Measuring the Electronic Economy:
Current Status and Next Steps

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Abstract

The recent growth of consumer retailing over the Internet draws attention to the electronic economy. However, businesses also conduct other business processes over computer networks, and many have been doing so for some time. Uses of computer networks attract attention because of assertions that they lead to new products and services, new delivery methods, streamlined or re-engineered business processes, new business structures, and enhanced business performance. These changes, in turn, potentially affect the performance of the entire economy, including economic growth, productivity, prices, employment, trade, and the structures of businesses, regions, and markets.

Evaluating these assertions, and their effects on economic performance, requires solid statistical information about the electronic economy. This paper develops principles for identifying information critical to measuring the size and evaluating the potential effects of the electronic economy, relates that information to current data collection programs, and notes relevant measurement issues. Some of the required information about the electronic economy can be collected by adding questions to existing surveys, making the scope of existing surveys consistent, or developing new surveys. However, many key pieces of information pose significant challenges to economic measurement. While some of those challenges are specific to the electronic economy, others are long-standing ones. Interest in the electronic economy highlights the importance of continuing attempts to address these challenges. Improving and enhancing the statistical system to provide information about the electronic economy, therefore, would also substantially improve the baseline information available for evaluating the performance of the entire economy.

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Table of Contents

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I. Introduction

The recent growth of consumer retailing over the Internet draws attention to the electronic economy. However, businesses also conduct other processes over computer networks, and many have been doing so for some time. Uses of computer networks attract attention because of assertions that they lead to new products and services, new delivery methods, streamlined or re-engineered business processes, new business structures, and enhanced business performance. These changes, in turn, potentially affect the performance of the economy as a whole, including economic growth, productivity, prices, employment, trade, and the structures of businesses, regions, and markets.

Evaluating these assertions requires solid statistical information. The first requirement is for basic information about the dimensions of the electronic economy, such as the number and kinds of businesses participating in it, and the value of the products and services those businesses produce. The federal statistical system is just beginning to collect this kind of information. Assessing the effects of the electronic economy requires information about both the electronic economy and baseline information about the entire economy. The federal statistical system currently collects detailed information from businesses and households. Current baseline statistics, however, are not uniform: the amount of information and level of detail collected, and the presence of important measurement problems, vary across economic sectors. Understanding the ways the electronic economy affects the performance of businesses and the economy requires expanding and improving the current set of baseline information.

This paper develops principles for identifying the key additional pieces of information needed to measure the size and evaluate the potential effects of the electronic economy, relates that information to current data collection programs, and notes relevant measurement issues. Some of the required information about the electronic economy can be collected by adding questions to existing surveys, making the scope of existing surveys consistent, and developing new surveys. However, other key pieces of information pose significant measurement challenges. While some of those challenges are specific to the electronic economy, many are difficult and long-standing ones. Interest in the electronic economy highlights the importance of addressing these challenges. Many of the improvements needed to provide information about the electronic economy would also substantially improve the information available to evaluate the performance of the economy as a whole. The discussion highlights these enhancements and expansions of the Census Bureau's existing measurement program.

The paper is a companion to a recent Census Bureau paper that proposes definitions of electronic business (Mesenbourg 1999). As with the definitions in that paper, this framework is presented for discussion purposes, is based on reviews of available information and consultations with interested professionals, and is intended to provide a framework for developing official statistical measures and data products. Comments and suggestions are requested.

II. Definitions

Measuring the electronic economy requires defining it. The Census Bureau has developed preliminary definitions of three key components of the electronic economy: electronic business, electronic commerce, and the infrastructure for electronic business. These definitions are presented in greater detail in Census Bureau papers (Mesenbourg 1999 and 2000; see also Fraumeni, Ehmann, and Lawson 1999). Similar elements are being presented by other national and international agencies, such as Statistics Canada (1999) and the OECD (1999).

- Electronic business (e-business) is any process that a business organization conducts over computer-mediated network channels. Business organizations include any for-profit, governmental, or nonprofit entity. Examples of these processes are on-line purchasing; on-line sales; vendor-managed inventory; production design and control; on-line logistics; customer support; employee training; and recruiting.

- Electronic commerce (e-commerce) is any transaction completed over a computer-mediated network that transfers ownership of, or rights to use, goods or services. Transactions occur within selected electronic business processes. Transactions are Acompleted@ when the agreement between buyer and seller to transfer the ownership or rights to use goods or services occurs over computer-mediated networks. Only priced transactions will be measured.

- E-business infrastructure is the economic infrastructure used to support electronic business processes and conduct electronic commerce transactions. It includes the capital (hardware, application software, human capital, and telecommunication networks) used in electronic business and commerce.

A key feature of the Census Bureau definitions of electronic business and electronic commerce is that both require not just computers alone, but the use of computer-mediated networks.

- Computer-mediated networks are electronically linked devices that communicate interactively over network channels. A variety of devices may be linked, including computers, Internet-enabled cellular telephones, and telephones linked with interactive telephone systems. Such links generally involve minimal human intervention, although some businesses are providing customers with capabilities for on-line or Internet telephony conversations with customer support representatives. Networks include Internet, Intranets, Extranets, Electronic Data Interchange (EDI) networks, and telecommunication networks. These networks may be open or closed.

This flexible definition of computer-mediated networks includes both the kinds of networks that companies have been developing and using for a number of years, and the more recent Internet-based networks. Within this definition, data collection and processing are able to focus on specific technologies, such as retail transactions over the Internet, when such focus is appropriate. The definition is flexible, including new and emerging electronic communications devices, such as computers, personal digital assistants, Web-TV, internet-enabled cellular telephones, and interactive telephone systems, as well as devices yet to be developed.

Differences in definition matter. For example, a narrower definition that singles out a specific technology may apply to relatively few users in any industry or sector, making it more difficult to collect reliable estimates from a given sample. It would also preclude collecting the information needed to track the use of evolving technologies. Broad definitions that permit a range of technologies and applications make it possible to collect the information needed to track whether businesses typically transition to Internet-based processes from closed or proprietary systems (such as EDI), or move there directly from traditional (e.g., non-networked, or non-computer mediated) processes.

III. Questions about the Electronic Economy

The federal statistical system currently collects detailed information from households and businesses. However, it is just beginning to collect information on the electronic economy. The additional statistical information that is needed depends on the sets of questions being asked (for example, Haltiwanger and Jarmin 2000; U.S. Department of Commerce 1998 and 1999; Triplett 1999a; Atrostic, Colecchia, and Pattinson 2000). Many questions about the electronic economy are related to questions about the overall economy that the present system of economic statistics already is called on to answer. The first major group of questions focuses on describing the dimensions of the electronic economy. The second major group of questions is about the impact of the electronic economy on businesses, workers, sectors, regions, and the entire economy.

A. Dimensions

Primary dimensions of the electronic economy are its size and characteristics, and how it is distributed over businesses, industries, regions, and time. Separate sets of questions about the dimensions of each component of the electronic economy include:

Electronic Business Processes

- What electronic business processes are used?
- How pervasive is this use?
- How are the electronic business processes used, e.g. to integrate business operations?
- What are the characteristics of the economic actors engaged in electronic business processes?

- What proportion of the entire economy is made up of people, firms and organizations using electronic business processes?

Electronic Commerce Transactions

- What is the value of electronic commerce transactions in specific industries and sectors?
- What are the characteristics of the economic actors engaged in electronic commerce transactions?
- Which products are purchased or sold?
- Do the electronic commerce transactions represent intermediate or final demand?

Electronic Business Infrastructure

- How large is the electronic business infrastructure (that is, the stock of electronic business capital)?
- How large are its components (e.g., hardware, software, human capital, and telecommunications networks)?
- How much is invested in electronic business capital each year?
- How is this investment distributed among the components of electronic business capital?
- What are the depreciation rates for the physical and human capital components of electronic business?
- How do the stocks and investment flows vary by economic actor, industry, sector, and region?

