1

Accelerating Globalization: Why Focus on Information Technology?

The US economy is experiencing accelerating globalization. Yet this book starts much more narrowly with a look at information technology (IT). Why focus on IT first? How does IT relate to globalization and the acceleration of change that is its consequence?

First, IT is the most robust growth sector in the global economy, with demand in the world marketplace that outpaces investment and trade growth for any other product. Chapters 2 and 3 will discuss these patterns in much more detail. Second, IT ushers in a dramatic and accelerating pace of change in industries and the workplace, as examined in chapters 4 and 5.

If IT is a global phenomenon, why focus on the United States? The answer is because the United States is not only a leading IT producer and buyer but also the leading IT user, as evidenced by the broad-based diffusion of this technology throughout the economy. Through foreign direct investment and offshore affiliate relationships, US firms are leading forces in globalizing the use of IT. As will be discussed in chapters 5 through 7, the effects of IT—globalization and the acceleration of change—are most apparent in the US economy, as are the consequent policy issues. More broadly, the US experience is a useful harbinger of what may be in store for other countries as they become increasingly exposed to rapid globalization through the pervasive use of networked IT.

Why does IT accelerate change? IT is a special kind of general-purpose technology with significant network effects and a high measured rate of economy-wide return from investment. It is not surprising that demand for IT is so robust. But IT also is becoming a force pushing for more globalization of many nontechnology industries. The technology itself enables

an ever-widening range of production of all sorts of goods and services that can be fragmented and carried out in far-flung locations. Since trade and technology demonstrate this complementary dynamic, the globalization of IT by both the United States and other countries feeds on itself to increase investment in and diffusion of IT throughout the US economy. This, in turn, accelerates the overall globalization of America.

Globalization in a Petri Dish

The story of the accelerating pace of globalization of the US economy starts with IT. The sector has seen dramatic and rapid innovation, as evidenced by unprecedented declines in quality-adjusted prices of computer hardware. Recognition of the globalization of production and demand came with the Information Technology Agreement in 1997, when 44 economies accounting for more than 90 percent of trade agreed to eliminate all tariffs on six categories of key products related to IT and communications by 2000. The communications network of the Internet burst on the global scene only in 1995 and now encircles the world, enhancing the globalization of business and professional services.

Investment in and pervasive use of IT throughout the economy is probably the most important single factor precipitating dramatic and rapid changes that affect firms and workers. Just as scientists use the Petri dish to accelerate the production of bacteria for study, so too does a study that starts with IT inform how technological and global forces accelerate change in the US economy.

IT also has an enormous effect on the US economy because of the strong synergies it creates between global and technological forces. IT and global networks reduce the transaction costs of global production of many kinds of goods, allowing for greater fragmentation of the production process to different locations. Computers, software, and communications networks enhance the digitization and codification of services, which allows them to be functionally separated from the main activities of a firm. Globalization of technology tools and networks facilitates production fragmentation and functional separation along a wider and wider spectrum of goods and services, resulting in innovation-driven and globalization-enhanced change that affects an increasingly larger segment of the US business community and workforce.

Examining the US experience yields insights into the role that IT and networks play in accelerating change not only in the United States but also in other countries. The United States is the worldwide leader in almost every key area of the IT experience, including

- the fragmentation of the production of IT goods and the functional separation of services activities;

- global sourcing for the production of goods and, increasingly, services;
- research and development that advances innovation further in the IT sector, with implications more broadly throughout the economy; and
- most importantly, the pervasive use of IT outside technologically advanced sectors to enhance economic performance and promote broad economic change.

Thus, understanding the globalization of IT is a prerequisite for understanding both the historical and potential future path of the performance of the US economy.

Defining Information Technology

The IT package used throughout the world has numerous components: hardware, software, services, and communications equipment and networks, just to name a few. IT and communications are often analyzed as a joint sector, but this book disaggregates the two sectors, not only addressing them separately but also making even further distinctions. Much of the first half of the book focuses on IT hardware—where it is produced, who buys it, and how it is used throughout the US economy. In part, this focus is because the data are available and superior for a sufficiently long time series for analysis. However, IT services and software as components of the IT package are becoming more important in terms of marketplace size and growth. Finally, communications equipment and networks are extremely important as well, since it is the networked nature of the IT package that makes it particularly valuable for economic performance. Moreover, the changes around the globe in terms of access to communications networks and their price are the key to greater international tradability of business and professional services that goes beyond just IT services to include, for example, call centers and financial analysis. Along with the globalization of IT hardware, software, and services, this increased international tradability of business and professional services is a particular accelerant for the globalization of America (box 1.1).

