The Digital Economy: An Overview

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Outline

Glossary

Bandwidth
Technically, the difference between the lowest and highest frequencies in a transmission channel, but more often informally used to refer to the speed with which digital data can be transferred over a specific connection (telephone wire, cable, optical fiber, or wireless), e.g., 10 Mbps, or 10 megabits per second.

Cyberspace
All electronic interactions and data, especially those that are mediated by the Internet. The term was coined by William Gibson in his science fiction novel, *Neuromancer*.

Digital divide
A situation where particular socio-economic groups have access to the Internet and information technology at levels that are substantially higher than other groups.

Digital economy
A term that emphasizes the importance for the overall economy of information that is stored, processed and exchanged in digital electronic or optical formats.

E-business
A subset of e-commerce, including all electronically aided transactions and activities of businesses, including internal accounting, inventory control and communications.

E-commerce
Short form of electronic commerce, refers to doing business electronically, based on the electronic processing, storage and communication of information, including activities that provide the enabling physical infrastructure and software.

E-commerce interaction types: B2B, B2C, C2G, C2C, B2E
Acronyms for different interactions, implicitly, but not necessarily, electronic, between businesses, consumers, governments and employees, e.g., B2B means business-to-business).

EDI
Electronic Data Interchange – refers to the use of proprietary software and leased telecommunications lines for communications between firms, typically at different points of the value chain

E-tailing
Short for electronic retailing, which is the use of the Internet and World Wide Web for offering consumer products and services for sale, and for completing transactions.

Flexible mass customization
The ability to quickly satisfy the diverse wants of large numbers of individual consumers.

Information economy
A term that emphasizes the importance for the overall economy of all kinds of information, including entertainment, news, market and business information, research, and personal communications.

Information revolution
A term that emphasizes the dramatic effects of the steep fall in the costs of processing, storing and communicating information as a result of advances in information technology.

Information technology
Any aspect of technology, including hardware, software and services, that involves data in digital electronic or optical formats, including technologies for processing, storing and transmitting such data.

Intellectual property
Useful inventions, original expressions of ideas, and names or symbols used in business the ownership of which is protected by various categories of law (trade secret, patent, copyright and trademark).

Knowledge economy
A term that emphasizes the importance for the overall economy of all kinds of knowledge, including various types of expertise, skills, and understanding of particular markets, with an implicit emphasis on science, mathematics and technology.

Moore's Law
An empirical regularity, described by Intel co-founder Gordon Moore, that the processing power of microprocessors (measure by the number of transistors per square inch on integrated circuits) doubles every 18 months; therefore an indicator of the rapid pace of innovation in the digital economy.

Network externalities
A situation where the value of being part of a network depends on the number of other members of a network – typically this value is positive. For example, if the value of a network with n members to an individual depends on the number of possible connections in the network, then this value is proportional to $n(n-1)/2$ (roughly, the square of the number of users, which is known as "Metcalfe's Law"), and the marginal value of an additional member is proportional to n, the network size.

New economy
A term that encompasses the ideas behind the terms 'digital', 'information' and 'knowledge' economy, but also sometimes connotes that the working of the economy are changed, either because information is a good with high fixed and low marginal costs, so competition is less stable, or because faster information flows reduce adjustment times and hence swings in the economy.

Online
Being actively connected to, or being a user of the Internet (and possibly other electronic networks).

Supply chain
From the perspective of a firm, this is the portion of its value chain that involves its direct and indirect suppliers. From the perspective of the industry, it coincides with the value chain, with the emphasis being more on the physical processes and logistics as opposed to value added.

Value chain
A schematic representation of a firm's (or industry's) stages of production, possibly including activities that take place upstream or downstream of the firm's own activities. Examples of value chain stages include inbound logistics, production operations, outbound logistics, marketing and sales, and after-sales support. The emphasis is on the value added at each stage.

Winner-take-all
A market situation where the leader dominates because high fixed costs and low marginal costs of producing information favor one or a few large firms, or because users of a network get much higher benefits when the network is larger.

Abstract

The digital economy refers to the general importance of information or knowledge in the economy, including e-commerce as an important, but not the sole, component. The digital economy still has a relatively small direct share of the economy, but its importance is growing rapidly, and IT can have significant impacts on other sectors of the economy. Business strategy in the information age includes greater possibilities for managing information, both as a product in its own right, and as information about other products and services. The organization of firms, as well as their interactions with consumers changes as information becomes easier and cheaper to store, process and transmit. The technological developments that make the information revolution possible have implications for intellectual property rights (especially those covered by patents and copyrights) and contracts. Other areas where government policies must adapt are contracts, privacy, antirust, and international trade. Ultimately, the information revolution has profound implications for the organization of work and play, and for all kinds of communities of interest.

1 Introduction

"IT and the Internet amplify brain power in the same way that the technologies of the industrial revolution amplified muscle power."

Bradford DeLong, Professor of Economics, University of California, Berkeley, quoted in "The New Economy", Pam Woodall, *The Economist*, September 21, 2000, Survey p. 6.

The purpose of this essay is to explain what the **digital economy** is, and how it fits into broader economic trends that are shaping the economies of the US as well as other countries. Essentially, the term 'digital economy' can be taken as referring to the use and impact of digital information technology in various forms of economic activity. As such, the term includes more specific activities such as e-commerce and e-business, and is closely related to terms such as knowledge economy and information economy.

All groups in the economy are affected by the pervasive use of information technology: this includes consumers, business firms and governments. Activities that are not directly commercial, such as personal communications, are also affected. The fundamental driving force is the falling costs of processing, storing and transmitting data or information that has been put in digital electronic form, as a result of innovations in these areas. These declines in costs have made further innovations possible that permit easy and widespread communications over extensive networks, the existence of large and rich databases of information and knowledge that are freely or easily accessible, and the ability to conduct most or all stages of economic transactions over long distances, without relying on alternative methods of information exchange. These new applications have, at the same time, spurred innovation in the core technologies of storage, processing and transmission, creating a 'positive feedback loop.'

The further results of these expanded capabilities for accessing, using and sharing information in digital form include new and more efficient ways of organizing markets; new and more efficient methods for businesses to communicate and transact with each other and with consumers, employees and job seekers; dramatically lower costs for individuals in locating or gathering information of all kinds, including market and product-related information; changes in the organization of business firms and in their strategic behavior; and changes in the overall societal organization of work, leisure and general communities of shared interest.

The essay is organized as follows. In Section 2, we discuss the definitions of the basic terms, including those we have used in this introduction. Section 3 provides some data on the size and growth of the digital economy and e-commerce, and discusses the measured impacts of information technology on the economy as a whole, as well as some of the problems of measurement. Section 4 describes changes in the nature, structure and performance of firms and markets as digital technologies help make information more ubiquitous, and as information increases in importance as an economic good. Section 5

examines several aspects of security, and how they interact with or affect the other developments in the digital economy. Section 6 examines several aspects of government policy with respect to the digital economy, including intellectual property law, privacy, antitrust and regulation, and international trade. Section 7 briefly discusses broader implications of the information revolution, examining how it changes the ways in which individuals work, play, and interact within organizations and communities. Section 8 is a summary conclusion.

2 Information Technology, the Digital Economy and E-Commerce

While there is no absolute agreement on what the 'digital economy' is, this section provides a working definition, discusses how the term is related to e-commerce and e-business, and discusses the measurement of the digital economy, and the impacts on overall economic activity.

2.1 Defining the Digital Economy

A computer is essentially a machine for storing and processing data. While one might count the abacus or mechanical, gear-based calculating machines as computers, the term typically refers to electronic machines that use on-off electrical signals to convey and process data. The two states, 'on' and 'off', based on whether an electric current is flowing or not, represent the digits 1 and 0. These are 'binary digits' or **'bits'**. Ultimately, all data that is input to a computer, and is processed by it, is translated into bits. 'Information' refers to data organized in meaningful ways, though 'information' is often used to subsume 'data,' and we follow this practice here. **Information technology** (IT) therefore refers to anything connected to this process of storage, process and transmission of information converted to digital form. The use of IT for purposes related to economic transactions gives us the term digital economy. Here is one possible definition:

> **The digital economy involves conducting or facilitating economic activities electronically, based on the electronic processing, storage and communication of information, including activities that provide the enabling physical infrastructure and software.**

Dramatic and rapid reductions in the costs of processing information, storing it and transmitting it to others (see Table 1) have made the uses and benefits of IT potentially span the whole economy, spurring further innovation in core technologies, and leading to an '**information revolution'**. On the basis of these falling costs, one has seen innovations such as personal computers, color graphics, point-and-click interfaces, and other developments that have made IT much easier to use. The Internet and the World Wide Web are the latest elements of the progress of IT over the last half-century, adding easy two-way communication of rich information (text, graphics, audio, video, etc.). The changes that the increased importance of IT brings about in people's daily lives are captured in the term '**new economy**.' The term suggests that IT and the Internet shift the focus of economic activity to information, and away from traditional activities

such as manufacturing, although it must be recognized that manufacturing industry has used IT to improve efficiency in various aspects of operations, such as scheduling, quality control and assembly. Similar terms are possibly more descriptive: **knowledge economy**, **information economy**, and digital economy. The last of these, as noted, emphasizes the fundamental technology that drives everything: the conversion of information to digital form.

Table 1: Falling Costs of Computing (US $)

Costs of computing	1970	1999	2004
1 Mhz of processing power	7,600	0.17	<0.02
1 megabyte of storage	5,260	0.17	<0.01
1 trillion bits transmitted	150,000	0.12	<0.01

Source: 1970 and 1999, Pam Woodall, "The New Economy: Survey," *The Economist*, September 21, 2000, p. 6, Chart 1 (see also, http://www.dallasfed.org/fed/annual/1999p/ar99.pdf, Exhibit 3); 2004 author's estimates from various sources and calculations, viz. processing power from Moore's Law and trends in prices of Intel chips; storage based on cost of desktop hard drives; transmission from current costs of basic data transfer.
Note: For processing and storage, these are hardware and basic software costs, and do not include ongoing costs of use and management of the hardware and software. For transmission, these are average costs based on full capacity use.

The terms 'information economy' and 'knowledge economy' focus on what is being digitized. Information and knowledge are related, but distinct concepts, even though the distinction is sometimes fuzzy (we postpone a discussion of information and knowledge as economic goods to Section 4). Information in this context is more general and basic, as it connotes anything that can be put into concrete form before digitization. For example, a popular song is information, from an IT perspective. The sounds can be reduced to a digital file that can be stored, transmitted and processed by various kinds of computers. If a person internalizes information about the song (its title, tune, lyrics, etc.), then that constitutes knowledge, just as the ability to write computer programs that allow users all over the world to share songs (as digital files) is knowledge. To push these examples further, the particular song-sharing software program is also information. In this case, knowledge helps to produce and transmit information. People can also gather information, process it in some way, and gain knowledge, as when they study how to program in a particular computer language. Some of the same distinction comes up in the differences between copyright and patent law, protecting different kinds of intellectual property rights (see Section 5) – copyright law protects particular expressions of ideas, or information, whereas patent law protects inventions, or the ideas themselves, if they are useful knowledge. In all these cases, digitization (through the use of IT generally, and the Internet in particular) amplifies the benefits of knowledge, and makes the spread of information easier.

