the economy is changing, the rate of real GDP change between *A* and *B* can be compared to the rate of change of the *H* index from *H(A)* and *H(B)*. In other words, the measuring rod of money meets the measuring rod of subjective wellbeing.

The merit of this form of the wellbeing survey approach is that it can be implemented at each point in Figure 2. The resulting indexes thus provide for a comprehensive assessment of the wellbeing associated with GDP and GDI and it evolution over time. It is certainly more comprehensive than the $\theta$-EGDP framework of the preceding sections, which surveys the willingness-to-pay for specific goods. Moreover, if there is an autonomous $\theta$ effect for a particular good, the additional wellbeing would also (in principle) be recorded in the comprehensive index *H* and thus subsumed into the total change in wellbeing. In practice, however, the more limited willingness-to-pay approach of the EGDP framework has the advantage of presenting fewer empirical difficulties than the broader but also more subjective *H*-index approach, as we shall see in the section that follows.

B. In his 2017 survey of the subject, *Measures of Happiness: Which to Choose?,* Veenhoven remarks that, as of 2016, the *World Database of Happiness* included “more than two-thousand measures of happiness.” and thus many possibilities for different paths of wellbeing for the move beyond GDP. Other sources, in addition to the *World Database of Happiness*, are the annual editions of the World Happiness Report. While many (but by no means all) of the aggregate happiness metrics are potential candidates for the aggregate beyond GDP project, the development of a consensus index has proved difficult. Some of these difficulties are summarized in the paper by Gill (2022), who provides a long critique in her "The Unhappy Quest for a Happiness Index." As the title suggests, she presents a somewhat pessimistic view of the subject in her review of the survey literature. For example, the way questions are asked can lead to different answers from the same person. Moreover, interpersonal experiences and perceptions are heterogeneous and hard to characterize by a single index.

In a recent working paper, Daniel Benjamin and his colleagues observe:

"Our conclusions are both negative and positive. On the one hand, respondents' reports regarding commonly used SWB [self-reported well-being] questions do not neatly fit what would be predicted by any of the utility notions that researchers assume. Moreover, we find heterogeneity across respondents in the extent to which a given utility notion is consistent with their reports. On the other hand, we find that small variations in question wording have large, predictable effects on respondents' reports, which suggests that SWB questions could be designed that come closer to capturing a desired utility notion" (Benjamin et al. (2023)).

There is a note of cautious optimism in this assessment, but it seems safe to conclude that the development of a consensus self-reported wellbeing index, while it is a potentially important indicator of economic progress, is still a work in progress (as Benjamin et al. (2020) observe).

C. The survey results from various empirical studies are also a source of controversy. This is nowhere more apparent than in a time series data shown in Landefeld et al. (2020) in their Chart 5. This chart plots the time path of U.S. real GDP per capita along with the results from the results of a self-reported survey of wellbeing, derived from Veenhoven, for the period 1965 to 2011 expressed in index form with 1965 equal to one. It thus provides an illustrative example of how the time path of a happiness index might relate to the path of GDP, but one that is not dependent on any particular conceptual framework that links the series (although "average happiness" line is readily interpreted as a version of the *H(t)* index). (There is also a plot of the Michigan index of consumer sentiment).

The flatness of the happiness index is remarkable. It implies that that there has been no increase in wellbeing over half a century despite an increase in real U.S. GDP p.c. of 250%. In other words, there has been no progress toward a greater sense of wellbeing despite significant growth in real income.

This is all the more remarkable since the apparent lack of progress occurred over a period during which some of the most widely accepted indicators of progress, including the growth in health and education. There has been considerable growth in the latter in the U.S. over the period from the 1960s to the present: in 1960, only 41% of the U.S. population 25 years or older had a high school education or higher, and only 8% had a Bachelor's degree or higher; by 2015, these numbers had increased to 88% and 33%. Moreover, life expectancy for women increased from 73 years in 1960 to 82 years in 2015; for males, it increased from 67 years in 1960 to 78 years in 2015. And the official poverty rate fell from around 20% in the early 1960s to a range that has fluctuated between 11% and 15 % since then.

