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BEA'S MEASURES OF CAPITAL: A BRIEF OVERVIEW

Prepared by the United States Bureau of Economic Analysis

I. INTRODUCTION

1. This paper describes the scope of capital measurement by the U.S. Bureau of Economic Analysis (BEA). BEA's core national accounts currently include estimates of the stock of "fixed assets," including equipment, software, and structures, as well as estimates of inventory stocks. BEA is also conducting exploratory studies that measure other types of capital, although these experimental measures are not currently part of BEA's core national accounts. A joint project by BEA and the U.S. Bureau of Labor Statistics (BLS) seeks to integrate BEA's national accounts and the BLS productivity statistics and to extend this integrated production account to the total U.S. economy (Harper, Moulton, Rosenthal, and Wasshausen, 2009). In 2006, BEA launched a research and development (R&D) satellite account to explore investment in R&D and its larger economic effects (Robbins and Moylan, 2007). Building on earlier work by Jorgenson and Fraumeni (1992) and others, BEA is conducting research to measure individuals' investments in human capital. In another study, Landefeld, Fraumeni, and Vojtech (2005) estimate a household production account that reflects the capital services of consumer durables.

2. In expanding the asset boundary of its measures of capital and capital services, BEA has encountered some of the same measurement challenges that the Task Force on Sustainable Development (TF) will face. The TF seeks to identify indicators that reflect the capital approach to sustainable development, defined as non-declining per capita wealth over time. The capital approach to sustainable development requires broadening the definition of "capital" to include not only financial capital and produced capital but also natural, human, and social capital. Expanding the capital asset boundary can be difficult because these other forms of capital often lack clear-cut definitions as well as reliable data on investment, valuation, depreciation rates, and capital services.

II. BEA'S FIXED ASSET ACCOUNTS

3. BEA's featured measure of the fixed nonfinancial wealth of the United States is the net stock of fixed assets and consumer durables. (BEA also produces estimates of inventory stocks, which I will not discuss.) BEA estimates the stocks of private and government fixed assets (durable equipment, software, and structures) and consumer durables, as well as underlying investment expenditures and depreciation, for 1925 onward. "Fixed assets" are produced assets that are used continuously in processes of production for more than one year. The acquisition of

fixed assets by private business is presented in the National Income and Product Accounts (NIPAs) as part of gross private domestic investment. The acquisition of fixed assets by government is presented as part of government consumption expenditures and gross investment. Consumer durable goods, tangible commodities purchased by consumers that can be used continuously over a period of three or more years, are presented as part of personal consumption expenditures. [1]

4. The depreciation estimates, in the form of consumption of fixed capital (CFC), are also an integral part of the NIPAs and are used in the context of measuring sustainable income and product. As a cost incurred in the production of GDP, CFC reflects the use of private and government fixed assets and is defined as the decline in the value of the stock of assets due to wear and tear, obsolescence, accidental damage, and aging. CFC is deducted from Gross Domestic Product (GDP) to derive net domestic product, and from gross national income to derive net national income—measures of the level of consumption that can be maintained while leaving capital assets intact. Similarly, CFC is deducted from the appropriate NIPA gross investment to obtain net investment in fixed assets. These measures of net investment are indicators of whether the corresponding capital stocks have been maintained intact. In the NIPAs, the services of general government fixed assets are assumed to be equal to CFC; this measure does not provide an estimate of the full value of these services because the net return on the assets is not included.

5. For the vast majority of these asset types, BEA estimates net stocks using a perpetual inventory model that calculates the net stock in each year as the cumulative value of gross investment through that year less the cumulative value of depreciation through that year. The calculations are performed for each of dozens of detailed asset types. For current- and real-cost estimates, these detailed estimates are initially constructed in constant-dollar terms. In the perpetual inventory model:

Net stock: $S_t = (1-d)*S_{t-1} + (1-d/2)*I_t$
where S_t = constant-dollar net stock at time 't'
d = depreciation rate
I_t = constant-dollar investment at time 't'

Depreciation: $M_t = I_t - (S_t - S_{t-1})$

6. As the formula indicates, BEA assumes most assets have depreciation patterns that decline geometrically over time. For data on flows of gross investment in these fixed assets, BEA relies mainly on the U.S. Census and a variety of other sources.