B. Impacts

Assertions about its anticipated impacts on businesses, government organizations, and society drive interest in the electronic economy. They also lead to two related sets of questions about it. First, data users, researchers, and policy-makers want to know how the electronic economy affects individual businesses and other economic actors. Second, they want to know how it affects the performance of industries and sectors, and of the economy. Both sets of questions seek an understanding of the underlying economic mechanisms through which the electronic economy makes its effects felt.

While these are important policy and research questions, they also are inherently difficult to answer. Understanding the impact of the electronic economy on the performance of individual businesses and on the overall economy is a fundamentally different task from measuring the size of the electronic economy. Concepts such as size can generally be measured directly. Statistical agencies can collect and process the necessary data, and release an estimate. However, assessments of the electronic economy's impact on such key performance measures as productivity can not be measured directly. Instead, these assessments are based on inferences

developed by data users applying analytical and econometric models to information on both productivity and on the use of electronic business processes. Estimating these models is especially difficult when it requires addressing long-standing challenges to economic measurement, and filling existing, as well as new, information gaps.

For example, consider the questions of how adopting electronic business processes affects costs for establishments operating in a particular industry. Economists would typically estimate an econometric model of costs. The model would include as explanatory variables available information on factors hypothesized to affect costs, including a measure of the use of electronic business processes at each establishment. Estimating the relationship between electronic business processes and costs requires statistical agencies to provide data on the costs businesses incur in producing the goods or services they sell, and on their use of electronic business processes.

For some sectors, particularly manufacturing, detailed information on costs are collected from well-defined economic units (e.g., establishments) on an annual basis. However, less information is available for other sectors. The same concept of economic unit may not apply across all economic entities included in a particular industry survey, and the basic concept of economic unit may differ across surveys in non-manufacturing industries. In addition, there is less detailed information on the components of costs. This lack of detail makes it difficult to assess how using electronic business processes affect a business' costs.

Business processes also pose a challenge. Rarely, if at all, is information collected on whether businesses conduct specific business processes (such as sales, inventory management, procurement, or recruiting) themselves, or outsource them. Information on whether the processes are conducted through traditional processes (such as whether procurements are made through direct sales calls or ordered from catalogs) or electronic business processes, is even more rare. But such information is required to identify, for example, how electronic business processes are affecting costs.

1. Individual businesses

The primary economic impacts of the electronic economy are expected to manifest themselves at the level of individual businesses and other economic actors. New ways of doing business are emerging as businesses review and redesign their activities to take advantage of electronic processes that reduce the costs of acquiring, managing, and sharing certain kinds of information. These reductions in the costs of sharing information could also change the boundaries of the firm. It may become possible to outsource parts of operations that were once conducted internally or routed through highly specialized intermediaries. Electronic business processes, therefore, have the potential to alter the supply chains for many goods and services. For individual businesses, the use of electronic business processes potentially affects what they purchase, what they produce, the way they produce it, their marketing and selling activities, and their productivity and profitability.

Questions about the impacts on specific businesses and other actors include:

- How does electronic business change a business' profits?
- How does electronic business change a business' productivity?
- How does electronic business change a business' product mix?
- How does electronic business change what a business purchases?
- How does electronic business change a business' capital stock?
- How does electronic business change a business' demand for different types of labor?
- How does electronic business change the prices a business gets for its products?
- How does electronic business change the prices a business pays for its own purchases?
- How does electronic business change inventory, procurement, and other supply chain practices?
- How does electronic business affect the existence and role of intermediaries?
- How does electronic business change the boundaries of the business, e.g. through outsourcing and vertical integration?
- How does electronic business change the costs of getting products to market?
- How do these impacts vary over time and across businesses, regions, and industries?

2. Aggregate effects

Whether electronic business has brought about "a new economy" remains an open question. The importance attached to answering it can be seen in the steady stream of reporting in the financial media and in major new research endeavors at research institutions and government agencies. The improvements in information technology (IT) and software, and the new electronic business practices that they permit, like other technological changes, are diffusing throughout the economy. The previous section noted that characteristics of individual businesses might change because they invest in electronic business infrastructure and adopt electronic business processes. Changes in the characteristics of individual businesses, in turn, could lead to changes in the characteristics of broader economic entities of which they are a part, such as industries, sectors, and countries. These broader changes could affect a range of aggregate measures of economic performance, such as economic growth; productivity; price, employment, and wage levels; and international trade balances. Among these measures of economic performance, policymakers, data users, and researchers all pay particular attention to productivity growth because of its close relationship to rising living standards and sustainable rates of economic growth (see, for example, Blinder 2000).

Key questions about how the electronic economy affects measures of aggregate economic performance include:

- How does electronic business change productivity and economic growth?

- To what extent do electronic commerce sales simply substitute for sales at traditional "bricks and mortar" or mail order outlets, and how does this vary across industries and regions?
- How does the use of electronic business vary across regions and countries, and how does this affect the competitiveness and relative economic performance of regions?
- How does electronic business change the boundaries of industries and sectors, e.g. retail and wholesale?
- How does electronic business alter the flows of commodities through sectors of the economy, from raw through finished materials (i.e., the input – output structure of the economy)?
- How do electronic commerce and electronic business change prices in industries, sectors, and the economy as a whole?
- How does electronic business change the labor force – the nature of jobs, how jobs are distributed across industries, the skills required to perform those jobs?
- How do electronic commerce and electronic business change the competitiveness of markets?
- How do electronic commerce and electronic business affect international trade flows?
- What are the specific mechanisms and factors through which all these changes operate?

IV. From Questions to Data

Questions about the electronic economy range broadly. This section links those questions to the statistical information needed to begin addressing them, to ongoing economic data collection programs of the Census Bureau and other statistical agencies, and to important measurement issues. The linkages are illustrated for two key questions, the size of the electronic economy, and its effects on productivity. While these are only two examples from a constantly evolving list of questions about the electronic economy, they apply broadly because much of the information needed to address them is the same information needed to address other important questions, such as its effects on prices, employment, and economic growth. The examples illustrate a conceptual template that can be expanded or deepened as new questions arise that require new or modified statistical information. Although information provided by several statistical agencies typically is needed to address many of these questions, this paper focuses on the economic data collection programs of the Census Bureau.

The distance between these relatively abstract questions and the presence or absence of specific items in current economic data collection programs is large. To bridge that distance, the following sections first give a brief overview of two distinct, but complementary, analytical approaches, the micro and macro approaches. The way each approach would use existing economic information to address size and productivity questions is illustrated first for existing data and then supplemented with specific examples from the electronic economy. The examples are based on publicly available information about three computer manufacturers (Acer, Compaq, and Dell) and their use of electronic business processes.

A. Two Approaches

Addressing the kinds of questions posed in the preceding section typically requires two complementary approaches. Some of these economic questions can be addressed using aggregated (macro) data, at any of several levels of aggregation, such as the national level, or specific sectors or industries. Major economic indicators, such as Gross Domestic Product, the unemployment rate, and retail sales, provide frequent updates on aggregate behavior. Addressing other questions, such as the distribution of outcomes among businesses in a given industry, or between businesses using a specific electronic business process and those that do not, requires information at the level of the individual business (micro data). Because aggregate economic statistics typically are developed from micro data, there is potential for significant feedback and improvement from research that identifies or resolves issues at the macro and micro levels.

