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Abstract

The United States and Japan exhibit striking differences in economic performance in the last decade although both invested heavily in information technology (IT). Recent growth accounting exercises by Jorgenson and Motohashi (2003, 2005) find that the contribution of IT capital services to economic growth in the late 1990s is about the same in Japan as in the United States. Behind the aggregate data in growth accounting lie productivity and IT investment at the firm level. Do the links between IT and productivity depend only on whether businesses use computer networks, or also on how they use those networks? Are these firm-level links the same in each country? Several studies use establishment and firm-level data to study these questions separately for the United States and Japan, or to conduct a comparative analysis of the effects of IT on productivity. However, these comparisons looked only at the presence of IT. No studies directly examined how specific information technologies such as the presence of computer networks or different applications of computer networks affect productivity in the two countries.

This paper presents the first such comparative analysis using firm-level data for the manufacturing sector of the United States and Japan. Computer networks appear to be a general-purpose technology in both countries. Networks, and specific uses of networks, are found across all manufacturing industries, although with much higher diffusion rates in the United States. For each country, the diffusion rates vary across industries and among firms within an industry. Our preliminary results show positive and significant links between computer networks and labor productivity in both countries. However, that link is roughly twice as large for U.S. as for Japanese manufacturers.

How businesses use computer networks may affect productivity. Our findings on these links are preliminary because the data available for the United States and Japan are not strictly parallel. We have data about how businesses use computer networks for all U.S. manufacturing plants but only for Japanese manufacturers that conduct e-commerce. For the United States, coefficients of the intensity of network use are positive and increase with the number of processes, and coefficients of specific uses of those networks are positive and significant for U.S. manufacturing, but none of these coefficients are significant for Japan. These results hold when we expand our sample from single-unit manufacturing firms, which are comparable units in the two data sets, to the entire manufacturing sector in each country, as well as to the wholesale and retail sector of Japan. The next phase of our analysis will use new data to make parallel estimates of the relationship between productivity and how businesses use computer networks using new data on network use by all Japanese manufacturers.

Introduction

Are computer and other information technologies (IT) a driving force of the recent productivity upward shift observed in the United States and other counties? Oliner and Sichel (2000) show that about two-thirds of the 1.5% U.S. productivity revival after 1995 can be attributed to the growth in IT investment. Gordon (2000) argues that the growth in U.S. labor productivity growth is not a structural shift but simply a pro-cyclical movement. In that view, productivity growth is observed only in the sectors that produce IT, while sectors that use IT cannot take advantage of their often substantial IT investments. After the IT bubble burst, U.S. economic growth did slow, but labor productivity continued to be strong. Baily (2002) suggests that the IT investment surge explains a significant portion of the post-1995 productivity revival in the United States.

In contrast, the Japanese economy of the 1990s was mired in unfavorable conditions following the collapse of the bubble economy in the early 1990s. Japan's GDP growth rate averaged 1.4% in 1990s, in contrast to 4.1% in the 1980s. This sluggish Japanese economy is puzzling because Japanese firms also heavily invested in information technology.

Jorgenson and Motohashi (2003 and 2005) conduct growth accounting exercises to compare the role of IT in economic growth in the two countries. They find that IT capital services make similar contributions to economic growth in both countries during the late 1990s. They also find that TFP grows more rapidly in Japan in the second half of 1990s than the first half. As a result, the slow pace of recent Japanese economic growth comes mainly from the negative contribution of labor inputs to GDP growth.

While growth accounting gives a global view on the relationship between IT investments and economic growth, it shows only a snapshot of what happened. Behind the aggregated data in growth accounting lie productivity and IT use at the firm level. Several studies use establishment and firm-level data to study these questions separately for the United States and Japan (such as Atrostic and Nguyen 2004 and 2005b, for the United States; and Motohashi 2001 and 2003, for Japan). One micro data study conducts a comparative analysis of the effects of IT on productivity in the U.S. and Japan (Jarmin and Motohashi 1999), but looks only at the presence of IT. A more recent analysis (Atrostic, Boegh-Nielson, Motohashi, and Nguyen 2004) compares the relationship between productivity and computer networks for Denmark, the United States, and Japan, but the data cover different sectors in each country and econometric specifications differ. No studies have used comparably defined data sets and econometric specifications to examine directly how specific technologies such as the presence of computer networks or different ways of using computer networks affect productivity in the two countries.

The main contribution of this paper is using new firm-level data for the manufacturing sectors of the United States and Japan to test the hypothesis that IT is a multi-faceted technology, where different uses of computer networks are different technologies that shift the production function. Each data set contains information on both the presence of a network in a firm and the specific ways firms use those networks to conduct their business processes. We focus on single-unit firms because those are the most comparable between the two data sets. For each country, we find evidence that computer networks are a general-purpose technology that is used in a variety of applications across industries, such as flexible manufacturing systems and product delivery logistics. Within a firm, network applications are varied, ranging from financial accounting to inventory control and human resource management.

Our preliminary results indicate that there are positive and significant links between the presence of networks and labor productivity in both countries. However, the links between productivity and specific uses of those networks differ between the United States and Japan. Most uses of computer networks in the United States have positive and significant links with productivity, while there are no statistically significant links between specific uses of computer networks and productivity in Japan. The broad findings for single-unit manufacturing firms are similar to those for the manufacturing sector in both countries, and our findings appear to be robust to alternative econometric specifications.

However, while the U.S. and Japanese data on the presence of computer networks are parallel, the data on how businesses use networks are not, so our findings about the productivity links of specific uses of networks are necessarily preliminary. Both the U.S. and Japanese data collected information about the presence of computer networks from all manufacturers. Information on how those networks were used was collected only for Japanese manufacturers that buy and sell on line, i.e., that conduct e-commerce, while U.S. data were collected for all manufacturers. When new data become available on how networks are used by all Japanese manufacturers, the next phase of our analysis will re-estimate the relationship between productivity and how businesses use computer networks.

I. How IT Affects Productivity

Computers may affect productivity when used directly as an input, a specific form of capital, in the production process. This is the approach taken in many national and industry-level studies, as well studies at the plant or business level (*e.g.* McGuckin *et al.* 1998, Brynjolfsson and Hitt (2000), and Dunne *et al.* (2000)). Consider a steel mill. Computers and automated processes are used to control production processes in modern steel mills (e.g., Feldstein 2000). Many supporting business processes can also be computerized. For example, computers can be used to maintain a database of customers or shipments, or to do accounting or payroll. Computers may substitute for paper-based systems without changing the underlying business processes.

But computers may also be used to organize or streamline the underlying business processes. When these computers are linked into networks, they facilitate standard business processes such as order taking, inventory control, accounting services, and tracking product delivery, and become electronic business processes (or e-business processes). These e-business processes occur over internal or external computer networks that allow information from different processes to be readily exchanged. Shipments may be tracked on-line, inventories may be automatically monitored, and suppliers notified when pre-determined levels are reached.