7. BEA values the net stocks and depreciation of fixed assets and consumer durables at current cost, real cost, and historical cost. Current-cost estimates of net stocks and depreciation reflect the market prices (replacement value) of the given period. For instance, the estimate of the net stock for 2005 reflects the value of the stock expressed in the prices that would have been paid for those assets if they had been purchased at the end of 2005. In equilibrium, this market value will equal the present value of all expected future services embodied in existing assets. Current-cost estimates of net stocks and depreciation are derived by converting the corresponding constant-dollar estimates of depreciation and net stocks to the prices of the

[1] For a detailed discussion of BEA's fixed asset accounts and methodology, see U.S. Department of Commerce. BEA (2003, 2008), and Fraumeni (1997).

current period. Real-cost estimates, which are expressed as chain-type quantity indexes or as chained (2005) dollars, remove the effects of price change and are often called “physical-volume” estimates. Historical-cost estimates of net stocks are analogous to book value estimates used on financial statements in that assets are valued at the prices prevailing when they were purchased.

8. In the perpetual inventory method, the pattern of depreciation charges for an asset of a given type is determined by its “depreciation profile”—that is, how the price of that type of asset declines as it ages in the absence of inflation. BEA bases its depreciation patterns on empirical evidence of used asset prices in resale markets wherever possible. For most asset types, geometric patterns are used because the available data suggest that they more closely approximate actual profiles of price declines than straight-line patterns. The geometric rates for specific types of assets are determined by dividing the appropriate declining-balance rate for each asset by the asset’s assumed service life.

9. The main advantage of applying the perpetual inventory method to this very traditional definition of “capital” – produced fixed assets – is that for the most part, comprehensive, detailed, and relatively reliable data on new investment, market prices, and depreciation are available to implement it. Although the estimates have some limitations, including the uncertain accuracy of the depreciation rates, the methodology provides a general model for estimating capital stocks and sustainability. Measures of other forms of capital are likely to be less well-defined and are likely to be based on less reliable source data.

III. INTEGRATION WITH BLS PRODUCTIVITY STATISTICS

10. A recent joint BEA-BLS project (Harper, Moulton, Rosenthal, and Wasshausen, 2009) develops a prototype integrated production account for the nonfarm business sector, and creates experimental multifactor productivity (MFP) estimates that expand the core MFP estimates to include non-market government and non-profit sectors. This project uses BEA’s fixed asset accounts to expand the capital asset boundary in the MFP calculations to include the non-market government and non-profit sectors. It builds on the work of Fraumeni, et al. (2006), which developed the first steps toward integrating the national accounts with the productivity statistics. Jorgenson and Landefeld (2006) identified the expansion and improved integration of the nation’s national accounts and productivity statistics as a high priority of their “new architecture” for the U.S. national accounts.

11. In the U.S. statistical system, BLS estimates multifactor productivity (MFP), which measures output per unit of a combined set of inputs, both capital and labor. A change in MFP reflects the change in output that cannot be accounted for by the change in combined inputs of labor and capital. As a result, multifactor productivity gains reflect the joint effects of many factors including new technologies, economies of scale, managerial skill, and organizational changes.[2] Presently, BLS publishes MFP for private business and private nonfarm business. This measure covers about three-fourths of U.S. GDP but excludes the value added of government, nonprofit institutions serving households, owner-occupied housing, and compensation paid by households to domestic workers. The BLS excludes these sectors because

[2] For additional details on MFP statistics and methodology, see U.S. Department of Labor. Bureau of Labor Statistics (1997 and 2006).

direct measures of the outputs of these sectors are unavailable, in part because these outputs are usually not sold in markets.

12. The MFP estimates are based on a production account framework, a model of how labor, capital, and intermediate inputs flow between sectors and help account for the production of output in each sector. A first step toward integrating BLS MFP estimates with BEA GDP estimates is to better understand how the BLS output and input measures relate to corresponding GDP measures. Building on a reconciliation presented by Fraumeni, et al. (2006), the BEA-BLS study develops a detailed reconciliation table that will enable BEA and BLS to identify and correct any differences in treatment and to determine whether these differences are valid. The differences are mainly due to differences in source data vintages and adjustments to match agency concepts with definitions.