Both size and productivity can be estimated for individual firms or establishments (the micro level), and for industries (the macro level). Size at the micro level is measured directly from surveys and censuses of businesses. These data collection instruments are just beginning to include the information needed to identify the electronic economy separately. Size at the macro level is measured by aggregating data collected in economic censuses and surveys, and by model-based estimates for concepts such as gross product and gross output. While the current macro level baseline captures the output of the electronic economy, it typically can not identify that output separately. Productivity at both the micro and macro levels is estimated from model-based calculations. Developing measures of the productivity of the electronic economy and information for assessing its impact on the productivity of other economic sectors or actors will require modifying and enhancing those models. Estimating the size and productivity of the electronic economy requires enhancing the data available for the baseline macro and micro approaches. Both approaches are discussed in greater detail in the following sections.

B. Example: Size

The size of the electronic economy receives intense scrutiny in the media. In the absence of official statistics, private estimates abound, and diverge from each other by as much as a factor of ten[1]. Measures of the size of the electronic economy matter for several reasons. Policy makers and data users want to gauge the magnitude of the emerging electronic economy. For this, they require credible estimates of its size. Important economic policy questions also require accurate estimates of the size of electronic commerce and electronic business. For example, the rising volume of sales over the Internet may affect the administration of state and local sales taxes; and telecommunications, international taxation, and international trade policies. However, while electronic commerce sales are already captured in official statistics, they simply can not be identified separately. Companies that sell online already report online receipts as part (or all) of their total receipts, but the statistical system is only beginning to ask companies to report online receipts separately.

[1] See Table A1 in the Appendix. It presents illustrative private estimates of electronic commerce transactions in the United States. It also presents the Census Bureau's first official statistics on electronic commerce sales in the retail sector in the 4th quarter of 1999 and the 1st quarter of 2000.

There are several ways to measure the "size" of an economy or economic sector. The possibilities include the number of businesses, the size of their workforces, as well as the amount they produce, that is, their "outputs."[2] Measuring size requires information such as estimates of transactions (both economy-wide and by characteristics such as industry), types of output (or product), class of customer, and region. Output itself could be measured in several ways, including counts of goods or services sold and the value of receipts or shipments. Data collection instruments measuring the value of transactions would need to include questions on whether the business engages in various types of transactions (e.g., electronic vs. non-electronic) and on the value of those transactions. Information needs for the micro and macro approaches to measuring "Size" are illustrated in Table 1. The "Information Needs" column gives specific examples of the kinds of information needed to develop micro and macro measures of output.

To see how the size of the electronic economy might be measured at the business, industry, and economy wide levels, an example from personal computer (PC) manufacturing is helpful. Case studies of several PC manufacturers show their diverse corporate and distribution structures (see Dedrick, Kraemer and Tsai 1999, Kraemer, Dedrick, and Yamashiro 1999 and Dedrick and Kraemer 1999). Dell, Compaq, and Acer occupy different spaces in the PC value chain. Acer is a vertically integrated producer that makes many of the components it puts into its PCs (see Dedrick, Kraemer and Tsai 1999). Compaq is also relatively integrated vertically, especially after purchasing component makers Digital Equipment and Tandem Computers in the late 1990's. Dell, on the other hand, manufactures only the final PC from parts and components obtained from suppliers (see Kraemer, Dedrick, and Yamashiro 1999).

The three firms differ markedly in how they distribute the PCs they manufacture. While Compaq and Acer recently began selling over the Internet, both sell primarily through traditional PC marketing channels (e.g., to distributors, value-added resellers, retailers, and system integrators). Dell, by contrast, ships directly to the final business or household customer, avoiding the traditional PC distribution network. Dell takes orders by phone and via its Web site. Electronic orders enter directly into Dell's integrated vendor-managed inventory, manufacturing process control, and order fulfillment systems.[3]

In developing information on the size of the PC industry, the output of each PC manufacturer would be summed together. To estimate the size of electronic commerce in the PC industry, firms would need to be asked to report separately on the portion of their sales that were made electronically. This information is useful at the micro level in understanding the link between the use of electronic business processes, such as electronic inventory management and electronic customer support systems, and business and industry performance. It is useful at the macro level in providing measures of the value of electronic commerce transactions and in developing measures of the contribution of the electronic economy to GDP.

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[2] Set aside for purposes of this illustrative example are any issues of double-counting outputs or limiting measurement to "final-outputs," and any discussion of issues associated with output being defined differently in different industries or sectors.

[3] This example ignores any complementary products or services sold by the companies.

It is important to understand how macro measures are developed in official statistics. The value of output of specific industries, such as the manufacturing and retail sectors, are themselves official statistics. Collecting the kinds of additional information discussed above and shown in Table 1 can develop parallel estimates of the value of online sales in those sectors.

However, the output of PC and other manufacturers, and the output of other economic actors in the value chain, including their online outputs, can not necessarily be added together directly to develop an estimate of their contribution to Gross Domestic Product (GDP) in the National Income and Product Accounts. To see this, consider a stylized example of the traditional value chain for manufactured products. Manufacturers purchase raw materials, energy, labor, and other inputs (including services such as electronic business processes) and then add value by transforming them into manufactured products. Their products could be sold for use as inputs in further processing elsewhere, or could be destined for ultimate use by households (consumption), businesses (investment), government, or exported. Adding together the value of outputs from each step of the manufacturing process would count the same basic input (for example, raw silicon, a computer component, or an automated inventory service) several times over. Moreover, the amount of double counting would vary among manufacturers in the PC example, because their degrees of vertical integration differ. Standard national income accounting practices address and prevent such potential double- (and multiple-) counting.

Electronic commerce also alters some underlying assumptions about the components of components of GDP. In the traditional value chain, manufactured products are routed through the wholesale and retail sectors before being sold to the ultimate user and entering final demand in GDP calculations. Consumption by households is by far the largest component of GDP. Thus, sales at retail establishments are a primary input to GDP estimates. However, as the PC industry example demonstrates, electronic business and electronic commerce make it possible for products to reach their final users without passing through the standard wholesale and retail sectors. Dell and other PC manufacturers supply final demand directly by selling to PC users at businesses and households. Because the example of the PC industry is well documented, statistical agencies have made allowances for it, and national income accounting practices again avoid double counting. The full value of Dell's sales directly to final users is included in GDP. But Acer and Compaq also sell through the marketing channel (that is, through distributors, re-sellers, retailers, etc.). The full value of Acer and Compaq's sales is included in GDP, but only the marketer's margin. Because electronic commerce and electronic business processes are likely to bring similar changes to other industries, statistical agencies must meet the challenge of continuous monitoring.

Table 1

Macro and Micro Approaches to Measuring Size

Question	Measure (Agency)	Information Needs	Methodology	Current Status	Gaps and Challenges
Micro Approach (establishment, enterprise (or firm), or enterprise segment)					
Size	Output (Census)	Shipments Sales/Receipts Value put-in-place Distribution margins By: Method of selling Class of customer Industry	Direct estimates of totals from: Economic Censuses; Annual, quarterly, and monthly surveys	Economic censuses cover all sectors Economic surveys: Coverage and questions vary by industry Electronic commerce detail for some annual surveys.	*Gaps:* Coverage and specific questions vary by industry *Challenges:* Reporting units differ among censuses and surveys Appropriate reporting unit may be plant, firm, or something in between Measuring output in services sectors
Macro Approach (industry, sector, nation)					
Size	Gross Product Gross Output (BEA)	Sales of goods and services Investment Net exports Government consumption expenditures and gross investment Detail on: - Method of selling - Class of customer Industry Prices	*A combination of:* Direct estimation from: Economic Censuses; Annual, quarterly, and monthly surveys *And* Indirect (model-based) estimates using these, and other, sources	All sectors and industries covered Detail varies by industry	*Gaps:* Some sectors available only in highly aggregated form due to source data limitations. *Challenges:* Measuring output in services sectors – e.g., banking, the information sector. Measuring nominal output for services – price deflators.

