

## **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<sup>1</sup> 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.<sup>2</sup> Much of this debate has revolved around the question 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?<sup>3</sup> Several economists think that measurement may be an important piece of the solution to the puzzle.

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<sup>1</sup> 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 digital economy as including both information technology and electronic commerce.

<sup>2</sup> 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 1970's.

<sup>3</sup> The productivity paradox was first articulated by Solow (1987). Recent discussions of the productivity paradox include Diewert and Fox (1998), Gordon (1998), Jorgenson and Stiroh (1999), Sichel (1999) and Triplett (1999). Note that the productivity slowdown was not limited to the U.S., but was seen broadly across industrialized countries.

In addition, the IT revolution has raised questions about the ability of the Federal statistical system to keep up with the 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 and 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 demonstrated to provide very good information about the movements over the business cycle of production, aggregate demand and its components, income, and prices.<sup>4</sup>

The digital economy is not a standard classification for economic data, so 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 and related equipment, a component of nonresidential fixed investment, was \$233 billion in the first quarter of 1998, or 2.7 percent of GDP. Preliminary estimates of private investment in software suggest that it is about \$100 billion or a little more than 1 percent of GDP. At this point, 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 tended to be 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 amounting to perhaps tenths of a percent per year, but which 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.<sup>5</sup> In the case of computers, its contribution to the percent change of GDP can be approximated by simply excluding the computer components in the various sectors of GDP (e.g., producers’ durable equipment, personal consumption expenditures, government

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<sup>4</sup> See Grimm and Parker (1998).

<sup>5</sup> See Landefeld and Parker (1997).

gross investment, etc.) 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 STAT-USA web site. As shown in table 1 below, the direct contribution of final sales of computers to real GDP growth averaged about 0.1-0.2 percentage point per year from 1987-94, then accelerated to 0.4-0.6 percentage point per year from 1995-98. The acceleration reflected both increases in current-dollar final sales and more rapid declines in computer prices, and suggests that computers have recently become more important to the business cycle.

Table 1  
Real GDP, Final Sales of Computers, and GDP less Final Sales of Computers:  
Percent Changes From Preceding Year

	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
GDP	2.9	3.8	3.4	1.2	-0.9	2.7	2.3	3.5	2.3	3.4	3.9	3.9
GDP less final sales of computers <sup>1</sup>	2.7	3.6	3.2	1.2	-1.1	2.5	2.2	3.4	1.9	2.9	3.4	3.3
Difference	.2	.2	.2	.0	.2	.2	.1	.1	.4	.5	.5	.6
Final sales of computers, total	24.2	20.5	13.7	6.9	14.6	24.8	21.0	14.9	48.3	63.1	55.3	62.5

<sup>1</sup> For some components of final sales of computers, includes computer parts.

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 had been 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 persons 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 multi-decade decline in prices and growth in output of computers and peripheral equipment.<sup>6</sup> 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 information technology products, such as semiconductors and telephone switching equipment.<sup>7</sup> The BEA has recently worked on developing improved price indexes for some types of software, which it plans to introduce in the comprehensive revision of the national economic accounts scheduled for release in October of this year. 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

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

<sup>7</sup> See Grimm (1998), Parker and Seskin (1997).

overstate growth). Prior to 1996, the national accounts measured changes in “real” (that is, inflation-adjusted) product by measuring changes in product, 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 so that this bias could 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 are 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.<sup>8</sup>

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<sup>8</sup> See Landefeld and Parker (1995, 1997).

## Agenda for Improvements

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 to 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 better capture electronic commerce and its consequences.

*Separating quality change from price change.* I have already mentioned that the BEA intends to improve its measures of the price changes of computer software in this year’s comprehensive revision. Besides computers and peripheral equipment, semiconductors, and telephone switching equipment, there remain 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.<sup>9</sup> As I have mentioned, I view this as largely a problem of data and resource limitations. More cooperation with the private sector, which is often the only source of the detailed data that are needed for measuring quality changes, would be a major step forward. Lacking such data, significant resources would be required to collect the requisite data 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.<sup>10</sup> If the output of these industries can not be measured adequately, then it is impossible to determine the extent to which computers contribute to producing that output. Among the industries that are the most

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<sup>9</sup> 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).

<sup>10</sup> See Griliches (1994), Dean (1999), and Gullickson and Harper (1999).

intensive users of computers are wholesale trade, finance, banking, and 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 by the difference between the interest rates paid by borrowers and those received by depositors. The national accounts presently make an imputation for this service, but it is not clear whether some of this imputed service should be assigned to borrowers (presently it is all assumed to go to depositors), nor is it clear how changes in real services should be separated from price changes. BEA's strategic plan acknowledges that the outputs of these industries are difficult to measure, and that conceptual and statistical improvements are needed.<sup>11</sup>

To the extent that service 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. To the extent that their output is sold to final consumers, however, errors in measuring their output will affect the measure of overall GDP.

To accurately measure the real growth of an industry's output, it is necessary to have either an accurate price index or a quantity index. For services broadly defined (that is, including trade, finance, insurance and real estate, and other services), producer price indexes are either not available at all, or have only become available recently. 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.<sup>12</sup> It would undoubtedly be more

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

<sup>12</sup> See Gullickson and Harper (1999).

realistic to assume that labor productivity has grown as these industries have invested in IT, so it is likely that improved measures of services output would raise the real growth rate.

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

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. 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.

