GDP and the Digital Economy: Keeping up with the Changes

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The perception is widely held that the growth of the digital economy[1] is unprecedented and has been a major contributor to recent economic growth, the booming stock market, and the revival of productivity. What do we know about the growth of the digital economy? What would we like to know that the data currently do not reveal? And what does the federal statistical system need to do to provide that information? Because the economic data do not tell an unambiguous story about the digital economy, knowledgeable observers disagree about the importance of information technology (IT) and electronic commerce in the economy.

Economists have been engaged in a debate over the so-called productivity paradox, which asks how productivity growth could have slowed during the 1970s and 1980s in the face of phenomenal technological improvements, price declines, and real growth in computers and related IT equipment.[2] Much of this debate has revolved around questions of measurement—for example, are the output and growth of industries that use IT equipment being adequately measured? There are reasons to think that they are not, that is, that the measures of output for the banking, insurance, and several other industries are particularly problematic, and the measured productivity of these industries appears to be implausibly low. If productivity in IT-using industries is not being measured adequately, can the measurement errors explain the productivity paradox?[3] Several economists think that measurement may be an important piece of the solution to the puzzle.

In addition, the IT revolution has raised questions about the ability of the federal statistical system to keep up with a changing economy. The availability of inexpensive IT equipment and services has enabled businesses to do their work in new ways and has led to the creation of new firms and even entire industries. Are these new forms of business and production being adequately counted in our gross domestic product (GDP)? Have our economic statistics kept up with electronic commerce, new kinds of financial services, and new methods of inventory and product distribution?

The economic data produced by the Department of Commerce are critically valuable to our nation's economic information infrastructure. The monthly releases of GDP are meticulously followed by policymakers and financial analysts, serving as a barometer of the economy's health. These economic data provide information for understanding major policy issues, for forecasting the economy's potential for future growth, for conducting monetary policy, for understanding the tradeoffs between inflation and full employment, for projecting tax revenues and conducting fiscal policy, and for studying long-term issues such as the future of the social security system. While these data serve as very good indicators of overall economic activity, they must constantly be improved and refined to keep up with our rapidly evolving economy.

What Is Measured Well?

There are many aspects of IT and electronic commerce that are measured well in the official statistics. Some features of the digital economy are captured perfectly well by the same data collections that regularly provide information about the rest of the economy. The U.S. economic statistics for product and income are benchmarked to input-output tables that are painstakingly constructed from data collected in the economic censuses. The incomes earned from production are benchmarked to tax and administrative data. Adjustments are made to remove any sources of bias that are known and measurable. Because the IT and electronic commerce sectors, like most other sectors, are covered by the economic censuses, tax statistics, and unemployment insurance programs, data on the digital economy enter into the overall

measure of how the economy is doing in general. The GDP and other basic economic statistics have been shown to provide very good information about the movements over the business cycle of production, aggregate demand and its components, income, and prices.[4]

Because the digital economy is not a standard classification for economic data, there may be some disagreement on what it entails. However it is defined, though, as a share of total GDP it is still fairly small. (For example, private investment in information-processing equipment and software, a component of nonresidential fixed investment, was $407 billion in 1999, or 4.4 percent of GDP. At this point, Census Bureau estimates of the magnitude of electronic commerce are more speculative but are still quite small as a percentage of all retail and wholesale sales.) Furthermore, at least so far, movements in IT investment have not been highly correlated with the ups and downs of the business cycle. Consequently, the measurement problems that are central to the debate about the effects of IT on long-term growth and productivity are not questions about the usefulness of the national economic accounts for measuring the short-term movements of the business cycle. Rather they are questions about small biases or omissions that amount to perhaps tenths of a percent per year, but that cumulatively affect the measurement of long-term trends in growth and productivity.

