PRODUCTION AND WELFARE:

Progress in Economic Measurement

by

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Abstract

While the GDP was intended by its originators as a measure of production, the absence of a measure of welfare in the national accounts has led to widespread misuse of the GDP to proxy welfare. Measures of welfare are needed to appraise the outcomes of changes in economic policies and evaluate the results. Concepts that describe the income distribution, such as poverty and inequality, fall within the scope of welfare rather than production. This paper reviews recent advances in the measurement of production and welfare within the national accounts, primarily in the United States and the international organizations. Expanding the framework beyond the national accounts has led to important innovations in the measurement of both production and welfare.[1] JEL Codes: C8, D6, I3, O4,

1. Introduction

At the beginning of the year 2000 the U.S. Department of Commerce completed a review of its achievements during the 20th century, then drawing to a close. To the surprise of many economists, the Department's greatest achievement of the 20th century was the development of the U.S. national income and product accounts, abbreviated as "the GDP". This was reported by Steven Landefeld, Director of the Bureau of Economic Analysis, in an article in the January 2000 *Survey of Current Business*, the monthly publication devoted to the U.S. national accounts.

Landefeld's article was accompanied by a full page of quotations from leading government officials and prominent economists. The economists included Michael Boskin and

[1] Acknowledgements: The author is grateful to his collaborators on economic measurement, many for very helpful comments on earlier versions of this paper – Barbara Fraumeni, Frank Gollop, Mun Ho, Steven Landefeld, Koji Nomura, Jon Samuels, Paul Schreyer, Daniel Slesnick, Kevin Stiroh, Marcel Timmer, and Khuong Vu. He is also grateful for comments from Bart van Ark, Diane Coyle, William Nordhaus, Nicholas Oulton, Dirk Philipsen, Rebecca Riley, Amartya Sen, and Peter van de Ven, and from the Office of National Statistics (U.K.) and the Bureau of Economic Analysis (U.S.). He would like to thank the Editor and two anonymous referees for their comments and suggestions. Financial support for this research was provided by the Donald Marron Center for Economic Data at Harvard University. None of the foregoing is responsible for any remaining deficiencies of the paper.

Laura Tyson, former Chairs of the Council of Economic Advisers, Robert Eisner, former President of the American Economic Association, Janet Norwood, former Commission of the Bureau of Labor Statistics, and James Tobin, Nobel Laureate in Economics. Tobin captured the spirit of the occasion:

> GDP! The right concept of economy-wide output, accurately measured. The U.S. and the world rely on it to tell where we are in the business cycle and to estimate long-run growth. It is the centerpiece of an elaborate and indispensable system of social accounting, the national income and product accounts. This is surely the signal innovative achievement of the Commerce Department in the 20th century.[2]

Following the official announcement in late 1999 by the Secretary of Commerce, William Daley, three distinguished economists addressed a press conference: Alan Greenspan, Chair of the Federal Reserve Board, Martin Baily, Chair of the Council of Economic Advisers, and Robert Shapiro, Under Secretary of Commerce for Economic Affairs, the official overseeing the Bureau of Economic Analysis. All made appropriately laudatory remarks about the pioneering role of the Bureau in establishing the national accounts and improving them as new challenges emerged.

1.1. Production Measures

With the passage of seventeen years the GDP and the national accounts are again the focus of attention by leading economists, not only in the United States but around the world. However, the concept of GDP is hotly debated and the on-going debate has attracted enthusiasts and detractors. The GDP is one of the three concepts from economic statistics found in

[2] Landefeld (2000), p. 9.

introductory economics courses, the others being the Consumers' Price Index and the unemployment rate. However, the national accounts no longer figure in the undergraduate curriculum, even at the intermediate level. Many economists are unable to provide much guidance, reflecting the fact that national accounting courses have long been absent from Ph.D. programs in economics.

The growing intellectual ferment around the national accounts has generated a flood of official reports and a steady stream of books about the GDP, pro and con. The most prominent pro-GDP book is *GDP, A Brief but Affectionate History*, by the brilliant and prolific British economist and economic journalist, Diane Coyle (2014).[3] Coyle was Vice Chair of the British Broadcasting Corporation's governing body and is now Professor of Economics at the University of Manchester.

Coyle describes the key roles of the American Nobel Laureate Simon Kuznets in the U.S. and the British Nobel laureates James Meade and Richard Stone in the U.K. in establishing the national accounts. Kuznets submitted a report on the national income to the U.S. Senate in 1934, documenting the severe downturn of U.S. economic activity during the Great Depression. Estimates of national output were revived in 1942 to assist the war effort in World War II. In 1947 official estimates of national output assumed their present form of a double-entry system of accounts with output balanced by expenditure. Marcuss and Kane (2007) provided a brief official history of the U.S. National Income and Product Accounts.

Coyle agrees emphatically with vocal critics of the national accounts that the GDP is a measure of production and not welfare. While the GDP was intended by its originators, including

[3] See also the review article by Moshe Syrquin (2016).

Kuznets, as a measure of production, the absence of a measure of welfare in the national accounts has led to widespread misuse of the GDP to proxy welfare. This led Kuznets to call for development of a welfare measure as part of the national accounts.[4]

1.2. **Welfare Measures.**

It is worthwhile to note that there are two reasons why welfare, as well as production, is important for economic measurement. First, measures of welfare are needed to appraise the potential outcome of changes in economic policies and evaluate the results after the changes have taken place. Second, concepts that describe the income distribution, such as poverty and inequality, fall within the scope of welfare, rather than production. Concern about the distributional aspects of welfare has reached a fever pitch with Piketty's (2014) highly successful volume on the income and wealth of the top one percent, *Capital in the 21st Century*.[5]

A useful point of departure for discussing the extensive literature on welfare measurement is the short book by Nordhaus and Tobin (1972), *Is Growth Obsolete?* Nordhaus and Tobin carefully constructed a Measure of Economic Welfare (MEW) to meet the challenge posed by Kuznets. Although they described their measure as "primitive and experimental," the MEW became highly influential and successfully anticipated many of the major issues that have dominated the subsequent literature. An important omission was inequality and the distribution of economic welfare.

The Nordhaus-Tobin Measure of Economic Welfare is solidly rooted in the literature on economic measurement, including the national accounts:

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[4] Sen (1979) provides a very detailed survey article on measuring welfare.
[5] Piketty's book was the subject of two recent review articles: Krussell and Smith (2015) and Blume and Durlauf (2015).

> In proposing a welfare measure, we in no way deny the importance of the conventional national income accounts or of the output measures based upon them. Our MEW is largely a rearrangement of items of the national accounts.[6]

This description is overly modest, since major differences between the MEW and the GDP arise from imputations for components of consumption not included in the GDP, specifically, the value of leisure and nonmarket production activity.

A more recent approach to the measurement of welfare is presented by the World Bank (2011), *The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium.* This updates an earlier report of the World Bank (2006), *Where Is the Wealth of Nations? Measuring Capital for the 21st Century*. The methodology of both reports was proposed by Hamilton and Clements (1999). From the perspective of Nordhaus and Tobin, the World Bank shifted the focus of welfare measurement from the Measure of Actual Economic Welfare, denoted MEW-A, to the Measure of Sustainable Economic Welfare, labeled MEW-S.

Nordhaus and Tobin defined sustainable welfare as "… the amount of consumption in any year that is consistent with sustained steady growth in per capita consumption at the trend rate of technological progress."[7] The World Bank report implemented this idea through a comprehensive measure of genuine saving. Genuine saving includes saving in the form tangible and intangible assets from the wealth account of the United Nations (2009) *System of National Accounts 2008* (*SNA 2008*).[8] Genuine saving also includes saving through natural capital and human capital, not included in the wealth account of *SNA 2008.* An expanded concept of income is the sum of genuine saving and consumption, extended to include unpaid household work and

[6] Nordhaus and Tobin (1972), p. 5.
[7] Nordhaus and Tobin (1972), p. 24.
[8] *SNA 2008* is jointly sponsored by Eurostat, the International Monetary Fund, the OECD, the United Nations, and the World Bank.

leisure, as in Nordhaus and Tobin. Welfare is sustainable if genuine savings per capita in real terms is positive.

1.3.Outline of the Paper.

To provide a guide to the rapidly evolving economic agenda for measuring production and welfare, this review begins with the institutional framework in Section 2. The central institution is the United Nations Statistical Commission, an organ of the Economic and Social Council. Other key international organizations are the IMF, the World Bank and the OECD. A pivotal role is played by Eurostat, the statistical agency of the European Commission.

In the United States the national statistical agencies include the Bureau of Economic Analysis (BEA), the Bureau of Labor Statistics (BLS), the Bureau of the Census (Census), and the Federal Reserve Board (FRB). These agencies are an important part of the institutional framework. The international organizations rely on national agencies to provide measures of production, saving, and wealth.

Sections 3 and 4 of this paper describe recent developments within the national accounts, primarily in the United States and the international organizations. These developments are the starting point for system builders, like the authors of the United Nations *SNA 2008* and its European counterpart, the *European System of Accounts* (ESA), as well as "satellite" systems like the United Nations *System of Environmental-Economic Accounting* (SEEA).[9] Section 3 discusses progress in the aggregate and industry-level production accounts, including measures of output and productivity, while Section 4 considers the development of accounts for measuring welfare, including income, saving, and wealth.

[9] United Nations (2014). The SEEA is jointly sponsored by the United Nations, the European Commission, the Food and Agriculture Organization of the United Nations, IMF, OECD, and the World Bank.

Section 5 of this paper directs the spotlight to advances in economic measurement outside the national accounts. These include the extensions of the GDP to nonmarket measures of leisure time and home production considered by Nordhaus and Tobin (1972). In addition, the Task Force on Measuring Human Capital (2016) of the Conference of European Statisticians has shown how to extend the SNA to incorporate investment in human capital in its *Guide on Measuring Human Capital*. These and similar extensions would generate an expanded framework for the national accounts and new measures of production and welfare. Section 6 of the paper concludes.

2. Key Institutions.

The institutional framework for economic measurement is important because the participating statistical organizations maintain and enhance international standards. These standards have developed gradually since the implementation of official national accounts in the U.S., the U.K., and other countries. The national accounts and the GDP have been extended to incorporate the flow of funds for financial statistics, including income statements and balance sheets, as well as supply and use tables for production, introduced by Nobel Laureate Wassily Leontief. These remain central features of *SNA 2008*, published in 2009.

Stone emerged as the leading proponent of international standards through the United Nations. The international standards are embodied in the United Nations System of National Accounts (SNA), an elaborate model accounting system that provides guidelines for national systems around the world. This includes the GDP and the national accounts, but also the flow of funds and the inter-industry accounts. These three components have been welded into a unified system, but full integration remains a work in progress, even for highly developed statistical systems, like the United States, the European Union, and Japan.

The scope of GDP and the national accounts is largely determined by the production boundary and the asset boundary. Both refer to goods and services priced in markets or close substitutes. The production boundary includes transactions in goods and services on current account and defines the scope of national accounting concepts like production, income, consumption and saving. The asset boundary includes assets held on capital account and defines concepts like tangible and intangible assets and the financial assets and liabilities that appear on balance sheets.

As the scope of the SNA has expanded, revision of the international standards has become a lengthy process of consultation. This results in a consensus document, common in international agreements but rare in economics. The leisurely process of revision has the important advantages of achieving greater internal consistency and facilitating international comparability. At the same time, the SNA has become much too complex to be included in the economics curriculum at either undergraduate or graduate levels, severing the connection to the economically literate public and increasingly from the economics profession.

2.1. U.N. Statistical Commission

The central institution in the System of National Accounts is the United Nations Statistical Commission. The Commission was established in 1947 by the Economic and Social Council for convening the Chief Statisticians of member countries. The Commission consists of twenty-four members, selected by the Council to achieve geographical balance. The Commission meets annually to deliberate about standards for national and international statistics, including the SNA. The decisions are incorporated into a final consensus document.

The process that led to *SNA 2008* was initiated by the Commission in 2003 and the final document was approved at the annual meetings in 2008 and 2009. The European counterpart of

the United Nations Statistical Commission is the European Statistical System Committee (ESSC), which includes representatives of the member states of the European Union. This plays a similar role in arriving at a consensus document for the ESA, closely following the SNA. The most recent revision is *ESA 2010*, published in 2013 by Eurostat, followed by country reports, beginning in 2014. This has legal force within the EU and assures a high degree of uniformity among the accounts of the members of the European Statistical System.

2.2.International Standards.

Since the process of revision is laborious and time-consuming, international standards for the SNA and the ESA are changed infrequently. For example, national accounting standards prior to *SNA 2008* were set by *SNA 1993*, also established by the U.N. (1993). The revision of the 1993 standards was overseen by an Intersecretariat Working Group on National Accounts (IWGNA), supported by an Advisory Expert Group (AEG). These institutions considered issues raised by changes in the economic environment, such as the renewed interest in sustainability, methodological advances, such as new developments in productivity and growth statistics, and demands by users for greater accessibility and ease of use.

Undoubtedly, the revision process for international standards imparts a strongly conservative flavor to the outcomes. This is intentional and is motivated by the legitimate concern that national statistical agencies will fail to keep up with the latest standards. For example, the requirement that fundamental features of the revision in 1993 should be preserved in the 2008 revision was rationalized by the fact that not all of these features had been fully implemented by national statistical agencies including the U.S.

The role of the United Nations Statistical Commission in establishing and maintaining standards for economic measurement is not limited to the System of National Accounts. At the

44th Session in 2013 the Commission created the Friends of the Chair Group on Broader Measures of Progress (2013) and established a "programme of work on broader measures of progress to complement GDP in order to better inform policy decisions." These broader measures of progress were linked to the Sustainable Development Goals discussed in Section 5 below.

2.3. National Statistical Institutions.

The institutional framework for the GDP and the national accounts is important for the implementation of international standards. At the national level the institutional framework is useful in identifying potential barriers to implementation, as well as developing statistics to meet national requirements. The United States relies heavily on economic statistics as a guide to economic policy and serves to illustrate the role of national statistical institutions. As mentioned above, the most important statistical agencies that contribute to the U.S. national accounts are the Bureau of Economic Analysis (BEA), the Bureau of Labor Statistics (BLS), the Bureau of the Census (Census), and the Federal Reserve Board (FRB).

Many countries, including Canada and Mexico, combine the functions of BEA, BLS, and Census in a single agency – National Institute of Statistics and Geography (INEGI) in Mexico and Statistics Canada. In addition, most central banks have extensive programs to develop national statistics relevant to monetary policy and financial regulation. A perennial issue within the U.S. statistical system is the integration of the programs of the four leading agencies. For example, the U.S. national accounts generated by BEA did not include a comprehensive measure of wealth until very recently, although this was presented in the flow of funds accounts compiled by the FRB.

2.4.Conclusions.

The national accounts, defined as in *SNA 2008,* provide the starting point for economic measurement. However, the evaluation of economic policies, before and after they are implemented, requires much additional information about welfare. This information could be standardized by a process similar to that employed for the SNA. Secondly, international standards for economic statistics are not limited to the boundaries of the national accounts, as illustrated by the leading satellite system of accounts, the United Nations (2014) *System of Environmental-Economic Accounting* (*SEEA).* This is consistent with the *SNA 2008,* but also incorporates nonmarket information about emissions of pollutants and depletion of natural resources that is outside the production and asset boundaries of the national accounts.

This review considers developments in economic measurement that have resulted in statistical programs with reports at regular intervals like the national accounts. Those that adhere to national accounting boundaries for production and assets are "Within the GDP". Those that do not adhere to these boundaries are "Beyond the GDP". The first category includes potential candidates for inclusion in the national accounts. The second category includes data systems outside the national accounts that might benefit from standardization, such as the broader measures of progress discussed in Section 5.

3. Production.

Important advances have been made in coordinating the work of the leading U.S. statistical agencies. The initial results were reported in *A New Architecture for the U.S. National Accounts,* edited by Jorgenson, Landefeld and Nordhaus (2006) and published by the National Bureau of Economic Research in its long-standing series, Studies in Income and Wealth, established by Kuznets. This volume includes contributions from all four agencies, primarily

within the framework of the national accounts. A schematic and highly simplified system of national accounts, including wealth as well as income and product, was proposed by Jorgenson and Landefeld (2006) in Chapter 1, "Blueprint for Expanded and Integrated U.S. Accounts: Review, Assessment, and Next Steps."

(Figure 1 about here)

3.1. Production Account.

"Blueprint" includes a production account presenting the GDP and Gross Domestic Factor Outlay (GDO) in current and constant prices. The GDP in constant prices is a measure of real output and GDO in constant prices is a measure of real input, so that the production account generates productivity, the ratio of output to input. Since GDO includes outlays on capital and labor services, the primary factors of production, this measure of productivity is called Total Factor Productivity (TFP) or Multi-Factor Productivity (MFP). The incorporation of the quantity of inputs and productivity into the U.S. national income and product accounts represents the first major advance in economic measurement discussed in this review.

Before "Blueprint" GDP was compiled by BEA in both current and constant prices, but GDO was given only in current prices. Measures of MFP were developed by BLS for the nonfarm business sector and other sectors of the economy, but these were not presented in the national accounts. After "Blueprint" BEA and BLS joined forces in 2009 to generate a production account in current and constant prices for the nonfarm business sector. Output was measured by BEA, while measures of capital and labor inputs and productivity were constructed by BLS. A possible extension to the whole U.S. economy was outlined in the 2009 report co-authored by Harper, *et al.* (2009).

The integration of productivity into the U.S. national accounts is consistent with Chapters 19 and 20 of *SNA 2008*. Chapter 19 presents an index number for the quantity of labor services. This is comprised of hours worked for various types of labor, weighted by the hourly compensation for each type. Changes in the quantity of labor services can be divided between changes in hours worked and changes in labor composition or "labor quality". The price of labor services is the ratio of the nominal value of labor compensation to the quantity of labor services. A similar measure of the price and quantity of labor services was presented in *SNA 1993.* The measure of labor quality in the BEA-BLS Integrated GDP-Productivity accounts is based on the measures of labor input presented by Jorgenson, Ho, and Stiroh (2005).