13. To measure productivity in this framework, BLS needs to determine the flow of capital services provided by a given stock of capital assets. The capital service flow is similar to the flow of labor hours but, unlike labor hours, usually cannot be measured directly because companies own most of the capital assets that they use. However, in the literature on productivity measurement, procedures have been developed to estimate the service flow from historical data on capital investments, estimates of the rates of deterioration and depreciation of capital, and income data of firms utilizing capital. BLS, like BEA, uses a perpetual inventory method to estimate net capital stocks, using detailed gross investment data from BEA and estimates of how capital service flows "deteriorate" as assets age. (These deterioration rates and BEA's wealth-based depreciation rates are different but closely related.) The estimated capital stocks for various types of asset types are then aggregated by estimating implicit rental prices for each type of asset. Rental prices – the price one would be willing to pay to rent the asset – depend on the price of the asset, depreciation rates, and the rate of return of the asset.

14. To expand the MFP calculations to include the non-market government and non-profit sectors in this framework, the BEA-BLS project estimates output and capital inputs as well as labor inputs for these sectors. The outputs are generally estimated with input measures. While comparisons of such outputs to inputs might not be regarded as "productivity measures," this approach allows one to build production accounts that exhibit all of the outputs and inputs by sector for the total economy. The next step is to examine alternative approaches to measuring capital stocks and services for governments (Federal, State and Local, and Government Enterprises) and for nonprofit institutions. Estimates of capital stocks come from BEA's fixed asset accounts. To estimate rental prices, the study uses price indexes of capital assets and depreciation from BEA's capital stock work, and makes reasonable assumptions about rates of return on capital assets.[3]

15. In the experimental estimates based on this approach, the expanded measure of input grows at about the same rate while the expanded measure of output grows more slowly. The slower "productivity" growth reflects the use of inputs to measure output for government and nonprofits. This integrated, expanded BEA-BLS production account can will also help BEA trace the effect of innovation on productivity and economic growth.

[3] For this very preliminary exercise, the authors used internal rates of return (IRRs). Industry-specific IRRs (as calculated by BLS for private businesses engaged in similar activities) are used to generate rental prices for non-profit institutions. For government (Federal, State, and Local), the rate of return is based on a weighted average across industries of the IRRs of returns of the private businesses.

IV. BEA'S R&D SATELLITE ACCOUNT

16. BEA is engaged in a major ongoing effort to broadening its measure of capital by creating better measures of "intangible assets," or knowledge-based assets that contribute to economic growth. Most economists agree that intangible assets are an important input into the innovative process and are critical components of the modern economy. One study (Corrado, Hulten, and Sichel, 2006) found that business investment in intangible assets roughly equals investment in tangible assets.

17. Currently, the NIPAs do not treat intangibles other than computer software and mineral exploration as investment and thus cannot separately identify their contribution to U.S. economic growth, mainly because measuring investment in intangible assets is very challenging. Many intangible assets are developed in-house by firms and not bought and sold in markets. Many intangible assets have a public good aspect in that (1) some use of the asset can be made by the public without reducing the amount available and (2) some benefits from the use of the asset accrue to entities other than the owner. Because of these aspects of intangible assets, the standard inputs to estimates of capital stocks of assets -- quantities, prices, depreciation rates, and rates of return -- are all difficult to measure. These same measurement problems are likely to persist in many indicators natural and social capital as well.

18. As of now, BEA's main efforts to measure innovative activity have focused on its research and development (R&D) satellite account, which was produced in partnership with the U.S. National Science Foundation (NSF). [4] BEA has chosen to focus on measuring investment in R&D because experts broadly agree on its definition and authoritative time-series data exist from long-established R&D survey data published by NSF. The 2008 System of National Accounts (SNA) recommends treating R&D expenditures as investment.[5] The R&D satellite account shows how gross domestic product (GDP) and other measures would be affected if R&D spending were "capitalized," that is, if R&D spending were treated as investment rather than as an expense. The R&D satellite account format thus provides a means of exploring the impact of adjusting the treatment of R&D activity on the economy. Currently, BEA plans to incorporate R&D spending as investment into its core accounts around 2013.