Adopting e-business processes automates and connects existing business processes. It can also change the way companies conduct not only these processes but also their businesses. The surge of interest in supply chains exemplifies the potential for computers to affect productivity growth outside of the manufacturing sub-sectors that produce them. These effects are thought to occur through organizational changes. Many core supply chain processes are widely cited as examples of successful e-business processes that, in turn, are expected to shift the location of the process the participants in the supply chain. Brynjolfsson and Hitt (2000) argue that the effects of organisational changes may rival the effects of changes in the production process.

Viewed this way, computer networks are a productivity-enhancing technology. Bresnahan and Greenstein (1997) hypothesize that computer networks are a general-purpose technology. General-purpose technologies are sector-specific but are diffused widely across industries, and used in a variety of ways within an industry or firm. A characteristic of general-purpose technologies is facilitating complementary investments. In the case of IT, these complementary investments may include reorganizing or streamlining existing business processes. The IT and complementary investments together yield computers linked into networks that further facilitate reorganizing and streamlining business processes.

II. Data

Until recently, a lack of information on business-level uses of IT limited most micro data studies to exploring the links between productivity and simple indicators of the presence of IT. Japan was a leader in producing data on both the presence of computer networks and how businesses use them, beginning in 1991. Statistical agencies in many countries, including the United States, recently developed new data that permit micro-level analyses, such as the studies cited in Pilat (2004), of links between productivity and how businesses use IT. This study is the first comparative analysis using these data for Japan and the United States.

A. Japan

The data for Japan come from the Basic Survey of Business Structure and Activities (BSBSA), which collects data on productivity and network use. The BSBSA is the Ministry of Economy, Trade, and Industry's (METI) firm-level survey for all firms with no fewer than 50 employees and no less than 30 million Japanese yen (JPY) in capital. The BSBSA is the basis for various kinds of firm-level surveys by METI in the sense that firm-level surveys for special issues, including the ICT Workplace Survey, use the BSBSA firm list as their sample base. BSBSA is an extensive survey for all firms over a certain size so that even long panel data have enough observations for analysis. In each year, it covers over 25,000 firms, and about half of them are manufacturing firms. The survey items include a broad range of firm activities, such as

R&D, overseas production, and outsourcing. It also contains financial statement information that allows productivity calculations. The most recent data available as of December 2004 are for 2002, which were collected in the 2003 survey. Summary data and detailed description of BSBSA are available in METI (2004a).

IT network use variables are available in BSBSA for 1991, 1994, 1997 and 2000. In 1991 and 1994, firms were asked whether they used intra-firm or inter-firm networks, and were asked about specific network applications such as inventory control, logistics management, and customer relationships. In 1997, firms were asked whether they used intra-firm and inter-firm networks, but not about specific IT network applications. Instead, other items were collected, such as use of electronic data interchange (EDI), computer assisted design or manufacturing (CAD/CAM), and e-commerce (EC), as well as the number of personal computers per worker. In 2000, survey items were modified again, and focused on collecting data about e-commerce activities, as well as the use of intra-firm and inter-firm networks. Motohashi (2002) looked at the impact of information network use by type of e-business process, based on cross-section data from the 1991 BSBSA. To make analyses as parallel as possible between Japan and the United States, this paper uses BSBSA data only for 2000.

B. United States

The Computer Network Use Supplement (CNUS) data used in this study are part of a Census Bureau measurement initiative to fill some data gaps on the growing use of electronic devices and networks in the economy that is described in Mesenbourg (2001). The 1999 CNUS supplement to the 1999 Annual Survey of Manufactures (ASM) data provide the first large-scale picture of the presence of computer networks, and how businesses use them, in U.S.

manufacturing. Over 38,000 plants responded to the CNUS survey, with a response rate of 82 percent. Information about the survey can be found at U.S. Census Bureau (2004).

Respondents' answers to CNUS questions about networks can be linked to the information the same respondents reported on regular ASM survey forms in 1999 and prior years, such as the value of shipments, employment, and materials. Their CNUS and ASM responses can also be linked to their responses to the Census of Manufactures (CM), which is conducted every five years. Atrostic and Nguyen (2005b) provide more information about these data.

C. Data Used in This Study

The BSBSA is a firm-level survey covering both manufacturing and non-manufacturing sectors of Japan. The CNUS is an establishment-level survey that covers only the manufacturing sector of the United States. Although it is possible to identify establishments that belong to the same firm in the CNUS, there is no information about units in the firm that are outside the manufacturing sector. We select for this study the subsamples of the BSBSA and CNUS data that are nearly comparable: single-unit manufacturing firms. These firms have only one plant. We include only firms that have more than 50 employees, the minimum size for BSBSA. There are about 5,000 single-unit manufacturing firms in the CNUS, and about 4,000 in the BSBSA.

Each dataset is analyzed separately, and only by the researcher(s) from that country, because of the confidentiality provisions governing the use of these data. Because findings for single-unit manufacturing firms may not generalize to the manufacturing sector of either country, we compare estimates for single-units and the manufacturing sector for each country.

III. Descriptive Statistics on Computer Network Use and Productivity

In both the United States and Japan, manufacturing businesses with computer networks are bigger and more productive. They are roughly twice as large as businesses without networks: Table 1 shows that the relative employment ratio is 1.85 in Japan and 2.17 in the United States. Relative productivity measured by either gross output or value added is about 30 percent higher for manufacturing businesses that have networks.

Computer networks appear to be general-purpose technologies in both countries. They are widely diffused among manufacturing industries, occurring in about 88 percent of U.S. manufacturing plants responding to the survey (Census 2004) and about 78 percent of Japanese manufacturing firms (Appendix Table 1). Specific applications, such as monitoring production or inventory control, are found across all industries in both countries, and there are striking similarities in the specific industries that are most and least likely to have networks. However, the penetration of networked processes is much higher in U.S. manufacturing. This section presents basic comparative statistics about the diffusion of computer networks and specific network applications in both countries.

A. Japan

In the 2000 BSBSA data, information on several kinds of network variables is available. Survey items include whether a firm uses intra-firm and/or inter-firm networks. In addition, a detailed questionnaire on e-commerce (EC) collects information on the types of e-business processes, i.e., sales, production control, inventory control, design, and procurement, as well as logistics, that are used in e-commerce.[1] Diffusion rates for various types of networks and e-businesses processes by 3-digit NAICS industry are presented in Appendix Table 1.

About 80% of Japanese manufacturing firms introduced any type of network, but this share varies by industry. The share of networked firms is higher in computer and electrical industries (86 percent and 82 percent), as well as petroleum (83 percent). On the other hand, in wood products and leather and allied products, smaller shares of firms (56 and 55 percent) are hooked up with IT networks. This pattern generally holds for the shares of inter- and intra-firm networks.

EC processes have diffused relatively modestly in Japanese manufacturing, with averages ranging from 1.2 percent (EC design) to 14.6 percent (EC sales). Diffusion rates for most of these processes vary relatively little across industries. One exception is the diffusion rate for EC procurement. In computer and electronics components, 13.7% of firms are using e-commerce, while this share for all manufacturing is only 6%. This finding is consistent with an EC market estimate by METI suggesting that more than 40% of total business-to-business transactions occurred in electrical and electronics equipment and components (METI, 2004b). The diffusion rate for EC sales is higher than for EC procurement on average (14/6% vs. 6.0%) and for most industries, suggesting that electronic transactions between manufactures and wholesale/retailers are much common than electronic transactions within manufacturing transactions.