2.2 E-Commerce

E-commerce (or **electronic commerce)** is a popular term that emphasizes the use of the Internet and associated aspects of IT for business purposes. While businesses previously adopted IT for many internal and 'back-end' activities (Section 2.3), the Internet and World Wide Web have allowed business-consumer (**B2C**) commercial interactions to be more closely and comprehensively mediated by IT. Examples of e-commerce can include buying retail items using a Web interface and paying for them by providing credit card information **online;** downloading media-player or other software (for a trial, free use, or through a purchase) over the Internet; checking the news, weather and movie reviews on a portal, possibly "paying" for these services by giving attention to online advertisements; going to an auction web site, and bidding on collectibles or other items; and paying a monthly subscription for Internet access, to chat online with friends, or others one meets in **cyberspace**.

More formal definitions of e-commerce encompass all the above examples, and include commercial transactions between any kinds of organizations, not just B2C interactions. Here are two general definitions:

> "Electronic commerce refers generally to all forms of transactions relating to commercial activities, including both organizations and individuals, that are based upon the processing and transmission of digitized data, including text, sound and visual images."
>
> (OECD, 1997)

> "In ever greater numbers, people are shopping, looking for jobs, and researching medical problems online. Businesses are moving their supply networks online, participating in and developing online marketplaces, and expanding their use of networked systems to improve a host of business processes. And new products and services are being created and integrated into the networked world."
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> (*Digital Economy, 2000*, p. 7)

The scope of what constitutes commercial transactions is taken to be quite broad in these definitions. Information gathering or exchange that does not directly involve a direct monetary payment may still have an economic motivation. Even leisure-related activities typically require some measured economic activity. In the example of using the Internet for chatting, one pays for access to the infrastructure that enables the leisure activity. Activities that involve the government (e.g., filing one's individual tax return electronically over the Internet) are not "commercial" in the narrow sense, but are clearly related to economic activity that is measured in the national accounts statistics.

Of course, not all IT-based activities qualify as e-commerce in the sense of involving the Internet. For example, many home activities involving PCs do not involve Internet use at all: record keeping, children's homework, creating (paper) greetings cards, typing holiday newsletters, and so on. Similarly, small retail stores may have computerized

inventory systems that have no links to any other computer. However, this gap between computer use and Internet use is shrinking, and for many individuals and businesses, using computers or IT automatically means using the Internet.

2.3 E-Business

The encompassing definition of e-commerce presented earlier includes a broad range of online transactions and interactions that are connected to some economic motive. Therefore, this is broader than the term **e-business**, defined here as the use of IT, including networked computing, by business firms. For example, if individuals transact directly online, so that no business firm is directly involved, then that would qualify as e-commerce, but not e-business. Similarly, we include government-individual transactions in e-commerce but not in e-business.

E-business (and therefore e-commerce) includes not just transactions across firms, but also activities that take place within the boundaries of a business, but do not cross them. Internal accounting, inventory control and other forms of business record keeping and tracking have been electronically based in industrial countries for over a decade, especially in larger businesses. These purely internal records and transactions, when handled electronically, are often what e-business is taken to refer to. The use of IT provided cost advantages over traditional means (i.e., paper) in terms of storage, manipulation and retrieval of large amounts of information, provided that the scale of use was large enough to spread the substantial fixed costs initially associated with IT investments. In fact, until computers became affordable as household items, as a result of falling costs and associated innovations, large organizations were the only purchasers of IT products and services.

In fact, the digital economy, in the form of business-to-business (**B2B**) transactions based on older electronic communication methods (electronic data interchange or **EDI**, using proprietary software and dedicated communication links), substantially predates the Internet and the World Wide Web. Electronic links between financial firms, and between large retailers and their suppliers, were two prominent examples of this form of e-business, or B2B e-commerce. The Internet and World Wide Web have extended the economic feasibility of such links to a much wider range of businesses, through their use of shared networks and non-proprietary communication software, and the resulting reduction in the costs of information exchange. Advances in ease of use and speed of transmission have also contributed to this trend, by further increasing accessibility and flexibility. Another potential impact of these developments, which supports the use of broader definitions of terms such as e-commerce and e-business, is the blurring of the boundaries of the firm, as information flows more freely across firms as well as within them.

3 Size, Growth, and Impacts of the Digital Economy

The size and growth of the digital economy can be gauged in several ways. Basic measures of numbers of Internet users, web sites and so on are popular. Clearly, these do not directly measure economic activity that takes place online, though the provision of Internet access is itself an economic activity. More direct and better measures are data on transactions that take place online, as well as the share of IT-related activities in the overall economy. This section examines in turn these different approaches to measuring the digital economy and its impacts. None of the measures is perfect, reflecting the newness of the digital economy as a challenge for economic statisticians.

3.1 Internet Use

Three kinds of statistics that are often used to gauge the growth of the digital economy are the number of people with Internet access, the number of unique web pages, and the number of web sites, with the latter two being conceptually very close. The US Department of Commerce, using data from the US Census Bureau, reported[1] that 143 million Americans, or 54 percent of the population were using the Internet in September 2001, up from 117 million thirteen months earlier. Furthermore, a broader cross-section of Americans is using the Internet, reducing earlier fears of a '**digital divide'**, between those with access to these new communication tools, and those without (especially the poor). In fact, the growth in Internet use during the period (2000-2001) was fastest among Americans with household income less than $15,000 a year.[2] By February 2004, according to another survey, 204 million Americans had Internet access from home, representing close to 75% of the population.[3] Another important trend that has emerged recently in the US is the acceleration in the proportion of Internet-connected households with broadband access, crossing 45% in February 2004.[4]

The Internet is also increasingly global, with the worldwide number of users estimated[5] at 729 million, of whom over half used another language than English. With the exception of the US and a few European and Asian countries, the numbers of Internet users are still low relative to population sizes, reflecting generally lower levels of income in much of the world, but as costs continue to fall, even poor villagers in Asia, Africa or Latin America are beginning to use the World Wide Web to get weather and crop price information, or to check on village land ownership records from government web sites. This represents another aspect of overcoming the initial digital divide introduced by the Internet. Table 2 gives a sampling of Internet use by language, from Global Reach. In most cases, there is a close correspondence between countries and languages, with English, Arabic, Spanish and Chinese being more dispersed.

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[1] http://osecnt13.osec.doc.gov/public.nsf/docs/Evans-Census-Online, accessed January 23, 2004. Nielsen NetRatings estimated a higher number of Americans, 168 million, online in January, 2001 (http://www.nua.ie/surveys/index.cgi?f=VS&art_id=905356461&rel=true).
[2] http://osecnt13.osec.doc.gov/public.nsf/docs/Evans-Census-Online, accessed January 23, 2004.
[3] Three Out of Four Americans Have Access to the Internet, According to Nielsen//NetRatings, Press Release, March 18, 2004, accessed at http://www.netratings.com/pr/pr_040318.pdf on August 2, 2004.
[4] Reported at http://www.websiteoptimization.com/bw/0403/, accessed August 2, 2004.
[5] See http://www.glreach.com/globstats/, where links to the original data sources are available. Accessed August 2, 2004.

Table 2: Global Internet Use, 2004

Language	Internet users (millions)	Total population (millions)
English	287.5	508
European languages (excluding English)	276.0	1,218
Arabic	10.5	300
Chinese	102.6	874
Japanese	69.7	125
Korean	29.9	78

Rough measures of the Internet resources available to the growing number of users are given by counts of the number of web pages and web sites. The number of unique World Wide Web pages was reported to be more than one billion by January 2000, up from just 100 million in October 1997.[6] The number of web sites in August 2004 was over 53 million, well up from the 43 million estimated a year earlier, and a different order of magnitude altogether from the 19,000 sites estimated in August 1995.[7] Of course, neither measure indicates how much time people actually spend online, nor how that time impacts economic activity. In particular, they do not tell us how much money people spend directly or indirectly as a result of their Internet use. For that, one would use the approach of national income and product accounting, which estimates value added in market transactions. There are problems with this way of measuring economic activity, such as the failure to account for the value of time used in non-market transactions, or in activities that affect market transactions,[8] but official methods of calculating economic activity are the best we have. In particular, they are designed to capture market-based economic activity relatively well, and to avoid problems such as double counting, which occur if the gross values of transactions at various stages of the value chain are added up.

[6] The original sources are Inktomi, "Inktomi WebMap", Press Release, January 2000 (www.inktomi.com/webmap) and David Peterschmidt, President of Inktomi, quoted by Yahoo, "Internet Volume is Doubling Every 90 Days," October 3, 1997 (www.nua.ie).
[7] Data from http://www.netcraft.com/Survey/archive.html and http://news.netcraft.com/archives/web_server_survey.html, accessed August 2, 2004.
[8] For example, time spent in gathering information that affects purchase decisions is not valued in national accounts. Shifts in this activity from traditional, physical methods (such as browsing print media, telephoning, and driving around to stores) to online search will not show up in the data, except as changes in business spending (from magazine ads to Web ads), or even *reductions* in economic activity (less spending on magazines by consumers).

3.2 Types and Measures of Online Transactions

The problem of double counting is avoided when one looks at final sales to consumers. B2C e-commerce seemed to hold out great potential in 1999 and the early part of 2000, resulting in a rather frenzied burst of entrepreneurial activity backed by eager venture capitalists. This fever has cooled, but the growth remains. The US Bureau of the Census estimated electronic retail (**e-tail**) sales in 2001 to be $34.3 billion, $44.3 billion in 2002, and $56.0 billion in 2003. However, even after this impressive growth, online sales remained just under 2 percent of all US retail sales.[9] In Europe, figures for online retail sales are less standardized, but one estimate for 2002 put them at about $30 billion, or comparable to the US figures in magnitude.[10] A more recent survey by VISA estimated that e-tailing took off in the beginning of 2004 in several European countries, doubling in the first quarter as compared to a year earlier.[11] Statistics for online retail sales in Asia are still less reliable, but one can estimate them to be about one quarter to one third of European figures, based on various Internet sources.

B2B transactions may involve products that are indistinguishable from consumer products (computers and office supplies, for example). The only difference is that they are sold to businesses rather than to households or consumers. However, a large segment of B2B transactions involve raw materials and intermediate products, as well as services that are specific to businesses (for example, accounting, human resource management, and, increasingly, information technology services). While estimates of B2B e-commerce vary widely, it is widely agreed that the numbers are much more substantial than for B2C e-commerce. The reasons have to do chiefly with the historical scale of IT, compounded by the cost-saving incentives of businesses in competitive markets. As noted in the earlier discussion of e-business, Internet-based e-commerce represents the impact of cost reductions in expanding the size of the communications network, and hence the market, from just large firms to including small firms as well as households.