19. According to the updated R&D satellite account estimates (Robbins and Moylan 2007), treating R&D spending as investment would have a significant effect on BEA's measures of the economy. R&D investment would have contributed about 0.2 percentage point to the real GDP growth rate for 1995-2005. Current dollar GDP, gross investment, and the national saving rate would all have been higher, had R&D been capitalized.[6]

20. The capital approach is ideal for analyzing the effects of investment in R&D because R&D can add to output not only in the current period but also in subsequent periods. Because

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[4] The R&D account was developed with support from NSF's Division of Science Resource Statistics, which is responsible for national R&D statistics.

[5] Other intellectual property expenditures are also treated as investment: mineral exploration and evaluation; computer software; databases; entertainment, literary and artistic originals; and other intellectual property products.

[6] This section provides only a brief overview of the complexities of the R&D satellite account, and borrows extensively from the more detailed summaries in Aizcorbe, Moylan, and Robbins (2009), Fixler (2009), Robbins and Moylan (2007), and other references cited. For more information see these references and the documentation provided on the BEA website at http://www.bea.gov/national/newinnovation.htm.

the R&D asset is a final good, its value is recorded as investment and adds to GDP in the period that the asset is produced. The value of the asset may be thought of as the expected discounted present value of the stream of benefits it will provide into the future. Offsetting this entry, the costs of producing the asset—payments to factors of production—are recorded on the income side of the account. Once the asset is created, it becomes an input to the production process, and the flow of services to the production of other goods and services from the asset in each period of its service life is recorded in the income account. This flow of services may be thought of as the amount that producers would be willing to pay to rent the asset for a given period. In principle, the sum of all the rental payments would equal the price of the asset.

21. To measure the contribution of R&D investment to GDP in a capital framework, it is necessary to estimate the stock of R&D assets, which is not directly observable. The construction of these capital stock estimates requires nominal data on R&D investment, price deflators to translate nominal investment into real quantities, and depreciation rates.

22. Scope of R&D investment. BEA considers the scope of R&D investment to include both technological and nontechnological activity as long as the purpose is to increase the stock of knowledge, including knowledge of man, culture, and society that is used to devise new applications.[7] Comprehensive measures for R&D were facilitated by a long time series of data on R&D spending provided by the NSF. For technological activity, the NSF data on R&D expenditures and federal government outlays and obligations for R&D allow the measurement of R&D performed by private business, private nonprofit institutions, and government entities. Data on R&D performed by others at the government's expense and data on R&D performed by the government for its own use are both available. The R&D account also includes a portion of social science-related (non-technological) R&D, consisting of (1) the sale of social science R&D by private business based on economic census data, (2) the performance of social science R&D by federal government labs, and (3) the performance of social science and humanities-related R&D by academic institutions. The latter two estimates are based on NSF data.[8]

23. Prices: Ideally, one would want a price deflator that allows one to break out any changes in the dollar value of investment in these assets into price and quantity components. Prices for R&D are typically not observable because most R&D is performed "in-house" and not traded; even when sold, the traditional price index method breaks down because R&D products are unique. (Traditional price indexes are based on repeated sales of an identical product.) Similarly, the unit of output volume is not defined and not observable.

24. The R&D account therefore turns to indirect approaches to obtain prices, all of which have some limitations. One approach is to develop a price index for the total costs involved in producing the asset—such as wages of engineers and scientists. This type of "input cost index," however, ignores any productivity gains in the production of the asset.
A second option is the creation of "productivity adjusted prices," which adjust the input price index for productivity in the downstream (R&D using) industries. A third option is a "downstream product price" that uses a price index for the good that embodies that intangible asset. These last two options implicitly assume that the change in the price of R&D is the main

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[7] This definition of R&D is from the OECD (2002).

[8] Corrado, Hulten, and Sichel (2006) define intangibles more broadly to include computerized information (software and databases), innovative property (scientific and nonscientific R&D), and economic competencies (brand equity, such as certain advertising, and firm specific resources, such as worker training, management know-how, and organizational change).

factor driving changes in either the productivity of the R&D using industry of the price of the downstream product. A fourth option (Fixler and Copeland, 2008) is based on a model of an "independent innovator" and relies on an index that seeks to estimate the price of R&D from the change in profit arising from its use.

25. In the 2006 and 2007 versions of the BEA satellite account, business investment in R&D is deflated using price indexes for R&D output based on the output prices of the goods produced; spending by government and other nonmarket entities is deflated using input prices. The R&D satellite accounts (see, for example, Okubo and others, 2006) show that the impact of R&D on the growth of real GDP is dependent on the choice of the deflator. In the BEA satellite accounts, several different deflators were used—see Copeland et al (2007) for an in-depth discussion of the deflators used in the 2007 satellite account.