Cross-industry variation in network diffusion rates in Japan may be related to cross-industry variation in labor productivity premiums for firms using networks. Figure 1 shows the relative value added per employee of network users compared to non-users, by industry. In many industries, the labor productivity of network users is around 20% higher than that of non-

[1] The definition of EC is electronic transactions between firms including transactions conducted through propriety information networks. This corresponds to OECD's broad definition of e-commerce (OECD 2002).

users. However, some industries show only small differences, such as leather and allied products (where productivity is lower for network users), paper, petroleum and coal products, and furniture and fixtures.

B. United States

The CNUS data show that U.S. manufacturing plants use networks for much more than on-line sales and orders. Only half of U.S. manufacturing plants reporting that they have a network also report that they accept and/or place orders online (Census 2001). That finding is consistent with the long history of computer network use in the United States which pre-dates e-commerce by decades. The 1999 CNUS data for the United States therefore contain information on the use of e-business process by all plants, whether or not they conduct e-commerce.

U.S. manufacturing plants use computer networks in myriad ways, including running complex software that links multiple processes, and conducting specific business processes over their networks. This section presents a few stylized facts about business use of computer networks based on published tabulations (Census 2001).

<u>FIERP Software.</u> Fully integrated enterprise resource planning software (FIERP) is the kind of sophisticated software that links different kinds of business applications (such as inventory, tracking, and payroll) within and across businesses. FIERP software is found throughout U.S. manufacturing, although it remains relatively rare compared to computer networks. While about 88 percent of manufacturing plants in the CNUS have networks, only 26 percent have this kind of software. There is substantial variation among industries in the use of this software. FIERP is used by fewer than 15 percent of plants in four industries (Apparel; Wood Products; Printing and Related Support Activities; and Nonmetallic Mineral Products), but

by at least 33 percent of plants in five others (Chemicals; Machinery; Computer and Electronic Products; Electrical equipment, Appliances, and Components; and Transportation Equipment).

Specific E-Business Processes. The CNUS asks about two sets of e-business processes. The first set contains information about the presence of seven networked (or e-business) processes: 1) Design Specifications; 2) Product Descriptions or Catalogs; 3) Demand Projections; 4) Order Status; 5) Production Schedules; 6) Inventory Data; and 7) Logistics or Transportation. Plants are asked whether they use these processes to share information with other business units (many U.S. manufacturing plants are part of multi-unit businesses), customers, or suppliers. The second set asks whether the plant uses 28 detailed e-business processes in five broad groupings: 1) Purchasing; 2) Product Orders; 3) Production Management; 4) Logistics; and 5) Communication and Support. These two groupings are similar, but not identical.

All e-business processes are used in all U.S. manufacturing industries. Each of the seven e-business processes in the first set is used, on average, by at least 24 percent of manufacturing plants, and plants in all 21 manufacturing industries share each kind of e-business process information online (Appendix Table 2).

E-business process use differs across processes. Plants are much more likely to use networks to share some kinds of information, such as Design Specifications (39 percent, on average) and Product Descriptions or Catalogs (45 percent), than Demand Projections (24 percent).

E-business process use differs across industries. Some industries are much more likely to use networks to share information, such as Computer and Electronic products (73 percent); Electrical Equipment, Appliances, and Components (65 percent); and Machinery (61 percent).

These same industries are among those most likely to use network to share several other kinds of e-business process information, such as Design Specifications; Demand Projections; and Order Status.

However, there is less variation among industries for other e-business processes. For example, Inventory Data are shared on-line by 48 percent of plants in Chemicals, 45 percent of plants in Beverage and Tobacco, and 43 percent each in Textile Mills; Paper; Electrical Equipment, Appliances, and Components; and Transportation Equipment.

Manufacturing industries clearly differ in their use of on-line business processes. Some industries make scant use of them. For example, usage ranges from 14 percent to 29 percent in Wood products, from 18 to 36 percent in Apparel, and from 16 to 35 percent Nonmetallic Metals. Others industries, on the other hand use most of these processes. Usage ranges from 24 to 61 percent in Machinery, from 33 to 73 percent in Computer and Electronic Products, and from 35 to 65 percent in Electrical Equipment. The use of a few processes is widespread within those industries. Design Specifications are shared by at least 56 percent of plants in these three industries, and Product Descriptions or Catalogs are shared by at least 61 percent.

IV. Empirical Implementation

We base our empirical implementation on a Cobb-Douglas production function that we extend to take account of the features of our data. First, for single-unit firms, we estimate the relationship between labor productivity and conducting business processes over computer networks. We begin with an intensity measure to get a broad picture of whether a relationship exists between productivity and e-business processes, and then turn to measures of the presence of specific e-business processes. Second, we test the robustness of the empirical results in several ways. We use alternate measures of networked business processes in our core specification. We estimate country-specific alternative specifications. Comparing estimates for single-unit and multi-unit manufacturing firms in Japan, and single-unit and multi-unit manufacturing plants in the United States, lets us assess how well our findings for single-unit firms generalize.

A. Theoretical Model

Our core model is a three-factor Cobb-Douglas production function

(1) $Q = AK^{\alpha_1}L^{\alpha_2}M^{\alpha_3}$

where Q, K, L, and M denote output, capital, labor, and materials. The parameters α_1, α_2 and α_3 represent output elasticities of capital, labor, and materials. A is the usual Solow "technological change" term, which is specified as a function of IT such that

(2) $A = \exp(\beta_0 + \beta_1 IT)$.

Drawing on the new stylized facts from the BSBSA and CNUS data, we extend this model to allow different uses of IT to have different impacts on economic performance. The distinct uses of IT in these data are the k separate e-business processes (*EBProcess*) in the j^{th} set of processes. We incorporate them by rewriting the technological change term, A, as:

(3) $A = \exp(\beta_0 + \sum_k \beta_{kj} \mathit{EBProcess}_{kj})$.

B. Estimating Equations

Our empirical specification accounts for important plant characteristics that may significantly affect a plant's labor productivity but are not in our theoretical model. For Japan and the United States, separately, we estimate the specification given in Equation (4):

(4) $\text{Log}(Q/L) = \beta_0 + \sum_k \beta_{kj} \textit{EBProcess}_{kj} + \alpha_1 \log(K/L) + \alpha_3 \log(M/L) + \varepsilon$

Equation (4) relates the use of various electronic business processes (*EBProcess*) to (log) labor productivity. We include only one group of processes (the j subscript) in the estimations at a time.