There is a conceptual problem with most estimates of B2B e-commerce, which simply add up revenues from a variety of firms. Because B2B transactions involve intermediate products and services, aggregating revenues across businesses will involve double counting, since revenues for intermediate products sold to other businesses are a

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[9] These statistics are reported at http://www.census.gov/mrts/www/current.html (accessed August 2, 2004), which also gives historical data, calculation methods and charts. Other surveys give somewhat higher figures. For example, AOL reported that its members alone spent $33 billion online in 2001 (http://news.com.com/2100-1017-800049.html, accessed August 2, 2004). However, this may include travel spending, which, if excluded reduces estimates considerably. The figures reported in the text exclude travel spending, which would add another 50% to those figures if included. See http://www.comscore.com/news/ecommerce_2001_review.htm, accessed May 28, 2003

[10] The estimate is from Forrester Research, as reported in the International Herald Tribune, at http://www.iht.com/articles/78016.html, accessed August 2, 2004. Gartner, another IT research firm, estimated somewhat higher numbers (http://www.gartnerg2.com/press/pr2002-03-19b.asp), but they seem too high compared to US figures, given somewhat lower Internet penetration in Europe. Higher numbers for Europe may include travel and financial services transactions. See OECD (2002) for a discussion and detailed comparisons.

[11] European Online Sales up Across the Continent, June 24, 2004, http://www.emarketer.com/Article.aspx?1002885, accessed August 2, 2004.

cost for those businesses. Still, one can use the numbers, and changes in them, to get some idea of the importance of B2B e-commerce. While the US Census Bureau does not yet estimate B2B e-commerce, private forecasters do. Estimates for 2001 varied widely,[12] ranging in a sample of forecasters (based on a combination of surveys and guesswork) from US $ 474 billion to US $ 1,138 billion[13] for worldwide B2B e-commerce, with 70-80% of this being in the United States. The numbers vary greatly across sources, but they are all of similar orders of magnitude, and all project substantial growth. One can safely conclude that B2B e-commerce substantially exceeds B2C in size, and it may be growing somewhat faster on average. Finally, the cost advantages of using the Internet[14], plus the benefits of being part of a larger network, are expected to cause a relative shift to the Internet from EDI. Small businesses, in particular, can use Internet-based e-commerce where EDI would not be economical for them. Furthermore, electronic marketplaces are potentially economically viable using the Internet, but not with traditional EDI, because the Internet permits more flexible and less costly access.

One final category of e-commerce is consumer-to-consumer (**C2C**). While firms such as eBay – which is the dominant C2C marketplace, with over 60% market share[15] – have entered the popular imagination through their electronic auctions for collectible or unique items, the value of C2C transactions is relatively small. However, eBay now handles B2C and B2B transactions as well. In 2003, eBay's net sales, from transaction fees on $15 billion in gross revenues, reached $1.2 billion (Hof, 2003). Again, one should caution that the total value of a transaction does not represent the economic value added of an activity. If a used item is bought and sold through a dealer, the dealer's profit is a better measure of the value created in the overall transaction, and this is what is measured in the national accounts. Thus eBay's own revenues, adjusted appropriately for its market share, may be a better indicator of the importance of C2C e-commerce than the value of goods transacted through eBay.[16] Of course, a used item sold privately (say, in a flea market) will not show up at all in that official accounting.

3.3 Information Technology and GDP

While e-commerce, measured as actual transactions conducted online, represents only a small fraction of the US Gross Domestic Product (GDP), which was 10.9 trillion dollars in 2003. However, overall spending on information technology (IT) may be a better measure of the significance of the digital economy, since the use of IT has become

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[12] One area where differences in estimates can arise is with respect to EDI, which uses private networks and proprietary software, and has been restricted to larger firms. For example, the Boston Consulting Group estimated US EDI for 1998 at $571 billion, dwarfing its estimate of Internet-based B2B e-commerce of $92 billion. At the same time, they projected EDI to grow only slowly, to $780 billion in 2003, while projecting US Internet-based B2B e-commerce to be $2 trillion in 2003.

[13] Estimates are from surveys; source: eMarketer (2002), "E-Commerce Trade and B2B Exchanges", at http://www.emarketer.com/products/report.php?2000091, data in table accessed May 28, 2003

[14] For example, retailer Sears Roebuck, one of the pioneers of EDI, has an EDI system that costs it about $150 per hour. Internet-based exchange with its suppliers could reduce this figure to as little as $1 an hour. See Sandra Guy, "Sears, French Giant in Online Venture," *Chicago Sun-Times*, February 29, 2000.

[15] "Profiting From Online Auction Sites," October 06, 2003, by Corey Rudl, http://www.entrepreneur.com/article/0,4621,311268,00.html (accessed August 2, 2004).

[16] A complication for this approach is the increasing use of eBay for B2C sales.

pervasive in businesses of all kinds and sizes.[17] This includes the use of computers for managing transactions, inventory and logistics, even without use of the Internet. At the same time, the boundaries between general IT use and e-commerce are increasingly blurred. Networks exist within corporate walls and simultaneously are part of the larger network of the Internet. Telecommunications infrastructure that carries telephone conversations is also used for World Wide Web data. Total IT spending in the US (without any double counting) now makes up about 7% of GDP, or over 700 billion dollars.[18] This includes hardware, software, services and telecommunications spending. This means that there is still a substantial part of economic activity that is not directly related to information technology. However, it is a reasonable forecast that the 7% figure will increase over the next few decades. A slightly different measure, the percentage of ICT[19] value added in business sector value added, yielded an average of close to 10% for 25 OECD countries in 2000, with the US being somewhat above this average, and extremes ranging from over 15% for Ireland and Finland to about 5% for Greece and Mexico.

One factor working *against* an increase in IT as a proportion of GDP is the fall in the costs of IT. The empirical regularity observed by Intel co-founder Gordon Moore, and enshrined as "**Moore's Law**," says that the number of transistors per microprocessor doubles every 18 months. This ability to pack more and more circuitry on tiny wafers of silicon keeps on reducing the cost of processing power. Similar factors are at work in storage and communication of information, resulting in enormous reductions in the overall cost of computing (recall Table 1). To the extent that only expenditures are measured when economic activity is calculated, some of the impact of the digital economy is being missed. For a simple example, a $2,000 home computer is many times faster than a $2,000 home computer available five years ago; it has much more storage capacity; and it can communicate much faster with other computers than was possible half a decade earlier. Even neglecting adjustments for inflation (which would mean that the $2,000 computer now is cheaper in real terms), the same amount of money spent now allows one to work more quickly and effectively, or to enjoy one's leisure more. Thus, the same spending on information technology today gives much more "bang for the buck" than five years ago.

The changes in computing go beyond having more capacity or saving time, and encompass activities that were impossible in the past: online games, music listening and sharing, interactive distance learning, and so on. Again, these increased capabilities are not fully accounted for in the standard accounting of economic activity. Of course, these measurement problems have always existed. Innovation that introduces new products or improves the quality of old products has always been difficult to account for. One might argue, however, that IT has accelerated innovation, and magnified the problem of underestimating the benefits of certain economic activities (Brynjolfsson and Hitt, 2000).

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[17] A useful discussion and justification for this view is OECD (2002a).
[18] See Jorgenson (2001) for detailed estimates. Figures from IT market research groups such as International Data Corporation (IDC) are a little higher.
[19] The 'C' refers to 'communication', which has become increasingly digitized, and is counted with IT in many statistical and conceptual exercises. The data is from OECD (2002b).

The problem of accounting for improvements in quality and variety goes beyond the IT sector. If IT can be used to more effectively design new products, or improve the design of existing products, then its value will be greater than is simply reflected in spending on IT itself. In other words, better, cheaper, more versatile computers make it possible to have better, cheaper, more varied cars, houses, toys and so on. This is partly what Brad DeLong (see Introduction) means when he says that IT amplifies brainpower. For example, in crash testing new cars, actually crashing a car could cost something like $60,000 each time. This is how it used to be done, with the results analyzed partly by computer. Simulating the entire crash on a computer can now instead be done for close to $100.[20]

Despite the seemingly obvious benefits of IT illustrated above, one paradox that proponents of the new economy have faced has been the lack of hard evidence for these benefits in the overall GDP data, measuring economic activity. Initially, increased investment in IT did not appear to be improving productivity in any measurable way. The conclusion of skeptics was that much of this IT spending had no real impact. We turn to this issue next.

3.4 Information Technology, Productivity and Growth

Much of the attention to productivity growth has been with respect to the United States, which has spent the most on IT, and which had a prolonged slowdown in productivity growth in the 1970s and 1980s. Early investments in IT seemed to have no countervailing impact to reverse or mitigate this slowdown. Analysis of the introduction of electric power a hundred years ago (David, 2000) suggests that the benefits of innovation can take decades to appear in quantifiable form. This seems to fit with what happened in the last five years of the twentieth century, when US productivity growth did increase substantially, just as the penetration of PCs into homes approached 50%, and as the Internet took off.

Some work on the recent US experience (Gordon, 2000) suggests that the increase in productivity growth is confined to a small segment of the economy (computers and durable goods). Furthermore, the productivity boost may have been entirely the result of the prolonged economic expansion in the US (productivity rises during economic booms). This skeptical view is supported by studies that find productivity gains have been low in sectors where IT investments have been high. For example, measured productivity in banking and education actually fell from 1987 to 1997, even though these were the sectors with the highest spending on IT as a proportion of output. Possible explanations for the failure of IT investments to show up as improved productivity include, on the benefit side, the inability to account for time savings, increased outputs of public knowledge, availability of greater variety, and general improvements in the quality of products and services. Thus, some of the most important benefits of the digital economy could also be the ones that slip through the cracks in measuring economic activity. Alternatively, the benefits may simply not be there, rather than being

[20] Pam Woodall, "The New Economy: Survey," *The Economist*, September 21, 2000, p. 5.

unmeasured. Explanations include lags in learning how to get the most from new technologies, the need for complementary investments required to boost output, and the presence of network effects, which limit gains unless there are many adopters. Baily (2004) and Gordon (2004) provide detailed reviews of these and other cautionary arguments with respect to the impact of IT on productivity growth.

Despite the caveats, two recent, comprehensive analyses, by Jorgenson (2001) and Stiroh (2002), suggest that IT has been an important contributor to productivity growth in the 1990s. [21] Jorgenson directly traces this impact to the rapid fall in the prices of semiconductors and of IT products in general, especially after 1994. For 1995-99, Jorgenson estimates that two-thirds of the United States' productivity gains were the result of IT use. Stiroh goes even further, with a detailed, industry-level analysis of the US. He finds that the US productivity revival was indeed broad-based, that much of it took place in IT producing industries, and that industries that are IT-use-intensive also had higher productivity gains. Thus Stiroh's work appears to tilt the scales in favor of a positive assessment of the impacts of the digital economy, at least for the US. Work by Triplett and Bosworth (2003) provides additional positive evidence, estimating that IT investments have been significant in contributing to productivity growth in the services sector.

Studies for other countries are also beginning to find significant impacts of IT on productivity growth. Daveri (2000) reaches positive conclusions with respect to the impact of IT on overall economic growth. His exercise includes 18 OECD countries, and his results for the US are broadly similar to those of Jorgenson and Stiroh. For Canada, Japan, Australia, New Zealand and 13 European countries, he obtains varied results, with Canada, Australia, New Zealand, the Netherlands and the UK having relatively high contributions of ICTs to growth, with Italy and Spain being at the other extreme. Daveri also argues why his results are more positive than those of another cross-country study (Colecchia and Schreyer, 2002), which uses a narrower definition of IT. These studies use data for 1991-97, and therefore miss the end of the 1990s, when significant growth in IT, as well as overall growth took place. Jorgenson (2004) examines data for the G7 countries (Canada, France, Germany, Italy, Japan, the U.K., and the U.S.) for 1980-2001. He documents the importance of IT capital spending for the overall contribution of capital investment to growth, as well as the impact of IT production on overall productivity growth. The results across the G-7 are not too dissimilar, indicating that the US has not been an outlier in this respect.

