

The world of ones and zeros: social consequences of digitalization

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The World of Ones and Zeros

Social Consequences of
Digitalization

Working Paper of the
Research Group on the Global Future
Center for Applied Policy Research (CAP)

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I. Introduction

Ones and zeroes, the basic positions of computer switches, in their trillions make the digital revolution. Signals, switches, packets set the ones and zeroes in motion, making them more productive for the people who build, maintain and use the networks of digits. These networks, from the simplest cable connecting a computer to a printer or a sensor regulating fuel flow into an engine up to the private networks that speed billions of dollars around world financial markets or the public internet make the digital revolution beneficial and inescapable. Like DNA assembling proteins into cells and organisms, the simplest elements of the digital world give rise to unexpected complexity and consequences at the human scale. Ones and zeroes shape our lives today as surely as DNA does; the institutions of our societies could as little function without digital information as our bodies could function without oxygen. Coming to grips with the digital revolution is a question of survival as well as an opportunity for prosperity; it is simultaneously necessary and liberating. Fortunately, the benefits far outweigh the dangers for both individuals and societies.

What makes the process of digitalization, the conversion of information into computerized form, revolutionary? First, digitalization allows duplication with an unprecedented degree of accuracy at an extremely low cost. Second, it allows transmission of copies with no loss of contents and without destroying the original. Third, within the confines of the earth, copies can be transmitted effectively instantaneously, eliminating many of the barriers distance had previously posed to commerce, culture, and even personal relationships. Fourth, the capabilities of the machines necessary for digitalization are growing rapidly, setting up a cycle of increasing usefulness. Fifth, the costs of participating in the revolution's benefits are sinking, broadening greatly the number of people who stand to gain from digitalization. Finally, as with industrialization, each of other five processes of digitalization reinforces the others, increasing the contrast with non-digital approaches while spurring the further evolution of digital methods.

Each of these propositions deserves individual exposition, as well as demonstration of how it plays out in practical terms. One useful way of assessing the digital revolution, after clarifying some of its general aspects, is to consider its impact on four concentric circles in modern

What makes digitalization revolutionary?

societies: finance, business, government and society as a whole. These realms are obviously interrelated, but also nested within one another; that is, finance is more a subset of business than vice versa. In general, the digital revolution is further advanced in the smaller circles than in the larger ones, thus providing a preview of possible effects when changes wrought by digitalization reach the larger scale. Approaching concentric circles of change shows the time lags involved in coming to terms with digitalization and some of the disruption and misunderstandings that arise from those lags. With general propositions established and cases examined, it is also useful to point out areas of potential opportunity and conflict.

II. Six Reasons Digitalization is Revolutionary

1. Perfect Duplication

Digitalization allows duplication of items with an unprecedented degree of accuracy at an extremely low cost. In this sense, the digital revolution continues the legacy of the industrial revolution; the mass production of goods transformed life in the nineteenth century and became commonplace around the world in the twentieth. Unlike industrial goods, however, digital duplication is not limited to physical items, and thus the number of potential copies is theoretically unlimited. Furthermore, while the cost of a single new product or piece of information may be substantial, the costs of second and subsequent copies may be nearly negligible. This characteristic has serious consequences for manufacturers, indeed, for anyone trying to make money with digital technology. Ease of duplication provides incentives for piracy, creating an equal need for protection measures; alternatively, ease of duplication may make barter a more practical means of transaction in certain areas. Unit costs approaching zero also mean that in the digital realm sellers must compete by means other than price; these may include establishing a standard, aiming for technological lock-in, or making the good an experience in itself.

Extremely low-cost digital duplication, particularly coupled with low-cost transportation for physical objects means that businesses, governments and other institutions will reduce inventories to a minimum, effectively dematerializing much of the supply chain. Dematerialization

Perfect duplication:
Copies for nothing
and stuff for free

is not literal disintegration, of course, but rather reducing something to its pertinent information and dealing with physical objects as little as possible. Faxes have been dematerializing letters for years, lean manufacturing and just-in-time delivery are dematerializing inventories, and Amazon.com is trying to dematerialize book and music stores. Much of the excitement in internet innovation arises from people trying to dematerialize different aspects of business. The current experimentation shows efforts at fundamentally re-thinking commerce, efforts that may produce adaptations as profound as standardized parts and the assembly line. Governments have wisely let this experimentation proceed largely unhindered. Interestingly, low-cost duplication is also helping some services, such as airlines, rematerialize paying customers. By advertising low-cost flights at the last minute to millions of potential flyers, who can then book the flight electronically, the airlines have been able to fill seats that would have otherwise stayed empty. This points to strategies of personalized pricing which are not practical when the information must be conveyed by physical objects but become practical when transmitted digitally. Companies are also experimenting with many different forms of auctions online; buyers like auctions that tend to reduce prices, and firms are finding that they can create new markets by putting certain items up for auction. Electronic distribution of price information is also having the effect of creating spot markets in items, such as truck transport capacity, that would not previously have lent themselves to this approach.

The latest trick:
Dematerializing
inventories and
rematerializing
customers

Low-cost duplication and dematerialization have the side effect of reducing institutions' use of physical resources. The effect on the bottom line can be dramatic: Cisco Systems, one of the world's most successful online sellers, estimates that it saves \$500 million a year in operating costs by using networked systems. In coming years, positive effects may reach well beyond profit and loss. Along with normal efforts to improve efficiency and reduce waste, digitalization of regular processes promises ecological benefits. Companies depend on fewer raw materials to provide the same services to their customers. The more work is done with ones and zeroes in the digital world, the less physical resources are consumed. Although the paperless office will likely remain a just gleam in futurists' eyes, the environmental advantages of digitally improving inventory control, manufacturing, distribution and service may be significant. The benefits may, paradoxically, be less visible, since they are principally in the form of things not used. Pessimists will point to a slowing of the rate of increase rather than an actual decline; for example, paper use is

Walk of life:
Dematerialization
may bring ecological
benefits

expected to increase, even as paper's share of total documents shrinks. Further, it is not clear that net usage of energy will decline, so emission of greenhouse gases will likely remain a critical problem even in a highly digital world.

The consequences of the extremely low costs of producing digital goods are just beginning to be felt. No one can know how far dematerialization will proceed, but vigorous experimentation in free and open societies is the best way to find out what citizens prefer.

2. Preservation of the Original

Digitalization allows transmission of copies with no loss of contents and without destroying the original. While perfect copying is implied in the facet sketched above, retention of the original means that digitalization challenges one of the fundamental principles of capitalist economies: scarcity. In the traditional economy, if one person owns an object, no one else does; in a digital, knowledge-based economy, one person's knowing does not prevent another from knowing the same thing. In fact, the more people share some bits of knowledge – say, the bits that make up a common computer operating system – the more valuable that knowledge becomes. This tendency gives rise to the network effects already seen with fax machines: one fax is useless, two are only useful to each other, a third adds two additional connections, a fourth adds three more possibilities, and so on such that each new user dramatically increases the value of the network as a whole. Similar positive feedback occurs in knowledge of methods, or more concretely, using the same digital tools. Establishing a standard brings considerable commercial advantages, as the stories of VHS and Microsoft amply demonstrate.