Why treat IT and communications differently? First, the institutional, regulatory, and ownership structure of communications networks are quite mixed across countries, some partially or wholly government owned, others with limited domestic and cross-border competition in services delivery and investment. Thus, it is difficult to compare data on communications networks across countries. In contrast, virtually all IT hardware, software, and services firms are private-sector companies affected by domestic and global competitive forces.

Related to these market structure differences, technological change can be more easily seen and quantified in the prices of IT products than in the

Box 1.1 Technology definitions

Communications. The total value of voice and data communications services, such as local and long distance wire-line telecommunications, wireless telecommunications, paging, satellite communications, Internet access, private line services, and other data communications services. It also includes communications equipment, such as wire-line and wireless telephone handsets, personal digital assistants (PDAs), wired and wireless local (LAN) and wide area network (WAN) equipment, modems, multiplexers, and telephone answering machines and systems.

Internal company IT spending. A company's own IT staff salaries, software development, and customization expenditure.

IT hardware. The total value of purchased and leased computers, semiconductors, storage devices, memory upgrades, printers, monitors, scanners, input-output devices, terminals, mainframes, and other peripherals.

IT sector. Generally considered to include IT hardware, services, and software.

IT services. The total value of purchased services, such as IT consulting, computer systems integration, network systems integration, office automation, IT facilities management, equipment maintenance, web hosting, computer disaster recovery, and data processing services.

Semiconductors. Considered IT hardware rather than part of the IT services category, these components include printed circuits, semiconductors, memory chips, capacitors, electron tubes, and other miscellaneous electronic components.

Software. The total value of purchased or leased packaged software, such as operating systems, programming tools, utilities, applications, games, and outsourced software development. The last group would include computer programming, World Wide Web page design, and application development.

For additional definitions and information on technology definitions, see WITSA (2002, 2004). See also definitions specific to US statistical agencies in appendix A.

overall communications sector. To be sure, communications prices do change over the time period of analysis, particularly with respect to communications equipment and connection costs in some markets. But it is regulatory change, not technological change, that is the predominant factor affecting the price of communications services.

While the data do not always allow for optimal separation of information and communications technology into these two components, this book will always endeavor to do so, and when not possible, will clearly

explain why and how the interpretation of the data might be affected by the commingling of communications with IT.

Economic Characteristics of IT

What is it about IT that leads to such strong growth in demand? IT is an uncommon product—a general-purpose technology characterized by elastic investment. First, investment in IT rises more than one-for-one as an economy becomes wealthier, and as that IT is networked and used more pervasively throughout such economies. IT products generate important spillover effects in the industries that use them and between the firms that are networked using IT.

Moreover, investment in IT is price elastic, so that as prices decline, investment increases more than one-for-one with the declines in prices. These features are consistent with relatively high rates of return on IT investment as compared with investment in other types of plant and equipment or structures. All these characteristics are related to and promote widespread investment in IT by nontechnology industries.

It is also the case, however, as will be discussed in the chapters that follow, that these special characteristics of IT and their implications for generalized economic performance are augmented or tempered by the nature of business, product, and labor markets. Reaping the benefits of this general-purpose technology requires that the forces of change being generated by the IT investments be allowed to percolate through those markets.

Price Elasticity and Income Elasticity Properties of IT Investment

IT is income and price elastic. Income elastic means that as a measure of GDP grows, the demand for IT products increases more than one-for-one with it. Price elastic means that as prices decline, the investment demand for IT products increases more than one-for-one with the declines in price.

GDP elasticity is consistent with a situation where spending on IT products pervades an economy, extending beyond the confines of the IT sector itself. Such is the case in the United States to a great degree and in other countries to some extent. This extension of IT investment and spending is a crucial factor underlying the role that IT has played in enhancing economy-wide productivity growth in the United States.

Data for foreign markets reflect the superior GDP elasticity. In markets with fast-growing income—regardless of the level of that income—expenditures on IT products increase even faster. For example, as ranked by the World Bank's Human Development Index, real annual average GDP growth over the 1990s for Singapore, Korea, Poland, Malaysia, China,

and India was above 4 percent, while the increase in IT spending (measured in nominal terms) was more than double that, and in several countries, IT spending increased by more than 15 percent annually during the decade. Data for US producers reveal the same phenomenon. European sales by US IT firms in the 1990s rose 5.1 percent, while GDP in those countries grew by only about 2.5 percent. Asian sales by US IT firms increased by 12 percent, while GDP growth in those countries was 7 percent. A "pull" factor that promotes globalization for US firms is the relatively more rapid growth in GDP in many emerging markets.