Table 1 also gives the status of current data collection and lists some of the data gaps and measurement challenges associated with each measure. In the case of PC manufacturing, there are relatively few major gaps or measurement challenges. However, major data gaps and measurement challenges for sectors outside manufacturing increase the difficulty of valuing the contribution of the electronic economy. Statistical agencies have found it difficult to value the outputs of many service sector industries. For example, measuring the output of industries such as banks, wholesale trade, business consulting services, and hospitals, poses long-standing and difficult problems (see, for example, Griliches 1992 and Triplett and Bosworth 2000). Yet many of these industries are believed to among those most significantly affected by the electronic economy. In the case of banks, the range of services (outputs) they provide expanded as banks increasingly invested in electronic business infrastructure and adopted electronic business practices. Statistical agencies need to improve their measures of the baseline value of output for these poorly measured sectors of the economy before they can provide accurate measures of the size of the electronic economy.

C. Example: Productivity

The electronic economy's effect on productivity is a major economic policy question. The U.S. economy is currently undergoing a prolonged period of expansion. A notable feature of this expansion has been a lack of any serious inflationary pressure. The lack of strong inflationary pressures has allowed monetary authorities to avoid larger interest rate increases. One reason cited for this happy circumstance is that productivity improvements due to information technology and the growth of the electronic economy outpaced increases in wages.

What evidence is there to support this conclusion? And how much of that support is specifically due not just to the use of computers, but to the use of *networked* computers in electronic commerce and electronic business processes? Not long ago, data users, researchers, and policymakers struggled to explain the so-called productivity paradox[4]. A number of explanations have been offered (for example, Triplett 1999b offers eight). Some of those explanations point to measurement gaps and to challenges facing official statistics. For example, one explanation is that official statistics do not capture all the changes in output, quality, and cost savings associated with investment in information technology and, thus, understate its impact (see, for example, Siegel and Griliches 1992 and Diewert and Fox 1999). Other explanations, however, suggest the paradox stems from lags in technological diffusion, not from problems with the economic measurement system. For example, information technology could be compared to other important innovations in the economy, such as electrification (see David 1990 and Greenwood and Yoruglu 1997). The earlier innovations had considerable lags between investments and eventual productivity increases.

Recent economic research suggests that investment in computer hardware may have played an important role in U.S. economic growth in the 1990s. Examples include Greenan and

[4] The reference is to a statement by Solow (1987) that "you can see the computer age everywhere but in the productivity statistics." See also Berndt and Morrison (1995). Brynolfsson and Yang (1996) and Triplett 1999b review the literature examining the link between information technology investments and productivity.

Mairesse (1996), Brynjolfsson and Hitt (1995 and 1996), and Dunne, Foster, Haltiwanger and Troske (1999), Blinder (2000), Jorgenson and Stiroh (2000), and Oliner and Sichel (2000). Oliner and Sichel (2000) note that electronic commerce and electronic business could be responsible for a small part of that growth.

What additional information is required? Measuring productivity using either the micro or macro level approaches requires information on what businesses produce, and on the inputs—capital, labor, materials, energy, purchased services—businesses use to make products and provide services. Abstracting considerably from the complex set of estimations and computations underlying official productivity calculations (see BLS 1997), productivity is calculated by dividing real output quantities by real input quantities[5]. Labor productivity is calculated by comparing output to labor inputs, and is generally expressed as output per hour. However, many factors besides labor affect the growth of output. Multi-factor productivity measures address the joint effects of all these factors. Multi-factor productivity estimates compare an index of outputs to an index of inputs. That is, an index of outputs (deflated by an output price index) is divided by weighted values of a set of inputs (deflated by the appropriate input price indexes). Outputs are usually measured by values of shipments or receipts. Inputs include the costs of labor (wages and non-wage payments and benefits), as for labor productivity, and also include the costs of factors such as capital (including computers and software), energy, purchased services, and materials.

As was true for measures of the size of the electronic economy, the statistical system faces data gaps and measurement challenges in providing the information needed to improve baseline measures of productivity and to identify the specific effects of the electronic economy. Table 2 shows these information needs, data gaps, and measurement challenges at both the micro and macro level. For some sectors such as manufacturing, there are relatively few data gaps or measurement challenges in baseline labor productivity measures. But further detailed information on inputs is needed to calculate macro level multi-factor productivity for all sectors. To identify the effects of the electronic economy, additional information on the use of electronic commerce and electronic business processes would be required for all sectors.

The example of the PC manufacturers helps make clear how the information needs differ for analyses using the macro and micro approaches. For analyses using the macro approach, statistical agencies have several options about the way they collect information on inputs and outputs from businesses like the PC manufacturers. They do not need to collect both pieces of information from the same business, or to collect the information in such a way that data users can always link the inputs and outputs of the same business. Maintaining the linkage between each business' inputs and outputs is not required because analysts use each piece of information separately to construct aggregate statistics on, for example, industry output and industry input. Analysts use these aggregated data to estimate productivity characteristics of the industry, region, or nation.

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[5] Developing appropriate price indexes to calculate these real input and output indexes also requires addressing many data gaps and measurement challenges. However, these important components of the information needs for productivity statistics are not addressed in this paper because data for price statistics are not collected in Census Bureau statistical programs.

However, analysts may not want to rely solely on aggregate data. Constructing aggregate statistics on industry output and input implicitly assumes there is a "typical" firm, and that its behavior is described accurately by statistical averages. But as noted earlier, Acer, Compaq, and Dell differ considerably in a number of important dimensions. This heterogeneity is reflected in their spending on specific kinds of purchased materials, their use of outsourcing, domestic vs. foreign production, capital stocks, organizational structure and the types of workers they employ. What we want to understand is how investments in electronic business infrastructure and the adoption of electronic business practice impact productivity independently of other dimensions of establishment and firm heterogeneity that may be changing at the same time. For this purpose, many of the most interesting potential impacts on productivity are likely to be found at the establishment or firm level.

Analyzing aggregated data for the PC industry will not improve our understanding of how the characteristics of any of the firms, or their use of electronic commerce and electronic business processes, affects their productivity in producing PCs. What is needed are micro data studies that rely on the joint availability of information about inputs and outputs for each economic unit. Detailed econometric analyses using establishment and firm level micro data have contributed substantially to enhancing our understanding of basic stylized facts about businesses. For example, Caves 1998 reviews the new insights about turnover, productivity, and efficiency gained from research using micro data about businesses. Studies such as those done at the Census Bureau's Center for Economic Studies (e.g., Foster, Haltiwanger, and Krizan 1998, for productivity) [6] are an excellent way to leverage data collected by statistical agencies to address these types of questions.

Productivity analyses using the micro approach require that the input and output data used to construct productivity measures apply to the same productive unit. Thus, to the extent feasible within respondent burden and resource constraints, statistical agencies should collect both items from the same respondents. For most businesses, this may not be an issue since they are small, produce few products or services, and have only one physical location. The situation is more complicated for large companies that produce multiple products and have multiple locations. For these large firms, at least for some industries such as manufacturing, data collected at the establishment level may be more appropriate for productivity analyses since the establishment is the productive unit. Also, establishment data provide the richer industry and geographic detail needed by other data users (for example, BEA needs such detail to construct its input-output tables (see, Lawson 1997)).

[6] The Center for Economic Studies (CES) is a research unit of the Office of the Chief Economist, U.S. Bureau of the Census, established to encourage and support the analytic needs of data users, researchers, and policy makers throughout government, academia, and business. At CES, approved researchers can access confidential Census data in a secure environment.