Network effects and other challenges to traditional economics

Perfect copying without altering the original encourages piracy, that is, attempts by persons other than a product's originators to make money by selling additional copies. But establishing one's product as a standard is valuable enough that software makers have been prepared to tolerate a certain amount of copying, at least in a market's early phases, to ensure that their product becomes the one to dominate that niche. Perversely, pirate copies can thus increase the value of legitimate copies.

More fundamental challenges to scarcity are also arising in software. Famously, Netscape gave away its browser to establish its market

position while earning income from other parts of the web business, including service, host software, and advertising. Unix, an operating system for larger computers, has long been only semi-proprietary, with different providers earning revenue through means that range from hardware sales to technical support. Innovators are pushing these models even further: Netscape gave away its source code, effectively inviting programmers everywhere to improve on Netscape's core product, while aiming to profit from business other than software sales; Linux is a free system developed by programmers around the world which is challenging the networked version of Windows; internet providers in Britain now offer connections for free and make money from advertising or telephone charges; some retailers are now even selling some physical goods below their costs and recouping the difference through advertising revenue. While some of these schemes have been likened to selling dollars for ninety cents and making up the difference on volume, their proliferation points out the challenge to scarcity and traditional business models posed by digitalization. (Experiments are not confined to the internet; several European companies offer free local and long distance telephone service that is supported by short advertising messages.) Furthermore, the more radical models need not survive or even last long to have a dramatic impact on the market. Free internet service will likely remain the standard in the UK even if service providers find it very difficult to turn a profit, simply because of consumer perception and preference.

Preservation of originals may have a darker side as well. As it provides for network effects and challenges scarcity, digitalization erodes some of the certainties that have underpinned market economics. As J. Bradford De Long of the University of California at Berkeley notes, „the invisible hand of the market does a good job only if the typical commodity meets three preconditions. The commodity must be excludable, so that its owner can easily and cheaply keep others from using it without his or her permission. It must be rival, so that if I am using it now, you cannot be. And it must be transparent, so that purchasers know what they are buying.“ Information goods are seldom any of these; perfect copies and lasting originals make a mockery of the first two conditions; and the whole point of paying for an experience is that purchasers do not know exactly what they are buying. These market problems are not new to the digital world; books and movies have similar economic characteristics, as do many services. But the digital world may be more prone to market failures precisely because of the ways the technology challenges our

current views of economics. The tendency toward serial monopolies in the software field (Lotus 1-2-3 gives way to Excel, or WordPerfect to Microsoft Word) should serve as a warning that the need for oversight will not be dematerialized in a digital world.

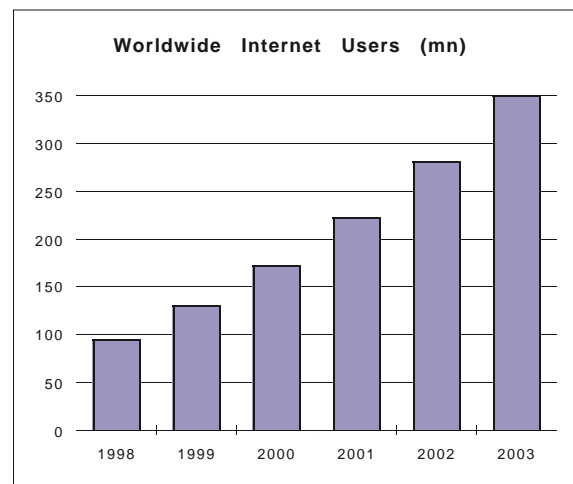
3. Surmounting Time and Distance

Within the confines of the earth, information can be transmitted effectively immediately, eliminating many of the barriers distance had previously posed to commerce, culture, and even personal relationships.

Skeptics have argued that this is nothing new, since news has been available instantaneously since telegraph wires were strung around the world in the second half of the nineteenth century. On the other hand, the reality of 150 million users means that global access is far more immediate and reachable than with technology defined by the telegraph, or even ten years ago by expensive intercontinental phone calls made by satellite.

The irrelevance of distance in cyberspace means that teams can collaborate globally and continuously. This was true in scientific endeavors among the internet's first users, and it continues in science and mathematics today, for example, among the widely distributed groups of cryptographers working to test the latest and strongest codes deemed acceptable by governments for public use. Business and media also function non-stop on the internet. The classical example is of programmers in Bangalore, India, whose working day begins as the day ends in Silicon Valley. A third team based in Europe takes over when India is finished, and by the time the project's originators in California return to their terminals, it has advanced by two more working days. In a globalized world, of course, the project might well have originated in India rather than California, but digitalization's erasure of time and space dramatically changes working patterns in knowledge industries. A similar pattern can be seen in the relocation of many support functions for large corporations, from call centers to accounting and records, away from generally expensive headquarters locations to less expensive hinterlands. At its best, this practice brings employment to changing rural areas and lets digital workers live in less crowded locations. At its worst, it concentrates high-paying jobs in a relatively

Nowhere is far away
in the digital world



small area and contributes to the divide between wealthy and poor regions.

Erasing time and distance can also mean that opportunities arise in unexpected places. One of the fastest-growing game-show sites on the internet, Uproar.com, was launched from Budapest. Although initially aimed at an American audience, the site came from central Europe because the people behind it found a collection of talent at the right price at the right time in the Hungarian capital. The old merchant's adage of 'location, location, location' assumes a different meaning in the digital realm. The desirability of an address becomes a function of human memory, logical ordering, and proximity to known location. When Yahoo! was just a hobby for its founders, the lower your Yahoo! number (the number of clicks you were away from the Yahoo! directory) the higher your prestige among California insiders. Today, location on users' bookmark lists, on a major destination, or lodged in people's memories plays an important role in determining a site's success. Inner geography has replaced outer geography. Marketers and psychologists will no doubt be mapping out which parts of the new landscape stay in our memories the best and applying their discoveries in shaping the terrain of the digital realm.

Inner geography has
replaced outer
geography

On a personal level, inexpensive communication across long distances is subtly affecting patterns of relationships in changes that will not be clear for many years. Particularly in the United States and other societies characterized by a high degree of mobility, electronic contact helps to span the gap between people who are involved in one another's lives but are physically separated. The archetypal story is of a college student who would not write or telephone but does send regular e-mail to his or her parents. They find they are closer than they were when the student lived at home. This story often has a second chapter in which the student encourages the grandparents to discover the online world, with increased contact between generations.