> Chapter 20 of *SNA 2008* presents measures of capital services, described as follows:
>
> By associating these estimates with the standard breakdown of value added, the contribution of labor and capital to production can be portrayed in a form ready for use in the analysis of productivity in a way entirely consistent with the accounts of the System.[10]

The incorporation of the price and quantity of capital services into the United Nations *SNA 2008* was approved by the United Nations Statistical Commission at its 2007 meeting.[11] This resolved a long-standing debate on the measurement of capital input. For example, the United Nations *SNA 1993* stated that this was impossible, thereby ruling out the incorporation of capital input and productivity into the national accounts.

After the inclusion of the price and quantity of capital services in the United Nations (2009) *SNA 2008*, Paul Schreyer (2009), head of national accounts at the OECD, prepared a second edition of the *OECD Manual*, *Measuring Capital*. This provided detailed

[10] United Nations (2009), p. 415.
[11] Intersecretariat Working Group on National Accounts (2007).

recommendations for the implementation of prices and quantities of capital services at industry and economy-wide levels. The aggregate and industry-level productivity measures are consistent with those presented by Jorgenson, Ho, and Stiroh (2005). Jorgenson and Schreyer (2013) showed how to incorporate industry-level measures of outputs, inputs, including capital services, and productivity into *SNA 2008*.

3.2. Income, Expenditure, and Wealth.

"Blueprint" presented an income and expenditure account, including income, consumption, and saving, and a domestic balance sheet or wealth account, containing domestic wealth, tangible assets, and the U.S. international position. Both income and wealth accounts were given in current and constant prices. The income and expenditure accounts were linked by a capital account, including data on investment and saving in current and constant prices. Investment and saving in constant prices and the revaluation of assets through changes in asset prices were linked to the change in wealth in the balance sheet.

Simultaneously with "Blueprint", an ambitious integration of BEA's GDP and national income and product accounts with the FRB's flow of funds was presented by Teplin, *et al.* (2006). Described as a draft of a U.S. version of *SNA 1993*, this was limited to national aggregates and did not include the industry-level supply and use tables of *SNA 1993*. Nonetheless, the Integrated Macroeconomic Accounts were a major step toward implementing *SNA 1993*. These accounts were incorporated into the U.S. statistical system in 2007 and have been updated annually by BEA and FRB. The implementation of the Integrated Macroeconomic Accounts was a second major contribution to economic measurement considered in this review.

The new architecture for GDP and the national accounts was recently revised and updated in a second volume, edited by Jorgenson, Landefeld, and Schreyer (2014), *Measuring*

Economic Stability and Progress, and published in the NBER series, Studies in Income and Wealth. Recent developments and future plans for SNA-USA were described by Cagetti, *et al*. (2014). Jorgenson and Slesnick (2014) updated the schematic system of national accounts presented in "Blueprint". They added measures of welfare, defined in terms of personal consumption expenditures. Measures of welfare within the national accounts were a third major contribution to economic measurement considered in this review.

3.3. Industry-Level Production

The implementation of an industry-level production account for the U.S. was a fourth major advance in the integration of the U.S. statistical system. This was developed by Fleck, *et al.* (2014). The industry-level production account gives output for each of 65 sectors of the U.S. economy, as well as industry-level inputs of capital (K), labor (L), energy (E), materials (M) and services (S). Both outputs and KLEMS-type inputs were reported in current and constant prices and the ratio of real output to real input incorporated industry-level productivity into the U.S. national accounts. This removed the final obstacle to implementation of *SNA 2008* for the United States.

The aggregate measures of productivity in the BEA/BLS GDP and Productivity Account and the industry-level measures in the BEA/BLS Industry-level Production Account are consistent with Schreyer's (2001) *OECD Manual, Measuring Productivity*. The measurement of capital input as capital services at both aggregate and industry levels is consistent with Schreyer's (2009) *OECD Manual, Measuring Capital*. The model for the OECD's aggregate and industry-level productivity measures is provided by Jorgenson, Gollop, and Fraumeni (1987). This was updated and extended to incorporate data on production and investment in information technology by Jorgenson, Ho, and Stiroh (2005). Jorgenson and Schreyer (2013) showed how to

implement these measures within *SNA 2008.* Surveys of productivity measurement were presented by Hulten (2001) and Diewert (2001).

3.4. Comprehensive Revision.

Comprehensive revisions of the U.S. National Income and Product Accounts are undertaken at approximately five-year intervals. The 2013 comprehensive revision, presented by McCulla, Holdren, and Smith, included important changes in the product and asset boundaries to bring them into line with *SNA 2008*. Research and development (R&D) expenditures were added to investment and included in the GDP. These expenditures were capitalized and the stock of R&D was included in produced assets, along with computer software, while services of R&D were treated as capital inputs into production.

The treatment of artistic originals and other forms of intellectual property in *SNA 2008* was similar to R&D. The BEA/BLS Industry-Level Production Accounts were revised to incorporate capital services from these intangible assets and updated to 1998-2012 by Russell, *et al.* (2014). The incorporation of these intangible assets into the national accounts was a fifth major contribution to economic measurement considered in this review.

The asset boundaries employed in the 2013 Comprehensive Revision of the U.S. National Income and Product Accounts extended the coverage of intangible assets to coincide with the United Nations *SNA 2008.* Corrado, Haskel, and Jona-Lasinio (2016) presented estimates of investment and capital services for a much wider range of intangible assets for 14 European Union countries. These assets included brand development, organizational capital, firm-specific training and design, and other new product development costs. Estimates for Japan and Korea are presented by Chun, et al. (2016). An earlier set of estimates of investments in intangible assets is presented by Corrado, Hulten, and Sichel (2006). Corrado and Hulten (2014) referred to a wider range of investments in intangible assets than *SNA 2008* as innovation accounting.

The U.S. national income and product accounts have developed into an integrated system that includes GDP and the national income and product accounts, the flow of funds accounts, and inter-industry accounts, along the lines of *SNA 2008.* Through collaboration between BEA and FRB, the U.S. has achieved a high degree of integration of the national accounts with the flow of funds accounts. In addition, productivity statistics have been incorporated into the national accounts through collaboration between BEA and BLS, first at the aggregate level and then at the industry level.

The U.S. has made important progress in bringing GDP and the national accounts into conformity with *SNA 2008.* This has required substantial advances for the U.S. statistical system, relative to the halting and incomplete implementation of *SNA 1993*. Although the GDP continues to play a central role, the interests of financial analysts are well-served by implementation of the integrated flow of funds and national accounts. This eliminated a significant data gap that otherwise could have impeded the response to the financial and economic crisis, beginning in the United States in 2007-2009. Implementation of productivity statistics within the national accounts was a major improvement in the production accounts. This was critical for addressing the issue of secular stagnation during the recovery from the Great Recession.

3.5. International Comparisons.

The starting point for international comparisons for two or more countries is the national accounts for each country, standardized through the U.N. System of National Accounts. The International Comparison Program (ICP), organized by the World Bank, provides the price information required to link the accounts for different countries. The most recent study is for the year 2011; the World Bank (2014) presented the results. These involved 199 countries, divided into eight regions, including the 46 industrialized countries covered by Eurostat and OECD.

The first challenge for international comparisons is that GDP and its components are expressed in domestic currency, for example, the U.S. dollar in the case of the United States or the Japanese yen for Japan. Market exchange rates relative to the U.S. dollar could be used to convert GDP in different countries into the dollar as a common currency. Japanese GDP in yen could be expressed in U.S. currency by using the exchange rate of 72 yen per dollar in 2011. The Japanese GDP could then be compared with the U.S. GDP with both expressed in U.S. dollars.

Changes in the composition of the U.S. GDP over time are crucial in calculating the growth rate of the U.S. economy. The obvious flaw in exchange rate comparisons between the U.S. and Japan is that they fail to capture differences in the composition of the U.S. and Japanese GDPs. Purchasing Power Parities (PPP) between the yen and the dollar are used to make appropriate comparisons between the U.S. and Japanese GDPs. For example, the PPP in 2011 was 102 yen per dollar by comparison with the exchange rate of 72 yen per dollar.

The price level index (PLI), defined as the ratio of the yen/dollar PPP to the yen/dollar exchange rate, is used to quantify the differences in prices between two countries. In 2011 the PLI between Japan and the U.S. was 142, the ratio of the PPP of 102 to the exchange rate of 72. The PLI is an indicator of the price competitiveness of Japan and the U.S. This shows that prices in 2011, expressed in U.S. dollars, were much higher in Japan, so that the yen was drastically over-valued relative to the U.S. dollar. Japanese producers had to overcome a price barrier of 42 percent relative to U.S. producers in selling a unit of the U.S. GDP in the United States.

3.6. International Comparison Program.

The World Bank's International Comparison Program is a vast exercise in collection of national accounting data and price comparisons for the commodity groups that make up GDP in 199 countries. With some justification the World Bank (2014) describes this as the largest and

most complex statistical program in the world. The project was organized by the ICP Global Office at the World Bank in collaboration with Eurostat and OECD, which carried out a parallel project for 46 industrialized countries.

The ICP grew out of a research project on international comparisons of the GDP at the University of Pennsylvania, established by Alan Heston, Irving Kravis, and Robert Summers. This project summarized the results in a series of Penn World Tables (PWT) at, roughly, five-year intervals, beginning in 1970. These were combined with national accounting data from the participating countries to provide annual data on real GDP back to 1950. Purchasing power parities for the latest available year were used to convert national accounts from domestic currencies into U.S. dollars. Recent versions of the PWT are available from the Groningen Growth and Development Centre (2016).

After 1980 the international comparisons of the GDP became part of the work program of the U.N. Statistical Commission. The program was decentralized to the U.N. Regional Economic Commissions; Eurostat produced benchmark comparisons of the GDP for members of the EU and non-member countries like Norway associated with the EU, while OECD generated comparisons for OECD member countries. Since 1990 Eurostat has made annual comparisons for EU members and countries associated with the EU, while OECD has made comparisons on a three-year cycle for all OECD member countries included in the program.

The World Bank assumed the role of global coordinator for what had become the ICP in 1993. Although comparisons within regions were made for 1993, no world comparisons were produced. The U.N. Statistical Commission asked the World Bank to develop proposals for more effective management, more detailed documentation and transparency, and funding future rounds. In 2002 the Commission approved a plan for ICP 2005 that led to international

comparisons for 146 countries by the World Bank (2010). A similar approach was employed by the World Bank (2014) for the 199 countries included in ICP 2011. The implementation of purchasing power parities within the ICP is a sixth major contribution to economic measurement considered in this review.

3.7. New World Order.

The international comparisons of the GDP in the World Bank's ICP 2011 are extrapolated annually by the International Monetary Fund (2017) in the *World Economic Outlook (WEO).* A striking finding from the April 2015 *WEO* is that China overtook the U.S. as the world's largest economy in 2014. In this comparison the GDP's for both countries were evaluated at U.S. dollars, using purchasing power parities from the World Bank's *ICP 2011*.

According to Angus Maddison (2001), the U.S. had been the world's largest economy for more than a century. The World Bank's 2005 ICP showed that China had overtaken Japan more than a decade earlier. By 2012 India had overtaken Japan, becoming the world's third largest economy, and has continued to grow more rapidly. Of course, exchange rate comparisons of GDP levels tell a very different story, but these are inappropriate for international comparisons like the PWT and successive rounds of the World Bank's ICP.

The PWT provided the international comparisons of the GDP that underlie the extensive empirical literature on "growth regressions". A detailed survey of empirical results and alternative econometric methodologies is presented by Durlauf, Johnson, and Temple (2006). The PWT was transferred to the University of California, Davis, and the University of

Groningen, beginning with Release 8.0 in 2013. Important changes in the methodology and scope of the project are described by Feenstra, Inklaar, and Timmer (2015).[12]

The World Bank's ICP is based on GDP comparisons across countries. The aggregate production account in *SNA 2008* also includes GDO or gross domestic outlay. In the U.S. national accounts both are expressed in current and constant prices and TFP is the ratio of real output, measured by real GDP, and real input, captured by real GDO. Real input includes inputs of capital and labor services, as in "Blueprint". However, the World Bank's ICP does not include purchasing power parities for inputs of capital and labor services. This gap was filled by Jorgenson and Vu (2005), who constructed purchasing power parities for inputs and presented international comparisons of levels and growth rates of GDP, GDO, and TFP, covering the period 1989-2003, for 110 countries.

Since 2007 the international comparisons of aggregate outputs, inputs, and TFP have been maintained by The Conference Board, a private, non-profit research group based in New York. This is called the Total Economy Database (TED) after an earlier database developed by Maddison. The latest version from The Conference Board (2016) includes PPP's for 2011 from the ICP and provides GDP comparisons for 128 countries, beginning in 1950. The purchasing power parities of capital and labor inputs for the 128 countries constructed by de Vries and Erumban (2016) are modeled on those Jorgenson and Vu (2005).

An important finding from the 2016 version of TED is that the TFP of the U.S. in 2015 remains far in advance of the TFP's of China and India, as well as the TFP's of Japan and other leading industrialized countries. More surprisingly, the double-digit growth rates of China in the 1990s and 2000s and India in the 2000s have been mainly due to increases in labor and,

[12] Feenstra, Inklaar, and Timmer (2015) use capital stocks rather than capital services as measures of capital input in the PWT, Version 8.0. This does not conform to Schreyer's (2001) *OECD Manual, Measuring Productivity*, Schreyer's (2009) *OECD Manual, Measuring Capital*, or the United Nations (2009) *SNA 2008.*

especially, capital inputs, rather than growth in productivity. This conforms to the model followed by the U.S. and other industrialized economies, which are growing much more slowly. The implementation of purchasing power parities for inputs and estimates of total factor productivity levels for the countries that make up the world economy comprises a seventh major contribution to economic measurement reviewed in this paper.

3.8. Industry-Level Production Account.

Jorgenson, Gollop, and Fraumeni (1987) constructed the first industry-level production accounts for the U.S., including a time series of industry-level outputs, capital and labor services, and intermediate inputs in current and constant prices. The intermediate inputs are based on a time series of inter-industry transactions tables, like those included in the U.N. System of National Accounts. These industry-level production accounts serve as the model for the international standards for productivity measurement presented in Schreyer's (2001) *OECD Manual, Measuring Productivity*.

Jorgenson, Ho, and Stiroh (2005) updated the U.S. dataset and revised it to include investment in information and communications technology (ICT) equipment and services. This required new data on the production of computer hardware, telecommunications equipment, and software, as well as industry-level ICT capital services. The new dataset demonstrated the importance of productivity growth in ICT production in the U.S. investment boom of the late 1990s. Jorgenson, Ho, and Stiroh (2005) provided the framework for the studies of industry-level productivity for Europe, Japan, and the United States presented in Jorgenson (2009).

In 2010 Jorgenson, Timmer, and van Ark established the World KLEMS Initiative. The purpose of this Initiative is to generate industry-level datasets with outputs, inputs of capital (K), labor (L), energy (E), materials (M), and services (S), and productivity for analyzing the sources

of economic growth for countries around the world. The growth of industry-level outputs, inputs, and productivity is employed in analyzing the sources of economic growth and the nature of structural change. Regional organizations in Asia and Latin America joined the European Union in supporting research on industry-level datasets and extended the new framework to emerging and transition economies, such as Brazil, China, India, Mexico, and Russia.

In the United States a critical role in establishing standards for KLEMS-type research was played by the Advisory Committee on Measuring Innovation in the 21st Century Economy to the U.S. Secretary of Commerce (2008). The recommendations of the Advisory Committee were implemented by BEA and BLS and industry-level productivity statistics were incorporated into the U.S. National Income and Product Accounts. These statistics were updated and revised to incorporate intellectual property products and assure conformity with *SNA 2008* after the 2013 benchmark revision of the U.S. accounts.

3.9. Value Added by Industry.

Jorgenson, Ho, and Samuels (2016) presented an industry-level production account for the United States for the period 1947-2012. This incorporated an annual time series of inter-industry transactions tables constructed by Mark Planting, formerly a staff member at BEA. These tables were combined with detailed data on capital and labor services to generate output, inputs of capital, labor, energy, materials, and services, and industry-level productivity for 65 U.S. industries. The data on capital and labor services were based on estimates by Jorgenson, Gollop, and Fraumeni (1987), Jorgenson, Ho, and Stiroh (2005), and the BEA/BLS industry-level production accounts for 1998-2012.

The NAICS industry classification includes the industries identified by Jorgenson, Ho, and Samuels (2016) as IT-producing industries, namely, computers and electronic products and two IT-services industries, information and data processing and computer systems design. Jorgenson, Ho and Samuels (2016) have classified industries as IT-using if the intensity of IT capital input is greater than the median for all U.S. industries that do not produce IT equipment, software and services. All other industries are classified as Non-IT.

Value added in the IT-producing industries during 1947-2012 is only 2.5 percent of the U.S. economy. Value added in the IT-using industries is about 47.5 percent and the remaining fifty percent is in the Non-IT industries. The IT-using industries are mainly in trade and services and most manufacturing industries are in the Non-IT sector. The NAICS industry classification provides much more detail on services and trade, especially the industries that are intensive users of IT. We begin by discussing the results for the IT-producing sectors, now defined to include the two IT-service sectors.

(Figures 2 and 3 about here)

Figure 2 shows a steady increase in the share of IT-producing industries in the growth of value added since 1947. This is paralleled by a decline in the contribution of the Non-IT industries, while the share of IT-using industries remained relatively constant through 1995. Figure 3 gives the contributions to value added for the 65 individual industries over the period 1947-2012.