Table 2

Macro and Micro Approaches to Measuring Productivity

Question	Measure (Agency)	Information Needs	Methodology	Current Status	Gaps and Challenges
Micro Approach (establishment, enterprise (firm), or enterprise segment)					
Impact	Productivity (Census -- Center for Economic Studies)	Output – as in Table 1 Inputs: Labor (e.g. payroll, hours) Other inputs (e.g. capital services, materials, energy) E-commerce, e-business processes	Model-based estimates of labor and multi-factor productivity (MFP) at the business level using: Economic censuses Annual, quarterly, and monthly surveys	Several studies completed for manufacturing. New studies for selected other sectors just started, subject to data gaps and measurement challenges.	*Gaps:* Limited information (e.g., detail on nonlabor inputs) in sectors outside manufacturing. None on use of e-business processes. *Challenges:* Capturing changes to the structure of firms, such as vertical integration and contracting-out.
Macro Approach (industry, sector, nation)					
Impact	Productivity (BLS)	Output – as in Table 1 Inputs: Labor (e.g. payroll, hours) Other inputs (e.g. capital services, materials, energy) E-commerce, e-business processes	Model-based estimates of labor and multi-factor productivity (MFP) at the industry and national level using: Economic censuses Annual, quarterly, and monthly surveys Other non-Census data	Labor productivity estimated for all sectors MFP not estimated for services	*Gaps:* Lack of detailed information on inputs to calculate MFP for industries outside manufacturing *Challenges:* Measures of inputs, outputs, prices

The additional information needed to address the electronic economy's effects on productivity varies among industries because the baseline statistical programs that cover them differ. For some industries, such as manufacturing, the Census Bureau and other statistical agencies are already collecting many of the baseline items needed to compute establishment-, firm-, or industry-level productivity measures. The primary data gap is associated with the electronic economy. In these industries, adding information on electronic commerce, electronic business practices and electronic business infrastructure at the establishment or firm level would allow researchers to statistically test for the effect of the electronic economy on productivity using *either* the micro *or the macro* approach.

In many other industries and sectors, however, baseline productivity measures at the micro and macro levels face significant data gaps. Estimating the effect of the electronic economy for these industries will require improving the baseline as well as adding information about electronic commerce, electronic business process, and the electronic business infrastructure. There are several kinds of baseline data gaps. In some of these industries, it is possible to obtain industry-level estimates of inputs and outputs. However, differences in the concepts of respondent units, or other differences in the source data, may prevent computation of meaningful industry productivity measures. In other industries, some data are available at the industry level, but not enough to create comprehensive benchmarks. Finally, the difficult conceptual or measurement issues facing some industries cause the lack of data. Unfortunately, the latter problem is faced by many industries, such as financial services, where many believe the impact of the electronic economy has been, and will continue to be, large.

D. Other Questions

The analyses in the preceding section, and the entries in Tables 1 and 2, are limited to questions of size and productivity. However, many other potential impacts of the electronic economy are of interest. The example of productivity was chosen for illustrative purposes for two reasons. Productivity is itself an important policy question. Productivity measures also share information demands with other important policy questions, such as economic growth (output is a key component) and prices.

Similar exercises could be done for other questions about the electronic economy, such as its effects on wages or outsourcing. As the example of PC manufacturing suggests, the impact of electronic business on companies' supply chains, including their own degree of vertical integration and use of outsourcing, is of great interest. Internal business processes may become electronic ones, or may shift to external electronic ones. Electronic market places may replace existing supply markets or create new ones. The three companies have significantly different supply chains. Attempting to describe a single chain and attribute it to the "typical" firm would result in the same problems noted above in the discussion of measuring inputs and outputs. The improvements to data collection efforts suggested in the following section apply to many of these important questions, not just to size and productivity.

V. The Electronic Economy in Statistics

The examples in the preceding section illustrate some of the major kinds of information needed to develop one basic statistic about the electronic economy (size), and to begin assessing one of its effects on the entire economy (productivity). This section discusses the primary data gaps statistical agencies must fill, and the measurement challenges that are most important for them to address, to begin painting a statistical picture of the entire electronic economy and its effects. As the range of questions discussed in Section III implies, these statistical requirements are broad.

There are two related, but distinct, statistical requirements: filling key gaps in the statistical baseline, and collecting the additional information needed to measure the electronic economy and model its effects. The first subsection gives a brief overview of both requirements. The remaining subsections discuss separately the enhancements and improvements needed for the three components of the electronic economy (electronic commerce transaction, electronic business processes, electronic business infrastructure). For each component, there are three groups of improvements. Some are straightforward changes to current data collection programs. Others involve more substantial change, or initiating new measurement programs. The third group consists of longer-term improvements that require an initial round of research to identify proposals for specific improvements.

Developing the recommended improvements in this section is a first step. The discussions in the remainder of this section focus on the data collection programs of one statistical agency, the Census Bureau. Guiding decisions about when to enhance current programs, and which ones, and when to initiate new measurement programs, will also require expertise in issues relating to the electronic economy, in current collection and measurement programs, and in the primary measurement challenges facing new and current programs. Gathering this expertise will require cooperation among statistical agencies as well as discussions with data users and with potential economic census and survey respondents.

A. Overview

Providing the statistical information needed to measure the electronic economy and assess its effects will require statistical agencies to focus on gaps and challenges. However, those gaps and challenges vary across economic sectors, among specific data items, and across statistical agencies. This variation reflects the historical development of economic statistics.

1. Overview of Baseline Statistics

The baseline improvements that are relevant for the electronic economy vary among industries and across current data collection programs. An overview of current economic data collection programs is provided in Table 3. It links key economic concepts with the information needed to address them, and with important gaps and challenges statistical agencies face in

providing that information. The first column shows the primary economic concepts (such as inputs and outputs) and the statistical agency responsible for providing the underlying data. The second column gives examples of the kinds of measures that are needed (such as materials used and hours worked, for inputs). The third column notes the major gaps in current data collections, and major challenges in economic measurement for these measures.

Little change is needed in the baseline statistical collections that provide basic statistics on business demographics, such as the number of businesses, their location, their economic activities, and births and deaths. These statistics can be provided for most sectors, as the first row of Table 3 suggests. Similarly, information on shipments and receipts generally is collected for all industries and sectors.

Some of the needed improvements to baseline data collections require relatively minor changes to current programs, and are potential short-term improvements. For example, detailed information on shipments and receipts, such as class of customer and method of selling, are collected for selected industries in censuses and surveys. Depending on the range of differences among businesses in the categories they use to group customers and sales methods, collecting this detail for additional industries may be relatively straightforward.

Other improvements present greater challenges. For example, rows two through five show that increased detail on inputs and outputs is needed in baseline collections for sectors outside of manufacturing. The additional detail is needed to allow assessments of whether, for example, firms conducting electronic commerce transactions or using electronic business processes use different mixes of capital, labor, and materials (or different mixes within each input). Collecting additional detail on inputs might be a relatively straightforward extension of concepts that are well developed for the manufacturing sector. However, while data on inputs and outputs generally are collected for the same conceptual unit (typically the establishment) in manufacturing, the reporting units for surveys of inputs and outputs often differ in other sectors. Research on the conceptually and operationally appropriate statistical unit will be needed. Similarly, measuring output itself is difficult in any industry or sector. The economic measurement community and the statistical system have greater experience measuring output in the manufacturing sector. While substantial progress is being made, developing good baseline measures of inputs and outputs in non-manufacturing sectors presents major challenges for statistical agencies (see, for example, Triplett and Bosworth 2000).

