The "New Economy": Background, Historical Perspective, Questions, and Speculations

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Introduction I.

Any attempt to analyze the meaning and importance of the "new economy" must grapple with four questions:

• In the long run, how important will the ongoing technological revolutions in data processing and data communications turn out to be?

• What does the crash of the Nasdaq tell us about the future of the "new economy"?

• How should the way the government regulates the economy change so as to maximize the benefits we reap from these ongoing technological revolutions?

• What impact will the shock to public confidence and the destruction caused by the terrorist attack of the World Trade Center on September 11, 2001, have on the American economy?

We do not know the answers to these questions. We do, however, have our informed speculations about what the answers might be. It is our judgment that:

• The long-run economic impact of the ongoing technological revolutions in data processing and data communications will be very large indeed.

• The crash of the Nasdaq tells us next to nothing about the dimensions of the economic transformation that we are undergoing. It does, however, tell us that the new economy is more likely to be a source of downward pressure on margins than of large durable quasi-rents.

• The principal effects of the "new economy" are more likely to be "microeconomic" than "macroeconomic," and they will lead to profound—if at present unclear—changes in how the government should act to provide the property rights, institutional frameworks, and "rules of the game" that underpin the market economy.

• The terrorist attack of the World Trade Center will slow private investment in new technologies, but U.S. military spending is likely to increase, and the increase in military spending will be concentrated on high-technology data-processing and data-communications products. On balance, therefore, the changes in economic structure that fall under the category "new economy" are not likely to be much affected.

Consider each of these in turn:

The first of our conclusions has to do with the long-run economic impact of the "new economy." Forecasting the rate of economic growth is always hazardous, but it is more hazardous now than usual. The rate of productivity growth in the United States was 1 percent per year in the late 1980s and early 1990s, 2 percent per year in the mid-1990s, and 3 percent per year in the late 1990s. When faced with the sequence 1, 2, 3, what is the next number? Is it 3—the latest observation? Is it 2—the average growth rate over the period? Is it 4—simple extrapolation?

The correct forecast is far from obvious: The sequence of numbers could support any of the three forecasts.

We, however, conclude that one of the larger of the possible forecasts is likely to be correct. We conclude this for two reasons. First, the pace of technological progress in the leading sectors driving the "new economy" is very rapid indeed, and it will continue to be very rapid for the foreseeable future. Second, the computers, switches, cables, and programs that are the products of today's leading sectors are general-purpose technologies; hence, demand for them is likely to be extremely elastic. Rapid technological progress brings rapidly falling prices.

Rapidly falling prices in the contest of extremely elastic demand will produce rapidly growing expenditure shares. The economic salience of a leading sector—its contribution to productivity growth—is the product of the rate at which the cost of its output declines and the share of the products it makes in total demand. Thus, unless Moore's Law ceases to hold or the marginal usefulness of computers and communications equipment rapidly declines, the economic salience of the data processing and data communications sectors will not shrink but grow.

The judgment that the long-run impact of the information technology revolution on productivity will be enormous runs somewhat counter to the conventional wisdom, especially in the aftermath of the crash of the Nasdaq and the terror attack on the World Trade Center. Willingness to invest in high-tech equipment and infrastructure has been profoundly shaken by the terror attack. One-time extreme optimism about the future of the high-tech sector has been destroyed by the crash of the Nasdaq.

However, it is unclear what the medium-run and long-run consequences of the terror attack on the World Trade Center will be. Private demand for information-technology products is likely to drop. Military demand for information-technology products is likely to rise. A quick resolution of the crisis is likely to lead to a rebound in private investment as businesses that had been waiting for uncertainty to be resolved proceed with their investment plans. A catastrophic, long, bitter, and resource-consuming war that triggers major mobilization is likely to lead to an acceleration of the transformation as military and civil defense demands for information technology products jump. Technological and structural changes speed up during wartime. Only in a middle scenario, in which uncertainty continues but in which military and civil defense demand remains low, could the consequences of the terror attack retard the economic transformation.

Moreover—and this is the second of our three conclusions—the crash of the Nasdaq did not take place because the pace of technological progress in the computer industry slackened, or because the rest of the economy suddenly recognized that they were satiated with computer equipment. The Nasdaq crashed because it became clear to previously overoptimistic investors that the supply of bigger fools ready to buy overvalued stocks had dried up, and that dominant market positions in high-tech-based businesses were not sources of profits unless they came accompanied by substantial barriers to entry—and that such barriers to entry were turning out to be remarkably hard to create. Over a wide range, the dominant effect of the "new economy" has been to make competition more effective, not to create scale-related cost advantages.

Our third conclusion is that the principal effects of the "new economy" are more likely to be "microeconomic" than "macroeconomic." The new economy creates the possibility for lower average unemployment rates by making it possible for employers to meet workers' wage aspirations at higher levels of employment. The new economy creates the possibility that better inventory control will diminish the inventory-driven component of business cycles. But the past century has seen a great deal of structural change, yet it has proven hard to link structural changes in the economy to changes in the business cycle.

The microeconomic effects, however, are likely to be far-reaching. The probability is that they will have powerful effects on how markets work and how governments must act to make the market economy function well. Issues of the benefits from the extent of the market, of price discrimination and the distribution of economic well-being, of monopoly, and of the interaction of intellectual property with scientific communication and research are all very important and very complicated. These sets of issues are harder to summarize, and our conclusions are more uncertain.

Nevertheless, several points are worth mentioning here. The first is that the creation of knowledge is a cumulative enterprise: Isaac Newton said that the only reason he was able to see farther than others was that he stood on the shoulders of giants. Whenever we consider the importance of property rights over ideas in giving companies incentives to fund research and development, we need to also consider the importance of free information exchange and use in giving researchers the power to do their jobs effectively.

