We See the Digital Revolution Everywhere Except in Real GDP

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Robert Solow's 1987 quip about computers could well be applied to the current debate about the digital economy. Solow's remark was interpreted by many as a mild rebuke to those enthusiasts who over-hyped the impact of computer on productivity growth. It could also be interpreted as an observation about the failure of national statics to capture the true impact of the computer revolution, a position championed by Alan Greenspan around the same time. We have seen how the former turned out, and the latter led to changes in the way price indexes are constructed and helped launch the intangible capital movement. We are now in a similar debate about the digital revolution, with Robert Gordon taking the position that its impact on economic grow is smaller than past technological revolutions, and that it is playing out in any event. Others, like Brynjolfsson and Sanders in their 2009 paper (who also note the Solow quip), proceed under the assumption that the impact is understated because of mismeasurement (see also the 2015 review by Hulten). We follow the latter by investigating the possibility that the digital revolution is not seen in the real or nominal GDP because much of it is not there, or, when it is there, it is in a form that obscures its impact.

The literature on the GDP mismeasurement has tended to focus either on how of innovation should be treated in the national accounts (one that includes a proper innovation account), or has estimated the quality bias in the prices of selected goods (e.g., computers, software, semi-conductors, fasteners (Sichel, 2011)), or has attempted to measure the consumers surplus associated with product innovation. We will approach the problem from a different angle and ask "where exactly are the smart-phones in current GDP statistics? Where is the internet?" Schmidt and Rosenberg state, in their book *How Google Works*, that "the internet has made information free, copious, and ubiquitous." How is this reflected in official statistics?

We will begin with a general overview of what is included in official estimates of nominal GDP, and the procedures (explicit and implicit) for incorporating new products and market arrangements into these estimates. This is not simply an issue of what is included and what is not. It also involves how goods are characterized (the value of the internet, for example, is partly linked to advertising), and how goods like the internet and smartphones are complex bundles of many goods. We will also review the procedures used by the BLS in its price index programs. This included the procedures for incorporating items involving into the PPI and CPI, with a focus on inclusion and sample rotation, and also methods used to introduce them into the existing price indexes. The problem of whether technological advances in the quality of existing goods and in the development of new goods are reflected in the price index used to

[1] These are our views and not those of the Federal Reserve Bank of Philadelphia or the Federal Reserve System.

deflate nominal GDP. This issue is at the forefront of the critique of current measures of real GDP.

The goal of this part of the paper is to gauge the potential extent of the mismeasurement or misclassification. While the digital revolution has brought tectonic technical change to parts of the economy, much of the rest of the economy lies outside the tectonically active zone or experiences milder technical disruptions. Moreover, current procedures do pick up some of the larger changes (in computer and software prices). Our aspiration is to adopt the Griliches hard-to-measure-goods sectors to identify the fraction of GDP in the current technologically hard-to-measure sectors. Where Griliches used this approach to attribute the productivity slowdown in the 1970s to the difficulty in measuring output in the services-producing sectors, we will update this framework to see if GDP in the technologically hard-to-measure sectors could possibly explain the recent slowdown in real GDP.

We then supplement this analysis with a more in-depth look at some of the most tectonic technologies. Our proposed list of "case studies" include smartphones (iPhones), search engines (Google), and social media (Facebook.) We will also investigate how the digital equipment increasingly embodied in autos and trucks finds its way into GDP, and examine how new medical devices (e.g. MRI and CT-scan equipment) appear in GDP. The individual cases also serve as a preview of how some major innovations in the development pipeline, like driverless vehicles, will be treated if current measurement procedures remain unchanged.

SMART PHONES CASE STUDY: The smartphone is, as its name implies, a telephone, but it is also much more. It replaces multiple devices, such as computers or laptops, GPS devices, and home entertainment systems and libraries. Also, smartphones may be production sites, from which households and businesses upload graphics, videos, tweets, and the like. When goods have many changing dimensions, how to classify the aggregate package becomes a challenge. This raises the question of how BEA and BLS resolve this issue. Where exactly are these devices located in their statistical framework? How are they actually valued? As just another telephone? This issue leads to a parallel study of one of the most important sources of smartphone value: mobile access to the internet and the many apps it contains.[2]

INTERNET APPS STUDY: A great deal of attention has been given to the "free" nature of the internet. It is not actually free, since resources are involved it its production and distribution, as shown by the research by Nakamura and Solveichik on the financing of the internet apps using adverting revenues. From a theoretical standpoint, internet access and its content could in principle be financed on a pay-per-use basis, but this would push the limits of administrative feasibility given the great number of apps and the frequency of use. In any event, the pay-as you-use model has not been adopted.

[2] Another issue has to do with the fact that iPhones are assembled in China and then shipped from there to the US and other countries, with much of the profits remaining overseas, although these profits are largely attributable to intangible assets created in the U.S. (Guvenen et al, forthcoming).