3.10. Total Factor Productivity.

The growth rate of aggregate productivity includes a weighted average of industry productivity growth rates, using an ingenious weighting scheme originated by Domar (1961). In

the Domar weighting scheme the productivity growth rate of each industry is weighted by the ratio of the industry's gross output to aggregate value added. A distinctive feature of Domar weights is that they sum to more than one, reflecting the fact that an increase in the growth of the industry's productivity has two effects. The first is a direct effect on the industry's output and the second an indirect effect via the output delivered to other industries as intermediate inputs.

The rate of growth of aggregate productivity also depends on the reallocations of capital and labor inputs among industries. The aggregate productivity growth rate exceeds the weighted sum of industry productivity growth rates when these reallocations are positive. This occurs when capital and labor inputs are paid different prices in different industries and industries with higher prices have more rapid input growth rates. Aggregate capital and labor inputs then grow more rapidly than weighted averages of industry capital and labor input growth rates, so that the reallocations are positive. When industries with lower prices for inputs grow more rapidly, the reallocations are negative.

(Figure 4 about here)

Figure 4 shows that the contributions of IT-producing, IT-using, and Non-IT industries to aggregate productivity growth are similar in magnitude for the period 1947-2012. The Non-IT industries greatly predominated in the growth of value added during the Postwar Recovery, 1947-1973, but this contribution became negative after 1973. The contribution of IT-producing industries was relatively small during this Postwar Recovery, but became the predominant source of growth during the Long Slump, 1973-1995, and increased considerably during the period of Growth and Recession of 1995-2012.

The IT-using industries contributed substantially to U.S. economic growth during the Postwar Recovery, but this contribution disappeared during the Long Slump, 1973-1995, before

reviving after 1995. The reallocation of capital input made a small but positive contribution to growth of the U.S. economy for the period 1947-2012 and for each of the sub-periods. The contribution of reallocation of labor input was negligible for the period as a whole. During the Long Slump and the period of Growth and Recession, the contribution of the reallocation of labor input was slightly negative.

(Figure 5 about here)

Figure 5 gives the contributions of each of the 65 industries to productivity growth for the period 1947-2012. Wholesale and retail trade, farms, computer and peripheral equipment, and semiconductors and other electronic components were among the leading contributors to U.S. productivity growth during the postwar period. About half the 65 industries made negative contributions to aggregate productivity growth. These include non-market services, such as health, education, and general government, as well as resource industries affected by depletion, such as oil and gas extraction and mining. Other negative contributions reflect the growth of barriers to resource mobility in product and factor markets due, in some cases, to more stringent government regulations.

3.11. Sources of Economic Growth

The price of an asset is transformed into the price of capital input by the *cost of capital*, introduced by Jorgenson (1963). The cost of capital includes the nominal rate of return, the rate of depreciation, and the rate of capital loss due to declining prices. The distinctive characteristics of IT prices – high rates of price decline and high rates of depreciation – imply that cost of capital for IT capital input is very large relative to the cost of capital for the price of Non-IT capital input.

The contributions of college-educated and non-college-educated workers to U.S. economic growth are given by the relative shares of these workers in the value of output, multiplied by the growth rates of their labor input. Personnel with a college degree or higher level of education correspond closely with "knowledge workers" who deal with information. Of course, not every knowledge worker is college-educated and not every college graduate is a knowledge worker.

(Figure 6 about here)

Figure 6 shows that about 80 percent of the sources of U.S. economic growth since 1947 is due to the growth of capital and labor services, the primary factors of production. The growth of total factor productivity, representing the impacts of innovation, accounts for only 20 percent. This reverses the findings of earlier empirical research on productivity growth by Robert M. Solow (1957) and Kuznets (1971) that underpins much of the theoretical literature on economic growth. An important element in this striking change in perspectives on economic growth is the belated appearance of information technology equipment and software in the productivity statistics recently incorporated into the U.S. national accounts. However, the reversal of the relative importance of the main sources of economic growth is due primarily to the adoption of capital services as a measure of capital input in the United Nations *SNA 2008.*

3.12. International Comparisons of Growth

The EU (European Union) KLEMS project applied international standards for productivity measurement to data for 25 of the (then) 27 countries of the European Union. The project also included datasets for Australia, Canada, and Korea, as well as Japan and the United States. The international standards were incorporated into a manual written by Timmer, et al.

(2007) and his colleagues at the University of Groningen and the National Institute of Social and Economic Research in London. This manual was employed by the twenty-one participating research organizations and statistical agencies that contributed to the project.

The EU KLEMS datasets are essential for analyzing the slowdown in European economic growth that preceded the current financial and fiscal crisis.[13] Timmer, *et al.* (2010) compared the sources of economic growth**,** as well as structural change for Europe, Japan, and the United States. Jorgenson and Timmer (2011) translated the results into a new set of "stylized facts" about economic growth. Mas and Stehrer (2012) provided international comparisons within Europe and between Europe and the advanced economies in Asia and North America. Updated estimates of the sources of European economic growth for the period 1999-2014 were presented by van Ark and O'Mahony (2016).

The Latin American regional organization of the World KLEMS Initiative, LA KLEMS, was established in December 2009. This organization was originally coordinated by ECLAC, the Economic Commission for Latin America and the Caribbean, an agency of the United Nations in Santiago, Chile, and included research organizations and statistical agencies in leading Latin American countries.[14] Cimoli, Hofman, and Mulder (2010) summarized the results of the initial phases of the LA KLEMS project, while Hofman, *et al.* (2016), presented production accounts for Argentina, Brazil, Chile, Columbia, and Mexico for 1990-2010. The LA KLEMS project was transferred to the Inter-American Development Bank (IDB) in December 2016. A remarkable

[13] Updated data for the EU countries are posted on the EU KLEMS website: http://www.euklems.net/eukNACE2.shtml

[14] Additional information about LA-KLEMS is available on the project website: http://www.cepal.org/cgi-bin/getprod.asp?xml=/la-klems/noticias/paginas/4/40294/P40294.xml&xsl=/la-klems/tpl-i/p18f-st.xsl&base=/la-klems/tpl-i/top-bottom.xsl

finding of recent research from the LA KLEMS project is that there has been no productivity growth in the leading countries of Latin America during the two decades from 1990-2010.

A detailed report on Mexico KLEMS was published in 2013 by the Mexican statistical agency INEGI. Mexico KLEMS includes a complete industry-level productivity database for 1990-2011 that is integrated with the Mexican national accounts and is updated annually. Since 1990 periods of positive economic growth have been offset by the negative impacts of the Mexican sovereign debt crisis of 1995, the U.S. dot-com crash in 2000, and the U.S. financial and economic crisis of 2007-2009. Mexican productivity at the economy-wide level has remained unchanged throughout these two decades.

Asia KLEMS, the Asian regional organization of the World KLEMS Initiative, was founded in December 2010 at the Asian Development Bank Institute (ADBI) in Tokyo. Asia KLEMS includes the Japan Industrial Productivity database, developed by Fukao, et al. (2016), the Korea Industrial Productivity database, presented by Pyo, Chun and Rhee (2016), and the China Industrial Productivity database, constructed by Wu (2016). Industry-level databases have also been constructed for India and Taiwan and work is underway to develop databases for Bangladesh, Malaysia, and Thailand.

Altogether, KLEMS-type data sets have been compiled for more than forty countries. Official systems of industry-level production accounts are now part of the national accounts in thirteen countries: Australia, Canada, Denmark, Finland, France, Italy, Korea, Mexico, The Netherlands, New Zealand, Sweden, the United Kingdom, and the United States. The World KLEMS Initiative is the eighth major contribution to economic measurement considered in this survey.

3.13. Industry-Level Purchasing Power Parities.

Datasets for two or more countries, linked by purchasing power parities at the industry level, are essential for analyzing the role of international trade and investment in economic growth. Jorgenson, Nomura, and Samuels (2016) linked KLEMS-type databases for 36 industries in Japan and the United States for the period 1955-2012. The two-country database covers the entire economy for both countries, as well as the trade links among the two countries and the rest of the world. The data are presented in current and constant U.S. dollars, using industry-level purchasing power parities (PPPs) for outputs and inputs, as well as imports and exports, developed specifically for the two-country database.

(Table 1 about here)

¡Error! No se encuentra el origen de la referencia. Table 1 presents estimates of PPPs and price level indices (PLIs) for Japan relative to the U.S. If the PPP is higher than the exchange rate, the Japanese price is higher than the U.S. price. Through the mid-1970s the Japanese price for output (GDP) was lower than the U.S. price. The Japanese prices of inputs of capital, labor, energy, materials and services (KLEMS), except for energy, were lower than the U.S. prices as well. After the Plaza Accord of 1985 the Japanese prices for output and all the inputs, except for labor input, were higher than the U.S. prices.

(Figure 7 about here)

Figure 7 gives the contribution of individual industries to the price level index for GDP. For example, the Japanese Wholesale and Retail industry has the largest contribution to the PLI for GDP. By contrast, Japan's Medical Care sector in services and Motor Vehicles and Primary

Metal sectors in manufacturing contributed negatively to the PLI for GDP. All three of these industries are highly competitive with their U.S. counterparts.

3.14. Productivity Gaps.

(Figure 8 about here)

The Japan-U.S. gap for total factor productivity (TFP) in 1955 was 54.6 percent. This gradually declined over the following 36 years and reached a low of 7.1 percent in 1991, as shown in Figure 8. The growth rate of TFP in Japan was 2.46 percent per year from 1955 to 1991, but became slightly negative after 1991, averaging -0.05. By comparison the growth rate of TFP in the U.S. was 0.46 per year from 1955–1991 and 0.53 percent after 1991.

(Figure 9 about here)

Figure 9 presents Japan-U.S. gaps in total factor productivity (TFP) in manufacturing and non-manufacturing sectors for the period 1955–2012. In 1955 both gaps were very large. The TFP gap for manufacturing disappeared by 1980 and the overall TFP gap reflected the lower TFP in non-manufacturing. Japanese manufacturing productivity relative to the U.S. peaked at 103.8 in 1991 and deteriorated afterward, leaving a current gap that is almost negligible. The gap for non-manufacturing also contracted from 1955 to 1991, when the gap reached 8.9 percent, but expanded until the end of the period in 2012.

(Figure 10 about here.)

Figure 10 presents the contributions of each industry to the overall TFP gap for the two countries. Industries are ordered by their contributions to the TFP gap. The contribution of each industry to the aggregate TFP gap uses the Domar weights described above. The TFP gaps for

Public Administration and Household sectors are zero by definition, since the outputs of these industries consist entirely of total inputs.

Jorgenson, Nomura, and Samuels (2016) found that the wide Japan-U.S. productivity gap that existed in 1955 shrank over the following three decades, so that Japan came close to parity with the U.S. in 1991. After the collapse of the "bubble economy" in Japan, the Japan-U.S. productivity gap widened again and in 2012 only a few industries in Japan retained a productivity advantage over their U.S. counterparts. Most remarkably, Japan has had no growth in TFP since 1991. The two-country production account for Japan and the U.S. is the ninth major advance in economic measurement considered in this survey.

3.15. World Input-Output Database.

Timmer, Los, and de Vries (2016) presented the World Input-Output Database (WIOD), a unified system of inter-industry accounts for thirty industries in forty countries for the period 1995-2011. [15] The WIOD includes a time series of inter-industry transactions tables containing inputs and outputs of intermediate goods for each country. The prices of inputs and outputs are expressed in terms of aggregate purchasing power parities from the World Bank's ICP and separate price indexes are used to deflate trade flows among the forty economies and the rest of the world.

Using the World Input-Output Database, Timmer, Los, and de Vries (2016) have analyzed changes in global value chains, the set of activities needed to generate value added in each country from 1995 to 2011. They find increasing international fragmentation in the

[15] The WIOD is described in detail by Timmer, *et al.* (2015). Current data from the WIOD are available on line; see: http://www.wiod.org/home . Like the PWT, the WIOD defines capital input in terms of capital stocks, rather than capital services, which is inconsistent with Schreyer (2001), *OECD Manual, Measuring Productivity*, Schreyer (2009), *OECD Manual, Measuring Capital*, and the United Nations (2009), *SNA 2008*.

production of manufactures, indicated by the growing share of foreign value added. This has been accompanied by a rapid shift towards higher-skilled activities in advanced economies. Emerging economies are increasing their shares in global value chains with much of the increase driven by China. One of the central findings is that regional value chains are now merging into global value chains linking economies around the world.

Timmer, Los, and de Vries found that tasks performed in global value chains are increasingly carried out in the service sectors. This intertwining of manufacturing and services implies that trade policy should focus on activities or tasks in global value chains rather than the industrial sectors. The WIOD provides a model for Trade in Value Added (TiVA), an expanded version at OECD (2016), developed with support from the World Trade Organization. An overview of the project is provided by OECD (2013). The next major research objective is to construct a world production account with inputs and outputs for all countries linked by industry-level purchasing power parities. This will make it possible to analyze the sources of world economic growth at the industry level. The World Input-Output Database is the tenth major contribution to economic measurement considered in this survey.

3.16. Conclusions.

Very substantial progress has been made in addressing limitations of the GDP and the national accounts. The U.N. System of National Accounts was revised and updated in *SNA 2008.* Chapters 19 and 20 resolved long-standing issues in the measurement of capital and labor inputs and made it possible to incorporate capital and labor services and productivity growth into systems of national accounts. Surprisingly, this resulted in a sharp reversal in the measured

relative importance of the main sources of economic growth – productivity growth and the accumulation of the primary factors of production – from earlier work by Solow and Kuznets.

Collaboration among the U.S. statistical agencies brought the U.S. GDP and the National Income and Product Accounts, as well as the Flow of Funds and the Inter-Industry Accounts, into much better alignment with international standards. Under Schreyer's leadership the OECD developed economy-wide and industry-level standards for productivity and capital measurement. These have been implemented for more than forty countries through the World KLEMS Initiative and incorporated into the national accounts for thirteen countries, including the United States.

The national accounts for 199 countries have been linked through the World Bank's *ICP 2011*. This required aggregate purchasing power parities for all countries, constructed from relative prices for different commodity groups and linked to prices for the U.S. in dollars. Inter-industry transactions tables for the U.S. and Japan have been linked through industry-level purchasing power parities. The results were used in analyzing the international competitiveness and relative productivity levels in the two countries. Similar methodologies have been proposed by Landefeld (2015) for the *System of Extended and Integrated Global Accounts* (SEIGA) for the world economy under development by the United Nations Statistical Division.

4. **Income, Saving, and Wealth**

The previous section of this paper reviews recent advances in the production account within the framework of *SNA 2008.* This section presents advances in the income and expenditure account and the national balance sheet. The income and expenditure account includes income, consumption, and saving, while the national balance sheet presents assets and

liabilities. The income and expenditure and wealth accounts provide the platform for addressing the issues that arise in measuring economic welfare.

An important obstacle to welfare measurement is the long-standing consensus among economists that measuring social welfare is impossible. There is a parallel consensus among national accountants that accounting concepts like production, expenditure, and wealth should not be given a welfare interpretation. For example, the discussion of welfare within *SNA 2008* begins with the following:

> GDP is often taken as a measure of welfare, but the SNA makes no claim that this is so and indeed there are several conventions in the SNA that argue against the welfare interpretation of the accounts.[16]

Support for the impossibility of measuring social welfare rests on constraints on the information available on individual welfare that were gradually relaxed through improvements in methods of measurement.

A second obstacle to welfare measurement is that information on individual welfare must be combined with value judgments about equity among individuals. This is unappealing to economists who prefer to separate the two and leave value judgments to philosophers, who are presumed to be specialists in this undertaking. This line of argument follows positivists like Lionel Robbins. Bringing philosophers into every discussion about value judgments has proven to be a formula for neglecting equity issues, an increasingly unpopular stance among economists.

Economists and national accountants seem to be far from a consensus about combining measures of individual welfare into indicators of social welfare. However, measures of poverty

[16] United Nations (2009), p. 12.

and inequality, as well as individual well-being and social progress, are attracting increasing attention. At the most elementary level this involves a trade-off between equity and efficiency, where efficiency can be identified with concepts that appear in the United Nations *SNA 2008.* Equity requires distributional information and involves value judgments, both discussed in more detail below.

4.1. Stiglitz-Sen-Fitoussi Report

The Report to former President Nicholas Sarkozy of France by Stiglitz, Sen, and Fitoussi (2010) is an appropriate point of departure for a discussion of progress in measuring welfare. Joseph Stiglitz, Nobel Laureate and Professor of Economics at Columbia, was President of the Commission on the Measurement of Economic Performance and Social Progress, appointed by President Sarkozy. Amartya Sen, Nobel Laureate and Professor of Economics at Harvard, served as Chair Advisor and Jean-Paul Fitoussi, Professor at the Institut d'Etudes Politiques de Paris, as Coordinator. The Commission included twenty-one additional members, among them Daniel Kahneman and James Heckman, both Nobel Laureates in economics, and many other distinguished economists.

The starting point for the Commission was familiar: "… GDP mainly measures *market* production, though it has been often been treated as if it were a measure of economic well-being."[17] The Stiglitz-Sen-Fitoussi Report summarized alternative approaches to welfare measurement, but did not present measures of welfare. The Commission's first recommendation was to focus on income and consumption rather than production. Within the "Blueprint" given in Section 3, this shifted the emphasis from the GDP and the production account to welfare and the

[17] Stiglitz, Sen, and Fitoussi (2010), p. 23.

income and expenditure account. The third recommendation was to consider income and consumption jointly with wealth, which requires a national balance sheet. The first and third recommendations of the Stiglitz-Sen-Fitoussi Report can be carried out within *SNA 2008.*

The latest version of the SNA was approved by the U.N. Statistical Commission in 2009, before the Stiglitz-Sen-Fitoussi Report was published in 2010. The Report diverged from *SNA 2008* with a second recommendation that emphasizes the "household perspective". This suggested the use of micro-economic data from surveys of the consumption, income, and wealth of households, in addition to macro-economic data from the income and expenditure and wealth accounts. The fourth recommendation was to present distributional information in the national accounts, an idea excluded from *SNA 2008*.