We account empirically for important plant characteristics that may significantly affect a plant's labor productivity, and that are available in both countries' data, but are not in our theoretical models. Our final common specification is given in Equation (5):

(5a—U.S.) $\text{Log}(Q/L) = \beta_0 + \sum_k \beta_{kj} \textit{EBProcess}_{kj} + \alpha_1 \log(K/L)_{97} + \alpha_3 \log(M/L) + \sum \alpha_{4i} (SIZE_i)$

$+ \alpha_5 \log(MIX) + \sum \gamma_i IND_i + \varepsilon$

(5b—Japan) $\text{Log}(Q/L) = \beta_0 + \sum_k \beta_{kj} \textit{EBProcess}_{kj} + \alpha_1 \log(K/L) + \alpha_3 \log(M/L) + \sum \alpha_{4i} (SIZE_i)$

$+ \alpha_5 \log(MIX) + \sum \gamma_i IND_i + \varepsilon$

E-business process variables. The parameters of interest are the coefficients of the e-business processes, the β_{kj}, which we model as technological shifts in the production function. Each group of e-business processes is entered in a separate regression. The first group of e-business processes is the presence of a computer network. The second group is the use of FIERP software (for the United States), or using the network to communicate within the firm or externally (for Japan). The third group is a measure of the intensity of network use, entered as a set of dummy variables corresponding to the use of one, two, three, etc., processes. The fourth group examines the effect of detailed e-business processes: five processes for the United States and six for Japan. We enter dummy variables for all five processes in a single equation. The coefficients in such a regression show the independent impact of a process, controlling for the presence of other processes.

Standard production function variables and plant characteristics. The dependent variable in both equations, Q/L, is gross output labor productivity, measured as the value of shipments (Q) divided by total employment (L). For the United States, both values come from the 1999 ASM. For Japan, both values come from the 2000 BSBSA.

The first group of explanatory variables is the standard production function variables. K is the book value of capital, measured relative to total employment (L). For the United States, both values come from the 1997 CM, and have the "97" subscript.[2] For Japan, both values come from the 2000 BSBSA. Materials inputs, M, are measured relative to total employment in the 1999 ASM for the United States, and in the 2000 BSBSA for Japan. The U.S. measure of materials includes business and contract services and energy used at the plant, as well as physical materials inputs. The Japanese measure may include expenses not directly related to production, such as advertising and communications.

The second group of explanatory variables characterizes the plant. MIX is the ratio of non-production to production workers, to proxy for skill mix. IND represents the plant's industry, coded in both data sets to the North American Industry Classification System (NAICS). $SIZE_i$ is a set of employment size classes. Details of the construction of these variables are given in Atrostic and Nguyen (2005b) and Motohashi (2004).

C. Empirical Findings for Network Use: United States vs. Japan

Our empirical work shows that the links between IT and productivity differ between U.S. and Japanese manufacturing. Computer networks have positive and significant links with labor productivity in both countries. While we find positive and significant links between specific ways that businesses use networks in U.S. manufacturing, we do not find any statistically

[2] Book value (K) for U.S. manufacturing is collected only in Economic Census years such as 1992 and 1997.

significant links for Japan. However, these findings are necessarily preliminary because we only measure how Japanese firms use networks if they engage in e-commerce, while we measure it for all U.S. manufacturing firms.

Computer Networks. Computer networks are positively related to productivity in both the United States and Japan. We report in Table 2 results for identical productivity specifications for single-unit manufacturing firms in both countries (column 2 for the United States and column 4 for Japan). These regressions explain 66 percent of the variance in productivity for U.S. single-unit firms, and 94 percent of the variance for Japanese single-unit firms. While network coefficients are positive and significant for both the United States and Japan, the U.S. network coefficient of 0.048 is almost twice the coefficient of 0.029 for Japan.

The differences between the network coefficients are interesting because of similarities between the two countries. The network diffusion rates of 80 to 90 percent are similar for both countries, reflecting the long use of networks in their manufacturing processes. Data on the presence of networks are collected for all manufacturers in both countries. Industry-level analyses find parallel relationships between increases in IT investment and total factor productivity (e.g., Jorgenson and Motohashi 2005). Differences in how those networks are used in each country may contribute to the difference in network coefficients.

Differences in the complementary investments needed to make effective use of computer networks between Japan and the United States may also contribute to differences in the relative productivity impact of networks. A large literature suggests that these complementary investments may take several forms (e.g. Bresnahan and Greenstein (1997) and Brynjolfsson *et al.* (2002)). Co-invention may be required to put networks in place and make them effective. Organizational changes may also be required, such as adopting innovative work practices, supply chain management, and customer relationship management. However, further organizational capital also may be required for such changes to have a productivity impact (e.g., Black and Lynch 2001 and 2003). Otherwise, simply adopting an application such as supply chain management would automatically make any business as productive as an industry leader (Motohashi 2004). Japanese firms conduct fewer such organizational changes, compared to U.S. firms, when they introduce new IT systems (e.g., Motohashi 1999 and 2004).

Production functions for single-units. Production functions for single-unit manufacturing firms differ in the two countries. Coefficients for these firms in the United States and Japan are shown in columns 2 and 4 of Table 2. The materials elasticity of 0.728 for these firms in Japan is nearly 60 percent higher than the elasticity of 0.461 for the United States. The capital elasticity for the United States of 0.090 is more than twice the elasticity for Japan of 0.037. Worker mix, the ratio of non-production to production workers, is positive and statistically significant at the 1 percent level in both countries, consistent with capital deepening. However, the economic importance of worker mix for productivity is much higher in the United States compared to Japan (coefficients of 0.070 vs. 0.012).

Specific e-business processes. The way U.S. single-unit firms use networks affects their productivity, by any of our measures of use. In contrast, only one way of using networks is associated with the productivity of Japanese single-unit firms. However, it should be noted that the Japanese data contain information on the diffusion of e-business processes only for the 14.6 percent of firms that conduct e-commerce. This is one reason why diffusion rates in Japanese manufacturing are low relative to U.S. manufacturing. Low diffusion rates lead to lower variance in productivity data between network users and non-users, which make it more difficult to evaluate the impact of networks. If data on the use of e-business processes were available for the 78.3 percent of Japanese manufacturing firms that have computer networks, the results likely would be different.

United States. Plants running FIERP software over a network have productivity that is about 5.4 percent higher in than plants without a network (column 1 of Table 4). This productivity gain is greater than the gain from only running a network (about 5 percent).

Intensity of use matters. Higher intensity is associated with higher productivity impacts (column 2).[3] Running a single process over a network yields about a 2 percent productivity gain that is significant at the 1 percent level. Plants running two or three processes are about 4 percent more productive than plants with no networked processes, significant at the 5 percent level. The most intensive uses are associated with even higher productivity of 7.4 percent for 4 processes and 5.4 percent for all 5 processes, both significant at the 1 percent level.

When all five e-business processes (purchasing, product orders, production management, logistics, and communication and support) are entered into the production function together, however, only the coefficient for production management of 0.031 is positive and significant at the one percent level (column 3 of Table 6). This suggests that for single-unit firms, using these processes in combination rather than separately is more likely to have an impact on productivity.

Japan. Productivity is about 3 percent higher in firms using networks for internal communications (columns 1 and 3 of Table 3). However, using networks to communicate outside the firm is not; the coefficient of 0.010 is not statistically significant (columns 2 and 3).

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[3] Previous work (Atrostic and Nguyen 2004b) analyzes both sets of e-business process variables, but the estimates in this paper use only the second set. The set of single-unit firms is much smaller than all manufacturing plants (roughly 5000 compared to the 27,000 plants analyzed in Atrostic and Nguyen 2004b) so we find more noise in the data when analyzing the set of seven processes.

