The Digital Economy

Nirvikar Singh
Professor of Economics, University of California, Santa Cruz

Outline

Glossary

Bandwidth
Most 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). It also has a more precise technical meaning, with similar implications.

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

Digital divide
A situation where particular socio-economic groups have access to the Internet and information technology at levels that substantially lag behind 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
In our definition, 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 types: B2B, B2C, C2G, C2C, B2E
Acronyms for different interactions, implicitly, but not necessarily, electronic, between businesses, consumers, governments and employees.

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.

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 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 and software, 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 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, it is proportional to $n(n-1)/2$ ("Metcalf'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
The portion of a firm's value chain that involves its suppliers.

Value chain
A schematic representation of a firm'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.

Winner-take-all
A market situation where the leader dominates because high fixed costs and low marginal costs of producing information favor 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 23, 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 digital economy refers 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 information that has been put in digital electronic form. These declines in costs have made 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.

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 government policy with respect to the digital economy, including contracting, privacy, competition policy, regulation, and international trade.

Section 6, 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 7 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 information. 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 information. 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 information that is input to a computer, and is processed by it, is translated into bits. **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 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 sending it to others (see Table 1) have made the uses and benefits of IT potentially span the whole economy, 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. Similar terms are perhaps 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	2003
1 Mhz of processing power	7,600	0.17	0.02
1 megabyte of storage	5,260	0.17	<0.01
1 trillion bits sent	150,000	0.12	<0.01

Source: 1970 and 1999, Pam Woodall, "The New Economy: Survey," *The Economist*, September 23, 2000, p. 6, Chart 1; 2003 author's estimates from various sources.

The terms 'information economy' and 'knowledge economy' focus on what is being digitized. Information and knowledge are related, but distinct concepts. Information is more general and basic, in that 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 form 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 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. This is one of the foundations of the digital economy.

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 (possibly free) 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 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 or individuals, 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. These do not directly measure economic activity that takes place online, though the provision of Internet access is itself an economic activity. More direct measures are figures 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.

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. 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.

[1] http://osecnt13.osec.doc.gov/public.nsf/docs/Evans-Census-Online. 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).

Furthermore, a broader cross-section of Americans is using the Internet, reducing fears of a '**digital divide'**. In particular, the growth in Internet use during this period was fastest among Americans with household income less than $15,000 a year.

Table 2: Global Internet Use

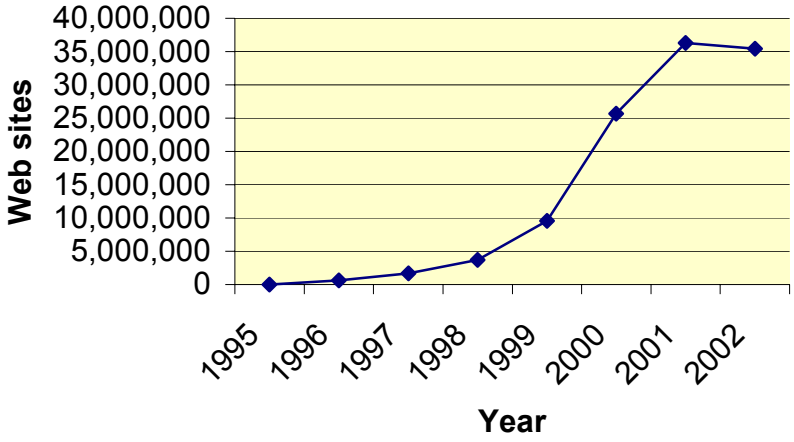
Language	Internet users (millions)	Total population (millions)	Percentage of world economy
English	230.6	508	33.4
European languages (excl. English and Spanish)	176.9	868	25.0
Spanish	47.2	350	8.9
Arabic	5.5	300	1.6
Chinese	68.4	874	13.0
Japanese	61.4	125	8.0
Korean	28.3	78	2.0

The Internet is also increasingly global, with the worldwide number of users estimated[2] at 619 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. Table 2 gives a sampling of Internet use by language, from Global Reach.

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.[3] The number of web sites in February 2003 was about 36 million, up from 19,000 in August 1995. The graph of web sites (Figure 1) is representative of the kind of growth that the Internet and World Wide Web have seen, in terms of availability and of use, with rapid early growth, slowing down dramatically, and even declining slightly, in 2001-02.