The Bureau of Economic Analysis (BEA) within the Department of Commerce has tracked the direct effect of computers on measured GDP growth using its "contributions to percent change" methodology.[5] The contribution to the percent change of GDP can be approximated by simply excluding the computer components in the various sectors of GDP (e.g., private fixed investment, personal consumption expenditures, government gross investment) in its calculation, and comparing the growth rate of real GDP less computers to the growth rate of real GDP. These data are now regularly published in the GDP news release and are also available from the BEA's web site. As shown in table 1, the direct contribution of final sales of computers to real GDP growth averaged about 0.1–0.2 percentage point per year from 1987 to 1994, then accelerated to 0.3–0.4 percentage point per year from 1995 to 1999. The acceleration reflected both increases in current-dollar final sales and more rapid declines in computer prices, and sug-

Table 1 Real GDP, Final Sales of Computers, and GDP Less Final Sales of Computers

	GDP (% change)	GDP less final sales of computers (%change)[1]	Difference	Final sales of computers (% change)
1987	3.4	3.2	.2	23.4
1988	4.2	4.0	.2	20.3
1989	3.5	3.4	.1	13.4
1990	1.8	1.7	.1	5.6
1991	−.5	−.6	.1	12.0
1992	3.0	2.9	.1	24.8
1993	2.7	2.5	.2	22.1
1994	4.0	3.9	.1	20.1
1995	2.7	2.3	.4	53.7
1996	3.6	3.2	.4	55.3
1997	4.2	3.9	.3	45.4
1998	4.3	3.9	.4	53.9
1999	4.2	3.8	.4	44.1

gests that computers have recently become more important to the business cycle.

The measurement of real growth of computers in the national accounts is an example of a major statistical success—an important aspect of information technology that is now being more accurately measured and better understood than it was a decade or two ago.

Fifteen years ago there was no adequate official price index for computers. Nearly everyone recognized that the price of computing had been falling dramatically, but the methods used by the Bureau of Labor Statistics (BLS) and the BEA for estimating price indexes could not adequately account for quality changes of the magnitude that were occurring in computers.

The computer price problem was resolved through an exceptional collaboration between a government agency (BEA) and industry (in the form of a team of researchers from IBM). The research group included people with technological and engineering knowledge as well as economists and statisticians. The quality-adjusted computer price index, which was introduced in the national accounts in December 1985, helped rewrite economic

history. The price index showed a remarkable multidecade decline in prices and growth in output of computers and peripheral equipment.[6] Application of the new index resulted in significantly higher real economic growth. The method that was used to adjust for quality improvements in the BEA computer price index has also been adapted by the BLS for the computer components of its producer, consumer, export, and import price indexes.

Since 1985, the work on quality-adjusted price indexes has been extended to several other IT products, such as semiconductors and telephone switching equipment.[7] The BEA introduced improved price indexes for some types of software as part of the comprehensive revision of the national economic accounts released in fall 1999. I must acknowledge, however, that progress on improved measures of output and prices for high-tech products has been slow and difficult. Developing the statistical estimates that are required for state-of-the-art quality adjustment is a resource-intensive activity, and the necessary data and other resources have not always been available.

Another success story in measuring the economic effects of information technology was the elimination of *substitution bias* (that is, the tendency of indexes with fixed weights to overstate growth). Prior to 1996, the national accounts measured changes in "real" (that is, inflation-adjusted) product by holding prices constant at their levels during a particular base year. It was known that this method led to a distortion or bias as prices moved away from the levels of the base year, but it was generally assumed that changes in relative prices tended to be modest and that this bias could therefore be ignored. Once the improved price index for computers was introduced, however, it became clear that its extreme and sustained downward trend wreaked havoc on the constant-price measures of real GDP. The substitution bias caused the estimates of real GDP growth to be overstated by as much as a percentage point. Furthermore, because the bias was not constant over time, it led to significant distortions in measuring the long-term trends in growth.