The presence of an e-commerce network has no statistically significant relationship with productivity (column 4 of Table 3).

For Japan, it appears that the intensity of network use by manufacturers engaged in e-commerce is not associated with higher productivity. Neither of two measures of intensity (the number of processes used, and a series of dummy variables that index the number of processes used, parallel to the U.S. measure) has a significant coefficient (see columns 5 and 6 of Table 3). Nor do the BSBSA data show links between specific processes and productivity for the Japan. When the six processes are entered together (column 7 of Table 3), none of the coefficients is significant.

V. Discussion

A strength of our study is that the data we use for Japan and the United States contain similar measures of key production variables such as capital and computer networks; business characteristics, including the same industry classifications; and the key technology variables of interest: computer networks and how businesses use them. These similarities make us more confident that the differences we find reflect actual differences between the economies of the United States and Japan.

This section assesses the robustness of our estimates for U.S. and Japanese manufacturing. It discusses how likely our estimates for single-unit manufacturing firms are to generalize to the manufacturing sector of each country, and to other sectors. Finally, we note some important data gaps that temper our conclusions.

Alternative specifications. For the United States, we estimate but do not report a number of alternative econometric specifications. One set of estimates includes dummy variables indicating whether a plant is new since 1997 as a proxy for possible technology and managerial vintage effects. Another set includes a measure of the firm's economic performance in a prior period. The third set includes both the dummy for new plants and the prior period performance measure, and is the preferred specification in prior research for U.S. manufacturing (Atrostic and Nguyen 2004 and 2005b). The coefficients and statistical significance of the computer network and e-business process variables, and the production function variables, are stable across these alternative econometric specifications.

Sample size. For the United States, estimates of the effects of detailed e-business processes appear to be somewhat sensitive to sample size. Diffusion rates for detailed processes are higher in the United States than in Japan, but even in the CNUS data, average diffusion rates of 24 percent for these processes are sparse compared to the 88 percent diffusion rate for computer networks. We find that the coefficients change when sample is expanded to include plants below 50 the employee cut-off. We also find that using the alternate group of seven e-business processes leads to fewer significant coefficients for those processes in this paper compared to Atrostic and Nguyen 2004. This finding, too, may reflect the relatively small sample size for single-unit firms with more than 50 employees.

Prior research using data for all manufacturing firms (Atrostic and Nguyen 2004) found that both sets of e-business process measures had stable coefficients. Also, when using the entire dataset, we found a negative and significant coefficient when networks were used to share information about production, and positive and significant coefficients when they were used to share information about supply-chain activities such as logistics, inventory, and order tracking. By contrast, when we use data for single-unit firms only, we found a significant, positive coefficient for the production management variable. This suggests that single-unit manufacturing firms may gain from using networks to manage production, compared to multi-units.

Economic performance in prior periods. Prior research for the United States (Atrostic and Nguyen 2005b) uses two-stage estimations to address potential endogeneity. In contrast to standard findings that estimated effects in two-stage estimates are smaller in magnitude and less likely to be significant than OLS coefficients, we find that the effects are significant and roughly twice as high in the two-stage estimates. We also find that neither including a dummy variable to control for new plants (perhaps more innovative or able to purchase the newest technology) nor a variable to control for relative productivity in the prior period changes the general level or broad pattern of significant e-business process coefficients.

Computers vs. networks. Our estimates do not include a measure of computer capital. Our computer network and e-business process measures may simply pick up the presence of computers, rather than add separate information about how businesses use computers. We test that hypothesis in Atrostic and Nguyen 2005a for a sample of CNUS plants for which we have good proxies of computer input, and find that computers and computer networks both have positive and statistically significant links with productivity. Further, when we have separate measures of networks and computer input, the coefficient of networks is much higher than when we only have measures of networks. This prior research suggests that our measures of e-business processes do add new information about how businesses use computers.

Motohhashi (2004) addresses the effect of unobservable firm-specific factors behind productivity performance by estimating fixed-effects models based on panel data. He finds that the effects of intra-firm and inter-firm networks are both positive, but not statistically significant.

This is consistent with the cross section-regression in this paper that finds weak explanatory powers for network variables for Japanese manufacturing firms.

Findings generalize beyond single-unit manufacturing firms. The key coefficient of interest, computer networks, appears to generalize from single-unit manufacturing firms to the manufacturing sector for each country. The coefficients reported in Table 4 of 0.044 and 0.048 for U.S. all manufacturing plants and single-unit plants are similar, as are the parallel coefficients of 0.020 and 0.029 for Japan. Capital and materials coefficients also are similar for single-unit firms and all firms. One variable whose coefficient changes markedly is the worker mix variable, the ratio of non-production to production workers. For the United States, the coefficient drops from 0.070 for single-unit plants to 0.037 for all plants, but remains significant at the 1 percent level. For the Japan, the coefficient of 0.012 is significant at the 1 percent level for single-unit firms. That coefficient drops to 0.000 for all manufacturing firms, and is not statistically significant.

Productivity impacts of IT networks are also found in non-manufacturing sectors. Table 7 presents the regression results of equation 5b for wholesale and retail sector in Japan. As is the case for manufacturing sector, we find positive and statistically significant coefficients for network variables. The network coefficient of 0.019 for these sectors is essentially the same as the coefficient of 0.020 for all Japanese manufacturing firms that is shown in column 3 of Table 2 although it is less than the coefficient of 0.029 for single-unit manufacturing firms.

VI. Conclusions

This research explores the relationship between productivity and the use of computer network technologies in the manufacturing sectors of the United States and Japan. The key contribution of our work is that ours is the first firm-level analysis to explore the link between productivity and the specific ways that businesses use computer networks in both countries. We find that using networks in general is positively linked to productivity in both countries. These micro-level findings are consistent with industry-level analyses that find parallel relationships between increases in IT investment and total factor productivity in the United States and Japan (e.g., Jorgenson and Motohashi 2005).

However, other findings differ between the two countries. For the United States, we find clear productivity increases associated with many networked processes, including production management, order status, logistics, communication, and support, but not for Japan.

What explains the difference between the two countries? Differences between the two countries may derive from the way each implements this general-purpose technology. The general-purpose technology literature stresses the need not just for using technology, but using that technology together with complementary investments, innovation, process change, and other facets of organizational capital. Motohashi (2004) addresses this question by testing the complementarity of information and business networks for productivity growth, and finds some evidence for such a relationship. Firms conducting joint production and R&D activities may be superior for networking activities with other firms, which will be one of the factors needed to make efficient use of information networks. Research for the United States finds that high performance work practices and decentralized organizational structures are important to achieving higher productivity performance (Black and Lynch 2001 and 2003, Bresnahan and Greenstein 1999). Some evidence shows that there are fewer such organizational changes and co-inventions in Japan than in the United States. This difference may contribute to our finding that the impact of IT networks on productivity is relatively weak in Japan. Exploring the effects of these complementary investments is one of our future research directions to improve our understanding of the difference in the relationship of network use and productivity between Japan and the United States.