Responsiveness to price changes—that is, price elasticity—is a second important ingredient in considering how the globalization of IT accelerates US productivity growth. As will be explored in chapter 2, to the extent that the globalization of IT production reduces the price of the IT product below what it otherwise would have been in the absence of globalization, then price declines are greater and demand for IT products increases. To the extent that investment demand is particularly responsive to price changes, the relatively greater decline in price associated with globalization is associated with more than a one-for-one increase in demand for IT products, which feeds into higher productivity growth. Considered another way, relatively lower prices for IT products due to the globalization of production raises the rate of return to IT investment, and more projects achieve internal benchmarks that firms use to decide whether to invest. Based on econometric estimates, it appears that IT investment is particularly responsive to price changes, meaning that the lower price due to globalization has a magnified effect on demand for these productivity-enhancing products.

Econometric analysis of the demand for IT products yields the key parameters of income and price responsiveness. Surprisingly, there are relatively few estimates of these key parameters. However, several researchers—using different countries, demand variables, time periods, and regression methods—find similar results that confirm that IT demand is particularly responsive to price and income changes. The price elasticity is at least –1.0 for IT hardware and often more elastic (a larger negative number in absolute value), and income elasticities are often well over 1.0.

Using sample ranges from 1975 or 1979 to 1994, Kenneth Flamm (1997) provides data for semiconductors. Aggregating all sectors that use semiconductors, he finds a price elasticity ranging from –1.22 to –1.48 and an income elasticity of about 1.0, which is not precisely estimated. When the income coefficient is constrained to 1.0, the price elasticities range from –1.12 to –1.25, depending on the choice of income variable. Flamm then decomposes the aggregate demand data into sectors that use semiconductors—consumer electronics, auto electronics, computer equipment, industrial electronics, communications equipment, and the government sector. For this disaggregated analysis he has to shorten the sample period to 1988–95. He finds price elasticities ranging from –0.6 (industrial equipment) to –1.1

(communications). On the other hand, the income elasticities of demand for semiconductors are large, ranging from 5 to 10.

Tamim Bayoumi and Markus Haacker (2002) use data for IT hardware, software, and communications equipment for 1992–99 from a sample of 41 countries (as well as subsamples of countries). They include time and country dummies in their econometric specification. They find price elasticities ranging from –0.9 (communications equipment) to –1.3 (IT hardware). The income elasticities range from 1.2 (communications) to 1.8 (IT software). As a robustness check, they examine a subsample of 18 countries (including the 12 largest consuming and 12 largest producing countries) and find price elasticities ranging from –0.6 (communications) to –1.1 (IT hardware) and income elasticities ranging from 0.7 (communications) to 1.6 (IT software). Finally, they use national income accounts data for the United States and France for 1980–98. For the United States, they find price elasticities ranging from –2.6 (communications) to –1.5 (IT hardware) and income elasticities ranging from 4.1 (communications) to 3.2 (IT hardware). The figures for France are similar.

In sum, IT products are GDP elastic throughout the world, and are price elastic in many subsectors. In the aggregate both characteristics are true for the United States as well. These elasticities are important underpinnings for the analysis to follow on how the globalization of IT enhances investment in the sector and thus accelerates productivity growth in the United States.

IT Network Externalities and the Rate of Return to IT Investment

Other approaches to estimating the special characteristics of IT products include examining externalities or spillovers and cost of capital or rate of return. These approaches confirm the findings of the econometric evidence on income and price elasticity of IT demand.

First, IT investment exhibits particularly strong network effects; that is, as more businesses use IT products, the value of using them rises. "Metcalfe's Law," named for Robert Metcalfe of Xerox's Palo Alto Research Center, is a formal enunciation of this observation, which states that the value of an IT product increases with the square of the number of users of the product. For example, a situation in which five people are using interconnected personal computers (PCs) is assigned a network value of 5 squared, or 25. Add another person using a connected PC and the value of the network leaps to 6 squared, or 36. Because IT products often involve information exchange, the benefit of investing in and using the product is greater when multiple parties invest in the same, or at least an interoperable, product, because now that information can be shared among more users. Adding this up in a macroeconomic setting, these network effects

at the product and business level suggest that a rise in the stock of IT capital within a sector or country is disproportionately beneficial to growth.