The BEA embarked on a research program that eventually led to the adoption in January 1996 of *chain-type* quantity and price indexes (that is, indexes in which the weights are continually updated, rather than held fixed). In other words, the prices used

for measuring year-to-year changes in quantities are now the prices occurring during the two adjacent years that are being compared. These new indexes corrected an *upward* bias in GDP growth—that is, the effect of the change was in the opposite direction from the effect of incorporating the new computer price indexes. Users of the national accounts data have had to become accustomed to these new measures, because the chained-dollar measures are not additive, and some changes were required in the methods used to analyze these measures. These changes have been worth making, however, because a significant and major source of bias was eliminated, using the best available statistical methods.[8]

Agenda for Improvements and Future Research

If the digital economy were more accurately measured, would the long-term rate of real GDP growth be higher? There are good reasons to think that improved measures would raise the long-term growth rate of GDP, and there are several specific areas on which we can focus. More work is needed on price indexes. Better concepts and measures of output are needed for financial and insurance services and other "hard-to-measure" services. Our measures of capital stock need to be strengthened, especially for high-tech equipment. Also, economic surveys need to be expanded and updated to do a better job of capturing electronic commerce and its consequences.

Separating Quality Change from Price Change

Besides computers and peripheral equipment, semiconductors, and telephone switching equipment, there are other high-tech or IT products and services that have achieved major improvements in quality that have not been adequately adjusted for in our price and quantity measures.[9] As mentioned before, I view this as largely a problem of data and resource limitations. More cooperation and collaboration with the private sector, such as occurred between BEA and IBM, would be a major step forward. The private sector is often the only source for the detailed data needed to measure quality changes. Without such assistance, we would need to devote

significant resources to collecting the data needed to make quality adjustments. The resulting improved price measures for IT equipment and services would very likely raise the real rate of growth.

Measuring Output of Services

At least as serious are the problems of measuring changes in real output and prices of the industries that intensively use computer services.[10] If the output of these industries cannot be measured adequately, then it will be impossible to determine the extent to which computers contribute to producing that output. Among the industries that are the most intensive users of computers are wholesale trade, finance, banking, insurance, and business services. For some of these industries, the output cannot be measured directly—for example, in the case of banks, many services are paid for implicitly by the difference between the interest rates paid by borrowers and those received by depositors. The national accounts presently make an imputation for these services, but it is not clear whether some of these imputed services should be assigned to borrowers (presently it is assumed that all go to depositors). In fall 1999 BEA introduced an improved measure of real banking services that resulted in a substantially higher measured growth rate (Moulton and Seskin 1999). BEA's strategic plan acknowledges that the outputs of these industries are difficult to measure, and that further conceptual and statistical improvements are needed.[11]

To the extent that industries produce intermediate services that are purchased by other businesses, mismeasurement of their output leads to a misstatement of the allocation of GDP and productivity changes by industry, but would not affect growth in overall GDP. In 1992 about 63 percent of the output of depository and nondepository institutions was sold to final consumers and therefore included in GDP. For business and professional services, about 17 percent was included in GDP.

To measure the real growth of an industry's output accurately, it is necessary to have either an accurate price index or a quantity index. The private service industries for which accurate price indexes are either not available or have only recently become available include depository and nondepository institutions, parts

of real estate, holding and investment offices, business and professional services, social services and membership organizations, water transportation, and transportation services. The gross product originating (GPO) of these industries collectively accounted for nearly 15 percent of GDP in 1997, up from 8.5 percent in 1977. Among these industries, the most significant in terms of both nominal GPO growth and investment in information technology are depository and nondepository institutions (which includes banking) and business and professional services (which includes computer services and management consulting services). These two broad industry groups together accounted for 11 percent of GDP in 1997, up from 5 percent in 1977. Lacking adequate price indexes, real output for many of these industries has either been extrapolated using trends in inputs—in particular, labor inputs—or else deflation has been based on indexes of input costs. Use of these methods makes it virtually impossible to identify any growth in labor productivity and may lead to negative estimates of changes in multifactor productivity.[12] It would undoubtedly be more realistic to assume that labor productivity has grown as these industries have invested in IT, and for this reason it is likely that improved measures of services output would raise the real growth rate.