The lack of significant links between business processes and Japanese manufacturing firms' productivity may be because the Japanese data set includes information on e-business processes only for manufacturers that conduct e-commerce. There may not be as much variation in the use of e-business processes among these businesses as among all manufacturers. The next phase of our analysis will use a new dataset for Japan that measures the use of e-business processes for all Japanese firms, not just firms that engage in e-commerce. These data will allow us to make parallel estimates of the relationship between productivity and how businesses use computer networks for Japan and the United States.

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Table 1.

Relative labour productivity of network users in Japan and the United States

	Japan (2000)		United States (1999) (all manufacturing plants)	
	With networks	Without networks	With networks	Without networks
Sales/employment	1.37	1	1.28	1
Value added/employment	1.29	1	1.29	1
Employment	1.85	1	2.17	1

Table 2
OLS Regression Results for U.S. and Japanese Manufacturing Sectors: Computer Networks

Dependent variable: Log of gross output labor productivity

(t-statistics in parentheses)

	United States[a]		Japan[b]	
	All Plants	Single-Unit Plants (Firms)	All Firms	Single-Unit Firms
	1	2	3	4
Log (M/L)	0.532	0.461	0.768	0.728
	(182.57)**	(79.38)**	(410.81)**	(197.19)**
Log (K/L)	0.099	0.090	0.040	0.037
	(37.60)**	(17.09)**	(29.45)**	(14.58)**
Computer Network	0.044	0.048	0.020	0.029
	(3.95)**	(2.86)**	(6.10)**	(4.35)**
Log (Mix)	0.037	0.070	0.000	0.012
	(9.65)**	(9.00)**	(0.16)	(3.32)**
$100 < L \leq 200$	-0.008	-0.017	0.010	0.016
	(-1.21)	(-1.54)	(3.12)**	(2.50)*
$200 < L \leq 1000$	-0.008	-0.032	0.029	0.054
	(-1.24)	(-2.36)*	(8.80)**	(6.63)**
$L > 1000$	0.070	-0.027	0.070	0.141
	(5.24)**	(-0.34)	(11.85)**	(4.07)**
Constant	2.608	2.861	0.907	1.035
	(126.50)**	(79.90)**	(137.89)**	(76.09)**
Industry dummy	yes	yes	yes	yes
Observations	22,431	5033	13,016	3755
R-squared	0.74	0.66	0.95	0.94

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

Sources:
a Atrostic and Nguyen calculations of CNUS data; plants with more than 50 workers.
b Motohashi calculations of METI data

Table 3
Japan: OLS Regression Results for Single-Unit Manufacturing Firms, 2000,
Type of Computer Network, Intensity of Business Process Use, and Network Uses
Dependent variable: Log of gross output labor productivity

(absolute value of t-statistics in parentheses)

	1	2	3	4	5	6	7
Log (M/L)	0.728	0.729	0.728	0.729	0.729	0.729	0.729
	(197.52)**	(197.10)**	(197.12)**	(197.43)**	(197.43)**	(197.17)**	(197.14)**
Log (K/L)	0.037	0.037	0.037	0.037	0.037	0.037	0.037
	(14.42)**	(14.55)**	(14.47)**	(14.50)**	(14.50)**	(14.48)**	(14.52)**
Log (Mix)	0.011	0.012	0.011	0.012	0.012	0.012	0.012
	(3.14)**	(3.44)**	(3.17)**	(3.41)**	(3.41)**	(3.41)**	(3.41)**
Intra firm network	0.024		0.025				
	(4.19)**		(4.20)**				
Inter firm network		0.010	0.010				
		(1.75)	(1.77)				
E-commerce				-0.002			
				(0.27)			
Total network processes					-0.001		
					(0.18)		
Number of network processes =1						0.000	
						(0.02)	
Number of network processes =2						-0.017	
						(0.95)	
Number of network processes =3						-0.002	
						(0.09)	
Number of network processes =4						0.016	
						(0.50)	
Number of network processes =5						0.003	
						(0.07)	
Number of network processes =6						-0.006	
						(0.09)	
Sales							-0.012
							(1.15)
Production							-0.023
							(1.27)
Inventory							0.036
							(1.56)
Design							0.015
							(0.47)
Procurement							0.01
							(0.75)
Logistics							-0.01
							(0.40)
Constant	1.04	1.051	1.038	1.054	1.054	1.054	1.055
	(78.08)**	(80.52)**	(77.46)**	(80.92)**	(81.06)**	(80.80)**	(80.98)**
Observations	3755	3755	3755	3755	3755	3755	3755
R-squared	0.94	0.94	0.94	0.94	0.94	0.94	0.94

* = significant at 5%; ** = significant at 1%

Notes:
Regressions include industry dummies and firmsize dummies
1 both inter and intra included
2 ec=1 if any type of EC, 0 otherwise
3 netsum: number of EC types (0-6, there are EC for sales, production, inventory, design, logistics)
4 net=1,2,3,4,5,6: dummy variables for the number of EC types, net=0 as a base
5 each type of EC included all together

Source: Motohashi calculations of BSBSA 2000.

Table 4
U.S.: OLS Regression Results for Single-Unit Manufacturing Firms, 1999,
Type of Computer Network, Intensity of Business Process Use, and Network Uses
Dependent variable: Log of gross output labor productivity

(t-statistics in parentheses)

	1	2	3
Log (M/L)	0.457	0.461	0.462
	(74.92)**	(79.43)**	(79.48)**
Log (K/L)	0.095	0.090	0.090
	(17.11)**	(16.97)**	(16.92)**
Log (Mix)	0.066	0.068	0.068
	(8.22)**	(8.73)**	(8.72)**
Network only	0.049		
	(2.79)**		
FIERP & Network	0.053		
	(2.79)**		
Number of network processes=1		0.016	
		(0.82)**	
Number of network processes =2		0.043	
		(2.44)*	
Number of network processes =3		0.043	
		(2.48)*	
Number of network processes =4		0.071	
		(4.09)**	
Number of network processes =5		0.057	
		(3.09)**	
Purchasing			-.001
			(-0.09)
Product Orders			0.009
			(0.82)
Production Management			0.031
			(2.54)**
Logistics			0.001
			(0.82)
Communication and Support			0.014
			(0.96)
100 < L ≤ 200	-0.017	-0.018#	-0.018
	(-1.54)	(-1.64)	(-1.63)
200 < L ≤ 1000	-0.034	-0.037	-0.037
	(-2.41)*	(-2.67)**	(-2.70)**
L > 1000	-0.017	-0.037	-0.039
	(-0.21)	(-0.46)	(-0.48)
Constant	2.856	2.861	2.868
	(76.71)**	(81.79)**	(83.10)**
Industry dummies	Yes	Yes	Yes
Observations	4640	5033	5033
R-squared	0.66	0.66	0.66

= significant at 10 %, * = significant at 5%; ** = significant at 1%

Note: Number of observations in column 1 differs from number of observations in columns 4 and 5 because column 1 estimates omit plants with inconsistent responses to question about FIERP

1 FEIRP and Network included

4 net=1,2,3,4,5: dummy variables for the number of E-Business processes used, net=0 as a base

5 All e-business processes included

Source: Atrostic and Nguyen calculations of CNUS data.