4 Implications for Markets and Organizations

This section discusses how the use of IT and the Internet affect the structure and outcomes of markets, and the organization and strategies of firms, all from a microeconomic perspective. The consequences of the special nature of information as an economic product are also highlighted.

[21] See also Oliner and Sichel (2002).

4.1 Information and Markets

The most basic way that the information revolution changes the economics of the marketplace is in making information about all kinds of products and services more widely available. While basic models of the market system often take it for granted that information about products and about buyers and sellers is abundant, in practice, this is not the case. In fact, one of the virtues of the competitive market system is its ability to economize on the use of information. Textbook-style competitive markets cannot overcome some kinds of lack of information: for example, the quality of a product may be observable to sellers who provide it, but not to buyers. In practice, many kinds of institutions arise to overcome informational problems: brand names, warranties, consumer protection laws, and so on. Business firms and other organizations may themselves be viewed partly as a response to information problems that prevent the use of markets for all transactions (Coase, 1937), with such transactions being internalized within firms. With firms as major actors, the market economy can be viewed as a scene of constantly shifting attempts to create advantages over competitors, by finding opportunities for greater efficiency or satisfying wants more effectively.

In this situation, the availability of greater information about products and services may upset existing institutions, changing the relative costs and benefits of current ways of doing things. How firms organize their own internal operations and transactions can change, and how they interact with consumers can also change. New kinds of firms may arise simply to manage the new possibilities for market interaction. For example, firms may specialize in providing price or quality comparisons to consumers, in ways that were not cost-effective before. Firms may find it easier to outsource manufacturing, because they can maintain closer links with suppliers through regular electronic information exchange. Other firms may provide combinations of services that were impossible or unlikely in the past, combining traditional media content (news, entertainment and product information) with individual services such as auctions and communications.

From the perspective of consumers, or buyers more generally, the Internet lowers search costs, by providing large amounts of product-related information ‘anytime, anywhere’. In addition to information from sellers, buyers can also more easily access information from intermediaries that rank products or make price comparisons, or from other buyers. In consumer markets, this ability to gather information from dispersed buyers represents a major extension of ‘word-of-mouth’ methods of information sharing.

Preliminary work on the functioning of markets online suggests that there are measurable effects of the greater availability of information. A survey by Smith, Bailey, and Brynjolfsson (2000) examines the evidence on four dimensions of price competition in B2C online markets, as compared to traditional transactions mediated through physical stores:

1. **Price Levels:** Are posted prices lower online?
2. **Price Dispersion:** Are prices of online sellers less spread out?
3. **Price Adjustment:** Do sellers adjust posted prices more finely or frequently online?

4. **Price Sensitivity:** Are buyers more responsive to price changes online?

Overall, the results of various empirical studies indicate that prices are lower online, there is less price dispersion, and prices are adjusted more often and in smaller increments. All of these conclusions are consistent with the general hypothesis that online markets are more competitive. The results on price sensitivity are mixed, and may be related to factors that cannot be controlled for, such as differences in the characteristics of online consumers. The lack of evidence for perfect competition (persistence in price dispersion, for example) can be explained by the continued importance of factors such as trust and reputation, switching costs associated with search that is still costly (though less so), investments by consumers in seller-specific information, loyalty programs, and price discrimination – possibly supported by customization of offerings (e.g., with "dynamic packaging" of vacation packages at online travel sites) where resale or consumer to consumer information exchange is not effective.

The studies discussed above examine only posted price markets, in the context of a small number of products such as books and CDs. Possible efficiency gains exist through the better matching of buyers and sellers in markets that otherwise relied on more costly methods of intermediation. In addition to online auctions of collectibles and other 'used' items, job markets, personal-relationship matching markets, and many fragmented B2B markets appear to have taken off precisely because the Internet and Web allow buyers and sellers to match more efficiently, creating higher value matches, as well as lowering costs associated with agreeing on a price and completing a transaction. Three important consumer markets where the Internet also appears to have had an impact are those for automobiles, housing and financial services. All these markets have been characterized by high search costs, and the presence of intermediaries with significant market power (car dealers, real estate agents, stock brokers, insurance agents and so on). The use of the Internet for basic information search and price comparisons appears to be providing some degree of increased competition in all these cases. In some cases, particularly digital products such as financial assets, the entire transaction can be completed online. In others, the Internet provides a vehicle for a significant proportion of the information exchange that accompanies a transaction.

The Internet also expands market across national boundaries, and impacts international trade, through its ability to increase the quantity and richness of information that is available. As in complex transactions within national boundaries, the kind of information that the Internet can provide does not remove the potential need for traditional face-to-face interactions, particularly when a relationship is being formed. However, it reduces the cost of much of the search process, in terms of where a potential buyer might want to invest more time and money in gathering the information necessary to decide whether or not to transact. Furthermore, once a relationship is established, the ongoing costs of routine information exchange and even transactions are reduced. In such case, the products that are traded may well be traditional physical products: e-commerce does not involve transforming the products, but rather changing the nature of the search and transaction processes. Even in this case, the savings in terms of transaction costs may

be substantial enough to significantly boost international trade. For small consumer items such as handicrafts, the Internet and Web provide a cost-effective way for even rural artisans in developing countries to advertise globally.

4.2 Information as an Economic Product

A basic impact of the information revolution is on information itself as an economic good. The best-known example of the magnitude of this impact is what happened to the *Encyclopedia Britannica*. The *Britannica* was the premier encyclopedia, with thousands of pages of articles by renowned experts. It sold for thousands of dollars, priced to recover the cost of a well paid direct sales force as well as the high printing cost for its two dozen volumes. This business was destroyed by the ability to put a reasonably large amount of information on a single CD-ROM, sold for under a hundred dollars, or even bundled in "free" with a home computer system. CD-ROM encyclopedias were inferior in academic quality, but were "good enough" for most people, and the price was right.

The ability to store, process (including copying) and transmit large quantities of digital information at lower and lower costs is now the central characteristic of information as an economic product. A world where the marginal costs of providing information approach zero is a world where businesses that deal in information have to find new ways to provide value to consumers, ways for which they can actually charge enough to recover the costs of producing the information in the first place. In order to do this, information may have to be bundled, personalized, or managed within a service that creates a long-term relationship with the buyer. To the extent that other products and services have also been bundled with information in the marketplace, and that this bundling changes, firms have to create new bundles of value. For example, online retailers try to provide their customers with suggestions and ideas, based on tracking the buying and browsing patterns of individual customers and those with similar interests. This is not dissimilar to the old personalized service in the local store, but can be done at a scale that was earlier impossible. Bundling may also take place without personalization, the combination of hardware and software being the most obvious example.

The ability to process large quantities of information in increasingly sophisticated ways is at the heart of the information revolution, extending not only to the ability to make suggestions about existing products, but also to design products in collaboration with individual customers, and to do it at a large scale. **Flexible mass customization**, referring to the ability to quickly satisfy the diverse wants of large numbers of individual consumers, is one of the possible pillars of business strategy in the digital economy (Section 4.3). In all these cases, businesses also have to be able to capture the value that they create, which may require strategies including a combination of technology (e.g., software to control copying), law (e.g., enforcement of copyrights – see below), and economics (e.g., pricing).

In addition to the low marginal cost of providing information, there are several additional aspects of information or knowledge as an economic product that affect the working of markets and organizations. In particular, information is a shareable or non-

rival good in consumption, where the terms refer to the ability of more than one person to consume the same thing. Low cost copying, storage and transmission enable this shareability to be implemented in new ways, such as peer-to-peer music file swapping, which bypasses traditional commercial distribution channels. In many cases, the use value of the information is unaffected by its being shared, or it may even be increased. For example, news and entertainment can be conveyed to large numbers of people simultaneously or sequentially, and no single person's enjoyment of a TV program is diminished as a result, and may even be higher if the program can subsequently be discussed with friends (a positive externality). In other cases, the value of information may be reduced if others have access to it (a negative externality). Information that affects the value of financial assets is a good example, where insider knowledge bestows an advantage in the market place. A seller's knowledge of a buyer's circumstances (or vice versa) is another example, in which one party may be better off without the other side knowing their valuation. In the examples of the previous subsection, where the impact of better information about the products and market opportunities was discussed, the market-related information could involve either type of externality. In cases where information is the final consumption good itself, such as entertainment, status considerations might create negative externalities, but the positive externality case seems more common.

The shareable nature of information and knowledge also raises concerns for the legal definition and enforcement of property rights, which are crucial for all market economies. In the digital economy, knowledge is increasingly important as a driver of economic activity and growth. To play this role, it must be part of the system of economic incentives. Knowledge or information is legally characterized as **intellectual property** (IP), but this is fundamentally different from physical property, and requires its own system of legal definitions and rights. Thus, IT and the Internet amplify not only brainpower, but also the importance of the legal system that governs the economic rewards to brainpower. Furthermore, technological advances that make copying and sharing of information of all kinds incredibly quick and inexpensive are having a major impact on legal issues relating to intellectual property, as in the case of music file swapping. We give a flavor of the issues here.

Briefly, there are four areas of IP law: (1) trade secret law, which protects valuable information not generally known that has been kept secret by its owner; (2) trademark law, which protects words, names, and symbols used by manufacturers and businesses to identify their goods and services; (3) patent law, which protects new, useful, and "nonobvious" inventions and processes; and (4) copyright law, which protects original "works of authorship." All these concepts of intellectual property predate e-commerce by centuries, of course, developing along with capitalism and the industrial revolution. The information revolution provides some new challenges in this arena, especially in the area of copyright law, though patent law also has been stretched by the information revolution and the rise of e-commerce, and issues of trademarking have arisen with respect to basic online activities such as the use of hyperlinks on the World Wide Web.

While patents are not granted for scientific truths or their mathematical expression (including computer programs as mathematical algorithms), an invention including software is patentable if the software controls real-world processes, or numbers that represented real-world concepts. The commercial use of IT fits this description in ways that were unimaginable when the courts ruled in this way, and software patenting has exploded in the last few years. E-commerce software patents include broad (many argue, too broad) ideas such as 'one-click buying' and 'reverse auctions'. In addition, the increased use of IT to govern internal business processes such as inventory control and workflow has also generated numerous software patents. While a strong system of granting and enforcing patents is consistent with the idea of providing incentives for innovation, it may reduce the social benefits that accrue from widespread adoption of innovations. Policy and legal debates are likely to continue, since there is no universal "right" answer to the issue of the nature and degree of optimal patent protection.

Copyright law differs from patent law, in preventing the unauthorized copying of the expression of ideas, but not ideas themselves. Therefore, copyright law does not protect against someone stealing an invention or someone else independently creating a similar expression. However, copyright does provide some protection against "non-literal infringement", such as the near duplication of screen displays. The primacy of information products, or "content", in e-commerce, and the ease with which digital information can be copied and distributed, have made copyright law for the Internet a major area of concern. Again, there are arguments on both sides, with associations of copyright owners of content such as music and movies pushing for strict controls on digital copying, and others supporting broader notions of fair use and free expression as limits on copyright law.