Table 3

Baseline Statistics: Concepts to Data

Concept[1] (Primary Agency) (1)	**Information Needed** (2)	**Current Status, Data Gaps and Measurement Challenges** (3)
Business Demographics (Census)	Number of Firms Number of Establishments Establishment Business Activity (industry, kind of business) Establishment Location Establishment/Firm Births Establishment/Firm Deaths	Information for these items for most sectors is available from the Census Bureau's business register.
Variable Inputs (excluding labor) (Census)	Materials Used Energy Used Producer Services Used Other Inputs	Census and survey coverage for these items is fairly complete in manufacturing. For other sectors, coverage typically less complete. Inputs and outputs are collected in separate surveys in these sectors, so reporting units for input data often differ from those for output data.
Capital Inputs (Census and BEA)	Investment Gross Value of Assets	Enterprise segment-level survey covers all sectors. Industry and asset type information available, but not for establishments outside of manufacturing. Manufacturing has some establishment level data. No vintage or service flow information available. Tangible wealth estimates available for all sectors.
Labor Inputs (BLS and Census)	Number of Workers	March 12th (full and part-time) employment available for the universe of establishments from census, survey, and administrative sources. No annual full-time equivalent estimates collected.
	Hours Worked	Survey data available for some sectors and some types of workers.
	Worker Occupation, Skills (Human Capital)	BLS survey data available. Micro data can not be linked to Census micro data on other inputs and outputs. Occupational classification systems need updating.

(continued on next page)

Concept[1] (Primary Agency) (1)	**Information Needed** (2)	**Current Status, Data Gaps and Measurement Challenges** (3)
	(continued from preceding page)	
	Payroll, Wages, other compensation	Annual Payroll available for all establishments from census, survey and administrative sources. Wages available for some sectors and types of workers. BLS survey data on wages and non-wage compensation available. Micro data can not be linked to Census micro data on other inputs and outputs.
Prices (BLS)	Producer Prices Consumer Prices	Data available from BLS Producer and Consumer price programs. Quality adjustments are important and not yet applied in all cases. Industry level deflators are not well suited for micro data analyses.
Output (Census)	Shipments or Receipts By: Value Physical Quantities Method of Selling Class of Customer Detailed Products or Services	Shipments and receipts data are available at the establishment, enterprise, and/or enterprise segment level from census and survey sources. Revenue information is available for single unit enterprises from administrative sources. Detailed data on products, physical quantities, and class of customer are available for selected industries from the economic census. Recent Census surveys are beginning to ask about method of selling. Although progress is being made, defining and measuring outputs in many non-goods producing industries remains difficult.

2. *Overview of Information Needed about the Electronic Economy*

New information specific to the electronic economy – on electronic transactions, electronic business processes, and the electronic business infrastructure – is needed for all industries and sectors. An overview of information needs for measuring the electronic economy is given in Table 4 using the same format as Table 3.

In many cases, relatively minor changes to data collection programs are already providing initial information on electronic commerce transactions. For example, collecting information on the dollar value of a business' electronic commerce transactions, or their share of the value of its shipments or receipts, are straightforward extensions of current programs that collect information on the value of total shipments or receipts. Many such changes are already underway.

Some potential short-term improvements are minor changes to current data collection programs that would provide additional detail on electronic commerce transactions. Others would be new initiatives that provide basic information on electronic business processes.

Fundamental research on business processes is a pre-requisite to identifying specific proposals to collect information about the use of electronic business processes. Although using electronic business processes is widely thought to drive the effects of the electronic economy, statistical agencies have little experience collecting information on business processes. When Scrooge, Inc., replaced Bob Cratchit's ballpoint pen with a desktop PC in the 1980s, and networked that PC to their mainframes in the early 1990s, such changes in a specific business process (accounting) went unobserved by the statistical system. So, too, did Scrooge's recent shift to automated inventory replenishment for its ballpoint pens, paper clips, and other office supplies. Recent attempts to develop listings of business processes revealed a lack of standard groupings, or classifications, to use in developing economic survey and census questionnaires.

Before statistical agencies can collect information on electronic business processes, they must undertake several specific research endeavors about business processes in general. Research is needed to ascertain the relevant range of business processes that have economic implications. This is a first step towards developing standard categories of business processes. Subsequent research, similar to the research statistical agencies conducted to develop their current industry and product classification systems, will lead to specific lists of business processes to be added to existing measurement programs. Once those lists are identified, information can be collected on the uses of specific processes, and which processes are electronic business processes.

Research also is needed to identify additional information needed to measure the electronic business infrastructure. For example, research might develop measures of the value of annual capital consumption related to the electronic business infrastructure, or the value of annual investment in human capital associated with the same infrastructure. The remainder of this section reviews proposed improvements in greater detail.

Table 4

Electronic Economy: Concepts to Data

Concept[1] (Primary Agency) (1)	**Information Needed** (2)	**Current Status, Data Gaps and Measurement Challenges** (3)
Electronic commerce (Census)	Sales by product or service Purchases by commodity or service Electronic commerce demographics	Recent surveys have begun to collect total e-commerce. E-commerce sales by broad product classes will be available for some sectors.
Electronic Business Processes (Census)	Online sales, customer service, etc. Automated inventory control Information Technology (IT) in production processes Purchases of Electronic business services	Manufacturing establishments will be surveyed on their use of several e-business processes. Currently, no plans to extend this to other sectors. Determining the appropriate reporting unit and whom to contact for different e-business processes may be challenging.
Electronic Business Infrastructure (Census and BLS)	Computer Investment Other IT Investment Stocks of IT equipment Depreciation of IT equipment Vintage of IT equipment Software Purchases IT Research &Development (R&D) Software R&D	Some establishment and enterprise segment information available for computer and software investments. Recent enterprise segment level surveys break investment spending out by asset types including computers. No data available for stocks, vintage or depreciation. Quality-adjusted deflators not yet available for all components of IT investments.

B. Improving Data on Electronic Commerce Transactions

Measuring electronic commerce transactions is a new undertaking for the statistical system. It requires information on the values of sales or shipments, or on purchases, made through electronic commerce. It also requires information about the demographic characteristics of businesses conducting electronic commerce, such as their size, location, and distribution among industries. Information about electronic commerce transactions and the businesses undertaking them is more valuable if it can be compared with parallel information about standard transactions and businesses. This information can be estimated by adding questions about whether businesses conduct transactions through electronic commerce, the value of the transactions, and the specific technologies used, to existing surveys and censuses of businesses. Current efforts at the Census Bureau to estimate the electronic commerce share of sales and purchases in the economy are discussed in the first subsection below. Most of these efforts are new, and will apply to data collected in 2000.

Steps the Census Bureau could take to continue to improve measurement in this area in both the near and longer terms are outlined in the second and third subsections below. (Of course, some important data items, such as measures of the prices of goods and services in electronic commerce transactions, are outside the Census Bureau's scope.) By filling data gaps, and refining and expanding its measurement efforts, the Census Bureau will be able to give data users a much better understanding of important characteristics of electronic commerce. Those characteristics include the amount transacted between businesses, and between businesses and consumers; features of the businesses involved (e.g., size, industry, and region); and how electronic commerce transactions affect the value chain.

1. Improving Data on Electronic Commerce: Current Efforts

- Monthly Retail Trade Survey: asks a sample of retailers to give dollar volume of sales online, and online sales as percent of total sales. Fourth quarter 1999 and first quarter 2000 estimates are available.

- 1999 Annual Survey of Manufactures Supplement: asks sample of manufacturing establishments to give percent of shipments and purchases (of materials and goods) conducted online. Forms for survey year 1999 will be mailed in the summer of 2000.

- 1999 Annual Retail Trade Survey: asks about electronic commerce sales for 1999 and 1998, and whether they make purchases online. Additional information will be collected for non-store retailers, computer and office supply stores, including total electronic commerce sales by class of customer, to non-U.S. customers, and total sales and electronic commerce sales for 11 selected product categories.

- 1999 Annual Accommodations and Food Services Survey: asks about electronic commerce sales for 1998 and 1999.