Furthermore, to calculate either an industry's real GPO (that is, value added) or its multifactor productivity accurately, we also need accurate price and quantity indexes for inputs. Because many service industries also consume services as intermediate inputs, it is seldom possible to measure their real GPO or multifactor productivity accurately.

Economists have debated for decades about the appropriate definition of output for some of these industries. In several cases the output is not directly priced and sold, but takes the form of implicit services that must be indirectly measured and valued. The BEA and its sister statistical agencies are committing resources to improving measurement of the output of these industries, but the conceptual issues are extraordinarily deep and complex, and progress will likely be measured in a series of modest steps.

Measurement of the digital economy presents some additional challenges.[13] Services such as information provision are more commonly provided for free on the web than elsewhere. There may

therefore be less of a connection between information provision and business sales on the web than there is elsewhere. The dividing line between goods and services becomes fuzzier with E-commerce. If you receive a newspaper on-line, is it a good or a service? E-commerce prices and goods and services quality are frequently different from brick-and-mortar outlet prices and goods and services quality. Do we need price indexes for E-commerce goods and services that are different from price indexes for brick-and-mortar outlet goods and services? On the household side, notably, E-commerce may be bringing about a significant change in distribution methods. For households, the effect of E- commerce on distribution is similar to that of the mail-order business, but the size of the effect is expected to be significantly larger. In addition, the digital economy may be bringing about a significant growth in Business-to-Consumer (B-to-C) sales, in new business formation, and in cross-border trade. Because existing surveys may not fully capture these phenomena, private-sector data might be useful supplements to government surveys.[14] Meanwhile, the nature of the products provided by these industries continues to evolve very rapidly, driven in part by the availability of powerful IT equipment and software and the appearance of many new products, including new investment goods.

Accounting for Capital Stock

One reason for our difficulty in measuring the effects of information technology on the economy is that it often enters the production process in the form of capital equipment.[15] The BEA publishes data on the nation's wealth held in the form of capital structures, equipment, and software as well as on consumer durable goods, and the BLS publishes data on the productive services provided by the capital stock. The two agencies have gone to considerable lengths to develop information on investment flows, service lives, and depreciation patterns. Sophisticated perpetual inventory methods and user-cost formulas are used to estimate capital inputs, but some of the data entering these formulas (for example, service lives and industry breakdowns) are rather meager. Further progress in replacing assumptions with validated observations is one of BEA's goals for improving the capital stock estimates.

Another weakness of the capital stock estimates is that important components of capital may not be adequately captured in the measures. Intellectual property (for example, software, inventions, patents, and other forms of knowledge) has been an important omission. In the 1999 revision, the BEA changed the treatment of software in the economic accounts and began counting the development or purchase of software as a capital investment that enters the capital stock and brings returns for a number of years.

Research and development and other intellectual property are presently not treated as capital investment in the national accounts, though in principle they probably should be. Considerable measurement difficulties remain in developing such estimates, though the BEA has done some promising work in developing a satellite account for research and development.[16]

Expanding and Updating Surveys

The Census Bureau is working to expand and modernize its surveys to improve its tracking of businesses involved in electronic commerce and its measurement of transactions conducted via the Internet, to track new firms that enter electronic business, and to measure the increased spending on equipment and services that support Web-based commerce. To measure GDP, it is critical to know whether output is being consumed by final users (so that it enters GDP) or is consumed by business as intermediate inputs (so that it is not directly added to GDP). The rapid developments in the Internet may change some of the assumptions that have historically supported the BEA's estimates and the Census Bureau's surveys. For example, there have been substantial increases in direct sales by manufacturers to households, to other businesses, and to foreigners.

Electronic commerce has contributed to changes in transportation and distribution services because it relies heavily on the increased availability of air and courier services and local trucking to get products to consumers. Eventually we may even expect the occupational structure and geographic location of the labor force to shift in response to the reduced cost of communication and the availability of electronic transactions.

The Census Bureau has been developing and planning initiatives to capture better growth and innovation in electronic commerce in its surveys. Similarly, the BLS has been rapidly extending its coverage of service industries in the producer price index program, to capture better the growth of business, financial, and high-tech services.