In addition to legal and technological strategies to enforce copyrights (Section 6.1), intellectual property (IP) holders have also turned to innovations in business strategy to capture the potential value of their IP. Several initial attempts to create web-based music download services foundered because of lack of breadth of offerings, mispricing, or poor marketing. More recently, Apple's iTunes service has been a substantial success, offering a wide range of songs for download at 99c each in the US. In addition to pricing, marketing and breadth of product offering, a key success factor in this case has been the availability of attractive portable hardware for playing the downloaded music. In fact, Apple's sole source of profits so far has been sales of its iPods, rather than song downloads. Attempts by competitors to offer compatibility across hardware and software platforms suggest that this market may not have reached long run equilibrium. Nevertheless, there does seem to be evidence that viable business models of paid digital delivery of copyrighted material can be constructed. In fact, this observation extends to other forms of digital content, such as news and research material, though these markets are not as prominent as that for music and other entertainment.

4.3 Market Structure and Strategy

The nature of information, where marginal costs of delivery are small and fixed costs of production may still be large, is often alleged to favor **winner-take-all** outcomes, because a single firm serving the whole market has the lowest average costs.

These supply side economies are reinforced by economies of scale on the demand side, i.e., the benefits of creating and controlling large networks. Consumers will presumably join the network that is already large, to get the highest benefits of being able to select a transaction partner from a bigger pool, or other advantages of interaction. Thus buyers will look on eBay, because it is the largest online auction site, while sellers will list there for the same reason. The size advantage associated with these positive **network externalities** (joining a network increases the benefits to others as well as oneself) keeps reinforcing itself, since the marginal value of the network is increasing in the network's size. On the other hand, if individuals can simultaneously participate in more than one network, and if a smaller, competing network can offer a price break to attract them, then the advantage of the winner will be limited, and taking all may not be feasible. Intellectual property rights may also create winner-take-all outcomes, if a single firm is able to establish a default technical standard for an entire market (e.g., desktop operating systems). All these factors may push firms to seek first-mover status, with competition being for the market itself rather than market share.

Even in cases where traditional competition for market share remains paramount, focusing on information leads to a different emphasis in terms of the economics of business strategy. Pure price competition has to be less important than competition along an array of different dimensions, because price competition over homogeneous goods in a world of high fixed costs and low marginal costs will lead to firms losing money.[22] Pricing itself becomes more complex, since the use of IT increases the possibilities for price discrimination, differentiating across consumers and over time. Pricing strategy must be combined with strategies for marketing, product differentiation, and raising the costs that customers incur in switching to competitors. All these dimensions of strategy exist independently of the Internet and e-commerce, but they become more salient in a world where information technology operates throughout the stages of production (what business strategists call the "**value chain**"), as well as in the interaction of buyers and sellers in the marketplace. The ability to gather information about buyers and sellers, to organize this information, and to analyze it, creates the potential to integrate the different dimensions of strategy in ways that were not possible earlier. For example, travel packages offered online can be created, priced and offered in real-time as a potential customer searches, taking account of aspects of the individual's search pattern and even past purchase information.

One can distinguish between two separate aspects of firms' strategies, and how they can change as a result of information technology and the Internet. First, firms can create more value, by meeting consumer wants more effectively. Thus, being able to elicit consumer preferences more directly and at lower cost potentially allows firms to design products and services that create greater consumer surplus. The design, manufacture and delivery (the last particularly in the case of digital products such as content or software, though IT also improves the logistics of physical delivery) of these products can also be more efficient, through the use of IT within the firm, and in its

[22] For example, the Bertrand model of price competition suggests that firms with homogeneous products will be pushed toward pricing at marginal cost, making it impossible to recover their sunk fixed costs.

communications with its direct and indirect suppliers (its "**supply chain**").[23] Furthermore, consumer tastes can not only be better matched on average, but also through greater customization, where products and services can be designed and manufactured to precisely meet individual tastes, as specified by the customer online. This customization is particularly valuable for information products, such as content, and also for very personal items such as cosmetics and beauty products. The use of IT internally, and through the supply chain, allows for the more flexible approach to production required by mass customization. Where the products and services are digital, product differentiation can also include bundling in new ways. For example, online portals provide bundles of content and services that are not matched by traditional media companies or content aggregators such as newspapers and magazines.

The second aspect of business strategy is value capture. In this case, the greater ability to gather information about buyer preferences through tracking online behavior – including observational and information gathering behavior as well as buying patterns – allows for pricing to be more finely tuned, so that prices are closer to buyers' maximum willingness to pay. Thus, the ability to potentially use online interactions to gather and analyze buyer information allows for greater value capture through various kinds of price discrimination. In such cases, product differentiation may be an important supporting strategy for value capture, in addition to its role in value creation. Product differentiation can reduce the ability of competitors to undercut a price discrimination strategy. The ability to vary prices more easily and often in online markets may also be used as part of a price discrimination strategy, just as seasonal sales are used in traditional retailing. Bundling of products is another example of how firms may tailor products to capture greater value from buyers, though it is not always used for this purpose.

A slightly different way of analyzing business strategies in e-commerce is to think of online shopping as offering a bundle of three different categories of goods and services: the products themselves, the service of time in physically assembling the order and delivering it, and an information service that is made possible by the infrastructure of the Internet and the World Wide Web. The digital information processing and communication capability of this infrastructure is what makes the bundling of the other two services economical. In the case of many physical products, such as groceries, the service of assembling the order and delivering it would not be cost-effective without the information infrastructure and service. The nature of the information service is what particularly distinguishes catalogue shopping for physical products from online shopping, since catalogue shopping offers more limited information exchange. In the case of shopping in a store for physical products, the bundle offered to the buyer is further differentiated, since in store shopping the buyer bears the costs of 'last-mile' fulfillment, i.e., bringing the product home. Interestingly hybrid models of online search and transaction, with physical pick-up by the buyer from a store, are also emerging. In the case of digital products and services, the differences are greatest as compared to

[23] As discussed in the next subsection, these efficiencies may come about through changes in the organization of firms, with less need for vertical integration of the stages of production under common ownership.

traditional methods, since the product itself can be delivered over the same infrastructure that is used for ordering. As one might expect, online transactions for digital products and services provide greater potential for changing ways of doing business.

4.4 Changes in Firm Organization

The use of digital technologies has several different possible implications for the organization of firms. A simple hypothesis is based on the transaction cost theory of the firm (Coase, 1937), which argues that firms exist to overcome transaction costs associated with market exchange. If using IT and the Internet reduces market transaction costs, by increasing the speed and richness of information flows, then firms will be replaced by markets. While this argument has merit, the use of IT within firms also improves, so the opposite case can be made, that firms are able to become larger as a result of information technology. Certainly, the globalization of firms in areas such as sourcing inputs, or serving different geographic markets, appears to be aided by the use of IT, and the Internet in particular.

One reason that firms will not disappear is that the need to control complementary assets, especially different kinds of skilled labor or human capital, is a reason for the existence of firms that is not invalidated by improved information flows. In general, one can argue that efficient incentive provision – for current effort as well as investment-related activities – often requires the use of hierarchical organizational forms, rather than pure reliance on market transactions.

Nevertheless, two trends are evident, and both appear to be accelerated by the developments in IT and communications. First, the growth of markets, which has been driven by lower transportation costs and trade barriers, and by higher incomes, as well as dramatically improved communications, permits greater outsourcing, and therefore some decrease in vertical integration of firms (Brynjolfsson and Hitt, 2000, p. 36). This is an example of Adam Smith's classic maxim that the division of labor is limited by the extent of the market. The economic logic is that serving a larger market allows specialized firms to emerge along portions of the value chain, because they are able to spread the fixed costs of a separate organization more effectively. Contract manufacturing is an important example of the phenomenon of outsourcing, where the supply chain becomes more geographically dispersed as well as being more divided among different firms. Business process outsourcing has, more recently, followed manufacturing along this path. These trends illustrate a broader concept, that of "virtualization," which emphasizes the use of IT to create changing networks of firms along a value chain. As we have argued, the need to control complementary assets in a coordinated manner places limits on virtualization to the extent that it involves separation of ownership.

Second, even when they do not outsource, firms themselves are becoming more decentralized, as they incorporate IT in their internal business processes. For example, one study of large firms found that greater internal levels of IT use were associated with "increased delegation of authority to individuals and teams, greater levels of skill and education in the workforce, and greater emphasis on pre-employment screening for education and training." (Brynjolfsson and Hitt, 2000, p. 35). Other studies indicate that

the IT investments of decentralized firms are more productive and have such firms have higher market values, suggesting that market pressures will favor greater decentralization in the long run. The use of IT within an organization can also be seen as a form of virtualization, since control and collaboration can be retained in essential ways without physical proximity.

From the perspective of economies of scale and scope (Chandler, 1990), the factors affecting firm organization pull in different directions. On one hand, firms can become more specialized, because their ability to serve geographically dispersed markets is enhanced by the Internet. For example, niche retailers can potentially sell globally, as their marginal costs of reaching new customers are substantially reduced. Trading off scope for scale means that the overall impact on firm size is indeterminate. In general, however, the lower cost of entry in online business – a website is cheaper to set up and operate than a physical store – suggests that smaller firms will thrive. At the other extreme, large firms can expand their scale and scope more easily using online presence and interactions, and especially in the case of digital products and services, offer very large ranges of offerings. Therefore one plausible prediction is that the size distribution of firms will become more spread out, with firms in the middle losing out to those at either end (e.g., *The Economist*, 2002).

Returning to globalization, an important consequence of digitization is the ability to deliver digital products and services across national boundaries, using the Internet. A related issue is the impact of greater information availability, which expands market reach. In both cases, the ability to complete transactions online is an additional feature, though not an essential one. Skills provision and services provision are examples of electronic delivery across national boundaries, with examples of these broad categories including software development, business process outsourcing, retail transactions, and customer care. Small IT projects may be handled entirely online. In other cases, there is typically some face-to-face meeting (the "high bandwidth" information exchange) and agreement, followed by more routine exchanges or deliveries of services that take place online. The outsourcing of software development from the developed world to countries such as India and Israel represents an important example of such activities. In another example, retail financial services may be conducted entirely online across national boundaries. An investor in Europe trading in US stocks can fill out the application forms, transfer money into a US account, and trade without using paper or moving from her screen. Commissions earned by the online brokerage then represent a payment for services that are international.

A final aspect of changes in firm organization in the digital economy is related to the new kinds of products, services and delivery methods that are possible. In many cases, new types of digital economy firms are essentially new intermediaries, providing expertise or reputation, or economizing on transaction costs. The following classification of firms is in terms of how they combine information, time services, and goods and services in new ways, in their offerings to customers. It does not include traditional firms that merely include the Internet as another communication channel, nor does it classify firms by traditional sectors (e.g., finance) or functions (e.g., manufacturing).