The Stiglitz-Sen-Fitoussi Report's fifth recommendation was to incorporate nonmarket dimensions of income, for example, measures of household production and leisure time, like those provided by Nordhaus and Tobin (1972). The Report departed even more conclusively from the national accounts by including subjective measures of well-being, quality-of-life measures such as education, health, and numerous others, and measures of sustainability, including physical indicators of environmental quality. These could be presented as a "dashboard" like the Sustainable Development Goals of the United Nations or as a composite index like United Nations Development Programme's Human Development Index (HDI). Both are discussed in Section 5 below.

4.2. Distributional Information

Since the Stiglitz-Sen-Fitoussi Report appeared after *SNA 2008*, it is too soon to determine how the Report will influence national accounting practice. However, one component

of the overall agenda of the Stiglitz Commission has already attracted attention from national accountants. This is to incorporate distributional information on income, consumption, and wealth into *SNA 2008*, while preserving the production and asset boundaries. To achieve this objective statistical offices have combined their professional expertise on national accounting with expertise in micro-economic surveys, both within the structure of *SNA 2008.*

Eurostat and the OECD established two Expert Groups on incorporating distributional information into the national accounts. The task of the Expert Group on Disparities in the National Accounts (EG DNA) was to provide international standards and the results were reported by Fesseau, Matteonetti and Wolff (2013). The task of the Expert Group on Income, Consumption, and Wealth (EG ICW) was to reconcile the definitions of income, consumption, and wealth in the national accounts with the definitions in household data sets. The results were reported by Fesseau and Matteonetti (2013). This left open the potential applications of these results in measuring individual and social welfare within the framework of *SNA 2008*, discussed in more detail below.

4.3. Individual Welfare

Jorgenson and Schreyer (2017) summarized the issues that arise in measuring individual and social welfare. The first issue is the choice of an appropriate consumer unit. Individuals are the apparent subjects of the theory of consumer behavior, for example, in the classic formulation of Eugen Slutsky (1915), which recently celebrated its centennial. However, survey data on consumption, income, and wealth are collected for households, that is, groups of individuals sharing a budget and often a residence. Paul A. Samuelson (1956) presented a theory of household behavior appropriate for the analysis of these survey data, using the concept of a

household welfare function to combine the preferences of the individual members. The theory of household behavior was also discussed by Gary S. Becker (1981) and Robert A. Pollak (1981).

The second issue in measuring social welfare was to adjust survey data on households to be consistent with control totals from the national accounts. Fesseau and Matteonetti (2013) presented methods for imposing control totals from the national accounts on household survey data for consumption, income, and wealth. Consumption and income data appeared in the income and expenditure account, while wealth appeared in the national balance sheet.

Household consumer expenditure measures the current flow of economic welfare, while household income measures the value of the current flow of welfare, together with the value of increments to future welfare through saving. Finally, household wealth captures the present value of current and future welfare. To simplify the discussion of individual welfare only household consumption, measured by the national accounting concept of personal consumption expenditures (PCE) and discussed by Fesseau and Matteonetti (2013), will be considered.

4.4. Interpersonal Comparisons.

The most challenging issue in measuring social welfare is the comparability of levels of welfare for different households. The core of the widespread consensus among economists that the measurement of social welfare is impossible is that household preferences are not comparable. This argument was formalized by Kenneth J. Arrow (1963) in his famous "impossibility" theorem for social choice. In this context there are two different meanings for the comparability of household preferences. The first is the normative proposition that social judgments should not violate the principle of consumer sovereignty by comparing levels of

welfare for different households. This assumption leads to Arrow's impossibility theorem and ends the search for a measure of social welfare.

The second meaning of non-comparability of household preferences is that it is impossible to compare preferences for households with different demographic characteristics as an empirical matter. Drawing on a long line of empirical research on household expenditure patterns, extending back more than a century to the work of Ernst Engel (1895), welfare levels of different households can be compared by using household equivalence scales. The simplest version of this approach is to express household consumption in per capita terms. Households with the same per capita consumption are assumed to have the same level of welfare. An almost equally transparent approach is to express the household equivalence scale as a function of the numbers of household members, classified by age and gender. An example is the Oxford scale discussed by Fesseau and Matteonetti (2013).

Jorgenson and Schreyer (2017) reviewed a parallel literature in the economic theory of the household behavior. Anton P. Barten (1964) defined a household equivalence scale as the proportional change in household consumption required to make households with different characteristics equally well off. Equivalence scales are the same for all households with a given set of demographic characteristics and are expressed in terms of a single individual of a given age and gender. These scales may depend on prices, since household members with different characteristics may have different preferences. Jorgenson and Slesnick (1987) used this approach in constructing household equivalence scales by econometric methods. Lewbel and Pendakur (2003) provided an overview of the theory of household equivalence scales and Slesnick (2001) summarized the empirical literature.

The two definitions of household comparability, normative and empirical, can be brought into consistency by utilizing household equivalence scales in comparing levels of household consumption as measures of individual welfare. It is important to emphasize that this involves two different assumptions. The positive assumption is that equivalence scales can be derived from a model of household behavior. The normative assumption is that household equivalent consumption is an appropriate measure of household welfare in constructing measures of social welfare.

The fourth issue in measuring social welfare is to express household consumption in real terms for different price systems by dividing the value of nominal household equivalent consumption by a household cost of living index. Alexander Konus (1939) defined this as the ratio of nominal levels of household consumption required to achieve the same level of household welfare for two different price systems. The household cost of living index depends on the prices of all commodity groups, as well as household characteristics. Unless household preferences are homothetic, the cost of living index also depends on levels of household consumption. Jorgenson and Slesnick (1983) constructed household-specific measures of the cost of living from an econometric model of household behavior.

The appropriate measure of household welfare is the household equivalent level of consumption in real terms. Jorgenson and Schreyer (2017) showed that household-specific indexes of the cost of living have a very modest effect on measures of household welfare, while the form of the household equivalence scale has considerable impact. Slesnick (2001) reviewed the empirical literature on the cost of living and household equivalence scales in much more detail and reached similar conclusions. This led to a substantial simplification of measures of individual and social welfare by using the same cost of living measure for all households.

4.5. Social Welfare.

The final step in measuring social welfare is to introduce a social welfare function to combine measures of household welfare, as shown by Sen (1977) and Roberts (1980a). In the literature on social choice, measures of household welfare are classified as ordinal or cardinal. Ordinal measures are invariant with respect to monotone, increasing transformations, while cardinal measures are invariant with respect to positive, affine transformations. Roberts (1980a) showed that the greater the degree of comparability among measures of household welfare, the broader is the scope for representing social welfare. While Arrow (1963) assumed the household measures are ordinal and non-comparable, considerable progress was made by considering cardinal measures of household welfare that are comparable among households. Sen (2017) reviewed the extensive body of possibility and impossibility results for social welfare measures.

The next issue to be considered is inter-household comparability in the measurement of social welfare. In the literature on social choice, heterogeneity of households with different demographic characteristics is usually ignored, so that this issue is considered under the rubric of interpersonal comparability. If quantity measures of household welfare are cardinal, but comparable among households only in terms of differences –cardinal unit comparability (CUC) in the language of social choice – then social welfare functions must be utilitarian. Different value judgments about equity among households can be represented by the choice of a single parameter of a utilitarian social welfare function, the *degree of aversion to inequality*.

A more stringent assumption is that measures of household welfare are cardinal and fully comparable among households – cardinal full comparability (CFC) in the language of the theory of social choice. Social welfare functions then consist of a mean, as in a utilitarian social welfare

function, and a generalized variance, expressed as a linear homogeneous function of deviations of household welfare from mean welfare. A utilitarian social welfare function is a special case that omits the generalized variance.

Jorgenson and Slesnick (1987, 2014) demonstrated that cardinal full comparability is the appropriate assumption for household welfare functions derived from the econometric model of aggregate consumer behavior constructed by Jorgenson, Lawrence Lau, and Thomas Stoker (1982). In this model aggregate demand functions are obtained by exact aggregation over household demand functions.[18] Household demand functions incorporate total household expenditures, as well as demographic characteristics of individual households as determinants of household consumption patterns.

4.6. Distributional Measures and the National Accounts.

Jorgenson and Slesnick (2014) converted quantity measures of household and social welfare into appropriate money measures in order to incorporate them into the U.S. national accounts. For this purpose they used the social expenditure function proposed by Pollak (1981). They maximized the social welfare function for all possible lump sum transfers of a given level of personal consumption expenditures among households. Under this assumption the level of real equivalent household consumption is the same for all households.

The measure of potential social welfare from the national accounts is personal consumption expenditures from the Domestic Income and Expenditures Account in "Blueprint", Figure 1 above. This is expressed in constant prices per household equivalent member. Actual

[18]Lewbel (1989) showed that the household equivalence scales of Jorgenson and Slesnick (1987) are independent of the level of household consumption, the key assumption for the cardinal full comparability of levels of household welfare. Lewbel suggested that this approach could also be used for the model of consumer behavior proposed by Deaton and Muellbauer (1980). Details were provided by Fleurbaey and Hammond (2004).

social welfare also depends on the distribution of personal consumption expenditures over the population. Equity is defined as the ratio of the index of social welfare to this index of efficiency. Jorgenson and Slesnick (2014) present indexes of social welfare for utilitarian and egalitarian social welfare functions.

4.7 Equity and the Standard of Living.

[TABLE 2 ABOUT HERE]

Fesseau, Wolff, and Matteonetti (2013) showed how to combine national accounting totals with household survey information to obtain the distribution of household consumption over the population. The average growth rates for personal consumption expenditures in constant prices per household equivalent member in Table 2, the measure of efficiency, is given for the postwar period 1948-2010 and for five sub-periods. Growth rates of egalitarian and utilitarian measures of equity and the standard of living. The average annual growth rate of efficiency for the period as a whole was 2.16 percent. The average growth rate of the egalitarian measure of the standard of living was 2.34 percent, reflecting a modest gain in equity of 0.17 percent per year. For the utilitarian measure of the standard of living the growth rate was 2.24 percent and the growth rate of equity was only 0.08 percent.

The growth rate of efficiency was highest during the period 1948-1973. Since this is the only period when the growth of equity was positive, the growth rates of the standard of living were also highest for both egalitarian and utilitarian measures. The growth rate of efficiency dropped during the sub-period 1973-1995. Combined with the modest declines in equity, this resulted in a substantial decline in the growth rates of egalitarian and utilitarian measures of the standard of living.

A quantity measure of *equity* proposed by Jorgenson and Slesnick (2014) is given by the ratio of quantity measures of actual and potential social welfare. This varies between zero and unity and takes the value of unity only for a perfectly egalitarian distribution of household welfare. A convenient measure of *relative inequality* is unity minus the quantity measure of equity. This varies between zero and unity and takes the value zero for a perfectly egalitarian distribution. The distinctive feature of these measures of equity and relative inequality is that they are defined on quantity measures of individual welfare.

The quantity measure of social welfare is the product of the quantity measures of efficiency and equity. Taking the logarithms of both terms, the sum of the transformed values of efficiency and equity is the transformed value of social welfare. This completes the incorporation of quantity measures of social welfare, efficiency, and equity into *SNA 2008*. Links to the literature on social choice are useful in simplifying and decomposing measures of social welfare and are essential for providing a welfare interpretation. Although *SNA 2008* rules out a welfare interpretation of the national accounts, satellite accounting systems such as environmental accounts are often given this interpretation.

4.8. Alternative Approaches to Social Welfare.

Jorgenson and Schreyer (2017) showed how to incorporate distributional information on consumption into *SNA 2008*. Other studies of inequality in consumption include Attanasio, Hurst, and Pistaferri (2015) and Meyer and Sullivan (2012). There is a parallel literature on distributional information on income, exemplified by Fixler and Johnson (2014). Fisher, Johnson, and Smeeding (2015) provide a detailed survey of the literature on inequality of income and consumption.

Atkinson, Piketty, and Saez (2011) surveyed long-term studies of "top incomes" for twenty countries. Piketty's study of the top one-percent of incomes in the U.S. uses income tax data. The literature on the distribution of wealth is more limited, but Henriques and Hsu (2014) provide a recent example. The development of equity measures of wealth for a substantial number of countries would be infeasible without major investments in the generation and compilation of distributional data for wealth.

Muellbauer (1974a, 1974b) proposed an alternative approach for measuring social welfare. In Muellbauer's approach the social welfare function is defined on the money metric of individual welfare for all individuals given by the equivalent variation in total expenditure. This has the appeal that the equivalent variation is a monotone, increasing function of individual welfare; however, the equivalent variation also depends on prices. In the terminology of Roberts (1980b), a measure of social welfare is *price-independent* if Muellbauer's approach generates the same ordering of social welfare as a social welfare function defined on measures of individual welfare that do not depend on prices. Price independence is essential for the implementation of Muellbauer's approach to social welfare. Otherwise, social welfare judgments change whenever prices change, even with no changes in individual welfare.

Roberts' concept of price-independence requires restrictions on the social welfare function or measures of individual welfare or both. For example, with no restriction on the form of the social welfare function preferences must be identical and homothetic for all individuals. In this case, the allocation of consumer expenditures is independent of total expenditure and identical for all individuals. This is inconsistent with a large body of empirical studies of consumer behavior reviewed, for example, by Deaton and Muellbauer (1980) and Jorgenson,

Lau, and Stoker (1982). With no restrictions on individual preferences, Roberts (1980b) shows that the social welfare function must be dictatorial in the sense of Arrow (1963), depending on the preferences of a single individual. This is, of course, the Arrow impossibility theorem.

Muellbauer's approach to measuring social welfare has recently been revived by Fleurbaey and Blanchet (2013), two of the participants in the Stiglitz-Sen-Fitoussi Commission.[19] Fleurbaey was a member of the Commission and Blanchet a *rapporteur*. Their book is based on survey papers and reports to the Commission, but provides a more systematic overview and constitutes a very useful elaboration of the Stiglitz-Sen Fitoussi Report (2010).

Fleurbaey and Blanchet recognize the issue of price dependence. Their solution is to choose a reference price system for all comparisons by appealing to the concept of fairness. For incorporating distributional information into the national accounts, this has the unfortunate consequence of severing the connection between the distributional information and actual data on prices presented in the national accounts. In this context a reference price system corresponding to fairness does not resolve the issue of price dependence. The approach to welfare measurement presented in Section 4.6 overcomes this objection.

4.9. Conclusions.

The recommendation of the Stiglitz-Sen-Fitoussi Report that distributional information should be incorporated into the national accounts has been successfully addressed within the production and asset boundaries of *SNA 2008* by Jorgenson and Slesnick (2014). However, this requires distributional information on consumption that is absent from *SNA 2008*, as well as the

[19] Fleurbaey and Blanchet (2013) is reviewed by Asheim (2014).

aggregate data on consumer expenditures. The Eurostat and OECD expert groups, EG DNA and EG ICW, reviewed the experience of statistical agencies in combining distributional information from household surveys with control totals from the national accounts. Jorgenson and Slesnick (2014) showed how this information can be used to generate quantity and price measures of individual and social welfare within *SNA 2008*.

The theory of social choice is essential for generating money measures of welfare. These include measures of the cost of living and household equivalence scales. These concepts are excluded from *SNA 2008*, but are familiar to economic statisticians interested in measuring inequality. Econometric methods for implementing these concepts within a model of household behavior are useful in providing greater flexibility and generality. For example, Jorgenson and Slesnick (2014) generated money measures of welfare appropriate for augmenting *SNA 2008*.

Unlike the measurement of production and the GDP, there are no simple analogies to business sector accounting in the measurement of welfare. Taking Nordhaus and Tobin (1972) as a starting point, the initial approach involved a radical simplification based on the notion of a representative consumer. At the same time, many economists and national income statisticians were familiar with methods like the Gini (1912) coefficient that dealt with the heterogeneity of households in measuring inequality.

The concepts required for incorporating measures of welfare into *SNA 2008* are relatively straightforward and are well-known to economic statisticians interested in distributional issues. The challenge is to implement these concepts in sufficient generality to deal with the heterogeneity evident in survey data on consumer behavior. This required results from seemingly unrelated fields, such as social choice and micro-econometrics.

In addition, welfare measurement involved interpersonal comparability and value judgments that weigh one household's welfare against another's. These ideas proved to be major stumbling blocks for generations of economists schooled in the suppression of welfare issues by appealing to "Pareto optimality". The hypothetical cadre of philosophers trained in making value judgments has yet to make an appearance.

Jorgenson and Slesnick (2014), Jorgenson and Schreyer (2017), and the Stiglitz-Sen-Fitoussi Report, recommended incorporating distributional information into *SNA 2008*. The Eurostat and OECD expert groups showed that this is feasible for many statistical agencies. The next step is to provide measures of individual and social welfare that capture the heterogeneity of consumer units. The final step is to adopt a welfare interpretation of the results, drawing on the theory of social choice used in measuring the cost and standard of living as well as inequality and poverty. The incorporation of distributional information on consumption into the U.S. national accounts is the eleventh important contribution to economic measurement considered in this review.

5. Beyond the GDP.

Sections 3 and 4 of this paper considered advances in measurement within the framework of *SNA 2008.* The incorporation of distributional information on consumption and income into the national accounts could be part of the initial agenda for the United Nations Statistical Commission in revising the System of National Accounts. Extrapolating from the time elapsed between SNA 1993 and *SNA 2008*, a possible target date for the next revision would be 2023, so that work could be initiated as early as 2018. This section considers going beyond the framework of the national accounts to include nonmarket dimensions of welfare. This would include the

measures of household production and leisure time employed by Nordhaus and Tobin (1972). Diewert and Schreyer (2014) showed how to incorporate these measures into *SNA 2008.*

5.1. Digitalization.

Welfare measurement including nonmarket activity, like Nordhaus and Tobin (1972), is essential for many significant measurement problems. A leading example is the use of nonmarket time in analyzing the explosive growth of the internet. This is described as "digitalization" by Ahmad and Schreyer (2016). In Chapter 3 of the *Independent Review of U.K. Economic Statistics*, "Measuring the Modern Economy – Emerging Challenges", Bean (2016) provided a valuable survey of digitalization.