Using New Electronic Sources of Data

Accompanying the growth of the digital economy has been a simultaneous growth in the availability of new types of digitally recorded data. Almost every trip to the grocery store or the mall leaves an electronic track of items scanned through cash registers. Several private companies collect and market these data. Other private sources collect data on particular industries—for example, on motor vehicles, financial services, and information technology. In several cases, the BEA selectively purchases these trade source data to supplement the survey and administrative data collected by the federal statistical system. In other cases, important data are freely available on the Internet.

The BLS has been researching the use of scanner data to estimate its price indexes. Scanner data, at least in principle, should allow for expanded and improved collection of price and quantity information and should permit the capture of new products and services nearly instantaneously. The downside of some of these new forms of data is the sheer volume of data collected. One recent study of coffee prices in two metropolitan markets reported weekly observations of prices and quantities for about 1,200 distinct products.[17] If this level of detail were to be used in constructing official price indexes, significant resources would clearly be needed to track changing product characteristics and quality changes.

Looking to the Future

The digital economy continues to grow, and measuring it well will continue to be a concern. Serious measurement problems must be faced as we endeavor to understand its impact. More and better source data are needed for developing and carrying back in time

new quality adjustments or definitions of output. We must undertake fundamental research, both to develop better price indexes and to develop conceptual and statistical improvements in measuring service-sector real and nominal output. This work will enable BEA to continue to improve its measurement of macroeconomic activity in general, while also answering specific questions about the impact of the digital economy.

While it is not clear to me how much of the productivity paradox can be explained by measurement problems, I am confident that these problems are an important contributing factor. Solving them is important not only for assessing the role of the digital economy in the macroeconomy, but also for producing economic data that provide the best possible measure of our long-term growth and productivity. BEA's successful experience with measuring computer prices and converting to the chain-type measures of real GDP, as well as the current efforts to improve the measurement of software, all suggest that further progress is indeed possible.

Acknowledgments

Notes

1. The terms "digital economy," "information technology," and "electronic commerce" do not have standard definitions. When I refer to information technology, I will be referring to information processing and related equipment, software, semiconductors, and telecommunications equipment. References to electronic commerce will mean the use of the Internet to sell goods and services. I interpret the digital economy as including both information technology and electronic commerce.

2. There are two measures of productivity. Labor productivity measures output per hour worked. Multifactor productivity measures output per combined unit of inputs, where inputs are broadly defined to include capital and labor inputs and intermediate goods and services. Both measures slowed beginning in the early 1970s.

3. The productivity paradox was first articulated by Solow (1987). Recent discussions of the productivity paradox include Diewert and Fox (1999), Gordon

(1998), Jorgenson and Stiroh (1999), Sichel (1999), and Triplett (1999). Note that the productivity slowdown was not limited to the United States, but was seen broadly across industrialized countries.

4. See Grimm and Parker (1998).

5. See Landefeld and Parker (1997).

6. The joint BEA-IBM research is described by Cole et al. (1986).

7. See Grimm (1998) and Parker and Seskin (1997).

8. See Landefeld and Parker (1995, 1997).

9. For recent discussion of problems in making appropriate quality adjustments in the consumer price index, see the report of the Advisory Commission to Study the Consumer Price Index, which was chaired by Michael Boskin (U.S. Senate, 1996), and Moulton and Moses (1997).

10. See Griliches (1994), Dean (1999), and Gullickson and Harper (1999).

11. The BEA's strategic plan commits the agency to improving hard-to-measure services (U.S. Department of Commerce, 1995).

12. See Gullickson and Harper (1999).

13. See Fraumeni, Lawson, and Ehemann (1999).

14. Hitt and Brynjolfsson (1998) describe how the digital economy has changed the way businesses conduct business with reference to case studies and firm-level studies.

15. For discussion of computer capital inputs, see Sichel (1999).

16. See Carson, Grimm, and Moylan (1994).

17. See Reinsdorf (1999).

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