This said, it might also be noted that the apparent flatness of the average happiness finds support in the 2017 international survey by PEW asking the question "is your life better or worse today than 50 years ago" (Poushter, (2017)). A majority of the people surveyed in slightly more than half of the countries said that was, but for the other half, the answer was "no." In the U.S., 41% said it was worse and only 37% said it was better. The 50 year time interval of the 2017 was similar to the period covered by Landefeld et al. in their aforementioned Chart 5. Thus the PEW survey not only seems to support this flatness result, it even suggests that happiness may have declined somewhat in some places. And,more supporting evidence comes from a 2015 YouGov survey of selected countries.[23] That survey asked the question "All things considered, do you think the world is getting better or worse, or neither better or worse?" It found that, while the many people were optimistic, in some of the richest counties of the world only 10% or less of the population thought that the world

[23] From the July 2018 in Our World in Data.org (https://ourworldindata.org/wrong-about-the-world).2015 YouGov survey of selected countries, reported in July 2018 in Our World in Data.org (https://ourworldindata.org/wrong-about-the-world).

was getting better:  in the U.S. 6%, Germany 4%, the U.K. 4%, and France 3%.  The average in the more social-welfare oriented countries of Scandinavia was 8.5%.[24]

There is also a theory that supports the flatness pattern.  The Easterlin Paradox posits that personal happiness may in fact increase with income at a given point in time (in a cross-sectional survey of individuals), but over time, even large changes income do not affect happiness over time.  How is this possible?  This longer-term outcome may reflect what has been called the "hedonic treadmill."  This is the idea is that people tend to develop a fixed personal baseline level of happiness, and positive or negative life events (including an increase in income) may change the level of their happiness, but the change is temporary and tends to reset to this baseline.  By implication, long-term progress in happiness $H$ is not possible.

A relatively flat pattern also finds yet more empirical support from another source: the argument that there are many other sources of happiness other than income.  Evidence from a British survey reported in the 2020 study by Frijters et al. found that 46% of the overall wellbeing was attributed to depression and anxiety, 15% to physical health, and another 15% to being partnered.  Income accounted for only 10% (and, interestingly, education accounted for only 1%).  Helliwell et al. (2017) also find multiple sources of happiness beyond income.  Thus, it may be the case that the money is simply not a significant enough factor relative to the others to move the happiness index, and that the others, by their nature, are hard to change once they are set.[25]  The situation in which the path of the wellbeing index is more-or-less flat over time in the U.S. has important implications for the Beyond GDP project.  In this case, no significant growth or decline in the level of the happiness index over the years should be expected, despite significant growth in GDP.

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[24] For more on these studies and their implications, along with other relevant sources, studies, see Bonner (2023).

[25] The possibility that income may account for only a fraction of total wellbeing has an important implication for the formal modeling of utility maximization, as in Figures 2 and 4.  The utility functions $U(X,Y)$ of individual agents can be expanded to include the non-GDP sources of utility, which can be represented by the vector $\omega_i$ in an expanded utility function $U_i(X_i, Y_i, \omega_i)$.  The non-GDP factors also combine and interact with income to determine each individual's reported wellbeing survey index number, which we now represent by $H^*_i$.  The relative role of income may be sufficiently small that this reformulated index may be nearly flat (or even negative) regardless of the income effect.

If progress in wellbeing is in fact subject to a hedonic treadmill effect and its growth is thus zero, then it seems pointless to look there for additional wellbeing beyond GDP, although other metrics based on other approaches (for example the approach proposed by Benjamin et al. or perhaps indicators of health and education).

There is, however, another strand empirical work that does not does not support the flatness hypothesis. This includes the evidence presented in the study by Killingsworth et al. (2023) that reconciles earlier studies by Kahneman et al. (2010) and Killingsworth (2021), reported that income is a positive source of wellbeing. Another source is Stevenson and Wolfers (2013). This strand of the literature – which focuses on cross-sectional evidence -- allows for progress and is supported by correlations with log real income measures.

Thus, there are two competing narratives in the wellbeing/happiness story. However, the uncertainties discussed in the preceding subsection suggest that neither strand of the literature can currently be considered dispositive. The negative and positive conclusions offered by Benjamin and his colleagues seem to imply caution against rushing to judgment one way or the other.