- 1999 Annual Wholesale Trade Survey: electronic commerce sales for 1999 and 1998, and whether they make purchases online.

- 1999 Services Annual Survey: electronic commerce sales for 1999 and 1998, and product data for selected industries.

2. Improving Data on Electronic Commerce Transactions: Potential Short Term Improvements

Several steps that the Census Bureau could undertake in the near term to improve information about electronic commerce transactions build on its current efforts:

- Evaluate the costs and benefits of changing surveys to collect sales data by both method of selling (e.g., online vs. traditional channels) and class of customer (e.g., consumers, firms).

- Consider adding questions on electronic commerce to the 2002 Economic Censuses.

3. Improving Data on Electronic Commerce Transactions: Strategy for Potential Long Term Improvements

In the longer term, the Census Bureau has more options for improving the information it collects on electronic commerce transactions. Some of those options involve continuing to fill data gaps by collecting additional detail about electronic commerce transactions. Other options would refine related aspects of statistical methodology.

- Options to fill data gaps include:

    ° Fill baseline data gaps by adding separate questions on purchases of materials, supplies, and investment goods to retail, wholesale, and services surveys.

    ° Fill electronic economy data gaps by adding separate questions on electronic commerce transactions of materials, supplies, and investment goods to retail, wholesale, and services surveys.

    ° Work with other statistical agencies to foster the development of appropriate ancillary data items such as price deflators.

    ° Collect information on government purchases conducted through electronic commerce transactions

- Refinements to statistical methodology include:

- Explore alternative ways of collecting the necessary information (e.g., web-based data harvesting).

- Continue to conduct research on the conceptually appropriate reporting unit (e.g., establishment or firm), and whether that varies by sector (e.g., Trimble 1999).

- Conduct research on appropriate respondents within unit (e.g., whether typical respondents in accounting and payroll departments can answer questions about electronic business processes).

C. Improving Data on Electronic Business Processes that are not Transactions

Many observers expect the major changes to come from the electronic economy to result from new electronic business processes rather than from electronic commerce alone. For example, improvements in information technology have allowed many firms to achieve cost savings through better supply-chain and inventory management, process control, and customer support. Improved measurement of electronic business processes will allow data users, researchers, and policy-makers to identify those regions, sectors, industries, and types of firms that participate in this aspect of the electronic economy. These measures will also permit data users and researchers to quantify the importance of electronic business processes for productivity and economic growth. These measures can also be related to measures of electronic commerce and other important economic statistics to examine the impact of the electronic economy on the broader economy. Collecting information on business processes is a relatively new activity for statistical agencies, particularly outside the manufacturing sector, as the second panel of Table 2 shows, and presents measurement challenges (e.g., Fein *et al.* 2000). In some cases, new surveys would be required. Measuring these business services, whether electronic or not, also presents challenges to economic measurement (e.g., Triplett and Bosworth 2000).

1. Improving Data on Electronic Business Processes that are not Transactions: Current Efforts

- The 1999 Annual Survey of Manufacturers (ASM) Supplement will contain several questions about electronic business processes. The answers can be linked to the information reported by the same respondents on regular ASM survey forms, such as the value of shipments, employment, product class shipments, and other information of establishments reporting the presence and the absence of these processes.

2. Improving Data on Electronic Business Processes that are not Transactions: Potential Short Term Improvements

- Extend example of ASM electronic business process supplement to other sectors.

- Incorporate selected electronic business process questions in planning for the 2002 Economic Census.

- Conduct a new Supply Chain survey that would examine evolving relationships among suppliers, customers, and distributors, including electronic markets places and electronic intermediaries.

- Collect information on government use of electronic business processes.

3. Improving Data on Electronic Business Processes that are not Transactions: Potential Longer Term Improvements

- Consider developing a basic listing of electronic business processes (perhaps as part of a larger initiative to list other important business practices). Such a listing would facilitate data collection, processing, and reporting for business processes.

- Determine the most appropriate reporting units for electronic business processes. A new survey of Corporate Information Officers may be an effective way to collect this type of data.

- Re-visit questions periodically to determine their relevance to the current state of the economy.

D. Improving Data on the Electronic Business Infrastructure

Investments in electronic business infrastructure facilitate electronic commerce and electronic business practices. Measures of this investment, its rate of depreciation, and the resulting cumulated stock of infrastructure, will permit statistical agencies, data users, and researchers to quantify its importance to productivity and economic growth (e.g., through input-output tables). Detail about the specific technologies used – EDI, Internet, Extranet, etc. – may also be desired. These estimates would parallel estimates that use newly developed measures of information technology capital and its components to estimate their separate contributions to real output and productivity (see, for example, Jorgenson and Stiroh 2000 and Oliner and Sichel 2000).

1. *Improving Data on the Electronic Business Infrastructure: Current Efforts*

- Assess whether current questions about investment expenditures on computers and software on the ASM and the Business Expenditures Survey (BES) can be used to develop measures of investment in electronic business infrastructure.

2. *Improving Data on the Electronic Business Infrastructure: Potential Short Term Improvements*

- Consider refining and expanding inquiries about investments in information technology beyond current computer and software questions on the ASM and the BES. It may be productive to add questions to the Annual Capital Expenditure Survey. Response quality studies should be conducted to evaluate possible approaches to collecting electronic business infrastructure investment information. These studies should consider questions on the depreciation or obsolescence of the infrastructure as well.

3. *Improving Data on the Electronic Business Infrastructure: Potential Longer Term Improvements*

- Consider constructing a basic classification system for the electronic business infrastructure (for example, hardware, software, and e-business human capital). This work could be part of a larger initiative to classify other types of capital. The system would facilitate data collection, processing, and reporting for business infrastructure much as NAICS does for industry level data.

- Re-visit questions periodically to determine their relevance to the current state of the economy.

- Determine the most appropriate reporting unit for information on the electronic business infrastructure. A new survey of Corporate Information Officers may be an effective way to collect this type of data.

E. Improving Data to Assess the Impacts of the Electronic Economy

The electronic economy is expected to affect many important measures of economic performance. For example, investments in electronic business infrastructure and improved business practices (electronic business) are widely thought to be the driving force behind the current period of sustained U.S. economic growth with low inflation, low unemployment, and rising productivity. Data users, researchers, and policymakers are therefore interested in estimating the electronic economy's contribution to performance measures such as aggregate production and economic growth. Because any benefits of the electronic economy may not be spread evenly throughout the economy, there also is interest in assessing whether such impacts vary across firms, industries, regions, or sectors.

Despite the pertinence of such questions, the federal statistical system currently provides relatively little information to begin answering them. Developing the necessary statistical infrastructure requires both improved baseline measures of some aspects of the entire economy, and new information about the electronic economy. As the examples of PC manufacturers suggests, the effects of the electronic economy are likely to differ among businesses within an

industry, as well as across industries, sectors, and regions. Statistical agencies need to provide data with sufficient detail to estimate these differential impacts by firm size, region, and industry.

1. *Improving Data to Assess the Impacts: Current Efforts*

The Census Bureau currently collects data that is used to construct baseline measures of the performance of the economy against which the impacts of the electronic economy can be assessed. These data are collected in the Bureau's Economic Census and survey programs. They include basic data on the goods and services businesses use, and on what they produce, that are needed to estimate measures such as GDP and productivity[7]. (Of course, data collected by other agencies also are critical components of most of these measures of economic performance.)

Many of the improvements already underway for these programs will enhance their usefulness in assessing the effects of the electronic economy.

- Births of new businesses are now identified and included in the Census Bureau's business register more quickly. A new process reduced the time to nine months.

- The Census Bureau is beginning to collect some information about the electronic economy. It also is conducting research on fundamental changes in business models and their implications for current data collection programs, as described in the preceding sections.