Electronic communication also brings together people with common interests, regardless of their geographic distribution. The worldwide network of genealogists demonstrates a number of typical aspects of this phenomenon. First, the number of people interested in the topic in a given area is limited, but the overall number is fairly large. Second, the hobby is deeply involving; amateur genealogists are willing to develop a large

amount of time and resources to their interest. This increases their desire to interact with people who are similarly interested, as well as the depth of the interaction they will have. Third, there is a great deal of local knowledge that would be of broader interest but which is difficult to access. The combination of these factors has led to a thriving ecology of genealogists and genealogical resources on the internet. Some are amateur, some for-profit, some cooperative, and some professional but non-profit. (The coincidence of a strong high-tech industry and the headquarters of the Mormon church in Utah has contributed to the digitalization of genealogy, but does not detract from the general points about communication among enthusiasts.) The effects of being able to find like-minded souls from even the remotest locale are not clear; overall mobility may decline even as some clusters around particularly vibrant topics may draw people physically as well as virtually.

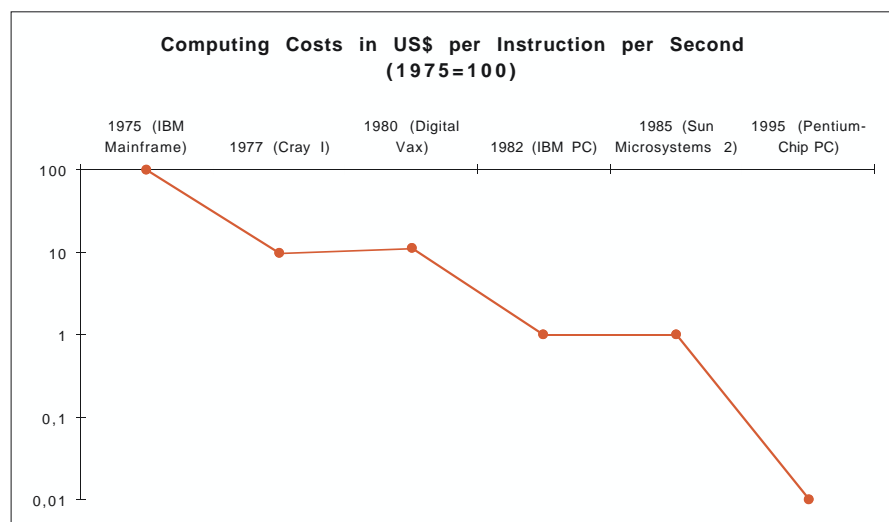
4. Shortening Cycles of Everything

The capabilities of the machines necessary for digitalization are growing rapidly, setting up a cycle of increasing usefulness. Furthermore, the rate at which these capabilities are increasing may itself be increasing, suggesting that the scientific and economic benefits will continue for a fair number of years to come. These tendencies were famously codified by Gordon Moore, one of the founders of Intel, who said that every eighteen months microprocessor power doubles while its cost drops by half. His statement was originally a goal set for Intel, but it has been achieved so regularly for thirty years that it has come to be known as Moore's Law.

One of the perennial debates in computer engineering is how much longer Moore's Law will hold true. On the one hand, the size of silicon atoms and quantum level interference will eventually set absolute limits on what can be accomplished with silicon chips. On the other,

the bottlenecks in current processors are not solely dependent on circuit size, so there is ample room to speed up processor speed before the

The law is too strong:
Moore's Law pushes
everything towards
increasing speed



physical limits of the technology are reached. Beyond that, electronics with materials other than silicon, as well as the possibilities of optical, quantum and DNA computing suggest that Moore's Law will continue to hold for at least fifteen more years.

The increasing power of computation echoes throughout industrialized economies, particularly in the United States where theories of new economic paradigms are being tested in the reality of the market. Aided by new capabilities and prodded by intensifying competition, manufacturers are shortening product development cycles. Items from machine parts to automobiles to CD players are being brought to market ever more quickly, usually with substantially improved features. This has the effect of magnifying small differences and putting a premium on time, so that a company that iterates on a shorter cycle may overtake market leadership from a company that concentrates on perfection but takes a long time to achieve that mark. The values that inform a company's home territory will clearly shape how it reacts to this intensification of time-based competition; societies that place a premium on speed and improvisation will tend to produce companies that fare better than those that emphasize planning and consensus.

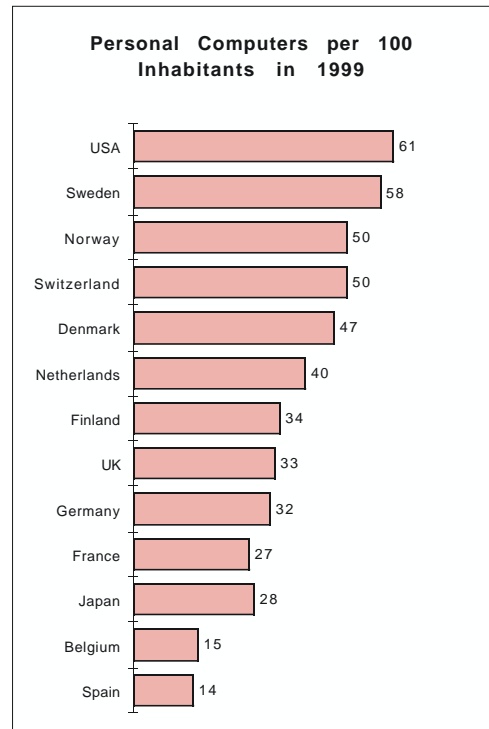
Shortening cycles brings direct material benefits by allowing for increasing customization. Buyers have the opportunity to get precisely what they want; combined with the new practicality of auctioning and other forms of comparison shopping, the power of customers may increase considerably in a digitized world. This effect is also starting to come to the service sector. For example, airlines are beginning to explore separating the different perks offered to flyers in different classes. A certain passenger in coach may pay for the perks of a business class meal or use of a lounge after a flight, while a first class flier may forego chauffeur service for a slightly reduced fare or, more likely, earning additional frequent flier miles. Shortening the cycle of feedback allows the airline to offer a service the customer perceives as better, while increased computing power makes it possible to keep track of all the necessary information.

The most dramatic examples of shortened cycles result in the phenomenon known as 'internet time.' By this adage, every three months in the life of an internet company is equivalent to a year in an ordinary enterprise. Part of this frenzy of innovation is part and parcel of being the

leading sector of a dramatic economic change, part of it is enabled by the increasing speed of the internet's primary tools, and part of it is likely to become a permanent part of the developed world's economies. The question is where the balance will fall among the three, but it is likely that the pace of business will continue to quicken and competition intensify.