## VIII. Income Inequality and the Social Welfare Function

A. Our analysis of the Beyond GDP problem has thus far omitted one of the greatest sources of discontent with current GDP as a measure of wellbeing: income inequality. How the GDP "pie" is sliced matters, not just its size. A lot of wellbeing may be lost through an unequal distribution of the total, particularly if the prevailing social ethic is highly egalitarian. This is a tendentious issue and part of a larger historical debate over social justice, a debate that considerably predates the national accounting movement and concerns about the relevance of GDP.

Income inequality implies that in the case of Figure 2, and those that follow, the assumption of identical preferences is no longer sufficient for the determination of GDP. Further structure must be added to the analytical framework to complete the model, and this is accomplished in standard formulations of the utility maximization model by the addition of a social welfare function.[26]

B. A social welfare function embodies the prevailing societal ethic about the fairness of economic outcomes. It makes interpersonal judgments based on the utility functions of different individuals and, in its modern form, is generally attributed to Abram Bergson and Paul Samuelson. It maps individual utilities into an aggregate index of overall societal welfare via a function $S(U_1,U_2)$, shown here for the two-good ($X$ and $Y$) and two person economy in which individual utility functions are represented by $U_i(X_i,Y_i)$. In this standard case (with no non-GDP wellbeing variables), the level of social welfare thus depends only on the total amount of $X$ and $Y$ produced and on how the totals, $X = X_1+X_2$ and $Y = Y_1+Y_2$, are distributed among the individuals. This is determined by the maximization of $S(U_1,U_2)$ subject to a utility possibility frontier that indicates the maximal combinations of utility $(U_1,U_2)$ that are possible given the limits imposed by the available inputs and the level of technology.[27]

The constrained maximization of $S(U_1,U_2)$ results in a socially optimal point $A^*$ on or inside the production frontier. The $A^*$ determines the optimal $X^*$ and $Y^*$ and the associated socially optimal GDP, along with its optimal allocation across individuals. Moreover, a comparison of the socially optimal point $A^*$ and the original equilibrium point $A$, gives rise (in theory) to the compensating and equivalent variations that can, in turn, be used to define a social $\theta^*$ parameter that measures the gain in social welfare. This extends the original

[26] In the identical-agent case, the indifference curves of the representative agent can be entered directly on the figures and an equilibrium point $A$ determined. This situation changes when there are two or more agents with different utility functions or levels of income. If both of their indifference curves were plotted on the basic Figure 2, there would be two points of tangency like $A$ on the same production possibility frontier. Therefore, neither could serve as a unique equilibrium point since each would support a different relative price system and GDP. Equilibrium cannot be achieved with a social welfare function to accommodate multiple heterogeneous agents.

[27] By way of a brief sketch, a separate Edgeworth Box and its contract curve are inscribed inside the production possibility frontier at each point $(X,Y)$. The contract curve for each box, which registers the Pareto Optimal combination of utilities for that box, is transcribed to utility space to form, *inter alia*, the utility possibility frontier. The social welfare maximizing point on that frontier is then determined by the tangency with the welfare function $S(U_1,U_2)$. This tangency determines the socially optimal distribution of utilities, which then determines output in the $XY$ space by working backward through the Edgeworth Box to a socially optimal equilibrium point $A^*$ on or inside the production possibility frontier.

Lancaster framework to include the valuation of this hard-to-measure distributional source of wellbeing.

B. At first glance, the abstract Bergson-Samuelson social welfare function would seem ideally suited for the objective of bringing the distributional equity into the GDP/EGDP framework. But a closer look reveals a deeper problem that theory and measurement alone cannot resolve: there are many plausible candidates for the role of social welfare function and some lead to very different outcomes than others. Each involves a different subjective judgment, and an arbitrary choice is thus needed to arrive at the general equilibrium solution that determines GDP/GDI.

The three leading candidates for $S(U_1, U_2)$ that we consider here are (1) the Rawlsian original position social ethic, with its emphasis on raising up the income of those at the bottom of the income distribution to a position of equality; (2) the Arrow political economy approach, with its Impossibility Theorem; and (3) the *laissez-faire* approach that assumes that the prevailing market distribution of income is perforce optimal.