A striking illustration of nonmarket accounting for digitalization is the study of "The Attention Economy" by Brynjolfsson and Oh (2012). Brynjolfsson and Oh imputed the value of free digital services on the internet from the opportunity cost of the time for users of these services. Since this time is appropriately classified as household production or leisure time, the value of the free services was allocated to welfare, as in Nordhaus and Tobin (1972), but not to production. The free services are outside the market and "beyond the GDP".

A competing perspective was presented by Hal Varian (2016), Chief Economist of Alphabet, who argued that free services should be included in the GDP. According to Varian, omission of these services produces a "bias" in the measurement of the GDP that accounts for the widely observed slowdown in growth of TFP. However, this definition of the GDP is inconsistent with the definition employed in *SNA 2008.* The value of "free" goods that require only the nonmarket time of the consumer belongs in a measure of welfare, like that of Nordhaus and Tobin (1972), but not in the GDP or the national accounts.

A detailed survey of issues that arise in measuring the impact of digitalization on productivity growth was presented by Byrne, Fernald, and Reinsdorf (2016). The conclusion of the paper was that digitalization affects the measurement of welfare, not production. The authors concluded that the U.S. and other industrialized economies have a productivity slowdown, rather than a measurement problem.

5.2. Beyond the National Accounts

As a further illustration of progress in economic measurement outside the national accounts, Jones and Klenow (2016) substantially extended the framework of Nordhaus and Tobin for measuring welfare. They began with the obligatory reference to the deficiencies of the GDP as a measure of welfare. They acknowledged, specifically, the Stiglitz-Sen-Fitoussi Report to President Sarkozy and then summarized their own proposal for welfare measurement beyond the GDP.

Rather than defining individual welfare in terms of the theory of consumer behavior, following Konus (1939) and others, Jones and Klenow (2016) used survey data on consumption directly. They carried out detailed computations for thirteen countries. Following Nordhaus and Tobin (1972), they included data on hours of leisure. Their measure of individual welfare is the lifetime utility from consumption and leisure. Under their assumptions lifetime utility is the product of life expectancy and expected flow of utility from consumption and leisure. The expected flow of utility is the sum of functions of consumption, leisure, and inequality in the distribution of consumption.

For Jones and Klenow (2016), social welfare is the average of individual welfare functions for different age groups. They expressed social welfare as a function of life expectancy

for the age groups, the consumption share of the GDP, leisure, consumption inequality, and leisure inequality, all relative to the United States. They implemented a simplified version of this formula for "macro" data, much of it taken from PWT, Version 8.0, discussed in Section 3 above. They also considered the growth rate of social welfare. In summary, the innovations in Jones and Klenow (2016), relative to Nordhaus and Tobin (1972), were the inclusion of measures of inequality of goods and leisure and the incorporation of lifetime income. None of this information is available in *SNA 2008*, so that these innovations produced a new measure of social welfare that is "outside the GDP".

5.3. Satellite Systems of Accounts

Abraham and Mackie (2005) edited a report for the U.S. National Research Council (NRC), *Beyond the Market.* This described satellite systems of accounts outside the framework of the U.S. National Income and Product Accounts (NIPAs). Satellite systems are consistent with the NIPAs, but incorporate imputations for nonmarket activities that are excluded in the NIPAs and are, therefore, beyond the GDP. The NRC report proposed satellite systems of accounts for home production, education, health, government, and well-being.

Nordhaus and Edward Kokkelenberg (2000) edited a report on environmental accounts for the U.S. National Research Council (NRC), *Nature's Numbers.* Nordhaus (2006) surveyed nonmarket satellite systems of accounts, and compared the proposal for environmental accounts in the NRC report with the United Nations *System of Environmental-Economic Accounting* (SEEA). He also considered a system of environmental accounts for the U.S., outlined by the U.S. Bureau of Economic Analysis in 1994 but never developed into a full-fledged system of environmental accounts.

Aizcorbe, Liebman, Cutler, and Rosen (2010) presented a system of health accounts for the U.S. Atkinson (2005), *The Atkinson Review,* provided a system of accounts for the U.K. government. Krueger (2009) edited a report on time use and subjective measures of well-being for the U.S. Abraham (2014) presented a comprehensive survey of the literature on human capital, including investments in education and health. Helliwell, Layard, and Sachs (2017) prepared a series of *World Happiness Reports,* presenting subjective measures of well-being for 156 countries.

The primary focus of the Stiglitz-Sen-Fitoussi Report (2010) was the "Quality of Life," aspects of well-being currently beyond the scope of the national accounts. Subjective measures of well-being would fall into this category, along with capabilities such as health, education, personal activities, political voice and governance. According to the Stiglitz-Sen-Fitoussi Report, measures of individual well-being could be combined and measures of disparities could be obtained by appealing to fairness, rather than measures of individual and social welfare like those considered in Section 4. Finally, the Report discussed the measurement of "Sustainable Development and Environment," including physical measures of environmental quality.

Stiglitz is serving as co-chair of the High-Level Expert Group on the Measurement of Economic Performance and Social Progress (2013). This Group is a successor to the Stiglitz-Sen-Fitoussi Commission convened by the OECD. The other co-chairs are Fitoussi and Martine Durand, Chief Statistician of the OECD. The focus of the Group is Income and Wealth Inequality, Multidimensional and Global Inequalities, Multidimensional Subjective Well-being, and Sustainability. Piketty is Coordinator of Income and Wealth Inequality. Stiglitz and Francois Bourguignon are Coordinators of Multidimensional and Global Inequalities. Arthur Stone and

Alan Krueger are Coordinators of Multidimensional Subjective Well-Being. Fitoussi and Durand are Coordinators of Sustainability.

5.4. Sustainability

Sustainability can be defined in terms of positive growth in a comprehensive measure of wealth per capita in real terms. The World Bank (2011) provided comprehensive measures of per capita wealth, including natural capital and human capital, for 124 countries for 1995, 2000, and 2005. National accounts for wealth are limited to the assets included in *SNA 2008* and exclude natural capital as well as human capital. The principal measure of sustainability used by the World Bank is Adjusted Net Saving (ANS) or genuine saving per capita. This is net saving, as it appears in *SNA 2008*, adjusted for resource depletion and environmental degradation and augmented by investment in human capital, which is beyond the GDP. The World Bank's concept of net saving is consistent with the Sustainable Measure of Economic Welfare proposed by Nordhaus and Tobin (1972).

The World Bank (2011) used a "residual" method for measuring human capital. This involved subtracting financial capital, produced capital, and natural capital from the present value of future consumption. The difference is the residual-based estimate of human capital. The World Bank launched a new study of comprehensive wealth that will replace the residual method for measuring human capital with a direct measure based on the lifetime income method of Jorgenson and Fraumeni (1989, 1992a, 1992b). The lifetime income method will be implemented for 138 countries, using more than a thousand micro-economic data sets from the World Bank's PovCal data base described below. This is a very important innovation in methodology, since human capital greatly pre-dominates in the World Bank's measures of comprehensive wealth.

Jorgenson and Fraumeni (1989) presented a complete set of accounts for the U.S. that extended the "Blueprint" proposed by Jorgenson and Landefeld (2006) and discussed in Section 3 above. However, the "full investment" presented in the Jorgenson and Fraumeni (1989) system of accounts includes investment in human capital, as well as the investment in non-human capital presented in "Blueprint". The account for investment in human capital is based on lifetime labor incomes for all individuals in the U.S. population. Using data from the U.S. Censuses of Population for 1950, 1960, 1970, and 1980, Jorgenson and Fraumeni distributed the population of each sex by individual year of age and individual year of educational attainment. Changes in the number of individuals classified by age, sex, and educational attainment reflect data on school enrollments, births and deaths, and migration.

5.5. Lifetime Labor Incomes

The starting point for the measurement of lifetime labor incomes for all individuals in the U.S. population was the database for market labor activities presented by Jorgenson, Gollop and Fraumeni (1987). This database included the number of employed persons, hours worked, and labor compensation for the U.S. on an annual basis, cross-classified by sex, age, education, employment class, occupation, and industry. The annual estimates of hours worked and labor compensation needed for measuring incomes from market labor activities were obtained by summing over employment class, occupation, and industry. Average hourly compensation for each of the 2196 groups -- two sexes, sixty-one age groups, and eighteen education groups – was obtained by dividing market labor compensation by hours worked for the group. A concise algebraic presentation of the lifetime income method is given in the Appendix of Jorgenson and Fraumeni (1992b).

The second step in the measurement of lifetime labor incomes was to impute labor compensation and hours worked for nonmarket activities. Six types of nonmarket activities are commonly distinguished in studies of time allocation: household production of goods and services, volunteer work outside the household, commuting to work, formal education, leisure, and the satisfaction of physiological needs such as eating and sleeping. Jorgenson and Fraumeni (1989) excluded time devoted to physiological needs and allocated the remaining time between market and nonmarket activities.

The third step in estimating lifetime labor incomes was to impute the value of labor compensation for nonmarket activities. This involved multiplying after-tax compensation per hour for employed persons to obtain imputed hourly labor compensation for nonmarket activities other than formal schooling. Jorgenson and Fraumeni (1992a) showed that their estimate of the value of nonmarket activities was similar to that of Nordhaus and Tobin (1972), despite important differences in concept and methodology.

5.6. Stages of the Life Cycle

To estimate lifetime labor incomes for all individuals in the U.S. population Jorgenson and Fraumeni (1989) distinguished among three stages in the life cycle. In the first stage individuals may participate in formal schooling, but not in the labor market. In the second stage individuals may enroll in school and also work. In the third stage individuals may participate in the labor market but not in formal schooling. For individuals in the third stage of the life cycle, lifetime total labor compensation includes the value of market labor compensation after taxes and the imputed value of nonmarket labor compensation. For individuals in the second stage of the life cycle, lifetime labor compensation also includes imputed labor compensation for

schooling. For individuals in the first stage of the life cycle, lifetime labor compensation includes only the imputed value of time spent in schooling.

Jorgenson and Fraumeni (1992a) applied the lifetime income method for measuring human capital to the measurement of investment in education through formal schooling. This estimate was incorporated into a complete system of market and non-market accounts to obtain the sources of growth for the U.S. economy. These included capital and labor services, both market and nonmarket, including investment in education. The estimate of private human wealth based on the lifetime income approach was around 18 times that of Kendrick (1976), who measured investment in human wealth by means of the cost of investments in education.

5.7. Comprehensive Wealth

A theoretical rationale for comprehensive wealth as a measure of sustainability was provided by Arrow, *et al.* (2012). This measure was based on a utilitarian social welfare function for a representative consumer with comprehensive wealth as the budget constraint. A similar model was employed by Weitzman (1976) and Sefton and Weale (2006). Sustainability was defined as non-decreasing real comprehensive wealth per capita or non-negative real comprehensive saving per capita. This implied that social welfare for the representative consumer was non-decreasing.

The framework of Arrow, *et al.* (2012) was employed by Munoz, *et al.* (2015) in generating estimates of inclusive wealth for 140 countries for the period 1992-2010. These estimates are similar in scope to the World Bank's (2011) comprehensive measure of wealth, but use different data sources. For both sets of estimates human capital emerges as the most important form of wealth. As an alternative methodology, the *Inclusive Wealth Report* (2015)

used a transformation of the average years of schooling from Barro and Lee (2015), introduced by Klenow and Rodriguez-Clare (1997), to obtain a measure of the value of human capital.

Gang Liu (2014) of Statistics Norway presented estimates of the stock of human capital from the OECD Human Capital Project. This study provided estimates of the real and nominal stock of human capital by educational attainment, age, and gender for eighteen countries. Except for Romania, all the countries are members of the OECD. The methodology used the lifetime income approach, but excluded nonmarket labor compensation. Christian (2014, 2016) presented updated estimates for the United States, also based on the lifetime income approach. A survey of alternative methods for estimating human capital was provided by Liu and Fraumeni (2015).

Liu (2014) found that Israel, Japan, Korea, Norway, the U.S. have declining human capital per capita. The interpretation of this finding is that aging of the population, which reduces human capital per capita, outweighs the increase in the average level of educational attainment, which increases per capita human capital. Surveys of empirical estimates for individual countries were presented by Fraumeni and Liu (2015) and Liu and Fraumeni (2016)[20].

Fraumeni, Christian, and Samuels (2015) updated and revised the complete system of accounts for the U.S. by Jorgenson and Fraumeni (1989) to cover the period 1949-2009. Figure 11 presents the production account of the complete system without human capital, while Figure 12 gives the production account with human capital. The maximum growth rate for private domestic product without human capital approaches five percent. The maximum growth rate including human capital is only 2.5 percent, reflecting the fact that investment in human capital

[20] Studies based on the lifetime income approach of Jorgenson and Fraumeni have been completed for Argentina, Australia, Canada, China, India, Italy, New Zealand, Norway, Sweden, the United Kingdom and the United States. Estimates of human capital for China using lifetime income approach of Jorgenson and Fraumeni are presented in Li, *et al.* (2011). Estimates for India using the lifetime income approach of Jorgenson and Fraumeni are given by Gundimeda, *et al.* (2006).

dominates investment and consumption. Human capital per capita, measured by three different methods of estimation – Jorgenson-Fraumeni lifetime income, World Bank residual method, and average education attainment – is presented for eighteen countries in Figure 13. [21]

Figures 11, 12, and 13 about here)

The concept of comprehensive wealth of Arrow, *et al.* (2012) can be interpreted as a measure of efficiency. The next step in this line of research would be to generate distributional information on comprehensive wealth and to extend the concept of social welfare to include a heterogeneous population of consumers. This would incorporate equity as well as efficiency in the representation of social welfare. An approach to measuring social welfare along these lines was presented by Jorgenson, *et al.* (2013). Measures of sustainability are the twelfth major contribution to economic measurement considered in this review.

5.8. Sustainable Development Goals.

The measurement of sustainability was given new urgency by the adoption of Sustainable Development Goals in 2016 by the United Nations. A roadmap for implementation of an indicator and monitoring framework for the Sustainable Development Goals was prepared by the Friends of the Chair Group on Broader Measures of Progress (2013) for the United Nations Statistical Commission. The terms of reference for the Interagency Expert Group on Sustainable Development Goal Indicators (2015) were approved by the Commission at its meeting in March 2015.

[21] Figure 15 is taken from Figure 12.3 of Liu and Fraumeni (2016), p. 443, Figure 16 is taken from Figure 12.3, p. 444, and Figure 17 is taken from Figure 12.5, p. 457.

The Sustainable Development Goals included seventeen specific goals and 169 associated targets. Achievement of each of the targets was assessed by one or more indicators. For example, the first goal is: “To end poverty in all its forms everywhere” by 2030. An indicator of this target is the number of people living in extreme poverty, reported by the World Bank (2016) in its PovcalNet database. The most recent version incorporates purchasing power parities for 2011 from the International Comparison Project and reported poverty rates for 138 countries, based on more than a thousand household surveys. The results are summarized by the World Bank and the International Monetary Fund (2016).

5.9. Welfare Beyond the GDP

A conceptual framework for development of estimates of welfare beyond the GDP was presented by Fleurbaey and Blanchet (2013). While not exhaustive, the first chapter summarized work in four areas – subjective measures of well-being or happiness, composite or hybrid indexes, like the United Nations Development Program’s Human Development Index discussed below, “dashboards” or collections of social indicators, like the United Nations Sustainable Development Goals, and monetary approaches, such as Nordhaus and Tobin (1972). Peter van de Ven (2015) edited a symposium on the measurement of well-being by statistical offices.

The United Nations Development Program’s Human Development Index (HDI), reported annually in the Human Development Report (2014), is the leading example of composite indexes and collections of social indicators. This has been published annually since 1992 in the Human Development Report, is regularly updated and revised, and is widely cited in the literature on beyond the GDP. While there are numerous other illustrations of the general approach, only the HDI resembles a statistical program like the regular reports of national accounts, following the

SNA 2008. However, the resemblance is only superficial. There is nothing like *SNA 2008* to provide a conceptual framework for the construction of the HDI. The key concepts are dashboards or collections of economic and social indicators. These are aggregated into composite or hybrid indexes. This is the sense in which the results are multidimensional.

The Human Development Index is compiled for 187 countries, based on life expectancy at birth, an indicator of health, mean years of school for individuals who have completed their education, expected years of schooling for individuals entering the educational system, and Gross National Income (GNI) per capita, a concept defined in *SNA 2008.* The component indicators are calibrated to fall between zero and unity and averaged to obtain the HDI. The HDI provides a ranking of countries that is a possible alternative to GDP per capita in terms of purchasing power parity by the World Bank's International Comparison Project. While the rankings in the ICP and the HDI are not identical, they are highly correlated.

To complete the picture, the HDI is supplemented by an Inequality-Adjusted HDI, defined on the same indicators, but adjusted for inequality by multiplying each component by equity index like that discussed in Section 4 above. Thirteen additional composite indexes are presented: gender inequality, gender development, multidimensional poverty, health of children and youth, adult health and health expenditures, education, command over and allocation of resources, social competencies, personal insecurity, international integration, environment, population, and perceptions of well-being. These are comprised of component indicators, averaged in the same manner as the HDI. Indexes are also presented for regions and published by 140 countries.