5. Declining Costs and the Push toward Pervasiveness

The costs of participating in the revolution's benefits are sinking, broadening greatly the number of people who stand to gain from digitalization. The second part of Moore's Law, that the price for a given amount of processor power falls by half every eighteen months, puts pressure on companies to innovate in order to retain their profit margins, but it also brings the potential for digital connectivity to an increasing amount of the population. In the US, for example, 90% of all schools have some form of connection to the internet. Ten years ago, Forsyth County Georgia was one of the poorest in the state, with a backwoods reputation. Now, it is the fastest-growing county in the nation, and there are five computers in every classroom in the public schools. Even learning-disabled children in poor inner city schools are learning computer skills in the classroom.



This commonality suggests that the skills useful in a digitized society are not esoteric, that they can be taught to at least as large a segment of the population as reading and writing, and that a society that makes a commitment to teaching computer usage as part of its basic curriculum need not fear a division of its population into the electronically literate and illiterate. The presence of computers in an overwhelming majority of workplaces, from diagnostic tools in car repair shops through computerized ordering systems in virtually every trade up society's rungs to the scientists or bankers whose entire working environment is digitized points to market incentives for learning computer skills. These incentives alone, however, are probably not enough to ensure that everyone in a society has some facility with the essentials of the digital world. The near universality of computers, particularly in the workplace, also suggests that within ten years, the question of computer literacy will no longer be asked; it will be a part of general literacy.

Anyone who can learn to read and write can learn to use a computer

Sinking costs have also set off a competition between provision of power and bandwidth for new applications and users' demands for ever-greater detail and verisimilitude in their virtual environments. (The shortening cycles mentioned above also play a role, as companies tout continuous improvements, with its downside of numerous upgrades, unwanted features, and reduced performance on older machines.) One of the possible versions of pervasive computing is a system in which computer cycles are metered utilities much like water and electricity. Plug into the net, in theory, and draw on collective computing power from the local utility - or, given the ongoing tendency of deregulation, your chosen computing provider. The technical hurdles are still substantial, and such a vision may also break against the rocks of the societal tendency toward individualization.

Another facet of pervasive computing is that not only are desktops much more powerful than today, but smaller objects have computers built into them as well. The apparent ability of Furby toys to learn to talk is a harbinger of this trend. Datebooks may know who they belong to, shoes could monitor a jogger's workout, the morning newspaper may be a rollable or foldable display that downloads today's news from a wireless network, and so on. As computing power becomes ever cheaper it becomes ever more dispersed into the fabric of society. Indeed, clothing may be able to adjust to absorb or reflect sunlight, with computers literally woven into its fabric. The first users may find it a bit eerie that the refrigerator tells the supermarket to send more milk, but citizens will quickly adjust to new conveniences.

6. Self-Reinforcing Trends

Each of the five processes described above reinforces the others, increasing the contrast with non-digital approaches while spurring the further evolution of digital methods. Sinking costs encourage shorter development cycles, developed at distributed locations across time and space, made possible by perfect duplication of indestructible originals. Each of these forces individually would be a powerful agent for change in society. Taken together, adding on, and strengthening one another they add up to a revolutionary impact.

Each of the five trends strengthens the others, like brothers in arms

In business, the impact of combining all of the aspects is clear. Cisco, a

leading manufacturer of internet-related computer equipment and possibly the world leader at selling over the internet, illustrates this trend. The company had \$8.5 billion in 1998 sales, over \$3.5 billion of it online. That is more than all of the internet retail sales in France in 1998. In fact, Cisco sold more online each month of 1998 than all of the retailers in all of France sold all year. While it is not a monopoly, Cisco also demonstrates the power of being number one in a digital world: the market value of the company is greater than that of its five nearest competitors combined.

For individuals, the self-reinforcing combination of these five aspects means that willingness to learn and adaptability to change will continue to be at a premium. Whether the digital revolution will bring greater changes in the twenty-first century than electricity and the internal combustion engine did in the twentieth is an open question, but it seems unlikely to expect substantially less change. Citizens should expect an increasing density of communication possibilities. Already we see that being unavailable is becoming a sign of privilege. Between mobile phones, e-mail, and voice mail, everyone is expected to be reachable at almost all times. This communication has the chance to strengthen existing ties, to forge new ones across large distances based on common interests, or to overwhelm the uncertain user. No citizen in a developed country should now grow to adulthood without familiarity with computers. For a few more years still, much of this task will fall to the schools; thereafter, it is likely to be an embedded part of growing up, like learning to turn on the lights or ride a bicycle.

For democratic governments, the biggest challenge is likely to be coming to grips with increasing speed. Republican institutions are generally designed to make haste slowly, and in the digital age governments will often find that operating conditions rapidly overtake efforts to build a consensus on rules or regulations. While governments will not lose their role of setting fundamental ground rules in markets and public life, they will often find it necessary to exercise an unaccustomed restraint in using their regulatory powers. Until governments have mastered the tasks and the responsiveness of digital governance as thoroughly as companies grasp digital commerce, society's institutions are likely to find themselves permanently trying to catch up to a rapidly changing digital environment. Sharp clashes will continue between the rapidly evolving digital world and institutions intended to take their time while society

makes up its mind. As frustrating as this will be for digital advocates, it is not a new process, as even a cursory examination of governance of any major technological change will show.

The impacts sketched in the abstract here become clearer in an examination of four concentric elements of society facing the digital revolution: finance, business, government, and society as a whole.

III. Four Concentric Circles: Spreading Digitalization

1. The Fate of Money: Finance

As Walter Wriston has observed since his retirement as CEO of Citibank, „Money goes where it is wanted, stays where it is well treated, and that’s all she wrote. This annoys governments to no end.“ At least since the world’s major governments abandoned the gold standard in the wake of the first oil crisis, money has been nothing but information. A currency’s value in relation to other currencies is the sum of individual decisions made by buyers and sellers in the international markets. Internally, the value of a dollar, yen, franc or mark is a similar sum of decisions and expectations about what the unit of currency ought to buy. Governments’ gradual coming to terms with the nature of money has been the source of profound policy debates and numerous crises beyond the scope of this paper. Wriston’s wry remark points out at least one consequence of large amounts of mobile private capital: governments must face up to the consequences of imbalanced economic policies, sooner rather than later. Sovereignty is no shield against the effects of the digital revolution. The fact that money is pure information means that in the contemporary world it is digital information, subject to the six theses sketched above.

At the highest level,
money is nothing but
information

Early access to information about money (or indeed any traded security such as stocks or bonds) has long been a source of large profits; this tendency has made the financial sector an early adapter of virtually every form of digital technology, from the first telegraph cables across the Atlantic to today’s sophisticated global networks and extremely fast computers for maintaining complex models of financial markets. Financial markets rival the natural sciences for the intensity of their computational demands, and the financial sector is one of the most thoroughly digitized parts of the economy. A number of consequences are now clear.