Table 5

Productivity regressions for Japanese Wholesale and Retail Firms, 2000

Dependent Variable: Log Gross Output Labor Productivity

(t-statistics in parentheses)

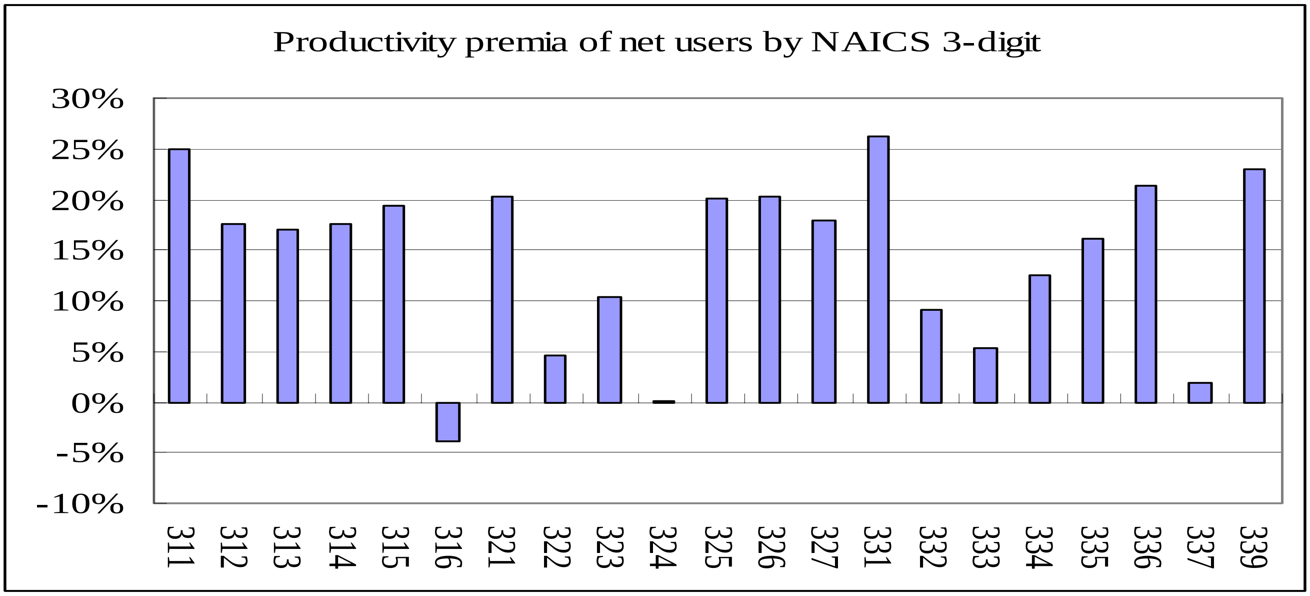
	1	2	3
Log (M/L)	0.842	0.843	0.843
	(450.82)**	(451.66)**	(450.41)**
Log (K/L)	0.011	0.011	0.011
	(11.30)**	(11.14)**	(11.34)**
Log (Mix)	0.017	0.017	0.017
	(3.97)**	(3.97)**	(3.99)**
Computer Network	0.019		
	(5.18)**		
Intra Firm Network		0.014	
		(4.60)**	
Inter Firm Network			0.012
			(3.94)**
100 < L ≤ 200	0.002	0.002	0.003
	(0.56)	(0.58)	(0.83)
200 < L ≤ 1000	0.010	0.010	0.012
	(2.66)**	(2.70)**	(3.10)**
L > 1000	0.016	0.016	0.018
	(2.42)*	(2.48)*	(2.79)**
Constant	0.75	0.76	0.76
	(108.07)**	(111.07)**	(113.74)**
Observations	14219	14219	14219
R-squared	0.97	0.97	0.97

Absolute value of t statistics in parentheses

* = significant at 5%; ** = significant at 1%

Source: Motohashi calculations of BSBSA 2000.

Figure 1
Productivity premia of firms using computer networks in Japan, 2000, by NAICS 3-digit industry



APPENDIX

Appendix Table 1a
Japan: Presence of Computer Networks by Industry and Specific Applications

NAI CS	Industry	N	Any network	Inter firm	Intra firm	EC sales	EC production	EC inventory	EC design	EC procurement	EC logistics
	All manufacturing firms	**13,219**	**78.3%**	**34.9%**	**67.4%**	**14.6%**	**3.7%**	**2.7%**	**1.2%**	**6.0%**	**2.7%**
311	Food manufacturing	1,462	70.7%	27.9%	61.1%	16.8%	1.4%	1.9%	0.1%	2.5%	2.4%
312	Beverages and tobacco	160	81.3%	35.0%	73.8%	29.4%	3.8%	4.4%	0.6%	5.6%	8.8%
313	Textiles and fabrics	141	67.4%	31.9%	51.1%	4.3%	6.4%	5.7%	0.7%	0.7%	4.3%
314	Textiles mill products	192	78.1%	34.4%	65.6%	11.5%	1.6%	3.1%	0.0%	2.6%	3.6%
315	Apparel and accessories	355	68.2%	29.0%	56.3%	11.0%	3.7%	2.8%	0.8%	1.1%	4.2%
316	Leather and allied products	40	55.0%	22.5%	45.0%	10.0%	7.5%	0.0%	0.0%	2.5%	0.0%
321	Wood products	160	56.3%	21.9%	47.5%	6.9%	2.5%	0.6%	0.6%	2.5%	0.6%
322	Paper	440	73.2%	32.3%	63.0%	14.3%	2.0%	1.8%	0.2%	3.0%	2.0%
323	Printing, publishing etc	825	77.6%	25.7%	70.9%	14.7%	3.0%	2.3%	0.5%	2.8%	1.6%
324	Petroleum and coal products	55	83.6%	40.0%	69.1%	16.4%	1.8%	3.6%	1.8%	5.5%	7.3%
325	Chemicals	944	81.1%	30.0%	72.9%	16.2%	1.5%	2.9%	0.6%	4.4%	4.4%
326	Plastics and rubber products	831	78.5%	38.5%	65.7%	16.6%	3.1%	2.6%	1.1%	5.4%	2.8%
327	Nonmetallic mineral products	554	69.0%	25.6%	58.1%	8.1%	1.3%	1.6%	0.5%	2.0%	1.1%
331	Primary metals	739	78.9%	39.9%	66.2%	17.1%	3.0%	2.7%	1.1%	6.2%	1.8%
332	Fabricated metals	1,001	78.8%	31.7%	68.6%	13.3%	3.7%	2.5%	1.3%	3.8%	2.2%
333	General machinery	1,703	81.1%	31.6%	71.7%	10.0%	3.8%	1.8%	1.8%	7.1%	1.8%
334	Computer and electronic products	1,445	86.6%	45.9%	73.3%	18.3%	6.2%	4.4%	1.7%	13.7%	2.8%
335	Electrical appliances and components	780	82.6%	42.8%	69.1%	15.9%	3.7%	3.2%	0.8%	10.4%	1.5%
336	Transportation equipment	1,121	81.4%	48.8%	68.2%	15.1%	8.5%	3.2%	4.4%	8.5%	4.5%
337	Furniture and fixtures	181	77.9%	28.2%	68.5%	12.7%	5.5%	2.8%	1.1%	2.8%	2.8%
339	Other manufacturing	90	84.4%	31.1%	76.7%	17.8%	3.3%	3.3%	0.0%	12.2%	2.2%