5.10. OECD's Better Life

A second major initiative involving a dashboard of social and economic indicators is the Better Life program of the OECD (2015), launched in 2011 to celebrate the organization's 50th anniversary. This is based on an extensive collection of social indicators on eleven topics judged by the OECD as essential in assessments of material living conditions and quality of life. Eight of the twelve recommendations of the Stiglitz-Sen-Fitoussi Report (2010) deal with measurement programs like the HDI and the Better Life program.

In Chapters 2-6 of their book, Fleurbaey and Blanchet (2013) provided a survey of the economic theory of welfare measurement. This is especially valuable in illuminating the references to "fairness" in the Stiglitz-Sen-Fitoussi Report (2010). Fleurbaey and Blanchet (2013) summarized the work of Fleurbaey and Francois Maniquet (2011), reconciling the measurement of social welfare with Arrow's impossibility theorem. Fleurbaey and Maniquet (2011) expressed social welfare as a function of money measures of individual welfare, following Muellbauer (1974a, 1974b). Their innovation was to apply the notion of fairness to these money measures. This enabled them to relax Arrow's assumption of the Independence of Irrelevant Alternatives and avoid Arrow's conclusion that the measurement of social welfare is impossible.

Welfare comparisons could be limited to a single set of prices determined by fairness. This was proposed by Fleurbaey (2009, 2015), illustrated by Fleurbaey and Gaulier (2009), and summarized by Fleurbaey and Blanchet (2013). However, comparisons over time for a given country, like those in *SNA 2008*, involve different prices at each point of time. The application of

Muellbauer's (1974a, 1974b) approach to welfare measurement in the national accounts requires *price-independence* in the sense of Roberts (1980b), as discussed in Section 4.

Similarly, cross-country comparisons of welfare like those in the *Human Development Report* involve different prices for different countries. These are measured by purchasing power parities like those compiled by the World Bank's (2014) International Comparison Project. Finally, incorporation of distributional information into the national accounts, as proposed by the Stiglitz-Sen-Fitoussi Report (2010), by the Eurostat-OECD Expert Group on Disparities in the National Accounts (2013), EG DNA, as well as by Jorgenson and Slesnick (2014) and Jorgenson and Schreyer (2017), would require data on prices for each period covered by the national accounts.

The framework for welfare measurement presented in Section 4 above relies on money metrics of individual and social welfare. This uses a social welfare measure based on cardinal full comparability of measures of individual welfare. The underlying theory of social welfare was developed by Roberts (1980a) as a generalization of the approach introduced by Sen (1977) and does not relax Arrow's assumption of the Independence of Irrelevant Alternatives. The money metrics are valid for all prices and not only those that conform to a concept of fairness, as required by Fleurbaey's representation of social welfare.

5.11. Conclusions

"Beyond the GDP" is a well-established area of economic research. This includes the "Blueprint" for a complete system of market and nonmarket accounts developed by Jorgenson and Fraumeni (1989) and updated by Fraumeni, Christian, and Samuels (2015). This system incorporates micro-economic data on human capital, generated from the U.S. Censuses of

Population and the Current Population Surveys. The measures of "full consumption" from the income and expenditure account includes consumption of market goods and services as well as leisure time. "Beyond the GDP" also includes the money measures of welfare originated by Nordhaus and Tobin (1972) and augmented by Jones and Klenow (2016) to include micro-economic data in their measures of inequality of consumption and leisure.

"Beyond the GDP" incorporates measures of sustainability like those presented by Nordhaus and Tobin's (1972) Sustainable Measure of Economic Welfare and the World Bank's (2011) comprehensive measures of per capita wealth. Monetary measures of investment in human capital generated by the residual method in previous World Bank studies will be replaced by direct estimates using the lifetime income method of Jorgenson and Fraumeni (1989). The direct estimates will be implemented for 138 countries, using more than a thousand micro-economic data sets from the World Bank's PovCal data base.

Economic research "Beyond the GDP" is not limited to systems of accounts in monetary form. This research includes composite indicators exemplified by the United Nations Development Program's HDI. This was initially motivated by the "capabilities" approach to the measurement of social welfare introduced by Sen (1985). "Beyond GDP" also includes "dashboards" of social indicators, some monetary and others non-monetary. The dashboard approach has undergone a major expansion with the adoption of the Sustainable Development Goals by the United Nations (2016). These goals have superseded the Millennium Development Goals originally adopted by the United Nations (2000).

Dashboards and the associated composite indexes are flourishing as empirical approaches to issues not yet included in the national accounts, such as measuring and monitoring the

attainment of the United Nations Sustainable Development Goals (SDGs). These will continue to be used in parallel with the national accounts and the two can be linked through the "equivalence approach" outlined by Fleurbaey and Blanchet. The indicator approach will receive a major boost from the creation of the broader measures of progress in support of the SGDs by the United Nations Statistical Commission.

Economic measurement teams at institutions like Eurostat, the OECD, various agencies of the United Nations, the World Bank, and statistical offices and central banks in many leading countries are continuing to develop new databases. These will provide important opportunities for new research in economic measurement. The success of the Penn World Tables in stimulating empirical research on economic growth is an indication of the potential of high quality data and sound economic theory for creating these opportunities.

6. Progress in Economic Measurement

(Table 3 about here)

Progress in the measurement of production and welfare is summarized in Table 3. Substantial progress has been made in the measurement of production through the World KLEMS Initiative. Jorgenson and Scheyer (2013) showed how to incorporate KLEMS-type data sets for production into the United Nations *SNA 2008*. New methods for the measurement of output and productivity have been successfully implemented for more than 40 leading economies. The resulting estimates have been incorporated into the official national accounts of thirteen countries, including the United States. Finally, the methodology has been extended to provide international comparisons by incorporating purchasing power parities from the World Bank's ICP.

The progress in measuring production supports the viewpoint of Coyle (2014) in her book, *GDP: A Brief but Affectionate History*, which focuses on measures of production within systems of national accounts or "the GDP". The United Nations Statistical Division is now developing a *System of Extended and Integrated Global Accounts* (SEIGA). Accounts based on *SNA 2008* for the individual economies will be integrated with comprehensive data on international trade among countries to generate a system of production accounts for the world economy. The new system of global accounts will provide measures of output and productivity for the world economy and its major regions, as well as individual economies.

The empirical results from recent advances in the measurement of production have altered economists' views about economic growth and its sources. The great preponderance of economic growth in the United States and other advanced economies, approximately 80 percent, can be attributed to growth in the primary factors of production, capital and labor services. The growth of total factor productivity, representing innovation, accounts for a relatively modest 20 percent of economic growth. This is precisely the reverse of the well-known views of Solow (1957) and Kuznets (1971), who traced more than 80 percent of the sources of economic growth to the growth of total factor productivity. This sharp reversal is due to the incorporation of new measures of capital and labor services described in Section 3 into the production account of *SNA 2008*.

Welfare measures can be based on the theory of social choice, as proposed by Fleurbaey and Blanchet (2013), Jorgenson and Slesnick (2014), and Jones and Klenow (2016). Although these measures have had relatively little impact on the practice of economic measurement, they have established alternatives to the real GDP per capita as indicators of social welfare. These indicators have incorporated value judgments as well as empirical measures of individual

welfare. Jorgenson and Slesnick (2014) have shown how to incorporate measures of welfare into the national accounts. This requires distributional information on personal consumption expenditures, as well as the totals that appear in the income, expenditure, and wealth accounts.

Important advances in measuring welfare outside the national accounts or "beyond the GDP" have been made by building on the foundations established by Nordhaus and Tobin (1972). A leading example is the measures of welfare proposed by Jones and Klenow (2016). Composite indexes, such as the United Nations Development Program's Human Development Index, and dashboards like the United Nations indicators for measuring and monitoring progress on the Sustainable Development Goals, are well-established alternatives to the GDP as measures of welfare. Dashboards also appear to be a primary focus of the OECD's High-Level Expert Group on the Measurement of Economic Performance and Social Progress.

The important remaining challenge is to re-introduce economic measurement into the training of undergraduates, who will comprise the economically literate public of the future. The national accounts, as represented in *SNA 2008*, appears to be the most appropriate starting point for these students and their teachers. Striking results, such as China overtaking the U.S. in terms of GDP in 2014, will motivate the introduction of the concept of purchasing power parities and comparisons between purchasing power parities and exchange rates.

A more demanding task will be to re-introduce economic measurement into graduate training in economics. The creation of an economically literate public, capable of using the new measurements in debating the economic issues of the day, will depend on the training of a new generation of professional economists. These economists will have to master the techniques for economic measurement and the data sources that support them, including systems of accounts like *SNA 2008* and the U.S. National Income and Product Accounts.

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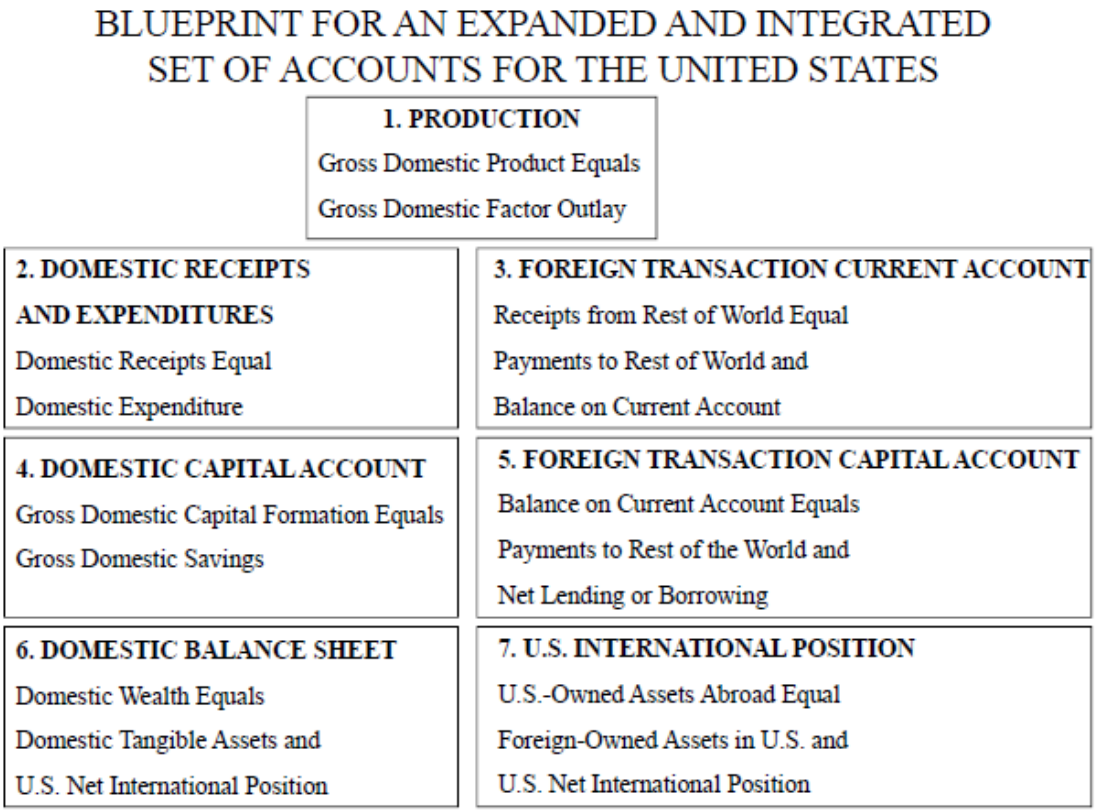

Figure 1. Blueprint for an Expanded and Integrated Set of National Accounts for the United States