Technology is
boosting transparency

First, the duplication and transmission of digital information are pushing financial markets of all types toward greater transparency. When not only prices but also background information on companies, governments, and financial products are available to all interested parties, a market no longer functions as a club of vested interests but moves much closer to economic models of perfect competition. Combined with laws against insider dealing and vigorous enforcement mechanisms, the tendency towards transparency increases confidence in the market and boosts its liquidity and importance. Second, speedy duplication of information has prodded innovation in finance. If a new product can be duplicated by competitors shortly after its introduction, the only way to maintain a profitable advantage is to invent new products and services continuously. Third, the death of distance in financial markets has been an accomplished fact for a number of years; the global foreign exchange market amounts to a trillion dollars a day, and trading in the major markets is very nearly continuous (the brief gap between trading hours in New York and Tokyo is partially bridged by exchanges on the US west coast and in Australia). On the other hand, many financial markets, particularly bond markets, were until recently determinedly insular, and they are still coming to terms with the entry of foreign players. International investors have often brought both increased liquidity and sharper competition, a double-edged sword for financial firms accustomed to clubby relationships. A more difficult public policy issue arises when international investors are able to command sums equal to sizable portions of a country's GDP. This is not a direct consequence of digitalization, but in a networked world, small countries must determine how they will coexist with large multinational investors.

Fourth, increasing computer capabilities in the financial sector mean that sophisticated techniques can be applied to many different areas. Where the legal framework supports it, commodification of many different types of loans, and the introduction of spot markets in many different areas are likely to proliferate. For example, student loans in the United States are now bundled and sold in groups, producing a steady stream of revenue like a bond, and allowing investors to profit from them without necessarily going into the business of making and collecting loans. The creation of such a secondary market has had the effect of increasing liquidity for education loans, often reducing both bureaucracy and interest rates. In a different vein, digital communications and increased

Spot markets may
arise in any tradeable
good or service

computer capacity allow for the creation of spot markets in many areas beyond traditional commodities or financial instruments. Telephone and data bandwidth, trucking capacity, and electricity are areas where open markets are experimenting with new means for making the sector more effective. This experimentation shows techniques from the financial sector spreading to other parts of the economy as the information (availability, time of delivery, etc.) about a product becomes at least as important as the product itself. Taking this trend to its logical conclusion, one arrives at the various internet auctions for all manner of retail or wholesale products; spot markets not only in pork bellies and gold futures, but in Beanie Babies or Backstreet Boys tickets.

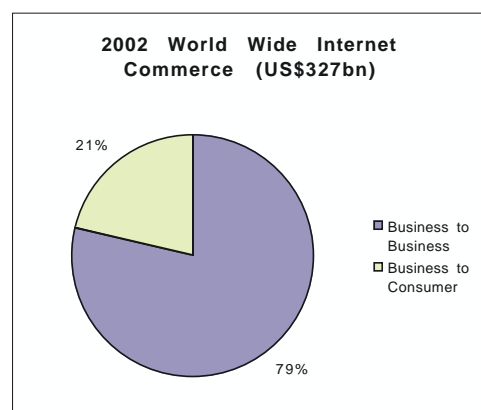
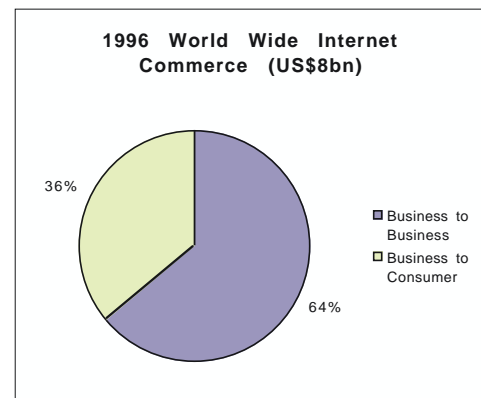
The spread of techniques from financial markets into other sectors of the economy is accompanied by increasing participation in the financial markets, driven not only by the fifth proposition – sinking costs – but by the failure of the traditional welfare state. More and more citizens, pulled by lower barriers to entry and pushed by the need to make more provisions for old age, are finding they are at least as capable as the state in securing their futures. Increased participation in the market at an individual level has also changed existing price structures in the US and is having effects on the shape of financial firms and on the markets themselves. As more individuals have invested, particularly in the stock market, they have demanded an end to preferential practices for existing market players. (In Europe, pressure for change has tended to come through competition among national financial centers, whether spurred by the coming of the euro in the west or by the need to establish markets and draw investment in the east. In Asia, pressure for change has tended to come from governments seeking either international investment, e.g. Malaysia, or to improve a market's importance in global competition, e.g., Singapore.) Companies catering to American consumer demands have been rewarded with increasing market share; digitalization has helped level the playing field between individual and institutional investors. A regulator firmly committed to openness and equality has been indispensable for these changes; the SEC prosecution of price-fixing on the NASDAQ market was a watershed event in this realm. New entrants are also taking this development to its logical conclusion: thanks to digitalization small companies that had previously performed technical jobs for the larger exchanges now have the ability to function as stock exchanges themselves. They are now in the process of receiving regulatory approval and are raising the fundamental question of what constitutes a market?

This question points to a dynamic in the US of dis-intermediation followed by re-intermediation with some new players. In the first wave, digital technology challenges established hierarchies; prices fall as information attempts to be free; companies with legacy operations are overtaken by newcomers unworried about cannibalizing existing business; innovation reaps large rewards; and much of a previously specialist process is given over to individuals. Over time, consumers find that they are not necessarily interested in doing all of the detail work themselves. Existing companies reassert the advantages of knowledge and experience, and newcomers build enough of a clientele to be concerned about sudden changes in their business. This dynamic shows the processes of digitalization reinforcing each other, and as long as barriers to change remain low, it can always start again, shaking an industry to its core before a new equilibrium emerges. This is as true for business in general as for the financial sector.

Re-intermediation
follows
dis-intermediation

2. The Speed of Everything: Business

One impact of the digital revolution on business is in many ways a continuation of the lean manufacturing and just-in-time delivery techniques pioneered in Japan. Where coordination among participants in a supply chain allows for reduced inventories and increased efficiency, digitalization allows a business to substitute information about an item to replace the item itself. The resulting dematerialization of goods promises substantial savings and profits for companies able to take advantage of it. For example, as long as delivery times are reliable, an end manufacturer only needs to know the location of components rather than having them on hand. Dell Computers uses this technique to turn over their inventory roughly every six days, as components are delivered and immediately assembled into already ordered computers. This has the added advantage of generating five sets of incoming payments within the average thirty days that Dell has to pay its suppliers. Beyond improvements in the manufacturing process, digitalization of sales and ordering is helping Dell achieve additional savings and efficiency; furthermore, because potential customers know they can



find out information about Dell products on the web at their convenience, the company's digital presence helps it to draw in customers rather than having to seek them out. The potential gains for firms are not trivial. As noted above Cisco expects to realize \$500 million in annual savings through digitizing its supply chain; IBM reckons it may save \$600 million in 1999 through customer self-service on the web.