26. User cost and depreciation. Constructing the capital stock and the flow of services from that stock requires assumptions about depreciation rates and a "rental cost" for the use of the asset, which is typically measured using a user cost formula. For intangibles, these depreciation rates are particularly difficult to measure because the depreciation is often related to obsolescence, which can vary immensely across intangible assets, rather than physical decay and wear and tear, a more readily observable phenomena. Depreciation rates for these intangibles are necessarily based on assumptions guided by limited evidence. [9] Several countries, including Australia and Israel, have engaged in surveys that attempt to get estimates of duration from performers of R&D. In the R&D satellite account, the choices of service life assumptions were based primarily on econometric studies of R&D depreciation and vary by industry, ranging from 11-8 percent. Relatively little is known about depreciation rates and profiles for the other intangible assets.

27. In the future, BEA is considering an expanded satellite account that would contain experimental statistics for a broader array of intangible assets alongside the existing measures for R&D. Research is currently underway at BEA to develop methodologies and data sources to incorporate film originals and sound recordings into the GDP accounts (Soloveichik, 2008). Current work by to expand the existing Business Research and Development Survey is an important step in this direction, and BEA hopes to continue to work with the NSF and the Census Bureau to expand current surveys of spending on R&D related activity and other intangible assets.

V. HUMAN CAPITAL AND HOUSEHOLD PRODUCTION

28. BEA is also conducting research to measure individuals' investments in human capital, another asset whose importance as a source of growth has long been recognized.[10] The National Research Council (2005), for example, suggests that "Separate education accounts would contain data essential for improving our understanding of how investment and the capital stock, defined more broadly to include both human and nonhuman capital, affect economic growth" This BEA initiative would provide estimates of the stock of human capital, the rate at which the

[9] The service lives for software, for example, are based on some indirect quantitative estimates of the relationships between computer expenditures and software expenditures, anecdotal evidence (including an informal survey of business use of software previously conducted by BEA about how long software is used before it is replaced), and tax-law based lives of software.

[10] This section is adapted from Aizcorbe, Moylan, and Robbins (2009).

stock depreciates, and the returns to human capital investments. This work would build on earlier work by BEA, Jorgenson and Fraumeni (1992) and others.

29. These measures, while useful, will have some limitations, largely because of limitations in source data. BEA currently plans to measure investments in traditional education --individuals' investments in their human capital -- and not on-the-job training. Although this approach would miss an important type of investment that firms make in their workers, the measurement of investment by firms in their workers' human capital is relatively new, and the data sources are sparse. Second, to remain within the scope of national accounting standards, BEA will focus on market-based activity and will only measure market-based investments in education, not individuals' investments in time.

30. The importance of nonmarket production has also been a recurring theme in the U.S. and international national accounts literature. In a recent National Research Council panel study, *Beyond the Market: Designing Nonmarket Accounts for the United States* (2005), Abraham and Mackie argue that given the developments in national accounting, detailed data on wages, data on nonmarket activities such as housing services, and data on how people spend their time from the new American Time Use Survey (ATUS), nonmarket household production can be measured indirectly with the "measuring-rod" of money.

31. Landefeld, Fraumeni, Vojtech (2005) utilize data from the ATUS to update earlier "satellite account" estimates of household production and highlight how this supplemental information can improve our understanding of economic growth and the impact of increasing women's labor force participation, and household production's role in investment and other spending. This study recognizes households as part of production, and accordingly reclassifies capital goods purchased by households, consumer durables, as investment, rather than as consumption. In addition, the satellite account presented here include services of some government capital (education, health care, and roads) related to household production.

VI. CONCLUSION

32. As this brief summary indicates, BEA is currently engaged in several projects to measure capital. BEA's core accounts measure fixed (produced) assets and consumer durables. BEA's exploratory projects in the area of capital measurement include the integrated BEA-BLS production account, the R&D satellite account, and research on human capital and household production. BEA's work to expand its measures of capital has addressed numerous challenges, mainly in the area of measurement – investment, capital stocks, prices, depreciation, and rates of return are often difficult to define, observe, and measure. The TF is likely to face similar challenges in creating indicators of sustainable development.

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