*Accounting for capital stock.* One aspect of information technology that contributes to the difficulty of measuring its effects on the economy is the fact that it often enters the production process in the form of capital equipment.<sup>13</sup> The BEA publishes data on the nation's wealth held in the form of capital structures and equipment, as well as 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

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<sup>13</sup> For discussion of computer capital inputs, see Sichel (1999).

and industry breakdowns) are rather meager. Further progress in replacing assumptions with validated observations is one of BEA's goals in further 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, other forms of knowledge) has been an important omission. In this year's revision, the BEA intends to change the treatment of software in the economic accounts, and begin 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.<sup>14</sup>

*Expanding and updating surveys.* The Census Bureau is working to expand and modernize its surveys to better track businesses involved in electronic commerce and measure 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. For measuring 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 it would not directly be 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, by relying on the increased availability of air and courier services and local trucking to

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<sup>14</sup> See Carson, Moylan, and Grimm (1994).

get its product 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 better capture 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 better capture the growth of business, financial, and high-tech services.

*Using new electronic sources of data.* With the growth of the digital economy, there 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 that are collected. One recent study of coffee prices in two metropolitan markets reported weekly observations of prices and quantities for about 1,200 distinct products.<sup>15</sup> 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.

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<sup>15</sup> See Reinsdorf (1999).

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 work, 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 it is an important contributing factor. Solving these problems is important not only for directly 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 our current plans to improve the measurement of software, all suggest that further progress is indeed possible.

## References

- Carson, C.S., B.T. Grimm, and C.E. Moylan (1994), "A Satellite Account for Research and Development," *Survey of Current Business*, Vol. 74, No. 11, pp. 37-71.
- Cole, R., Y.C. Chen, J.A. Barquin-Stolleman, E. Dulberger, N. Helvacian, and J.H. Hodge (1986), "Quality-Adjusted Price Indexes for Computer Processors and Selected Peripheral Equipment," *Survey of Current Business*, Vol. 66, No. 1, pp. 41-50.
- Dean, E.R. (1999), "The Accuracy of the BLS Productivity Measures," *Monthly Labor Review*, Vol. 122, No. 2, pp. 24-34.
- Diewert, W.E. and K.J. Fox (1998), "Can Measurement Error Explain the Productivity Paradox?" University of British Columbia, ms.
- Gordon, R. J. (1998), "Monetary Policy in the Age of Information Technology: Computers and the Solow Paradox," Northwestern University, paper prepared for the conference "Monetary Policy in a World of Knowledge-based Growth, Quality Change, and Uncertain Measurement," Bank of Japan, June 18-19, 1998.
- Griliches, Z. (1994), "Productivity, R&D, and the Data Constraint," *American Economic Review*, Vol. 84, No. 1, pp. 1-23.
- Grimm, B.T. (1998), "Price Indexes for Selected Semiconductors, 1974-96," *Survey of Current Business*, Vol. 78, No. 2, pp. 8-24.
- Grimm, B.T. and R.P. Parker (1998), "Reliability of the Quarterly and Annual Estimates of GDP and Gross Domestic Income," *Survey of Current Business*, Vol. 78, No. 12, pp. 12-21.
- Gullickson, W. and M.J. Harper (1999), "Possible Measurement Bias in Aggregate Productivity Growth," *Monthly Labor Review*, Vol. 122, No. 2, pp. 47-67.
- Jorgenson, D.W. and K.J. Stiroh (1999), "Information Technology and Growth," Harvard University (to appear in: *American Economic Review*, Vol. 88, No. 2).
- Landefeld, J.S. and R.P. Parker (1995), "Preview of the Comprehensive Revision of the National Income and Product Accounts: BEA's New Featured Measures of Output and Prices," *Survey of Current Business*, Vol. 75, No. 7, pp. 31-38.
- Landefeld, J.S. and R.P. Parker (1997), "BEA's Chain Indexes, Time Series, and Measures of Long-Term Economic Growth," *Survey of Current Business*, Vol. 77, No. 5, pp. 58-68.
- Moulton, B.R. and K.E. Moses (1997), "Addressing the Quality Change Issue in the Consumer Price Index," *Brookings Papers on Economic Activity*, No. 1, pp. 305-349.

- Parker, R.P. and E.P. Seskin (1997), "Annual Revision of the National Income and Product Accounts: Annual Estimates, 1993-96; Quarterly Estimates, 1993:I-1997:I," *Survey of Current Business*, Vol. 77, No. 8, pp. 6-35.
- Reinsdorf, M.B. (1999), "Using Scanner Data to Construct CPI Basic Component Indexes," *Journal of Business and Economic Statistics*, Vol. 17, No. 2, pp. 152-160.
- Sichel, D.E. (1999), "Computers and Aggregate Economic Growth," *Business Economics*, Vol. 34, No. 2, pp. 18-24.
- Solow, R.M. (1987), "We'd Better Watch Out," *New York Times Book Review*, July 12, 1987, p. 36.
- Triplett, J.E. (1999), "Economic Statistics, the New Economy and the Productivity Slowdown," *Business Economics*, Vol. 34, No. 2, pp. 13-17.
- U.S. Department of Commerce, Economic and Statistics Administration, Bureau of Economic Analysis (1995), "Mid-Decade Strategic Review of BEA's Economic Accounts: Maintaining and Improving Their Performance," *Survey of Current Business*, Vol. 75, No. 2, pp. 36-66.
- U.S. Senate, Committee on Finance (1996), *Final Report of the Advisory Commission to Study the Consumer Price Index*, S. Prt. 104-72, 104 Cong., 2 sess., Washington, D.C.: U.S. Government Printing Office.