Businesses that deal in information are finding that all six theses discussed above apply to them and their work. This is clearest in the media, where production and distribution are both in the middle of a digital transformation. Perfect duplication and near-instant transmission have provided means and incentives for large-scale piracy of media goods, mainly in music, movies and software. (Time sensitive media that are well distributed, such as daily newspapers or broadcast television, are less subject to piracy and mainly have problems controlling the revenue from reprints.) Some elements that contribute to piracy's profitability are a time lag between a product's introduction in one market and another, a steady stream of products only marginally different from one another, restrictions on the supply of products that interest the public, and a mismatch between the price and the perceived value of the product. For example, despite creation of simultaneous world-wide demand for the newest Star Wars movie, several months elapsed between the picture's US release and its introduction in other markets. Pirates took advantage of this gap. Music aimed at teenagers, marked by rapid turnover in artists, is also a tempting target because the products' limited shelf life discourages buyers from paying full price. In another segment of the music business, the popularity of bootleg recordings shows that there is greater public demand than the distributor is willing to satisfy, and monopolistic attempts at control result in profits for pirates. The music industry is likely to experience the dynamic of dis-intermediation and re-intermediation discussed above in relation to finance. Current technology undermines existing hierarchies in ways that legislated remedies are not likely to fix. Consequently, businesses that wish to stay afloat as mediators will have to rediscover which elements the public is willing to pay for. In software, the primary incentive for piracy is the perceived mismatch between a product's value and its asking price. Similarly, specialist academic journals, particularly in the natural sciences, are under pressure from electronic archives or electronic clearing houses of pre-published papers because subscription prices have risen beyond the value that scientists find in the journals. While this is not piracy, it is a

Markets, pricing,
time and piracy

technology-enabled challenge to an existing monopoly. All of the questions surrounding piracy point to a more fundamental dilemma: who should profit from information, how much and for how long? This question will arise in several contexts below.

The media — from newspapers and magazines through film and broadcasting — are also contending with another effect of digitalization, the creation of new forms of business that were previously impossible. These range from newsletters and specialist magazines delivered electronically to the desktop through networked games to movies on demand and web sites of every sort. Electronic books and increasingly sophisticated video games add to the mix of new media. (Video games bring in about as much revenue as first-release movies in the US.) In another example of internet effects reinforcing each other, the high market value attached to internet media companies is allowing them to purchase or merge on equal terms with much larger old media concerns. Dis-intermediation and re-intermediation are proceeding apace.

Many businesses have found themselves unexpectedly in the information business. For example, FedEx's ability to track packages within its own system has placed them on the cutting edge of information and logistics. Not only is this type of precision crucial for companies like Dell Computers operating digital supply chains, expertise in logistics has given FedEx a valuable information-based service to sell. Having mastered their own network, they have found a growing market in helping other companies master the same processes. Cemex, the largest cement company in Mexico, discovered that the information systems that allow it to deliver on time in Mexico's chaotic conditions apply in many different parts of the world, allowing the company to expand globally in what was traditionally a very local business. Companies are also finding revenue streams in their existing databases of customer preferences and behavior. They are able to correlate possible purchases, whether retail or wholesale, much more accurately when all of the information is digital. Sharing this information across different parts of large corporations, selling data to other firms, or merging information on the public record with private databases have all created controversy over consumer protection, both within single countries and among trading partners. The root question, again, is who should profit from information, how much and for how long.

Is every business an information business?

Businesses are migrating other activities online as well. Recruiting, particularly in technical fields, has moved online with a vengeance. Electronic ads are faster and more effective than print or word of mouth. Job-seekers have also found many advantages in posting resumes to the web. Automating the first steps of hiring new personnel speeds the entire process. It also raises the bar for potential workers; computer skills are no longer a beneficial extra, they are requirements for entering the workforce. Companies are moving reimbursement, travel, planning, and other internal functions online, speeding up all of the processes.

Finally, as more purchasing takes place electronically, price models can change. Like the financial sector, business as a whole may find that spot markets are more effective than individually negotiated agreements. Many types of auctions become more practical with networked communication than without it, and both buyers and sellers are finding advantage in adopting them. GE, for example, allows its suppliers to make bids on component contracts online; the system has cut procurement costs in half. Airlines can sell last-minute seats directly to likely customers by e-mailing them with special offers. With more market information, both buyers and sellers should be able to find fairer prices throughout the economy.

As a 1999 survey in *The Economist* noted, for businesses an internet strategy is „not easy, not cheap, and not optional.“ Digitalization and networking are spreading outward from finance and the technology industry. They are likely to affect every process in business, from hiring and firing to procurement and production, from product development to financing and pricing. That the world’s most influential businesses are only just getting started transforming themselves only underlines the size of changes still to come.

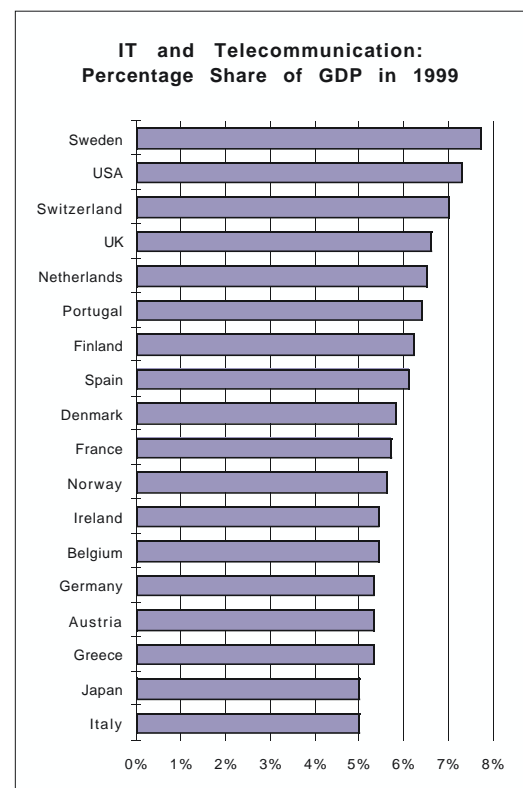
3. The People’s Business: Government

Governments are charged not only with setting the rules in which the digital world will emerge, but also adapting their own processes to digitalization and working toward a measure of balance within societies being changed by the new technologies. At the same time, the tendency of digital technologies to undermine hierarchies places a special burden on governments, most of whose bureaus and agencies are accustomed to operating in a very hierarchical fashion. Furthermore, most governments

One of the slowest adapters is charged with setting the rules

operate at a pace much slower than the developments in the technology and business of digitalization. Where real problems of public policy have arisen, governments have found that they lag well behind the events that are affecting their constituencies. Part of this is inevitable, given that consensus-building (whether democratic or bureaucratic) is slower than innovation, and part of it is self-inflicted, as people in government neglected to work through the ramifications of the digital revolution.