1. **Information request services** provide general information on demand through search engine technology, a very basic aspect of the World Wide Web.
2. **Content providers** package particular sets of content, rather than just enabling general searches for any kind of information, and can be considered a new kind of media firm.
3. **E-tailers** are a carryover from the world of physical retailing, including catalogue sales, but offer a different bundle of products, time and information services than traditional retailers.
4. **Exchanges and brokers** operate electronically without physically bringing together buyers and sellers or the objects being sold, and act as 'market-makers' or 'market-expanders'.
5. **Community creators** provide online mechanisms for communication, networking and collaboration.
6. **Infomediaries** focus only on providing information pertaining to potential market opportunities, and are potentially neutral with respect to buyers and sellers.
7. **Portals** are aggregators, or diversified firms, combining the six types of firms above.
8. **Infrastructure providers** make and sell the hardware, software and services that allows other firms to process, store and send the information that makes their businesses possible. These include communications equipment, Web hosting equipment, connectivity services, hosting services, application services, and many kinds of software developers.

As the seventh category itself suggests, there are many overlaps and combination possible in these functions within different digital economy firms.

5 Security

The need for security in exchanging information is as old as history. The earliest measures to ensure messages from falling into the wrong hands involved hiding the message itself. A famous example of this is the story told by the Greek chronicler, Herodotus, writing well over 2000 years ago. The sender shaved the messenger's head, wrote the message on his scalp, and waited for the hair to grow back before sending the messenger on his way. In more mundane instances, one simply seals communications in envelopes before mailing them, relying on legal penalties to deter would-be snoops. A different sort of concealment is obtained through writing a message in a code, which only the recipient knows how to decipher. Julius Caesar, for example, commonly used ciphers for military missives. Concealment and encryption are independent, and can be combined in many ways. Other security issues revolve around correctly identifying the sender and recipient of information, protecting information from tampering, and authenticating information.

5.1 Security Issues

One of the peculiarities of the Internet and the Web is their inherent openness. This openness is what has allowed them to grow so quickly and so fruitfully. As long as the information being exchanged can itself be made public without any loss, this is fine.

The job seeker who posts her resume, or the hobbyist who lists information about his favorite computer games may not mind if the whole world has access to that information. However, for electronic commerce to be successful, more and more commercially sensitive and private information, from business purchasing orders to individual credit card numbers, must be stored in electronic databases connected to the Internet, and transmitted over it. Hence, security for electronic storage and communications is essential, otherwise those possessing unauthorized information (ranging from individual credit card numbers to complete identities, as in "identity theft", can cause substantial financial harm.

There are several dimensions of security. First, we may want to prevent unauthorized people from accessing certain information. To accomplish this, the information may be encrypted, so that even if it falls into the wrong hands, it cannot be read. Also, barriers can be erected to prevent unauthorized access to information. In the case of postal mail, we simply use sealed paper envelopes, accompanied by heavy legal penalties for tampering with mail. Electronic barriers are more complex. An example of an electronic barrier is a **firewall**, which prevents unauthorized access. At the same time, security also must allow authorized recipients to have access to the information. When we receive an important legal document by courier, we typically have to sign for it. We provide private information that identifies us when we use an ATM machine or obtain bank balance information over the telephone. Similar kinds of authentication mechanisms are required for electronic transmission of information. One of the biggest problems emerging now on the Internet is the forging of corporate identities in email, in order to elicit personal financial information from unwary recipients (a practice known as "phishing"). Again, the problem can be seen as one of identity authentication.

Another kind of authentication involves authorization of transactions. A user of a credit card may not only have to establish identity, but also his or her credit status. The latter is done through a verification procedure, now purely electronic, but one that originally involved a telephone call to the card issuer. A related idea is non-repudiation of transactions, which ensures that a purchaser does not subsequently claim that he was not responsible for a valid transaction.

A third aspect of security is preventing tampering with information. This problem may well be correlated with the issue of access. A hacker may just as well want to damage information to which he obtains unauthorized access, as to use that access for personal benefit, without tampering. On the other hand, tampering may occur without unauthorized access. Authorized users of information could alter it, or they could be unsuspecting carriers of viruses or worms that damage digitally stored information. Thus firewalls have to deal with such problems as well, weeding out harmful programs as well as unauthorized access. Detection of tampering, or accidental alteration of information, is a related security tool.

Yet another aspect of security pertains to monitoring and auditing electronic databases. Much of this involves a carry-over of traditional financial auditing roles to electronic accounts. Issues here can involve internal as well as external fraud or theft. In

the former case, access may be fully authorized, but the individual acts in an illegal manner. Effective detection of such actions is the security objective in this case, and this is accomplished through the use of data mining or other statistical analysis, to identify unusual transactions, for example. A related issue is the auditing for regulatory compliance with respect to record keeping in general, in areas such as financial and health care services.

Table 3: Traditional Security Mechanisms

Security Service	Non-electronic Mechanisms	Electronic Mechanisms
Authentication	Photo ID card Knowledge of mother's maiden name Check with trusted person or institution	Encryption Passwords/PINs Biometric scanning Digital signatures
Access Control	Locks and keys Checkpoint guard Passwords	Passwords/PINs Firewalls
Confidentiality	Sealed letter Invisible ink	Encryption
Integrity	Indelible ink Hologram on credit card	Check-values
Non-repudiation	Notarized signature Certified mail	Digital signatures
Fraud detection	Inspection of ledgers and other records	Electronic inspection Data-mining

Source: Adapted from Table 4.1, *Secure Electronic Commerce*, p. 99, by Warwick Ford and Michael Baum, Upper Saddle River, NJ: Prentice Hall, 1997. Note: most electronic security mechanisms incorporate some form of encryption.

Table 3 provides a summary classification of security issues, and gives familiar non-electronic examples of achieving security goals, as well as electronic substitutes or equivalents for digital information. We next briefly consider the various security techniques that are employed on electronic databases and communication networks.

5.2 Security Techniques

We summarize techniques of encryption, authentication, and screening, as well as how combinations of these techniques are implemented through firewalls or similar measures. Details on these techniques can be found elsewhere in this Handbook.

Encryption The process of encryption involves using a rule to transform information, such as a text message, into something that is unintelligible without reversing the process. The rule used can be very simple (replace A with Z, B with Y, etc.), or can

involve complicated mathematical transformations. Digitized text, which is represented as a sequence of bits, can be encrypted in this way, using computers to perform the transformation. The real conceptual difficulty is in developing an encryption system that can be applied practically. The most straightforward system of encryption involves both the sender and the receiver knowing a "key" which is a string of bits used in both the encryption transformation and its reverse. Only the sender and the receiver know the key, which is private. Since the same key is used at both ends, the system is symmetric. IBM developed the first widely used commercial symmetric encryption system in the 1970s, the Data Encryption Standard (DES), adopted as a standard by the US government in 1977 and the financial industry in 1981. The practical difficulty with private key systems is how to securely and efficiently distribute the keys. This problem was conceptually solved in 1976, with the demonstration that public-key encryption systems were feasible. Later, the RSA encryption algorithm solved the further problem of constructing a usable asymmetric cipher. Such systems use a pair of different, but related keys, one for encryption and one for decryption. To protect message content, as when a customer is sending a credit card number over the Internet, the message can be encrypted using the public key. Only the merchant, who knows the private key, is able to use it to decrypt the message. All customers of the merchant can use the same public key, unlike the case of private key encryption, where each communicating pair requires a different key. The different keys make the encryption system asymmetric, since the person who has only the public key can encrypt a message, but cannot decrypt it.

Message Integrity Suppose that confidentiality of a message is not an issue, but that the recipient needs to be sure that the message was not tampered with, or accidentally altered, on the way. For example, in traditional postal communications, the recipient might see that the envelope has been opened and resealed, or the contents damaged. With digital communications over the Internet, the risk of tampering or accidental alteration could be relatively high, and how to detect it is not obvious. The approach that is taken is to use a mathematical transformation that calculates a particular value based on all the bits in the message: a "**check-value**." How this check-value is generated must itself be encrypted. This can be done with a symmetric, private-key system. A public-key system can also be used for encrypting the transformation that computes the check-value. In either case, the check-value is transmitted along with the message. The financial industry uses a standard called **MAC** (**Message Authentication Code**), which was agreed on in 1986.

Authentication Another problem that can be tackled with encryption technologies is that of making sure that the sender of the message is genuine. In face-to-face communications and transactions, or over the telephone, we use special numbers, other private knowledge, or photographs to establish who we are. An asymmetric encryption system can be used to achieve authentication in electronic communications. The sender uses her private key to encrypt her message. Recipients use the corresponding public key to decrypt it. Note that this does not achieve confidentiality, since anyone can get and use the public key to view the message. The roles of the private and public key are reversed from the case where message confidentiality is desired. However, anyone who decrypts the message knows who the sender is, since the public key only works with the sender's

corresponding private key. One proposed approach to controlling spoof emails (using false addresses) is authentication through encrypted digital signatures. Another uses a version of 'caller ID', where the authenticity of incoming e-mail is verified by checking it against the Domain Name System (DNS) database. There are several other aspects of authentication on the Internet. Passwords and PINs – familiar from using ATMs and telephone bank enquiries – are the most common ones in using the World Wide Web. Third-party authentication is also possible: for example, a trusted firm may perform the initial authentication, and then vouch for the identity of an individual thereafter. The identity of computers on a network may also be authenticated, using encryption or other checking methods, as in the case of dealing with spam emails. These tools also play a role in electronic authentication of transactions. In non-Internet situations, information technology can also enable the use of biometric authentication methods, where a computer analyzes facial features or physical characteristics to verify identity.

Digital Signatures A digital signature typically combines authentication with message integrity checking. Again, it uses basic encryption technologies to achieve this. For example, the sender "signs" the electronic document using a private key, and the receiver verifies the signature using a public key. Digital signatures must also be able to support non-repudiation. This means that the sender cannot later deny that the signature is hers. Obviously, the recipient or anyone else should not be able to forge the digital signature. One way to implement digital signatures is to use RSA-type technology in the authentication mode, encrypting the message with the private key, and sending it along with the unencrypted message. Decrypting the encrypted version and comparing it with the plaintext message provides a check on the contents and the sender. This can be costly in terms of computing resources and bandwidth, so an additional step is introduced in practice. A one-way mathematical transformation (i.e., one that cannot be reversed) is applied to the message. The transformation is called a **hash function**, and its output is a **message digest**. Tampering with the message will alter the digest. Now the digest is encrypted with a private key, and this acts as the digital signature. Different mathematical transformations provide alternatives to RSA-based digital signatures.

Access Control Passwords provide a standard form of individual access control. A different sort of control prevents access from certain machines. Finally, certain forms of content and applications may be prohibited or screened. A firewall typically acts as a screen for controlling access and the entry of content and applications. Firewalls typically exist between internal corporate networks and the public part of the Internet. They can control incoming traffic, only allow authenticated users access from outside, and limit how internal users connect to the external network. Firewalls can also screen for malicious programs, such as viruses, which can cause damage to the internal network. Antivirus programs themselves exist independently of firewalls, and are now a standard part of every computer's armory. Firewalls include special hardware and software, such as screening routers to filter incoming data, proxy servers to screen requests for Internet services such as access to Web sites, and perimeter networks that act as buffers between internal networks and everything outside. Firewalls may also perform encryption tasks in linking two physically separate networks securely over the Internet, to create what is called a Virtual Private Network (VPN).