Appendix Table 1b

Japan: Presence of Computer Networks by Industry and Specific Applications

	Single-establishment firms	N	Any network	Inter firm	Intra firm	EC sales	EC production	EC inventory	EC design	EC procurement	EC logistics
	All manufacturing	**3,896**	**75.5%**	**37.8%**	**61.2%**	**9.0%**	**4.3%**	**2.7%**	**0.8%**	**4.8%**	**1.7%**
311	Food manufacturing	437	62.9%	28.4%	49.0%	9.2%	1.1%	1.1%	0.0%	0.9%	1.1%
312	Beverages and tobacco	38	78.9%	36.8%	65.8%	18.4%	7.9%	5.3%	0.0%	0.0%	7.9%
313	Textiles and fabrics	78	67.9%	33.3%	47.4%	1.3%	6.4%	5.1%	0.0%	0.0%	3.8%
314	Textiles mill products	70	77.1%	48.6%	54.3%	8.6%	1.4%	1.4%	0.0%	0.0%	2.9%
315	Apparel and accessories	146	61.6%	28.8%	43.8%	6.2%	4.1%	4.1%	1.4%	1.4%	2.7%
316	Leather and allied products	17	35.3%	11.8%	35.3%	11.8%	5.9%	0.0%	0.0%	0.0%	0.0%
321	Wood products	59	45.8%	16.9%	40.7%	1.7%	3.4%	1.7%	1.7%	0.0%	0.0%
322	Paper	124	69.4%	29.0%	54.0%	9.7%	0.8%	1.6%	0.0%	1.6%	0.0%
323	Printing, publishing etc	232	75.4%	25.4%	67.7%	10.8%	2.2%	1.7%	0.4%	2.2%	0.9%
324	Petroleum and coal products	7	71.4%	57.1%	42.9%	14.3%	0.0%	14.3%	0.0%	0.0%	0.0%
325	Chemicals	119	79.8%	32.8%	63.0%	5.0%	0.8%	1.7%	0.0%	1.7%	1.7%
326	Plastics and rubber products	219	80.8%	43.8%	63.9%	11.9%	4.6%	2.7%	0.5%	3.2%	1.8%
327	Nonmetallic mineral products	103	62.1%	30.1%	44.7%	3.9%	1.9%	2.9%	1.0%	3.9%	1.0%
331	Primary metals	209	70.8%	34.0%	59.3%	11.0%	2.4%	1.9%	0.5%	4.8%	1.0%
332	Fabricated metals	269	76.6%	36.1%	62.1%	8.6%	4.8%	2.2%	0.7%	3.7%	1.9%
333	General machinery	473	83.5%	38.7%	71.9%	7.2%	5.1%	1.7%	1.5%	5.7%	1.5%
334	Computer and electronic products	545	85.0%	49.0%	69.5%	10.6%	6.6%	5.1%	1.1%	11.7%	2.8%
335	Electrical appliances and components	253	80.2%	46.6%	66.4%	9.9%	5.5%	3.6%	1.2%	9.5%	0.8%
336	Transportation equipment	407	78.4%	46.7%	61.4%	9.8%	6.9%	3.4%	2.0%	5.7%	2.2%
337	Furniture and fixtures	67	77.6%	34.3%	65.7%	10.4%	6.0%	1.5%	0.0%	3.0%	3.0%

Source: Motohashi tabulations of BSBSA 2000.

Appendix Table 2

The Share of Plants Using Fully Integrated Enterprise Resource Planning (FIERP) Software in 2000 Varies Across Manufacturing Sectors

NAICS Code	Description	Use FIERP
	All Manufacturing	26%
311	Food products	19%
312	Beverage and tobacco	24%
313	Textile mills	19%
314	Textile product mills	19%
315	Apparel	13%
316	Leather and allied products	21%
321	Wood products	9%
322	Paper	21%
323	Printing and related support activities	13%
324	Petroleum and coal products	21%
325	Chemicals	33%
326	Plastics and rubber products	29%
327	Nonmetallic mineral products	13%
331	Primary metals	28%
332	Fabricated metal products	25%
333	Machinery	35%
334	Computer and electronic products	46%
335	Electrical equipment, appliances, and components	41%
336	Transportation equipment	41%
337	Furniture and related products	18%
339	Miscellaneous	24%

Source: Authors' tabulations, based on U.S. Census Bureau, *1999 E-business Process Use by Manufacturers Final Report on Selected Processes* (March 1, 2002), www.census.gov/estats.

Data are based on the North American Industry Classification System (NAICS)

Appendix Table 3

United States: Percentage of Manufacturing Plants that Share Information Online with Customers or Suppliers, By Type of Information

NAICS Code	Description	6a Design Specifications	7a Product Descriptions or Catalogs	8a Demand Projections	9a Order Status	10a Production Schedules	11a Inventory Data	12a Logistics or Transportation
	All Manufacturing	39%	45%	24%	35%	30%	33%	28%
311	Food products	22%	31%	22%	32%	28%	34%	31%
312	Beverage and tobacco	20%	29%	32%	37%	34%	45%	37%
313	Textile mills	32%	36%	29%	39%	36%	43%	32%
314	Textile product mills	34%	46%	25%	40%	29%	32%	30%
315	Apparel	26%	36%	18%	34%	29%	30%	27%
316	Leather and allied products	23%	46%	17%	32%	24%	25%	24%
321	Wood products	23%	29%	14%	24%	19%	26%	18%
322	Paper	43%	36%	26%	42%	34%	43%	33%
323	Printing and related support activities	39%	44%	16%	35%	27%	26%	24%
324	Petroleum and coal products	30%	32%	28%	27%	31%	38%	30%
325	Chemicals	36%	49%	34%	43%	40%	48%	42%
326	Plastics and rubber products	43%	46%	28%	38%	32%	36%	32%
327	Nonmetallic mineral products	27%	35%	16%	23%	21%	26%	20%
331	Primary metals	38%	44%	28%	40%	34%	38%	32%
332	Fabricated metal products	39%	42%	20%	30%	26%	25%	22%
333	Machinery	56%	61%	24%	36%	30%	28%	24%
334	Computer and electronic products	61%	73%	35%	45%	37%	41%	33%
335	Electrical equipment, appliances, and components	57%	65%	35%	46%	40%	43%	38%
336	Transportation equipment	55%	49%	41%	48%	46%	43%	42%
337	Furniture and related products	34%	42%	16%	27%	23%	23%	22%
339	Miscellaneous	36%	53%	20%	31%	23%	25%	25%

Source: Atrostic and Nguyen' tabulations, based on U.S. Census Bureau, *1999 E-business Process Use by Manufacturers Final Report on Selected Processes* (March 1, 2002), www.census.gov/estats.

Data are based on the North American Industry Classification System (NAICS).
Column heading refers to questionnaire item number