In their dealings with the financial sector, governments have found that digitalization is a two-edged sword. Freer flows of information and the dispersion of financial resources have meant that smaller entities have access to larger capital markets. Networked markets, and the liberalization of capital rules that have accompanied the networking have meant that countries are no longer limited by local financial resources for the projects that they undertake. In the 1970s, notes Daniel Yergin, there were seven foreign stock markets in which American pension funds could invest. Today, there are over ninety just among emerging markets. The emergence of global capital flows has aided countries and companies around the world. On the other hand, the speed of information movement and money flows means that markets can react to policy developments with a speed that governments find unnerving. Walter Wriston's observation above points out that in a digitized world, governments no longer hold the advantages in knowledge and control that they once did, and that they are having a difficult time adjusting to the loss of control.



Government reaction to the digitalization of business has likewise been mixed. In countries where it is well advanced, e.g. Sweden, Finland, or the US, governments have approved of the impetus given to economic growth. The US Commerce Department estimates that a significant part of the current expansion is directly due to the effects of digitalization. Growth has brought both greater tax revenue and lower unemployment. The rise of digital-oriented services and the continued strength of the mobile phone industry have played important roles in Sweden's rebound, and the importance of high-tech manufacturing in Asia is hard to overstate. On the other hand, the wealth produced by digitalization is

sometimes proving more difficult to tax than that of the pre-digital economy. Governments have so far mostly shown restraint in imposing taxes on the digital realm, but the more money streams from that sector, the less likely that tax authorities will be able to resist tapping into the stream. At its more creative and radical edges, the internet economy also functions as a gift and barter economy, making taxation much more difficult.

Governments have also found that the digitalization of business has been accompanied by the digitalization of fraud of all sorts. Citizen and consumer protection has been playing catch-up in stock scams, money laundering, and other con games adapted to the online world. As these frauds often cross borders, the need for international cooperation is unmistakable. In the regulation of online content, however, the borderless nature of the digital world, and the preponderance of the United States within that world, have made common international standards difficult to agree on. Famously, the internet interprets censorship as damage and routes around it. That is, the structure of the net is much friendlier to the flow of information than to its control, whether that information is the text of Mein Kampf, an article criticizing the Chinese Communist Party, or pictures of naked people. Governments that are in the business of controlling information are finding it increasingly difficult to keep the genie in the bottle.

Governments are also looking for ways to use the internet and other digital technologies to serve their citizens. As noted above, digitalization has opened up new possibilities in financing government operations. Many of the average citizen's interactions with government agencies and bureaucracies can also be brought online, saving money for the public treasury and increasing the convenience to citizens. For example, Americans can now download all of the forms necessary for filing their national income tax; in many cases these can also be submitted online and additional payments made by credit card or refunds authorized for electronic deposit. Government-mandated filings in the American financial sector are now generally made online, and there are various pilot projects to put court records online as well. Police agencies can collaborate with online databases, for improved public safety. Public information can be brought online in the same way that corporate customer service has been, again increasing both efficiency and citizen access.

Serving the
digital citizen

Potentially, much of the legislative process can also be disclosed online, giving citizens away from the capital access to the latest versions of pending laws. As this is a direct assault on the power of lobbyists, insiders and, to a certain extent, legislators, implementation has been slow and sporadic. This concept is a prelude to online democracy, where citizenship is exercised over the wires as well as in person. Clearly, for electronic citizenship to take hold, access must be nearly universal, and means of identification at least as good as identification in person, but both of these technical hurdles seem more a matter of time than of principle. How much governments will be willing to open their processes, how deep citizen interest in politics really is, and how to make these novel possibilities serve the commonweal are all very open questions.

The process of dis-intermediation and re-intermediation appear to apply to citizen involvement with the government as well. The American experience is instructive. In the first two election cycles after the explosive growth of the internet, 1994 and 1996, citizen input to candidates and representatives via e-mail was limited, genuine, and largely spontaneous. Legislators' staffs heard unfiltered comments from constituents, and citizens often got much better responses from their representatives because e-mail was more likely to receive personal attention from someone than a written letter. By 1998, and even more for the 2000 races, digital communication is a part of the enormous apparatus of politics and campaigning. Special interest groups have learned to coordinate e-mail campaigns as cleverly as they do fax and mail campaigns. The publication of the Starr Report marks a turning part in the use of the internet in the American political process; after hundreds of thousands of people read the report online, no political player could afford to ignore the online world. Existing powers are mastering the necessary skills of online politics, even as new players are taking advantage of their special expertise. The hierarchy has shuffled a bit – internet organizing played a crucial role in electing a third-party candidate governor of the state of Minnesota – but the net has not rendered existing structures obsolete. In countries where politics is less entrepreneurial, the impact of the net will be felt more slowly. On the other hand, many net enthusiasts come from social groups where participation in politics has been declining, and parties or candidates that can speak to their interests may pick up the margin of victory by organizing a disaffected constituency. From this perspective, even a

difference of one or two percent could have a significant impact on elections throughout the industrialized world.

4. We Ourselves: Society

Despite rapid innovation in the digital realm, society as a whole will take a long time to adjust to the six propositions stated above, simply because people's habits take time to change. The effects to date are most visible in our working lives, changes closer to home are likely to become more visible as computing becomes ubiquitous, particularly as mobile telephones increase their capabilities. Many effects are also generational; younger people are adapting new technologies much faster than their elders. As Nicholas Negroponte observed in *Being Digital*, if you have a child in primary school, you know about CD-ROMs, whereas if you have teenagers, you know about chat. The true sign of the success of the digital revolution will come in a decade or two, when it is no longer a subject of discussion but rather a simple fact of life. Electricity and automobiles changed life dramatically in their time, but now they are simply a fact of life. Eventually the current excitement about the internet may look as quaint as enthusiasm over electric lights. Our grandchildren may well ask in wonder, couldn't computers always talk to each other everywhere in the world? Between now and then, however, industrialized societies can expect many changes in the fabric of daily life, and in the organization of society's components. Technology will make possible changes driven by existing values.