The choice of welfare function matters because the three alternatives imply very different socially optimal distributions and degrees of market intervention. Why? Because each social welfare function leads to a different socially optimal point $A^*$ on, or inside, the production possibility frontier. Under a pure *laissez faire* approach, the original market equilibrium at the point $A$ and the socially optimal the point $A^*$ are identical (by the definition of *laissez faire*). In this case, no redistribution is warranted. On the other hand, a strictly egalitarian function implies a policy of income leveling and thus complete income equality (although any highly redistributive tax and transfer system that lowers the Gini Index significantly can also be considered egalitarian). This leveling-up results in a different point $A^*$ in, or inside, the production frontier.

A political economy system that relies on voting, or some other democratic public choice mechanism, might result in either a highly egalitarian or a laissez-faire outcome, but it is more likely to produce a tax and transfer system that modifies the original pre-transfer market distribution of income to an intermediate result. The resulting post-transfer market income distribution (and the implicit social welfare function) might be considered socially optimal because of the public choice process by which it is determined.

An important implication of these different outcomes for the issues at hand is that they arise from the same total amount of labor, capital, and the prevailing level of TFP. This implies that the socially optimal distribution of income (and its Gini Index) is a matter of the assumption made about what constitutes social equity. In the strictly egalitarian case, for example, the assessed social wellbeing attributed to the Digital Revolution, with its Silicon Billionaires and its rising Gini Index, looks very different from that associated with the laissez-faire welfare function. Thus, to assume *a priori* a particular form for a social welfare function is – to an extent – to assume the conclusion about the optimal $A^*$ and the income redistribution it implies.

C. The redistribution of income (in one form or another) is not the only factor that can affect the level of social welfare. As noted previously, the very act of redistributing income may alter the structure of incentives in a way that leads to less total income (the Okun "equality versus efficiency" tradeoff). This efficiency penalty can be non-trivial for large income redistributions, and the intertemporal dimension of the efficiency penalty is particularly important since it affects the entire growth path of an economy as it unfolds over time. As economies evolve and grow, so do individual incomes, and the gains from economic growth may be shared unequally, raising the Gini Index over time. This is the Silicon Billionaires issue, again. But, it should also be recognized that even when a relatively few people are able to capture the lion's share of income growth, the incomes of the lowest percentiles of the population may still be considerably higher compared to the pre-growth era. China, with its era of double-digit growth and rising Gini Index, provides a good example. Having both high growth and egalitarian distribution may be deemed to be the best outcome under an egalitarian social welfare function, but may not be attainable if the process of income redistribution conflicts with the conditions and incentives necessary for that growth.

There is also the issue of intergenerational equity. Because future generations are not present to protect their interests, a social welfare function based on current voting may not adequately embody the utility of these non-voting generations. If this happens, the socially optimal intertemporal distribution of resources between current and future consumption may not occur, or even be sustainable. These considerations also involve deciding on the appropriate social rate of time discount.

D.  The equitable distribution of income is not the only dimension of the social equity problem.  The 2020 volume on "Deaths of Despair" by Case and Deaton focuses attention on the sharp decline in the wellbeing of a significant segment of the U.S. working class population, while the recent CDC report calls attention of the mental health problems of Gen Z youth.  And, as noted previously, the Surgeon General also spoke recently about the loneliness epidemic that is said to be sweeping the country. Noting that "we have more than one in five adults and more than one in three young adults living with a mental illness in the U.S," and that "addressing loneliness and isolation is critical in order to fully address the mental health crisis in America" ("Our Epidemic of Loneliness and Isolation", https://www.hhs.gov/about/news/2023/05/03/new-surgeon-general-advisory-raises-alarm-about-devastating-impact-epidemic-loneliness-isolation-united-states.html.  The homelessness problem has also been widely reported.  These problems impact directly on the social and psychological wellbeing of those affected, and are not necessarily caused by a decline in their income (although a decline may be a byproduct).  This distress is in sharp contrast to the general affluence and immense fortunes created during the Information Revolution.