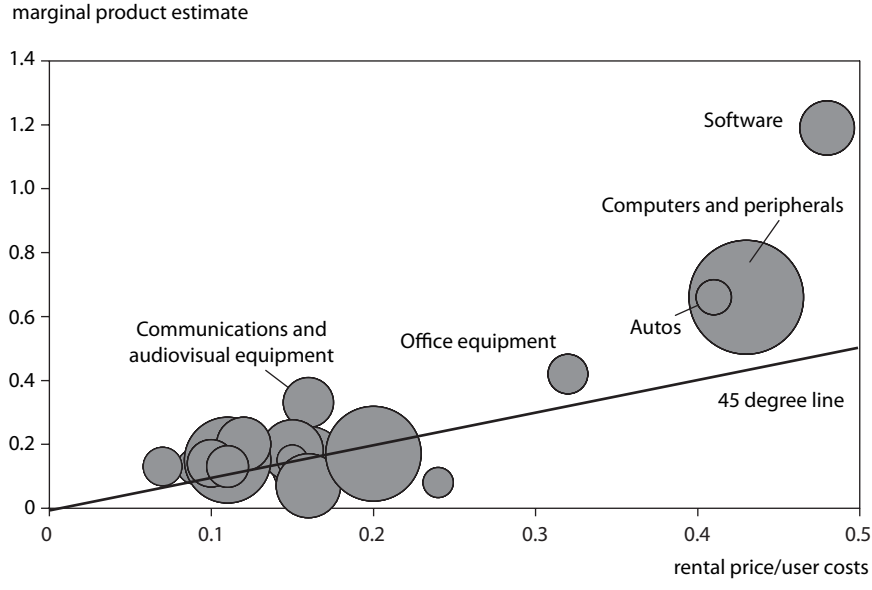
A number of researchers have found these network externalities in both micro and macro data. For example, for individual IT software application products (such as spreadsheets), the product purchased and used by a greater number of users is priced higher than the one used by fewer people—there is a "network premium" embodied in the price of that product (Brynjolffsson and Kemerer 1996, Shapiro and Varian 1999). Using data on IT investment and capital stock by industry sector, other researchers have found that spillovers or externalities, as measured by the reduction in costs and increase in marginal products, are greater in sectors that have larger stocks of IT capital and more extensive forward and backward transactional linkages with sectors that also have a high stock of IT capital in place (Mun and Nadiri 2002).[1] Chapter 3 will discuss the macroeconomics of network effects and the implication of the differences in investment in IT capital across sectors in the United States.

Because network connectivity augments the value of IT capital, the communications sector takes on added importance in supporting economic growth. The sector comprises the communications equipment, the presence of a network, and regulations on the use and pricing of the network. These factors show up in cross-country research. For example, when researchers segment a sample of countries into industrial countries and two groups of developing countries (divided between those with faster and slower increases in IT and communications technology relative to GDP), they find that the industrial countries and the developing-country group with the larger increase in domestic investment in these technologies have faster productivity growth (Lee and Wan 2001). Developing countries with lower rates of domestic investment in technology have muted productivity gains because they did not invest much themselves, but they did get some productivity gain just from being networked into the global communications network. Other research, particularly of emerging markets, finds that, controlling for the level of development, trade protection (particularly tariffs on PCs and communications equipment) and high-priced communications negatively impact the adoption of the Internet (Knight 2003). Policies that raise the price of IT and communications equipment through tariffs and raise the costs of transmission through regulated pricing reduce both domestic investment in IT and the networking gains from that investment.

Another manifestation of the special characteristics of IT capital is its relatively higher estimated marginal product compared with other kinds of capital. The marginal product of a type of capital is the additional value added in business output from investing in an additional unit of that type

1. See also Wilson (2004, 27) for a discussion of the fixed effects regressions suggesting a permanent component to the stock of IT capital.

Figure 1.1 Implied marginal products and Bureau of Labor Statistics rental prices, by asset type



Note: Size of bubbles indicates share of total investments.

Source: Wilson (2004).

of capital. This higher marginal product of IT capital can come from the network externalities just discussed, from being more technologically advanced than other kinds of capital, and from being positively related to changes in the organization of the workplace.

Using a very detailed dataset, Daniel Wilson (2004) finds that the marginal product of IT capital (which in principle equals what businesses are willing to pay for the product) exceeds that of other kinds of capital by several times over (figure 1.1).[2] Moreover, the estimated marginal product relative to rental price (the cost of a unit of capital services) is greater than 1 for IT products. Overall, the return to a dollar of IT capital service is more than the $1 that one would have to pay for it.

In this regard, the relative return-to-rent ratio is particularly great for software. There are a number of possible reasons why software might be particularly special, including its rapid rate of depreciation, its network benefits, and the extent to which it requires associated changes in the organizational structure of the workplace. These results may also be consequences of tax differences for IT equipment and software. Nevertheless,

2. The bubbles for IT products in figure 1.1 lie above the 45 degree line.

these results with respect to the higher relative return to software use are consistent with the higher estimated price elasticities reported earlier.

Going forward, as globalization of IT products expands from hardware into software, there is the potential for declines in the price of software. These price declines portend additional gains to IT investment and the associated acceleration of productivity and economic growth through channels similar to those to be analyzed more explicitly in the context of IT hardware in chapter 3.