People's habits
change slowly

One of the first changes is a sensation of increasing speed. Because communications are now instant, we expect answers to come instantly, and this expectation leads to a simultaneous push to give answers immediately to others. Because much information around the world is at our fingertips, we often expect all of it to be not only available but easily findable and generally free of charge. In business particularly, we expect immediate replies. This contributes not only to the pace of innovation, but to the sense many workers have of being overwhelmed by the immediate. Studies by private industry show a marked increase in the number of messages (phone, fax, e-mail or otherwise) received and processed by American office workers in the 1990s. Companies and people working on 'internet time' are driving the economy, but they are driving themselves very hard as well. The foreseeable backlash has started (asked about long hours, a worker for a Boston internet startup observed, „that's so 1995“),

but the drive for efficiency that digitalization fuels inevitably means that fewer people will be asked to do more tasks in less time. This leads to the sense that our societies are speeding up.

Another societal consequence of digitalization is the erosion of boundaries between personal time and business time. Working with partners on the other side of the globe means that business can not be confined to a narrow segment of the day. Cheaper and more available mobile phones and pagers mean that more and more people are not only able to remain in touch, they are expected to be reachable at all times. In some ways, this is a return to pre-industrial conditions when the division between work time and private time barely existed; the job that could be left at the end of the day, or even set aside for a four-week vacation with no ill effects, may come to be seen as a relic of the regimented industrial work system.

Ubiquitous mobile phones imply continuous availability not only for business but also for social purposes. Manners change: if you're caught in traffic and will be late for an engagement, an apology is no longer sufficient, you should call from your mobile. Similarly, people now use mobiles to find each other at crowded locations. This tendency is only likely to increase as phones become more data-capable. In Helsinki, where the latest phones can transmit short text messages and other data, the majority of traffic on the cellular phone network is already data rather than voice. Teenagers use the features to organize games, to coordinate with each other, and simply to send greetings without the interruption of a conversation. Adapting the technology to prevailing customs, and vice versa, will be a task for all advanced societies in the coming years.

Mobile rules
and netiquette:
digital manners

The digital revolution is also transforming the ways that we construct our peer groups. Geography is still critical – otherwise high prices would have long since driven everyone out of Silicon Valley – but digital communication and the creation of semi-public groups organized by interest allows continuous interaction among people separated in time and space. Since Howard Rheingold's groundbreaking book, few phenomena of the online world have received more attention than digital communities. How they form, what holds them together, and their potential impact on offline communities have all been the subject of controversy. While on the one hand it is clear that the term 'online community' is often misused by persons or companies for commercial

Multiplying choices
and elective
communities

gain, it is equally clear that people with common interests have formed durable bonds in groups that have been active over periods of years, sometimes reaching back over a decade to pre-internet online groupings. There are support groups for people suffering from various diseases, hobbyist groups, storytelling groups, fan groups, groups for speakers of minor languages, groups reflecting virtually every interest under the sun. As barriers to entry fall, communities of choice can be expected to multiply into the millions. For geographically or culturally isolated persons, for the ill or disabled, online communities can make a tremendous difference in the quality of life. Given that research is starting to show that online activity often takes the place of television viewing as a leisure time activity, there is even some reason to hope that people are becoming less couch potatoes and taking an active interest in topics of their choice. At any rate, the proliferation of online groupings also serves to reinforce the broader trend of individualization in western societies.

Digitalization is also starting to affect our relations with communities that we do not choose, particularly families in highly mobile societies. In practical terms, this is often a function of low barriers to communication; sending an e-mail is considerably less time-consuming than writing a letter, and it arrives much sooner. Thus children who have gone away to university communicate more often electronically than they would have by post. Siblings or childhood friends separated by later developments remain in contact, enhancing relationships that might otherwise have languished. Anecdotally, many senior citizens first venture online to receive e-mail from their grandchildren. By erasing distance at a low cost, the digital world offers the chance of enabling personal connections and working against the isolation that often accompanies increasing individualization.

Finally, the online world contributes both to homogeneity and multiplicity. On one level, a limited number of companies and services become firmly entrenched in the public consciousness as the sole representatives of a given idea. These firms span the globe with their approach, producing uniformity. Thus, students in Mongolia use Hotmail for free e-mail accounts, and people around the world search with Yahoo on browsers downloaded from Netscape. The internet aids and benefits from the broader trend toward global branding. On another level, the net makes the costs of building niche groups much lower. Fans of the Turkish baths in Budapest can coordinate visits with friends arriving from

California or the UK. A design movement based on making environmentally sound products cooler than anything else on the market can organize competitions, exhibitions and manifestos throughout the world. Even the global brands find it necessary to customize their products; thus, Yahoo Atlanta or Yahoo Denmark. As the networked world builds certain common elements, many of them commercial, it helps to retain the local, the provincial, the peculiar.

IV. Conclusions

Digitalization brings deep changes to industrialized societies for six reasons. First, it allows duplication of items and information with an unprecedented degree of accuracy at costs approaching zero. Second, it allows the transmission of these copies with no loss of contents and without destroying the original. Third, confined to the earth, these copies can be transmitted effectively instantaneously, eliminating many of the barriers distance had previously posed to commerce, culture, and even personal relationships. Fourth, the machines necessary for digitalization are improving rapidly, building a virtuous circle of increasing usefulness. Fifth, the costs of digitalization are sinking, broadening greatly the number of people who stand to gain. Finally, as with industrialization, each of other five processes of digitalization reinforces the others, increasing the contrast with non-digital approaches while spurring the further evolution of digital methods.

Along the way, digitalization is reshaping business, changing some basic assumptions of economics, and upsetting established routines in the financial world. Businesses have the opportunity to realize major gains in efficiency, but may simultaneously find their core competencies challenged. They may also have to jeopardize long-standing relationships in order to survive. These developments promise controversy for years to come as more businesses migrate functions online.

Governments must provide a stable environment for their citizens during these changes, while working to see that they enjoy the benefits. Simultaneously, governments are digitizing many of their processes, causing upheavals similar to those in business among people long accustomed to stability. Governments are further challenged by the tendency of digital technology to undermine established hierarchies. Command and control works poorly in the online world, and regimes that

are slow to adapt may find that the costs of delay are considerable.

Finally, digitalization is gradually reshaping society, altering our perceptions of normal behavior, and changing our expectations of virtually everyone we interact with. The pressures of constant availability, instant response and the blur between home and work are taking their toll, even as the online world promises new contact and new forms of community.

The ones and zeroes of computer networks are almost as potent as the four bases of DNA for shaping human interactions and institutions. As the implications of these changes reverberate for years, possibly the most amazing fact is that all talk of the internet revolution will gradually disappear, as future generations will simply take for granted the momentous changes discussed here.

Additional Information

The portal on digitalization, part of the web site of the Research Group on the Global Future (www.hoechst-forum.uni-muenchen.de) offers a wide range of additional literature, documents and internet links on the topic of the digital revolution.