Web Security Tampering with information on Web sites, and electronic eavesdropping to steal valuable information such as credit card numbers, are two of the greatest potential security problems on the Web. The most common general security software is the **Secure Sockets Layer (SSL)** protocol, developed by Netscape. SSL works on top of the TCP protocol used for Internet communications, and can be used to achieve security for HTTP and FTP communications. It performs several functions, including authenticating the Web server (through a private key mechanism) so that a fake site is not gathering sensitive information from unsuspecting customers, integrity check-values for message content, and encryption for confidentiality. SSL is not specifically for preventing "hacking" into Web sites: to stop that firewalls must be employed. Other security methods are also available for the Web. In particular, Visa and MasterCard combined to develop the **Secure Electronic Transaction (SET)** protocol for bankcard payments made during online shopping transactions. SET is based on a public key infrastructure that provides encryption, authentication of different participants in the transactions (cardholders, merchants, transaction processors), and integrity checking.

5.3 Legal and Market Approaches

Traditional commercial transactions are governed by well-defined laws and legal precedents. In particular, there is a clear concept of what constitutes a legally binding contract. Paper documents with signatures are the norm for contracts. Sometimes, notarization to authenticate the signatures is required. There are also disclosure requirements and escape clauses, particularly for consumers transacting with business. The legal issues in e-commerce contracting revolve around how identities can be verified, signatures can be authenticated, and content can be protected, when information is stored, processed and transmitted electronically. Such techniques were discussed in the previous subsection.

Another category of problems arises in communications. We accept the U.S. Mail and private courier services as reliable, secure methods of delivering physical documents. Tampering in such cases is difficult and costly to accomplish on a large scale, possible to detect, and subject to severe penalties. On the other hand, large-scale electronic eavesdropping or tampering with communications is not as difficult or costly. Scanning large volumes of electronic communications is quite different from opening hundreds or thousands of envelopes to check what is inside. As a result, ordinary e-mail over the Internet is much less secure than First-Class Mail via the U.S. Postal Service. Furthermore, tampering with the U.S. Mail is a well-defined and serious legal offense. The same kind of legal protections and standards are still evolving for Internet communications.

Certification Authorities In traditional transactions, where assuring identity is extremely important (large financial transactions in particular), signatures are often required to be authenticated by being done in the presence of a notary public, who acts as a trusted third party. Certification authorities in e-commerce are intermediaries that address verification problems relating to identity, but without the physical proximity that traditional methods require (you have to be physically present to sign in front of the

notary). A certification authority (CA), therefore, is a public or private entity that issues digital certificates to authenticate identities and messages, or to attest that an action has occurred. CAs can provide verification or assurance of identity, verification of message content, and verification of events or actions. Private CAs in e-commerce have stepped in to fulfill roles traditionally played by trusted government agencies such as the U.S. Postal Service. How do private CAs themselves establish trust? They may need to be certified themselves, or they can build reputation in the marketplace. In the long run, as e-commerce grows in scope and complexity, transactional certificates and time-stamping may be more significant functions of CAs than simple identification, which will become more standardized over the Internet.

Contracts The growth of e-commerce itself will depend on the ability of two parties to complete a contract, sign it in a legally binding manner, and transmit it, all purely electronically. The technology is not the stumbling block to this goal. The issue is one of clear, generally agreed on legal standards. For example, in the US, in June 2000, the President signed (electronically as well as with the traditional pen) a bill that sets these standards, and will make it possible for businesses to close deals with electronic contracts and digital signatures. Similar legislation has been passed in other industrial countries. Electronic contracts are especially attractive for B2B transactions. However, the possibility of electronic contracting will probably require some updating of rules that protect consumers. Since a large percentage of households are not online, presumably consumers should still have the right to have all contract details and subsequent pertinent notices on paper, without financial penalty. This makes the cost saving that electronic dealings offer to businesses harder to achieve, but presumably these will come with time, as electronic communications become cheaper and more ubiquitous. The technology of digital certification will also have to become more widespread and widely understood for it to serve the everyday needs of B2C transactions.

Communications The problem of electronic communications is more widespread and basic than that of electronic contracts, since many communications are not directly transaction-relevant. One area where electronic distribution of information is very attractive, because of its speed, flexibility and capacity, is in financial services. The Securities and Exchange Commission, which regulates financial services related to securities markets and transactions, noted in 1995 the "promise of electronic distribution of information in enhancing investors' ability to access, research, and analyze information, and in facilitating the provision of information by issuers and others."[24] The SEC went on to state, "given the numerous benefits of electronic distribution of information and the fact that in many respects it may be more useful to investors than paper, its use should not be disfavored." The SEC's approach used the analogy of traditional paper-based communications to define the parameters of what would be acceptable for electronic communications from financial services firms to investors. In 1997, the New York Stock Exchange handed down guidelines to its member firms, essentially following the SEC's lead. Prospectuses, stock trade confirmations and

[24] Securities and Exchange Commission, "Interpretive Release on Use of Electronic Media for Delivery Purposes," 13 October 1995

statements are examples of documents that are required to be sent to investors, and which may be delivered electronically once there is a sufficient level of trust and acceptance of the technology and the providers of the service. Content integrity, authentication, time stamping, and overall security and reliability, are important for such financial communications. Private startups, as well as the U.S. Postal Service, are developing products and services that meet these needs in ways that ordinary email does not.

6 Government Policies

Any market economy relies on government regulation, to maintain a framework of laws and property rights that allow production and exchange activities to occur in a stable environment. The rise of the digital economy has several impacts on government management of the economy. We briefly examine several of these impacts in this section.

6.1 Intellectual Property

Phenomena such as the widespread copying of digital music, using file-sharing software available from many different commercial and non-commercial providers, have heightened concerns about enforcement of copyrights on the Internet. Some have called for more stringent copyright laws, and, in the US, the Digital Millennium Copyright Act (DMCA) of 1998 did introduce some additional protections in the guise of updating previous law to cover new technologies. The DMCA, combined with previously existing laws provides quite strong protection, as indicated by court rulings against Napster and other providers of file-sharing software, as well as successful recording industry lawsuits against individual file-sharers. At the same time, the courts, in recent rulings, have placed some limits on the extent to which Internet infrastructure providers can be held responsible for illegal file sharing.

The DMCA included penalties for cracking protections designed to protect unauthorized copying. However, the legal application of the DMCA has had an effect on free speech, with examples such as a professor of computer science forgoing presentation of a research paper outlining methods of overcoming copy protection, in the face of a threatened lawsuit. Lobbying by industry groups that have ownership interests in copyright has also motivated potential US legislation that requires copy protection be hardwired into consumer electronics items. In such cases, the doctrine of “fair use” in copyright law also appears to come under attack. In the US, the DMCA was complemented by another law, extending copyright protections by 20 years. While European copyright laws have not tilted so much against users, the US is a global leader in the production of copyrighted material such as music and films.

In the arena of patents, it has been court interpretations, as noted in Section 4.2, rather than new legislation that has increased the scope of patent law, with hundreds of relatively broad software patents being granted in recent years. It has been suggested that a new category of patents, with a shorter lifetime, be granted for software, but this is likely to create further problems for assessing patent applications. It also misses the real problem, which is that of inadequate resources in the US PTO. Again, the US is the largest market for intellectual property, and US patent rules are disproportionately

significant in the global context. In general, the apparent broadening of both copyright and patent protection can be seen as a response to a situation where intellectual property is increasingly important for creating economic value, but also easier to copy or imitate. Thus, these legal trends are a symptom of the digital/information/knowledge economy.

6.2 Privacy

The digital economy, with its greater flows and tracking of information raises serious concerns about privacy. Information about consumers allows firms to increase profits through various kinds of price discrimination. At the same time, some consumer information can help firms to tailor their products more effectively to consumer preferences. Privacy concerns often center on how the information is collected – do consumers realize that their behavior online is being tracked, or that cookie files are being deposited on their computers?

Further issues arise with respect to who else may properly see the information collected. A customer may not mind a seller tracking my buying habits in order to serve her better, but she may not want the firm to sell that information to other firms. A related issue is the use of such information for mass marketing emails, commonly known as "spam". Employees, too, may find that their electronic communications and Internet browsing from work can be monitored by employers with great precision and intrusiveness. Finally, there are all kinds of information that various public agencies collect. Often such agencies are required to make that information available in response to requests from members of the public. However, making that information available online makes access much easier and broader than other forms of availability, with possible negative consequences.

The US legislative branch was actively considering Internet privacy legislation, after a report from the Federal Trade Commission in mid-2000 indicated that self-regulation was not working uniformly, with some websites proving resistant to privacy concerns. One stumbling block for legislative agreement was the simple issue of whether businesses should be required to explicitly get consumers to "opt-in" to allow their personal data to be used beyond the specific transaction or relationship, or whether the burden should be on consumers to explicitly "opt-out". Businesses naturally favored the latter approach, which gives them much more leeway. Business-supported groups have tried to argue that privacy legislation would be inordinately costly, and also that consumers do not care enough for it to be worthwhile. On the other side are groups such as the American Civil Liberties Union and Consumers Union that want stronger safeguards against data-collection practices that do not involve explicit consent. The aftermath of September 11th has tilted the scales against strengthening of privacy, since security has become a much greater concern. Therefore, it seems unlikely that any meaningful Internet privacy legislation will be passed any time soon in the US, leave its online privacy laws some way behind those of the European Union, which protect consumer privacy more stringently.

6. 3 Antitrust and regulation

Antitrust laws are designed to prevent monopolization of industries, as well as anticompetitive practices such as price fixing. Does the digital economy require modifications in the government's enforcement of antitrust policy, or even a change in the antitrust laws themselves? There are three key areas in which the proponents of a modified approach to antitrust make their points. First, there is the argument that antitrust enforcement must account for the impacts on future innovation. The second argument is that network externalities and the economies of scale associated with information goods make monopolies more likely or more natural ("winner takes all"), and hence they must be tolerated – otherwise there will be no market or unnecessarily high costs. The third argument is that complementarities in information goods require firms to cooperate in ways that might seem collusive by more traditional measures.

Considering the first of these, the increased importance of technological innovation, and of patenting, certainly makes these variables more important in a firm's business strategy, but it does not, by itself, imply that antitrust law has to change. Firms can innovate profitably, using patent law, without having to run afoul of antitrust law. Second, network effects are demand-side economies of scale, which can interact with the usual cost-side economies of scale to promote market dominance. If information goods are subject to both kinds of economies of scale, one might have to be resigned to more cases of "natural" monopoly, driven purely by the structural characteristics of the market, rather than by any illegal behavior. However, the importance of such natural monopolies is probably overstated, and their persistence is unlikely if the protection for patents is not too stringent.[25] Finally, technology goods have to work in systems, and are characterized by strong complementarities. This often requires firms to collaborate in research and development, as well as in production and installation. However, as long as single firms, or firms acting together, do not engage in behavior that reduces competition or harms competitors, there is no violation of antitrust laws. What is needed is not a reform of the laws, but simply enforcement by government officials who understand technology well enough to sort out different kinds of cooperative behavior among technology-oriented firms. Clearly, this is more difficult when markets are interrelated, and technology evolves very rapidly.