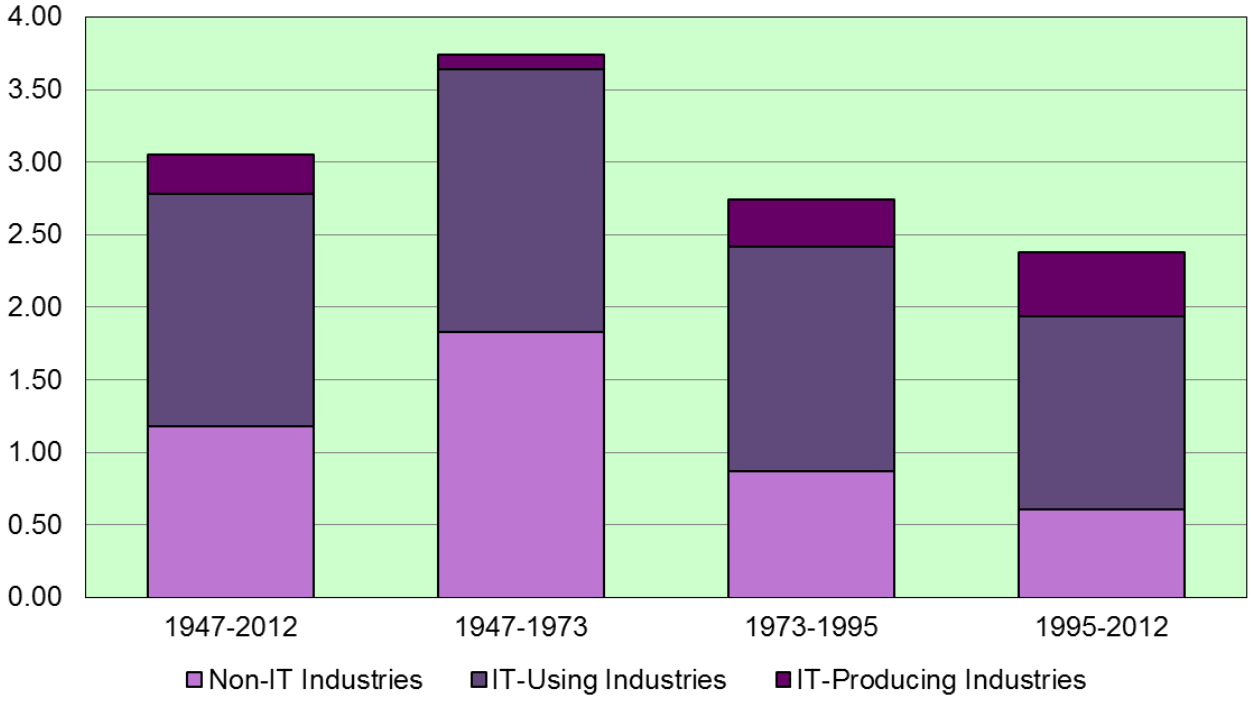

Figure 2. Contributions of Industry Groups to U.S. Value Added Growth, 1947-2012

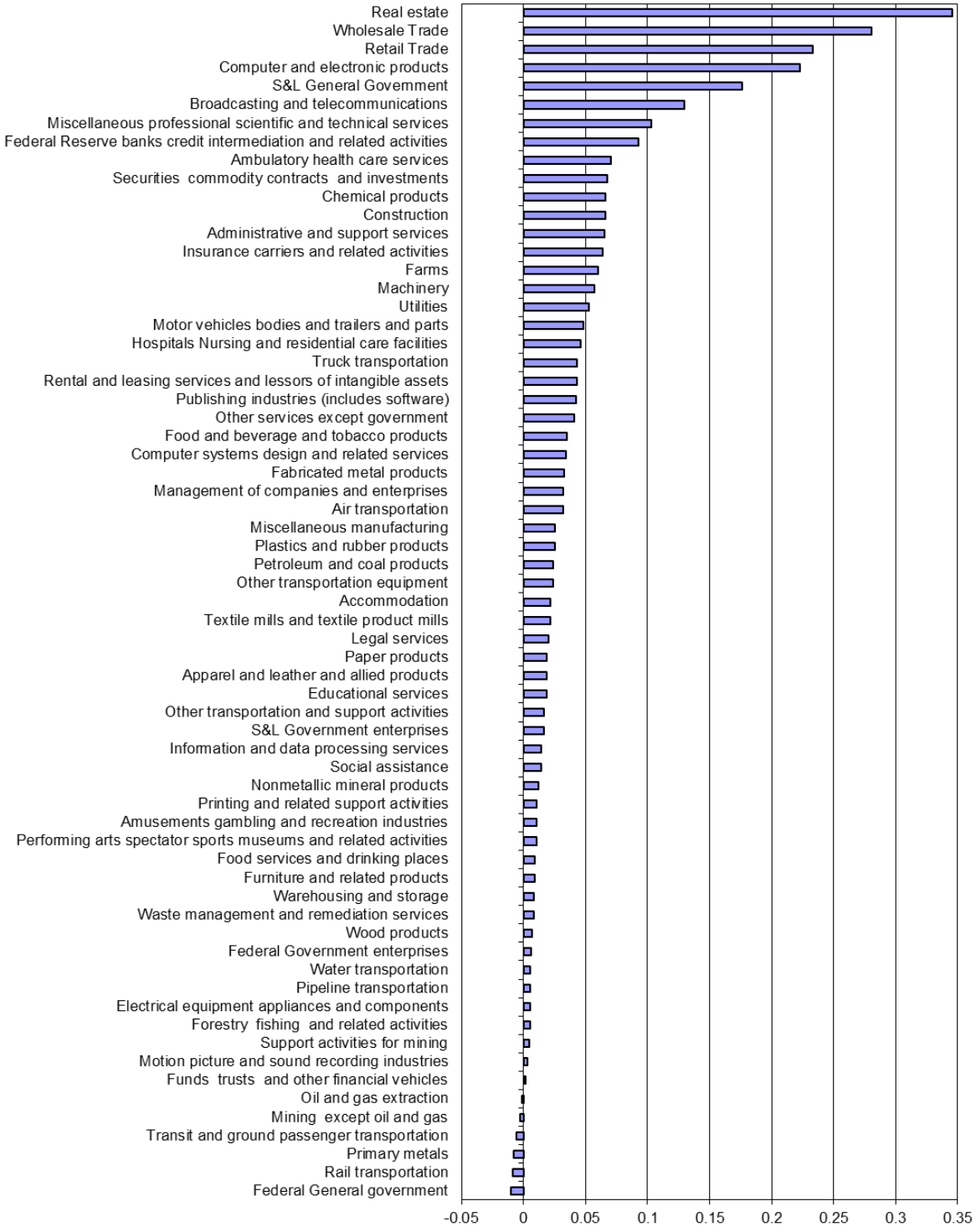

Figure 3. Industry Contributions to U.S. Value Added Growth, 1947-2012

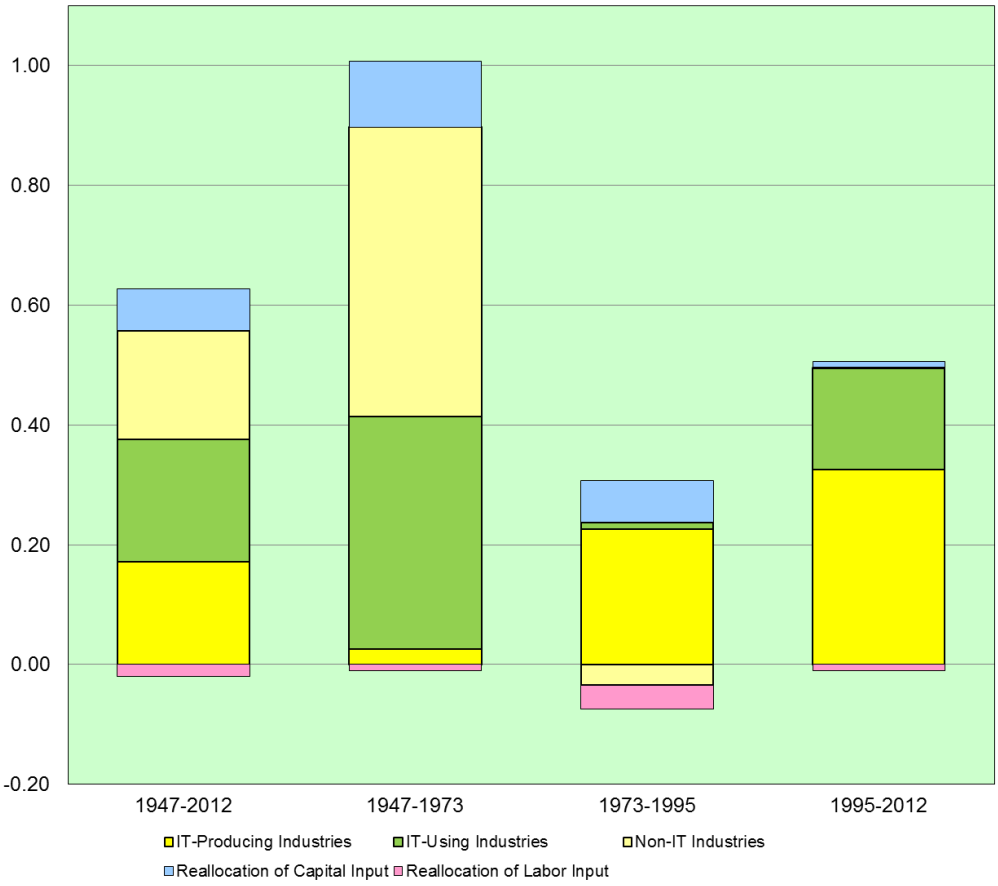

Figure 4. Contributions of Industry Groups to U.S. Productivity Growth, 1947-2012