[2] See http://www.glreach.com/globstats/ where links to the original data sources are available.
[3] 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).

Figure 1: Growth in Web Sites



Source: http://www.netcraft.com/survey/

Of course, the numbers of users or web sites does not indicate how much time people actually spend online, and 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,[4] 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.

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 $32.6 billion. This figure grew to about $43 billion in 2002, though even after this impressive growth, online sales remained only about 1 to 2 percent of all US retail sales.[5] In Europe, figures for

[4] 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).

[5] These statistics are reported at http://www.census.gov/mrts/www/current.html, 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). 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

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.[6] Statistics for online retail sales in Asia are even 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 large firms to small ones, and to 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. 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. Table 3 presents a range of estimates[7] and forecasts, based on a combination of surveys and guesswork. While the numbers vary quite a bit, reflecting differences in who was surveyed, and possibly how e-commerce is defined, they are all of similar orders of magnitude, and all project substantial growth. While actual estimates for 2002 are not available at the time of writing, they were probably substantially lower than the forecasts, given the slowdown in the global economy, and in business investment (particularly IT investment). One can safely conclude that B2B e-commerce substantially exceeds B2C in size, and is growing somewhat faster on average. Finally, the cost advantages of using the Internet[8], plus the

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those figures if included. See http://www.comscore.com/news/ecommerce_2001_review.htm. Figures for 2002 are from news reports on CNet.

[6]The estimate is from Forrester Research, as reported in the International Herald Tribune, at http://www.iht.com/articles/78016.html. 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.

[7] 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.

[8] 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.

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. Furthermore, electronic marketplaces are potentially economically viable using the Internet, but not with traditional EDI.

Table 3: Worldwide B2B E-commerce Estimates* ($ billion)

Source	2000	2001	2002 (forecast)	2003 (forecast)
eMarketer	278	474	823	1,409
Forrester Research	604	1,138	2,061	3,694
Gartner Group	433	919	1,929	3,632
Goldman Sachs	357	740	1,304	2,088
IDC	282	516	917	1,573

*Estimates are from surveys; source: eMarketer compilation, at www.emarketer.com/ereports/ecommerce_trade/.

One final category of e-commerce is consumer-to-consumer (**C2C**). While firms such as eBay have entered the popular imagination through their electronic auctions for collectible or unique items, the value of C2C transactions is quite small. In fact, eBay now handles B2C and B2B transactions as well. While its own revenues are still only in the hundreds of millions, these revenues represent only its commissions on transactions, which are therefore considerably larger in volume. Again, 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 revenues may be a good indicator of the importance of C2C e-commerce. 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

E-commerce, measured as actual transactions conducted online, represented only a small fraction of the US Gross Domestic Product (GDP) of 10.2 trillion dollars in 2001. However, overall spending on information technology (IT), a more liberal measure of the digital economy, is substantial. While IT is more than just e-commerce, increasingly the boundaries are getting fuzzy. 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.[9] This includes hardware, software, services and telecommunications spending. Of course, this means that there is still a substantial part

[9] See Jorgenson (2001) for detailed estimates. Figures from IT market research groups such as International Data Corporation (IDC) are a little higher.

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[10] 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).

The problem of accounting for improvements in quality and variety goes beyond IT. 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

[10] The 'C' refers to 'communication', which has become increasingly digitized, and is counted with IT in many statistical and conceptual exercises.

computer. Simulating the entire crash on a computer can now instead be done for close to $100.[11]

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. A particular problem has been that increased investment in IT did not appear to be improving productivity in any measurable way. The conclusion of skeptics has been 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 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.

Other 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 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.

Despite these 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. 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

[11] Pam Woodall, "The New Economy: Survey," *The Economist*, September 23, 2000, p. 5.

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.

Daveri (2000) also 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 (Schreyer, 200), which uses a narrower definition of IT. Note that 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.

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. The consequences of the special nature of information as an economic product are also highlighted.

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 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). 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 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, and of continued switching costs associated with search that is still costly (though less so) and with investments by consumers in seller-specific information, loyalty programs, and so on.

On the other hand, the studies discussed above examine only posted price markets. 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.