Laws to manage privacy issues and antitrust laws can both be considered as major examples of regulation by the government of private economic activity. They are not the only ones. There are specialized regulations for different sectors of the economy, such as financial services and telecommunications. There are also regulations meant to protect certain groups, or to control certain types of activity. For example, pornography and hate materials are controlled, and gambling is a heavily regulated activity. All these forms of regulation are affected by the Internet. Much of the problem is simply in the freedom with which information can be disseminated and shared on the Internet. The location of

[25] Arguments relating to network externalities as well as to innovation have been made in the Microsoft antitrust investigations, both of which concluded with out-of-court settlements. One can argue that any monopoly that Microsoft might have is related more to traditional anti-competitive practices such as the nature of its contracts with distributors, rather than any special features of the digital economy. In the European Union, there is an ongoing antitrust investigation of Microsoft.

activities is also a problem: for example, online gambling can escape controls that are designed to operate within geographic jurisdictions. Controls on forms of payment, for instance, by using the major credit card companies, can be a way to solve the jurisdictional problem. The credit card companies cannot afford to be partners in crime. Here the law needs to change to deal with ability of digital activities to escape the requirement of meeting in a particular place.

In the case of financial services, the issues have to do with the quantity and the veracity of information that is made available. The Internet makes scams easier to implement in some ways, but the basic laws do not need to adjust. In the case of telecoms, regulatory issues are centered on the technological changes that digitization has introduced, making more effective competition possible. The US Telecom Act of 1996 began the process of moving regulation into the modern era. Some regulation is still needed because parts of the network are still potential monopolies. Local telephone companies – the so-called Baby Bells – in particular, have maintained their strongholds. Regulations to allow interconnection to parts of the Baby Bell networks by competing carriers have not really enabled the latter to gain significant market shares. While protecting their traditional markets in voice communications, the Baby Bells have been lobbying for the ability to compete more freely in markets for data communications, that is, the underpinnings of the Internet. The convergence of communications technologies that have been governed by different regulatory frameworks also creates regulatory challenges. For example, in 2003, a US court ruled that the Federal Communications Commission (FCC) incorrectly classified cable networks as 'information services' rather than 'telecommunications services,' where only the latter are required to share their broadband access lines.

6.4 International trade

Countries often have customs duties or tariffs on imports, and these clearly affect international trade. They may also use quantitative restrictions on the entry of certain goods and services. An extreme case of this would be a total ban. Various reasons for restricting international trade do exist: government revenue raising, control of undesirable materials, protection of some domestic groups, and so on. Individual country choices made without coordination may lead to outcomes that are worse for all countries. Therefore, in order to try to achieve some measure of cooperation that can improve outcomes, trading nations use the World Trade Organization (WTO) to frame and enforce rules for international trade. Having such an organization does not remove conflicts, but it provides a mechanism for more orderly handling of disputes, as well as a clear set of "rules of the game."

The current provisional WTO agreement is that trade restrictions should not apply to electronic transmissions over the Internet. In the example of a European purchasing US stocks or a US hotel room while on vacation, this leads to a symmetric treatment of online and offline transactions. In other cases, however, there is a difference. Thus, purchasing a large number of music CDs from another country might be subject to a customs duty (small purchases from abroad are exempt in the US, though not in many countries), but obtaining the same quantity of music as electronic files would escape the

import tariff. This is superficially similar to the issue of sales taxation within the US, but here we are looking across national borders, and in the US sales tax case, the tax must be paid if the transaction is in-state rather than across states. Hence the two cases are somewhat different, though broadly related in spirit.

The WTO also includes provisions for trade-related intellectual property rights (TRIPS). The TRIPS agreement came about in the 1990s, and sets minimum standards for copyright and patent law for member countries. In addition, these laws cannot be discriminatory between local citizens and citizens of other TRIPS signatories. The TRIPS agreement was substantially predated by the World Intellectual Property Organization (WIPO), which is a United Nations agency, and has a substantially different governance structure. Global intellectual property rights (IPR) issues end up being debated in the WTO as well as the WIPO, with the former providing more stringent protections and enforcement mechanisms in theory. However, there are substantial difficulties in enforcing IPRs across national borders, and worldwide low cost digital copying of copyrighted material such as music, movies and software is a substantial concern for copyright holders in countries such as the US.

A further issue with respect to information products in particular is the blurred line between goods and services. For example, software development is a service that is now offered across national boundaries. Also, software is typically licensed rather than sold, and leasing software is common. Since traditional services, such as those in the financial sector, have been treated under a separate set of rules (the General Agreement on Trade in Services, or GATS), which is newer and more restrictive than the rules for goods or products, there is disagreement as to which set of rules should govern software. Countries such as the US, which are producers and net exporters of information and related services, argue for the application of the rules for conventional trade, rather than the GATS.

7 Work, Play and Communities

Work is a large fraction of our lives. It is useful to recognize how drastically work was altered by the industrial revolution, the introduction of factories, and the rise of large corporations. Cottage or home production became relatively insignificant, as mechanization and economies of scale caused work to be concentrated in factories and offices. Now IT has loosened the bonds of location, making work once again more flexible for many.

7.1 Work

Several trends have driven the changes in work. First, the increase in the importance of services relative to manufacturing, and of the information economy in general, reduced the proportion of factory jobs. Next, the falling cost of computing power allowed many tasks to potentially be performed at home, rather than in the office. Most importantly, the Internet has removed the isolation of the home worker. Communication and collaboration can take place among workers in different locations. Physical proximity for many jobs becomes only a part-time requirement. Clearly, this is

most pronounced for jobs that involve 'knowledge work,' where collaboration involves exchanges of information: software development is a prime example of this kind of job. In other cases, remoteness is no longer a barrier to carrying out some kinds or functions. A technical support person may guide a computer user through steps to repair a problem. Many software fixes can be done from a remote location. Even some surgery can now be performed by a doctor at a remote site, manipulating instruments through long distance communications and control. While these changes are just in freedom of location, as discussed in Section 4, there are also changes in the nature of the firm itself, sometimes reducing the bonds that define a firm. Employees in such cases can become independent contractors, with their own capital (human and physical), almost harking back to the pre-industrial era of home production.

Freedom of location has begun to affect the global distribution of work. The customer in the US may have a telephone query answered by someone in Ireland, India or the Philippines. Computer programming or program testing assignments may be sent over the Internet wherever people with those skills are available, to be completed and sent back the same way. The supply of some kinds of skills becomes global rather than local or national. There is also a time dimension to this geographical dispersion of work. Time differences across the globe allow 24-hour customer service to be more cost effective. In areas such as software development, they also allow global shift work. For example, two project teams in the US and India can collaborate to achieve an almost continuous workflow, utilizing the night-and-day time difference between the two countries. However, the ubiquity of digital communication devices means that the notion of times and places where work does not intrude is severely eroded. A knowledge worker may find she is expected to access her email via a wireless handheld computer at home, on vacation and in general outside the normal place and time of work.

Finally, there are concerns that the efficiency gains of the digital economy come at the expense of jobs and workers. This is an old concern, reflecting the continued substitution of capital for labor that has occurred since the Industrial Revolution. In the US in the early 21st century, this concern is arising due to the slow pace of job creation as the economy recovers from a recession. While there has been some shifting of service jobs, such as call centers and business processes, to developing countries, this currently represents only a small fraction of the jobs that would normally be created. The alternative explanation is that the use of IT reduces the need for workers. While such concerns may be valid in the short run, it is clear that in the long run new kinds of jobs are created, as productivity gains allow firms to develop new products and services, or to expand existing markets. Perhaps a more significant issue is that of potential impacts on income distribution: will a knowledge economy reward people more unequally? Clearly, access to education and training will be an important determinant of how this issue plays out in the future.

7.2 Leisure Activities

Leisure activities in the industrial age have been shaped by scale and specialization, just as happened in the case of work. Sports and the performing arts have become large-scale spectator or audience events. Radio and television introduced

broadcasting, creating mass markets for entertainment while removing locational barriers. Recording technologies expanded the scope for listening to music or watching movies, while introducing greater choice into consumer decisions. All these developments in people's leisure activities are enhanced and broadened by the Internet. Inexpensive digital recording and transmission of music and video provide a range of options unimaginable in the past.

Perhaps the greatest impact of the substitution of **bandwidth** for being in the same place has been in game playing. One can play traditional games, such as bridge and chess, over the Internet, with opponents and partners who may be anywhere in the world. More widespread is the enormous expansion of online game playing. Computer games become virtual worlds where individuals act out their fantasies and try out strategies. Game characters take on lives of their own, becoming valuable commodities themselves for game players who want to win any way they can. At one level, the interaction is no different from that of board games that have been played for hundreds or thousands of years, that of stylized competition. However, the complexity of such games has increased exponentially, and the Internet has demolished distance in creating the communities of game players.

Just as IT has allowed work to intrude into leisure spaces, it has also allowed the reverse phenomenon to take place. Workers who sit at a computer may play solitary games. If they have Internet access, they may engage in all kinds of leisure activities, including browsing news and entertainment content, shopping, and chatting as well as game playing. Hence, employers may respond with new kinds of monitoring and restrictions, as was discussed earlier in the context of privacy. However, the breaking down of barriers between work and play may be inevitable, to the extent that it represents a more natural existence for human beings. In this respect, the digital economy may provide the kind of interconnection that existed before the factory system came to dominate production methods.

7.3 Online Communities

From online game players to members of a project team designing a software program, people at work and play form communities based on shared goals or interests. Information technology allows these communities to be freed from the need to share a physical space. Interactions take place on computer screens instead of face-to-face, but the interactions that are possible in cyberspace are getting richer and richer, allowing more and more communities to form. In particular, work collaborations of increasing complexity are becoming possible on the Internet, with simultaneous or asynchronous participation in activities involving product research, design and development.

Work and play are not the only glue that binds communities. Any kind of shared interest can provide the impetus. Those suffering from a particular disease, fans of a rock star, or collectors of sports memorabilia can join together to exchange information, ideas and experiences over the Internet. These communities may provide commercial opportunities, since they provide access to that ever-scarcer commodity, "attention", but they may also lead to more profound social changes. Political organization, in particular,

takes on a new dimension, perhaps expanding the scope of democracy, while definitely changing its nature. Possibilities exist for Internet-based comment, feedback and even voting by citizens in communication with their governments. Many of these possibilities are now lumped together under the concept of 'social networking,' where the Internet is used as a tool to create and maintain general or special purpose communities, based on shared interest, mutual help or other common features.

Perhaps the most remarkable change of all is how, in just a few short years, the majority of people in the industrialized world have come to take for granted so many possibilities that alter their lives, and may reshape the social fabric. The Internet, at its core, is a very human-centered development. This may seem somewhat paradoxical. The underlying information technology is complex and abstract. But the Internet and its associated technologies allow people to be creative, to express their individuality, and to communicate and connect with other individuals in new ways and with new freedom. This extension of basic human capabilities, amplifying humanity and not just brainpower, is why the Internet excites so many, and inspires sometimes-overstated rhetoric.

8 Conclusion

The digital economy is much more than simply online shopping. It involves a fundamental transition that has been taking place for over two decades, and which is based on the rapidly falling costs of processing, storing and transmitting information in digital electronic form. Some of this transition was obscured by the dot.com mania, which often focused on using the Internet as a marketing and retailing channel. In fact, the digital economy includes this as just a small part. The internal organization of firms is changing, their nature is changing, the kinds of interactions that are possible between different economic agents are changing, and the location of different activities is changing. Social relations, governance and leisure activities are all affected by the pervasiveness of digital technology. Measures of the digital economy can understate or overstate the current impacts, but they do emerge in recent academic work, and the impacts appear to be increasing.

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