What does the social welfare function approach have to say about the distribution of wellbeing *per se*?  Social welfare $S(U_1,U_2)$ is a function of the individual utilities and they are the variables to be optimized, not income or the goods it buys.  The salience of this point is particularly evident when individual utility is recognized to depended on other factors than income, as in the formulation $U_i(X_i,Y_i, \omega_i)$.  We have also noted that a body of evidence exists that accords income only a small role in wellbeing.  In this case, there is a theoretical disconnect between the distribution of income and the distribution of happiness/wellbeing, as measured by the vector $\omega_i$.  In this case, maximizing total social welfare $S(U_1(X_1,Y_1, \omega_1),U_2(X_2,Y_2, \omega_2))$ is not a matter of redistributing income.  What is needed are policies that affect $\omega_i$ directly, like mental and physical health programs, educational and skill development programs for disadvantaged youth, and housing programs directed at the homeless.  And, even this may not be sufficient if the long-run pattern of happiness is truly flat, in which case neither income redistribution nor non-GDP policies will affect the long-run level of happiness.

E. A final observation is in order. Even if these other issues can be sorted out, there still remains a problem with the method by which the individual survey responses are aggregated into a group index. They generally appear to be a simple average of the individual responses. Under this procedure, an equal weight is assigned to each person's response regardless of the actual level of their happiness indexes (or real income)

One implication of this simple averaging can be seen in the following example in which there are two groups of people. In the first group, each person has the same reported index of happiness, say 5.0, and thus a group average of five. The second group had the same average but half that group has personal indexes of 9.0 and the other half reported indexes of 1.0. The average is the same and each group would thus be deemed to be equally happy on average but could hardly be deemed equivalent under an egalitarian wellbeing-based social welfare ethic. Moreover, the issues discussed in Section VII suggest that the equitable distribution of wellbeing may bear little relation to the optimal distribution of income as determined by an income-based (anti-plutocratic) Rawlsian social ethic. Indeed, it is conceivable that an individual in the second group with a happiness index of 1.0 may have the same level of income as a person with an index of 9.0.

## IX. Conclusion

The question posed in the title of this paper is whether GDP has become increasingly obsolete. Our answer is that it has not. GDP is far from perfect in a number of areas, if for no other reason than the economy that the GDP and its accounts are intended to describe is in a constant state of structural evolution, and that evolution presents constant measurement challenges (structural changes in the sectoral composition of the economy, new goods and new technology, etc.). However, the main impetus behind the development of the U.S. national accounts was the need for data on the performance of the economy to guide an informed counter-cyclical policy, and that goal has not changed significantly over time. While they have evolved, the GDP accounts continue to be an indispensable policy tool for addressing questions of unemployment, price stability, and resource utilization.

The stabilization and income focus of the GDP accounts has been on the market and public sectors of the economy and not on the long-term progress in the wellbeing of the population. Almost by default, the growth rate of real GDP has come to be regarded as virtually synonymous with that economic progress. The Beyond GDP movement seeks to correct this perception by including additional information and insights into the economic health and happiness of the society as a whole. Such insights are needed in order to address the important systemic question of whether overall wellbeing has increased more (or less) rapidly than real GDP.

However, while there is perhaps a consensus that accurate metrics of wellbeing are needed, there is no apparent consensus about how to do it. The literature of wellbeing and happiness indexes is still very much a work in progress, with many issues yet to be resolved. Progress is being made, but our reading of the current evidence suggests that wellbeing indexes are not ready to challenge GDP as the headline indicator of aggregate economic performance. Benjamin et al. (2020) reach the same conclusion in their paper titled "Self-reported wellbeing indicators are a valuable complement to traditional economic indicators but aren't yet ready to compete with them."

Our paper attempts to advance matters by exploring two ways that the theory underlying GDP can be extended or reinterpreted in order to link GDP and wellbeing within a common conceptual framework. Both fit into the Landefeld et al. (2020) broader taxonomy of viable accounting options for advancing the Beyond GDP project. This paper makes a start at forging a solid theoretical link between GDP and the wellbeing that lies beyond it.

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