Finally, the Internet expands market across national boundaries, and impacts international trade, through its ability to increase the quantity and richness of information that is available. The kind of information that the Internet can provide does not remove the potential need for traditional face-to-face interactions, at least 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 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 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 has to be bundled, it has to be personalized, and it has to be 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.

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).

The special nature of information (including knowledge) as an economic product also raises concerns for legal definition and enforcement of property rights, which is

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 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. 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.

Until a 1981 Supreme Court case, the United States Patent and Trademark Office was reluctant to grant patents on inventions relating to computer software. They reasoned that patents could not be granted for scientific truths or mathematical expressions of it, and viewed computer programs as mathematical algorithms, which are not patentable. In the early 1990s the courts clarified that an invention including software was patentable if the software controlled real-world processes, or numbers that represented real-world concepts. The commercial use of IT fits this description in ways that were unimaginable in 1981, 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.

Copyright law differs from patent law, in preventing the 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.

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. This is reinforced by 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. 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 **network externalities** keeps reinforcing itself. 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.

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 in a world of high fixed costs and low marginal costs will lead to firms losing money.[12] Pricing itself becomes more complex, with greater possibilities for differentiating across consumers and over time, and is joined by marketing, advertising, product differentiation, and ways of raising the costs for customers to switch 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.

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 (in the case of digital products such as content or software) of these products can also be more efficient, through the use of IT within the firm, and in its communications with its suppliers (its "**supply chain**"). 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. Again, 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

[12] 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.

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 it. The nature of the information service is what clearly distinguishes catalogue shopping for physical products from online shopping. In the case of shopping in a store for physical products, the bundle offered to the buyer is more different, since in store shopping the buyer bears the costs of 'last-mile' fulfillment, i.e., bringing the product home. In the case of digital products and services, the differences are greatest as compared to 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. In the case of physical products, online transactions must still rely on physical delivery using conventional transportation methods.

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 factors such as 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 removed 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. Contract manufacturing is an important example of this phenomenon, where the supply chain becomes more geographically dispersed as well as being more divided among different firms.

Second, even when they do not outsource, firms themselves are becoming more decentralized, as they incorporate IT in their internal business processes. For example, Brynjolfsson and Hitt (2000) summarize a study of large firms that 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." (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.

From the Chandlerian perspective of scale and scope, the above factors pull in different directions. 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 financial services provision are examples of electronic delivery across national boundaries. 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 physical goods and services in new ways, in their offerings to customers.

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 enabling general searches for any kind of information, and represent a new kind of media firm.
3. **E-tailers** are a carryover from the world of physical retailing, including catalogue sales, offering a different bundle of physical 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 and for 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, and many kinds of software developers.

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

5 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 and the legal environment within which it functions. We briefly examine several of these impacts in this section.

5.1 Contracts

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.

Security of content is provided by encrypting (encoding or scrambling) that content. Encryption is an old idea, but information technology permits the use of more powerful mathematical algorithms, and therefore more secure encryption. Security is different from integrity of content. Authentication of content integrity and of the sender's identity use mathematical ideas and technology similar to that for encryption. In physical markets, checking IDs or signatures is a well-established procedure. Even over the telephone, ID can be checked by providing certain information that authenticates identity (the last four digits of your social security number, for example). Digital signatures achieve similar goals for electronic communications: they can identify the sender, and also authenticate content.

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 still 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.

5.2 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. However, it may be that existing laws are quite sufficient, as court rulings against Napster and others suggest, as long as the interpretation of the laws is strong enough.

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 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, it is a symptom of the digital, information or knowledge economy.

5.3 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.

5. 4 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 profitably innovate, 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 case of "natural" monopoly, driven purely by the structural characteristics of the market, rather than 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.[13] 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.

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 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

[13] 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.

lobbying for the ability to compete more freely in markets for data communications, that is, the underpinnings of the Internet.

5.5 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.

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.

6 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.

6.1 Location of 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.

Some of the change is just in freedom of location. However, as we discussed in Section 4, some of the change is 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.

Another change that comes from the falling cost and increasing versatility of communication over the Internet is in 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.

6.2 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.

6.3 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.

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.

7 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. Measures of the digital economy can understate or overstate the current impacts, but they do seem to emerge in recent academic work, and the impacts appear to be increasing.

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