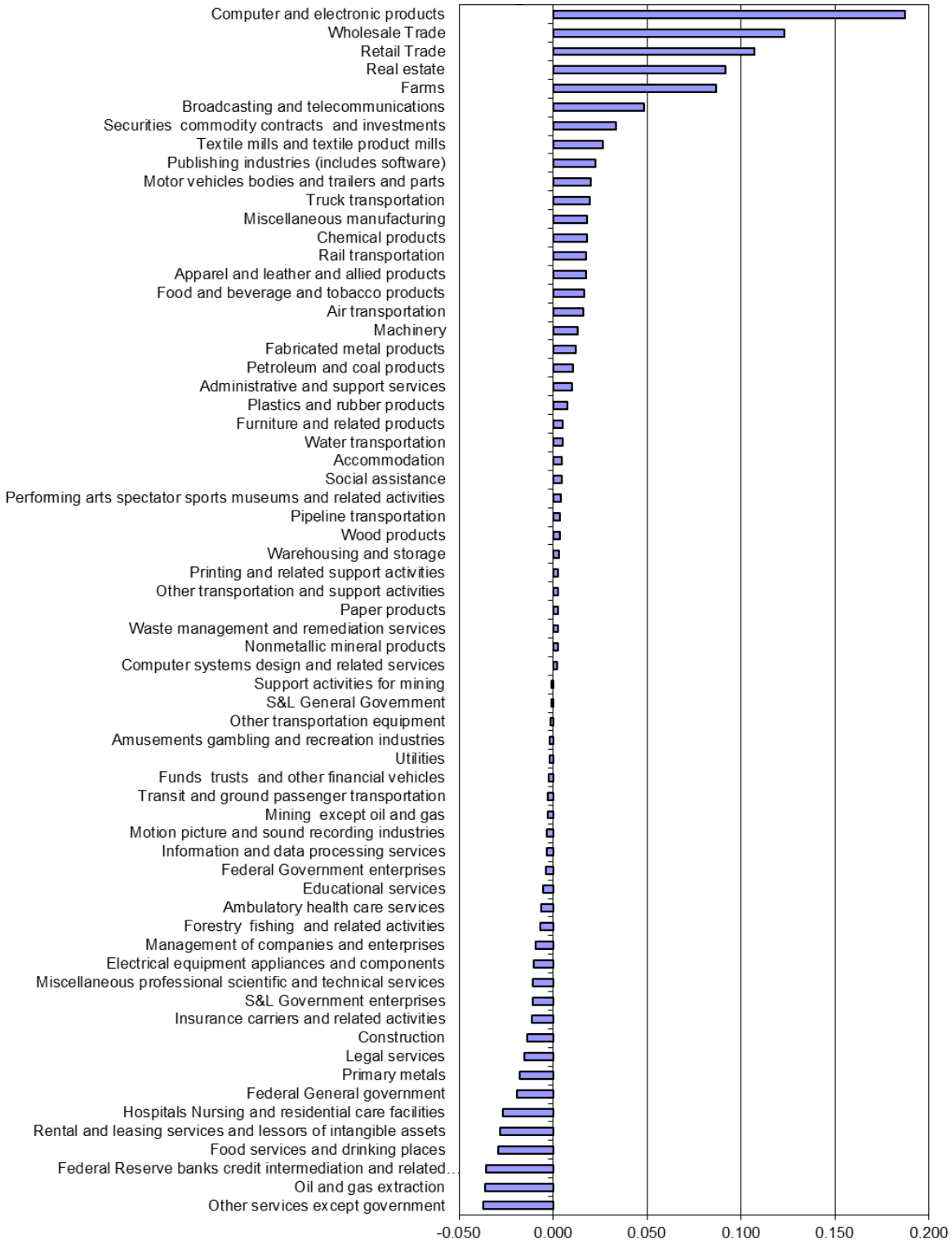

Figure 5. Industry Contributions to U.S. Productivity Growth, 1947-2012

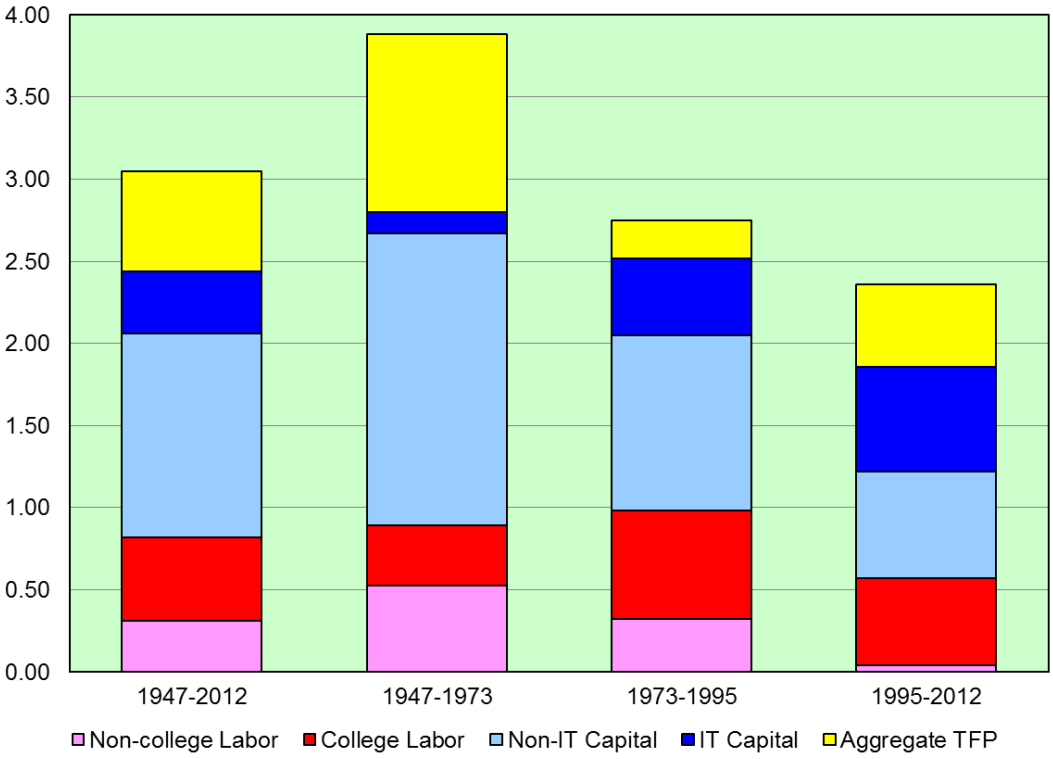

Figure 6. Sources of U.S. Economic Growth, 1947-2012

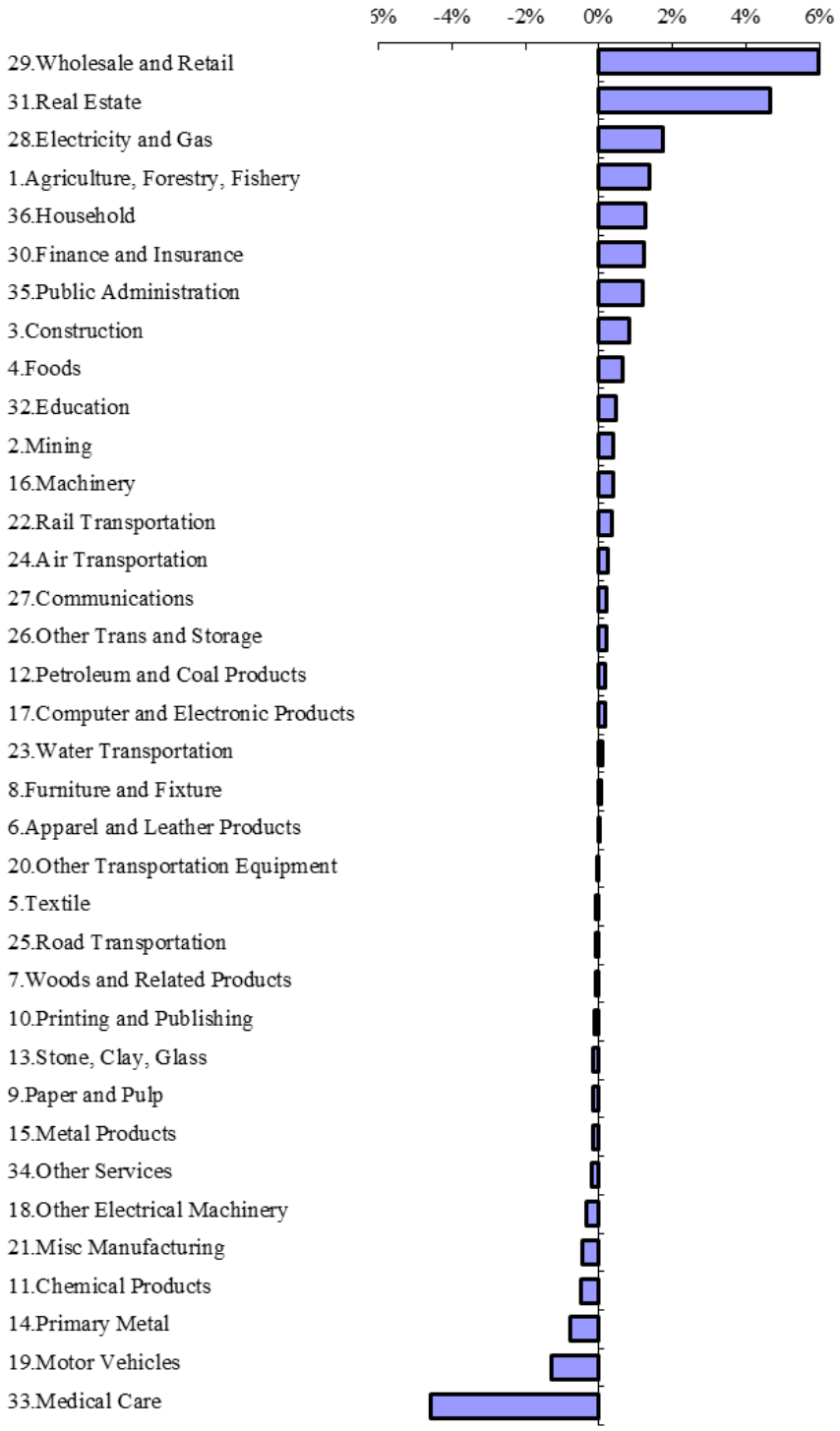

Figure 7. Industry Contributions to the Japan-U.S. Price Level Index, 2005

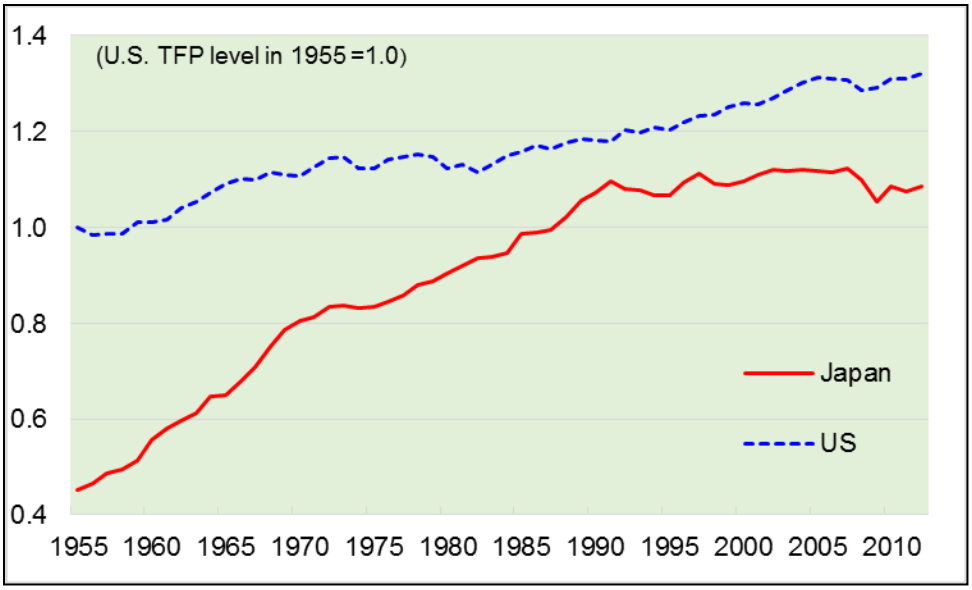

Figure 8. Japan and U.S. Total Factor Productivity Levels, 1955-2012

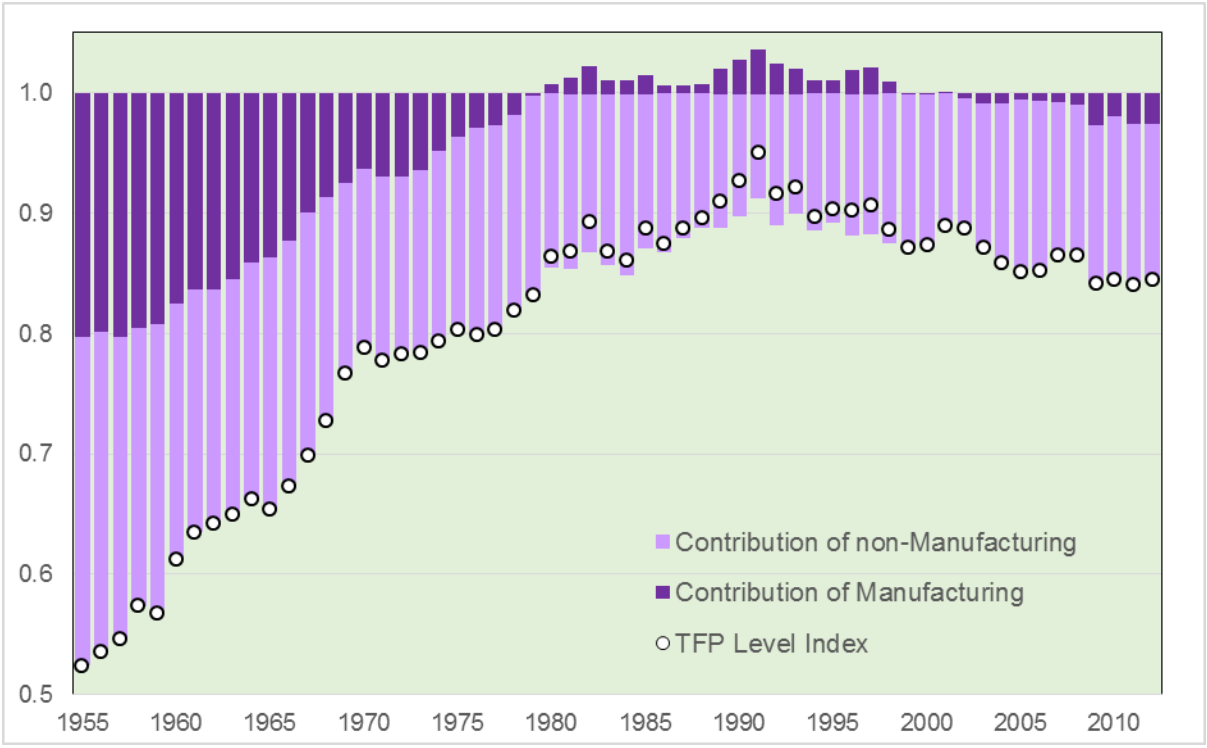

Figure 9. Japan-U.S. Total Factor Productivity Gaps, 1955-2012

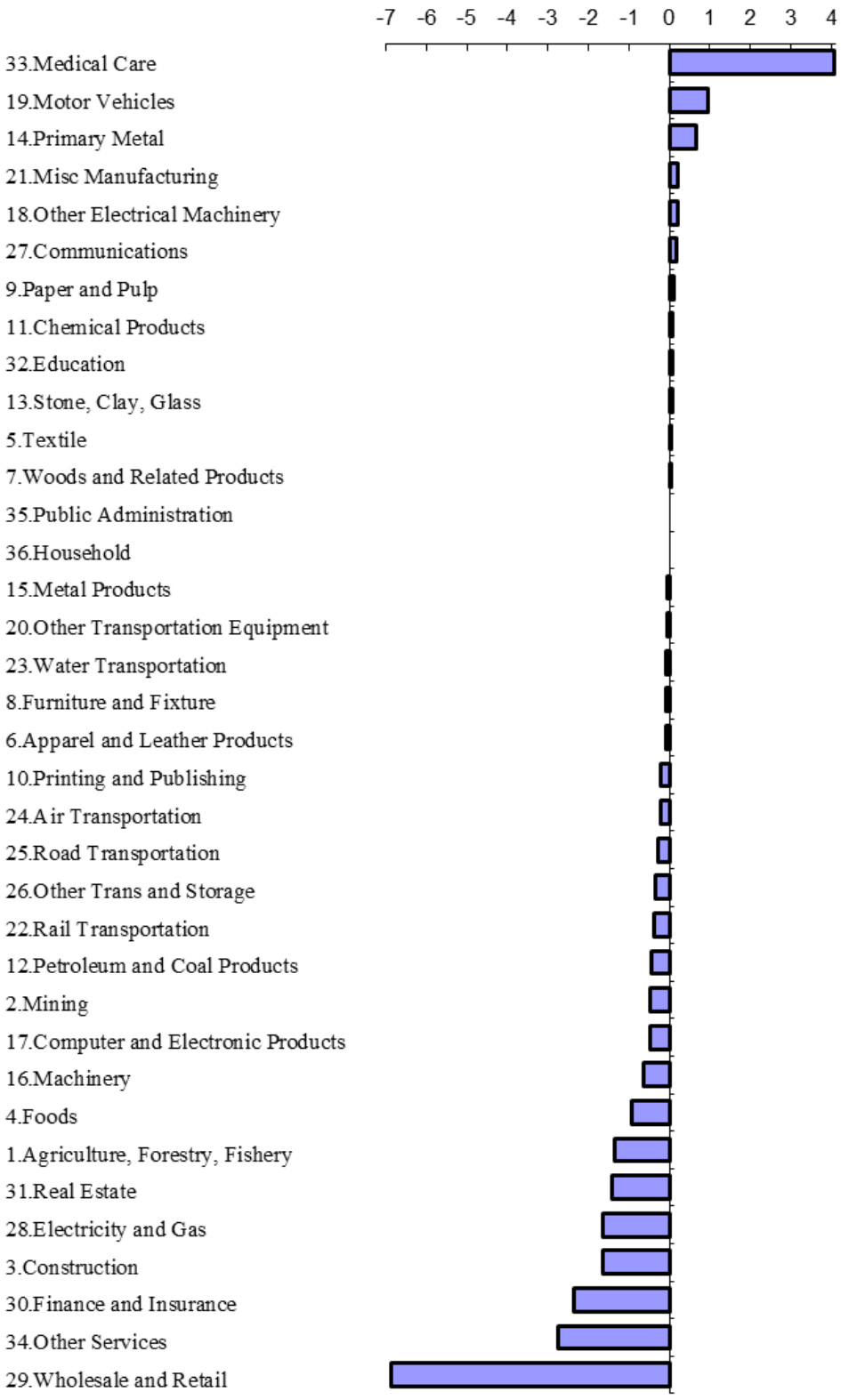

Figure 10. Industry Contributions to the Japan-U.S. Total Factor Productivity Gap, 2005

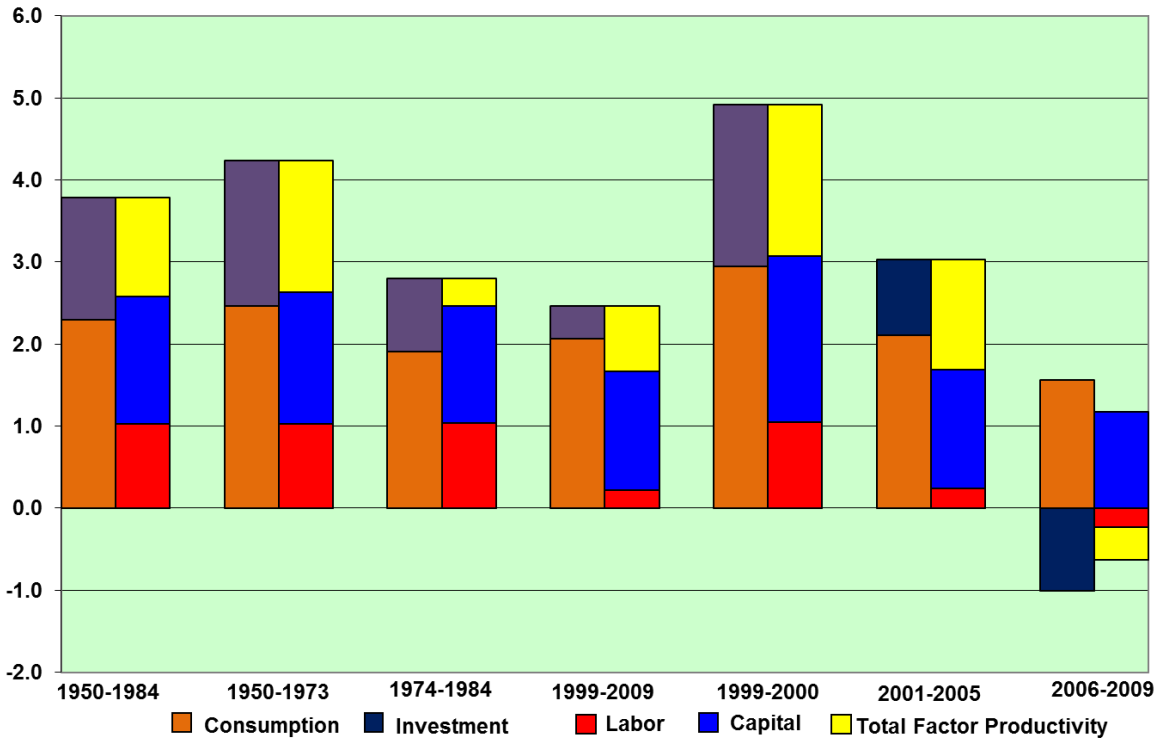

Figure 11. Contributions to Full Gross Private Domestic Product and Economic Growth without Human Capital

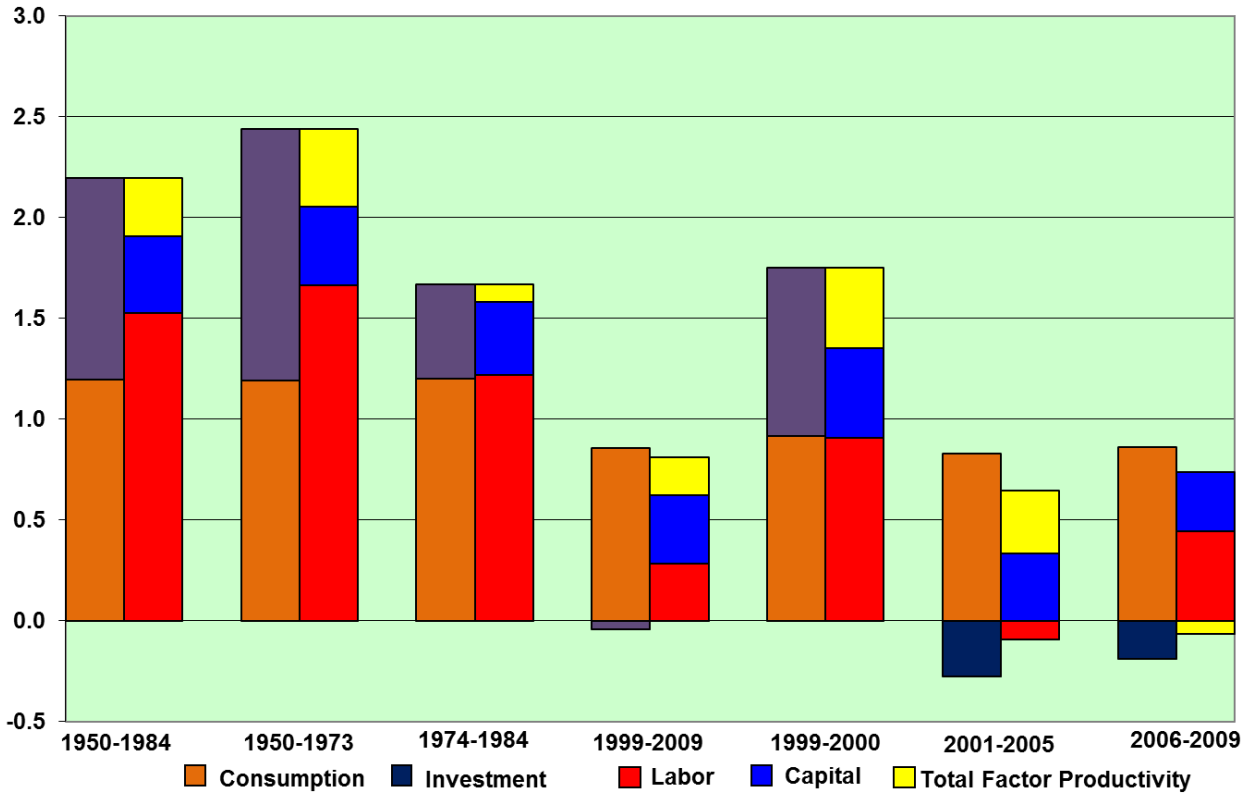

Figure 12. Contributions to Full Gross Private Domestic Product and Economic Growth with Human Capital

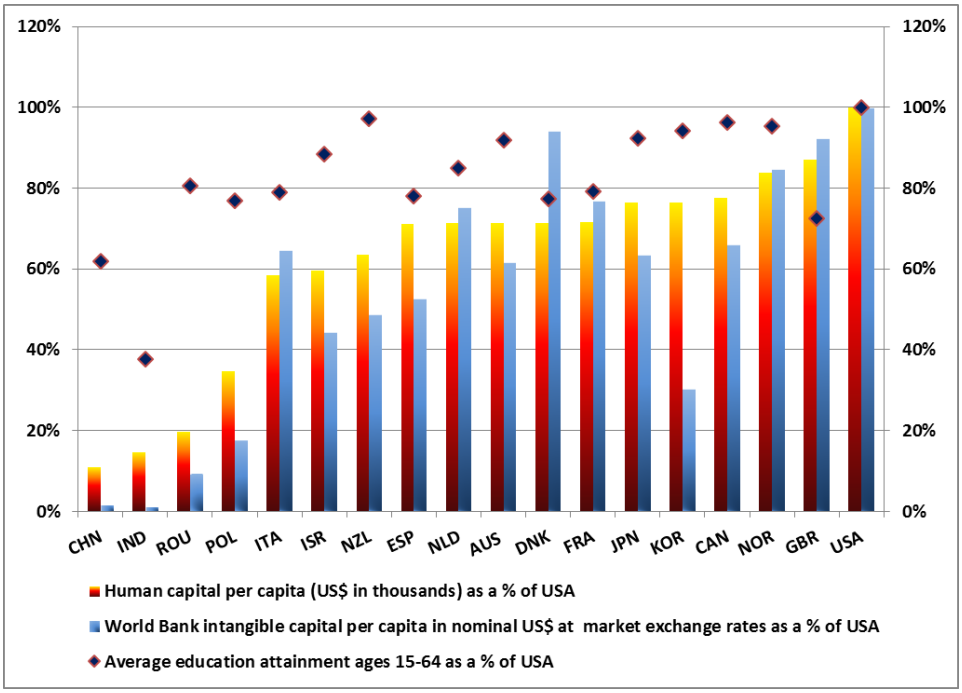

Figure 13. Human Capital Per Capita 2006 Compared with Average Education Attainment 2005 and World Bank Intangible Capital Per Capita 2005 (As a percentage of USA)

Table 1
PPPs and Price Level Indices for Output and KLEMS

Table 13.1: PPPs and Price Level Indices for Output and KLEMS

	1955	1960	1965	1970	1975	1980	1985	1990	1995	2000	2005	2010	2012
PPPs (Purchasing Power Parities)													
Output (GDP)	210.2	215.1	237.0	247.3	279.4	247.3	206.8	185.1	164.3	146.3	124.9	114.0	107.3
Capital	166.6	235.7	217.9	291.2	222.4	227.2	207.9	194.4	145.7	141.9	125.0	112.7	103.2
Labor	60.7	66.2	101.5	123.6	200.2	178.4	153.3	147.7	144.6	114.1	90.4	79.2	75.4
Energy	627.4	625.1	618.9	581.6	600.6	521.3	461.1	308.9	271.9	231.1	169.1	151.3	143.8
Material	270.8	254.3	259.3	255.3	255.8	218.8	193.6	154.3	135.5	128.3	112.3	100.1	93.1
Service	175.2	168.3	197.4	206.4	259.7	246.3	205.6	181.7	163.0	142.5	122.6	108.4	103.3
ref) GDP-expenditure based	---	170.6	204.1	226.0	266.0	245.6	206.9	189.2	174.5	155.0	129.6	111.6	104.6
Exchange Rate	360.0	360.0	360.0	360.0	296.8	226.8	238.5	144.8	94.1	107.8	110.2	87.8	79.8
PLIs (Price Level Indices)													
Output (GDP)	0.58	0.60	0.66	0.69	0.94	1.09	0.87	1.28	1.75	1.36	1.13	1.30	1.34
Capital	0.53	0.74	0.68	0.90	0.83	1.09	0.93	1.40	1.59	1.32	1.14	1.29	1.30
Labor	0.17	0.18	0.28	0.34	0.67	0.79	0.64	1.02	1.54	1.06	0.82	0.90	0.95
Energy	1.74	1.74	1.72	1.62	2.02	2.30	1.93	2.13	2.89	2.14	1.53	1.72	1.80
Material	0.75	0.71	0.72	0.71	0.86	0.97	0.81	1.07	1.44	1.19	1.02	1.14	1.17
Service	0.49	0.47	0.55	0.57	0.88	1.09	0.86	1.25	1.73	1.32	1.11	1.24	1.29

Note: The PPP for GDP-output based is defined as a translog index of industry-level PPP for value added, which is calculated by the double deflation method. The Price Level Indices are defined as the ratio of PPP to exchange rate. The PPP and exchange rate are defined by Japanese yen/ US dollar. The PPP for GDP-expenditure based is the estimate by the Eurostat-OECD.

Table 2
CONTRIBUTIONS TO GROWTH OF THE STANDARD OF LIVING, 1948-2010

EGALITARIAN	**1948-2010**	**1948-1973**	**1973-1995**	**1995-2000**	**2000-2005**	**2005-2010**
Standard of Living	2.34	3.45	1.87	1.96	1.82	-0.27
Efficiency	2.16	2.67	1.97	2.65	2.03	0.11
Equity	0.17	0.78	-0.11	-0.68	-0.21	-0.37
UTILITARIAN	**1948-2010**	**1948-1973**	**1973-1995**	**1995-2000**	**2000-2005**	**2005-2010**
Standard of Living	2.24	3.09	1.90	2.20	1.93	-0.12
Efficiency	2.16	2.67	1.97	2.65	2.03	0.11
Equity	0.08	0.42	-0.07	-0.44	-0.10	-0.23

Table 3
Progress in Economic Measurement: Summary

Appendix Table 1
Acronyms

AEG	Advisory Expert Group
ANS	Adjusted Net Saving
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
EG DNA	Expert Group on Disparities in the National Accounts
EG ICW	Expert Group on Income, Consumption, and Wealth
ESA	European System of Accounts
EU	European Union
FRB	Federal Reserve Board
GDO	Gross Domestic Factor Outlay
GDP	Gross Domestic Product
GNI	Gross National Income
HDI	Human Development Index
ICP	International Comparison Program
ICT	Information and Communications Technology
IMF	International Monetary Fund
INEGI	Instituto Nacional de Estadistica y Geografia
IT	InformationTechnology
IWGNA	Intersecretariat Working Group on the National Accounts
KLEMS	Capital (K), Labor (L), Energy (E), Materials (M), and Services (S).
MEW	Measure of Economic Welfare
NAICS	North American Industry Classification System
NBER	National Bureau of Economic Research
NRC	National Research Council
OECD	Organisation for Economic Co-Operation and Development
PLI	Price Level Index
PPP	Purchasing Power Parity
PWT	Penn World Table
R&D	Research and Development
SEEA	System of Energy-Environmental Accounting
SNA	System of National Accounts
TED	Total Economy Database
TFP	Total Factor Productivity
TiVA	Trade in Value Added

UN	United Nations
WEO	World Economic Outlook
WIOD	World Input-Output Database