2. *Improving Data to Assess the Impacts: Potential Short Term Improvements*

- Consider improvements to the 2002 Economic Census. These improvements should increase the basic information the Census Bureau collects on core components of GDP and productivity estimates. That information includes the goods and services businesses use, and what they produce. The improvements should focus on sectors where measurement is currently weak (either because relatively little information is collected, or because of the presence of measurement challenges) and the electronic economy is thought to have a large impact such as services; finance, insurance, and real estate; and retail and wholesale trade.

  A specific example already underway is:

  ° A new classification system, the North American Product Classification System (NAPCS) is being developed. NAPCS initially is developing classifications for products sold by service industries in four selected service sectors (information; finance and insurance; professional, scientific, and technical services; and administrative and support, waste management and remediation) in the North American Industry Classification System (NAICS). NAPCS, as was NAICS itself, is being developed jointly with the

[7] These data are used in productivity calculations at several levels of aggregation (e.g., establishment, firm, industry, sector and economy wide).

Bureau of Economic Analysis, the Bureau of Labor Statistics, and the statistical agencies of our North American trading partners.

- Consider improvements to on-going Census Bureau surveys. As with improvements to the 2002 Economic Census, these improvements should focus on improving the baseline data available for economic performance measures in sectors where measurement is currently weak and the electronic economy is thought to have a large impact.

- Efforts are underway to improve the Census Bureau's sampling frame for business surveys (known as the Standard Statistical Establishment List). These efforts should be expanded to study the structure of relationships among the various business units making up the firm, and whether that structure changes over time. That structure can be linked to information collected in economic surveys and censuses about the use of electronic commerce and electronic business processes in the establishments and firms.

3. *Improving Data to Assess the Impacts: Potential Longer Term Improvements*

Over the longer term, the information available for modeling and evaluating the impact of the electronic economy can continue to be improved in further work in several key directions:

- Continue to work on difficult methodological and measurement issues surrounding baseline productivity measurement in the non-goods producing sectors. Selected examples include:

    ° Information on outputs could be improved by developing product definitions and classifications in these sectors, and implementing them in data collections. The product classification project described above (potential short-term improvements) is a pilot project for four selected service sectors. The second phase of that project would extend the product classification system to the products of all goods and services sectors.

    ° As improved product definitions for outputs are developed, corresponding price indexes will be needed to develop measures of real output. Statistical agencies would also have to cooperate to develop the appropriate quality adjusted price indices for these products.

    ° Increase the information collected on inputs in sectors outside manufacturing. The increased information will allow measures of total factor productivity to be calculated for these industries.

- Develop the information needed to assess the impact of the electronic economy on the labor force. Basic questions include the effects on employment and earnings. Information needed would include wages, skills, and occupations of workers participating in the electronic economy.

    ° Information on these measures from the employer perspective might involve new or improved surveys of establishments and firms conducted by the Bureau of Labor Statistics or the Census Bureau. Information on these measures from the worker

perspective might involve new or improved surveys of households and individuals, conducted by the Census Bureau.

- Updated, consistent, and informative occupation classifications are crucial to developing good answers to these questions. The electronic economy may be defined by the skills of its workers, as well as by its capital stock and material inputs. Developing an occupational classification system is another effort that requires cooperation across statistical agencies.

- Link information about employers and employees. Currently there are multiple efforts underway to construct data sets that link information about employers and employees. Employer–employee data sets linked to measures of electronic commerce, electronic business practices, and electronic business infrastructure would be a powerful tool to help data users, researchers, and policymakers understand the impact of the electronic economy on the workplace.

VI. Conclusions

The recent growth of consumer retailing over the Internet draws attention to the electronic economy. But evaluating assertions that the electronic economy, defined by the use of the Internet and other computer networks, drives change in the overall economy requires solid statistical information. Improving baseline measures of the economy and developing measures specific to the electronic economy will provide the required information. All these new and improved measures will also substantially enhance our ability to evaluate the performance of the entire economy.

There are three groups of improvements. Some are straightforward changes to current data collection programs. Others involve more substantial change, or initiating new measurement programs. The third group consists of longer-term improvements that require an initial round of research to identify proposals for specific improvements.

The baseline improvements that are relevant for the electronic economy vary among industries and across current data collection programs. For example, assessing the full impact of the electronic economy on productivity would require increasing the amount of detail on inputs and outputs that is collected in sectors outside of manufacturing. Some of these improvements to baseline data collections require relatively minor changes to current programs, and are potential short-term improvements. Other improvements, however, would require substantial resource commitments. Decisions about pursuing any such improvements could come only after careful considerations of those costs.

New information specific to the electronic economy – on electronic transactions, electronic business processes, and the electronic business infrastructure – is needed for all industries and sectors. In many cases, relatively minor changes to data collection programs would provide initial information on electronic commerce transactions. Many of these minor

changes are already underway. Some potential short-term improvements are minor changes to existing data collection programs that would provide additional detail on electronic commerce transactions. Others would be new initiatives that provide basic information on electronic business processes.

A series of longer-term improvements would continue to improve baseline measures of the entire economy, and would allow better assessments of the impact of the electronic economy. Making these improvements often requires addressing long-standing measurement challenges by conducting research to identify specific proposals for the baseline and for the electronic economy. Baseline research projects might, for example, develop better measures of output in specific industries in the services sector, or begin classifying business processes. Research projects on information about the electronic economy might develop measures of the value of annual capital consumption related to the electronic business infrastructure, or the value of annual investment in human capital associated with the same infrastructure.

The suggestions in this paper are a first step in the planning process. Measuring the electronic economy touches on almost every aspect of the economy. No single statistical agency has the resources and technical expertise to independently resolve all the measurement issues and fill all the information gaps associated with measuring the electronic economy. Cooperation across statistical agencies is required. We invite our colleagues at the Census Bureau and at other statistical agencies, as well as data users and data providers, to provide feedback, corrections, and suggestions to improve this measurement proposal. Please direct your comments and suggestions to the authors, at the e-mail addresses on the title page.

Appendix

Table A1

Illustrative Private Estimates of Electronic Commerce in the United States
Selected Years, 1998 - 2003

		Year (US$ billion)				
		1998	1999	2000	2002	2003
Business - to - Business						
Forecasters[1]	early 1998				300	
Forrester Research[3]	mid 1999	43	109	251	843	1,300
IDC[3]	mid 1999	17	34	67	214	na
eStats[3]	mid 1999	12	23	52	131	na
Zona[3]	mid 1999	24	52	93	na	na
Yankee Group[3]	mid 1999	34	90	171	na	na
Business - to - Consumer						
Forecasters[1]	early 1998			7		
	mid 1999	7 to 15			40 to 80	
Internet retailers[4]	Late 1999		9[5]			
Jupiter[6]	Late 1999		15			
Addendum: U.S. Retail Sales[7]		2,729	2,972			
4th Quarter [8]			821			
4th Quarter electronic commerce [8]			5.2			
1st Quarter [8]				748		
1st Quarter electronic commerce [8]				5.3		

[1] Source: *The Emerging Digital Economy II*, U. S. Department of Commerce, June 1999, p. 5.
[2] *Report for the MITI* (Japan), p. 41, March 1999, cited in OECD (1999a).
[3] eMarketer, cited in Cross 1999.
[4] Kaufman 1999.
[5] November and December 1999, only.
[6] Evans 1999. AHoliday season@ sales forecast at $6 billion.
[7] U.S. Census Bureau, http://www.census.gov/mrts/www/mrts.html (monthly retail sales); http://www.census.gov/mrts/www/data/html/sal99.html (1999 total retail sales).
[8] http://www.census.gov/mrts/www/current.html (4th quarter 1999 and 1st quarter 2000 e-commerce sales).

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