Identifying the internet's contribution to nominal GDP has proved to be a challenge, but an even greater problem arises when tying to estimate its contribution to real GDP. The absence of a market price mechanism for internet services forecloses the direct pricing approach of the CPI. If advertising/marketing expenditures are used as a proxy for the nominal dollar value of the internet, the price deflator for advertising is presumably not correct. One possibility is to assume marginal cost pricing and use the latter as a proxy, but most of the cost of an app is the fixed costs of development and improvement and consumption is non-rival, so the marginal cost of serving an addition user is essentially zero. Non-rivalness implies that the Samuelson theoretically appropriate solution implies a different price for each user.

We will examine this issue in greater depth, but not attempt to offer a solution. We will, instead, follow the program of asking how this internet is treated by the BLS and BEA (where and if classified in the NIPA and CPI). We will also look at direct quantity indicators of usage for selected apps like Google search and maps, and Facebook. A look at the companies themselves may also give valuation clues.

AUTO CASE STUDY The software that is incorporated into a car can change its characteristics, as when Tesla allowed customers to download software to allow their cars to self-drive. How are software upgrades included in quality adjustment of motor vehicles? In principle, should the manufacturer's outlay for the software be spread out over the number of motor vehicles that are expected to incorporate that software? More generally, the value of any intangible is likely to increase with the size of the market over which the intangible expenditures are spread. How does this affect what we mean by the real quantity of intangible expenditures and the real stock of intangible assets?

MEDICAL EQUIPMENT STUDY: The incorporation of technological improvements in autos is an example of capital embodied technical change (ETC). ETC is a widespread phenomenon in both consumer and producer capital goods. Medical diagnostic equipment like MRIs and CT-scans are important examples in the delivery of health care. As in the other specific studies, the objective is to examine current statistical procedures to see if the substantial benefits flowing from these items are represented in real GDP.

There many other candidates for case studies, and a more comprehensive analysis might include such subjects as e-commerce, cloud computing, Big Data, new developments in the measurement of intangible capital, ETC in machine tools (robotics), and the development of major pharmaceutical drugs like the statins. We may take a quick look at some of these areas. However, a truly comprehensive accounting is really the responsibility of the statistical agencies themselves. The ones selected for this paper will hopefully help establish probable cause for thinking that a broader and deeper study would affect measured real GDP, or, on the other hand, perhaps moderate the expectation that it might not make as much difference as critics of the current statistics believe.

PARTIAL BIBLIOGRAPHY [REVISE]

Brynjolfsson, Erik, and JooHee Oh, "The Attention Economy: Measuring the Value of Free Digital Services on the Internet", 2012, www.informatik.uni-trier.de/~ley/pers/hd/b/Brynjolfsson:Erik

Brynjolfsson, E., A. Saunders, "What the GDP Gets Wrong.(Why Managers Should Care)", MIT Sloan Manag. Rev. 51(1), 2009, 95.

Corrado, Carol A., and Charles R. Hulten, "Innovation Accounting", in "Measuring Economic Progress and Economic Sustainability," in D.W. Jorgenson, J.S. Landefeld, and P. Schreyer, eds., Studies in Income and Wealth, vol. 72, The University of Chicago Press for the National Bureau of Economic Research, Chicago, 2014, 595-628.

Corrado, Carol A., Charles R. Hulten, and Daniel Sichel, "Intangible Capital and U.S. Economic Growth", Review of Income and Wealth, 55, 3, September 2009, 661-685.

Gordon, Robert J., The Rise and Fall of American Growth: The U.S. Standard of Living since the Civil War, The Princeton Economic History of the Western World, Princeton, New Jersey: Princeton University Press, January, 2016.

Griliches, Zvi, Introduction, Output Measurement in the Service Sectors, Studies in Income and Wealth, Vol. 56, Chicago, Illinois: University of Chicago Press, 1992; also, Zvi Griliches, "Productivity, R&D, and the Data Constraint," American Economic Review, 84(1), 1994, 1–23.

Guvenen, Fatih, Raymond Mataloni, Dylan Rassier, and Kim Ruhl. "Offshore Profit Shifting and Domestic Productivity Measurement" forthcoming working paper.

Hulten, Charles, "Measuring the Economy of the 21st Century", NBER Reporter, No 4, December, 2015, 1-7.

Nakamura, Leonard, "Hidden Value: How Consumer Learning Boosts Output", Business Review, Federal Reserve Bank of Philadelphia, Q3 2014, 9-14.

Nakamura, Leonard, Advertising, Intangible Assets, and Unpriced Entertainment, Working Paper 05-11, Federal Reserve Bank of Philadelphia, 2005.

Nakamura, Leonard, and Rachel Soloveichik, Valuing "Free" Media Across Countries in GDP, Working Paper 15-25, Federal Reserve Bank of Philadelphia, July 2, 2015

Schmidt, Eric, and Jonathan Rosenberg (with Alan Eagle), How Google Works, Grand Central Publishing, September 2014.

Sichel, Daniel, "What Happened to Prices of Simple, General-Purpose Products over the Centuries: Nails and Screws since about 1700," mimeo, Wellesley College, September 2011.

Stigler, George, and Gary S. Becker. "De Gustibus Non Est Disputandum," American Economic Review, 67 (March 1977), pp. 76-90.