Second, for most of the past century price discrimination—charging one price for one consumer and a different price for essentially the same good for another consumer—has been seen as a way for monopolies to further increase their monopoly profits. In the information age, the background assumption may be different. We may come to see price discrimination as an essential mechanism for attaining economic efficiency and social welfare. The most obvious and critical example right now is found in the pharmaceutical industry: Does anyone doubt that good public policy today should focus on providing drug companies with powerful incentives and tools for them to charge radically different prices to consumers in rich and in poor countries?

Third, if the new economy is more likely to see the rapid emergence of monopoly power in increasing-returns-to-scale, winner-take-all industries, it also seems likely to see a swifter industry life cycle. To have monopoly power in the making of instant-development film does a company little good when the instant-development Polaroid camera finds itself faced with cheaper, more versatile, and more instantaneous digital cameras.

Fourth, if we call the economy of the past two centuries primarily "Smithian," the economy of the future is likely to be primarily "Schumpeterian." In a "Smithian" economy, the decentralized market economy does a magnificent job (if the initial distribution of wealth is satisfactory) at producing economic welfare. Because goods are "rival"—my sleeping in this hotel bed tonight keeps you from doing so—one person's use or consumption imposes a social cost: Because good economic systems align the incentives facing individuals with the effects of their actions on social welfare, it makes sense to distribute goods by charging prices equal to marginal social cost. Because goods are "excludable"—we have social institutions to enforce property rights, in the case of my hotel room, the management, the police, and the federal courts—it is easy to decentralize decision-making and control, pushing responsibility for allocation away from the center and to the more entrepreneurial periphery where information about the situation on the ground is likely to be much better (see DeLong and Froomkin (2000)). The competitive paradigm is appropriate as a framework to think about issues of microeconomic policy and regulation.

In a "Schumpeterian" economy, the decentralized economy does a much less good job. Goods are produced under conditions of substantial increasing returns to scale. This means that competitive equilibrium is not a likely outcome: The canonical situation is more likely to be one of natural monopoly. But natural monopoly does not meet the most basic condition for economic efficiency: that price equal marginal cost. However, forcing prices to be equal to marginal cost cannot be sustained because the fixed set-up costs are not covered. Relying on government subsidies to cover fixed set-up costs raises problems of its own: It destroys the entrepreneurial energy of the market and replaces it with the groupthink and red-tape defects of administrative bureaucracy. Moreover, in a Schumpeterian economy, it is innovation that is the principal source of wealth—and temporary monopoly power and profits are the reward needed to spur private enterprise to engage in such innovation. The right way to think about this complex set of issues is not clear, but it is clear that the competitive paradigm cannot be fully appropriate.

The long-run impact of the "new economy" II.

The essence of the "new economy"

The essence of the "new economy" is quickly stated. Compare our use of information technology today with our predecessors' use of information technology half a century ago. The decade of the 1950s saw electronic computers largely replace mechanical and electro-mechanical calculators and sorters as the world's automated calculating devices. By the end of the 1950s, there were roughly 2,000 installed computers in the world: machines such as Remington Rand UNIVACs, IBM 702s, or DEC PDP-1s. The processing power of these machines averaged perhaps 10,000 machine instructions per second.

Today, talking rough orders of magnitude only, there are perhaps 300 million active computers in the world with processing power averaging several hundred million instructions per second. Two thousand computers times ten thousand instructions per second is twenty million. Three hundred million computers times, say, three hundred million instructions/second is ninety quadrillion—a four-billion-fold increase in the world's raw automated computational power in forty years, an average annual rate of growth of 56 percent per year.

There is every reason to believe that this pace of productivity growth in the leading sectors will continue for decades. More than a generation ago, Intel Corporation co-founder Gordon Moore noticed what has become Moore's Law—that improvements in semiconductor fabrication allow manufacturers to double the density of transistors on a chip every eighteen months. The scale of investment needed to make Moore's Law hold has grown exponentially along with the density of transistors and circuits, but Moore's Law has continued to hold, and engineers see no immediate barriers that will bring the process of improvement to a halt anytime soon.

This particular explosion of technology has had profound consequences for how we organize production. It has consequences for the type of goods we value. We used to live in an economy in which the canonical source of value was an ingot of iron, a barrel of oil, or a bushel of wheat. Such economies were based on knowledge just as much as our economy is, but the knowledge was of how to create a useful, physically embodied good. We are moving to an economy in which the canonical source of value is a gene sequence, a line of computer code, or a logo. As Chairman Greenspan (1998) has often emphasized, in such a world, goods are increasingly valued not for their physical mass or other physical properties but for weightless ideas (see Coyle (1998)). In such an economy, what you know matters more than how much you can lift.

Leading sectors and industrial revolutions

Now, in some respects, this is a new version of an old story. Past "new economies," past economic "revolutions" have also seen extraordinary growth in technology, the rise to dominance of new industrial sectors, and the transformation. The fifty years after the invention of electricity, 1880 to 1930, saw an increase in the mechanical horsepower applied to U.S. industry of perhaps a hundredfold and an enormous increase in the flexibility of factory organization—a rate of technological progress of more than 9 percent per year (David (1990)). The hundred years from 1750 to 1850, the core of the (technological) industrial revolution itself, saw British textile output multiply thirtyfold; in the middle of the eighteenth century it took hand-spinning workers five hundred hours to spin a pound of cotton, but by the early nineteenth century it took machine-spinning workers only three hours to perform the same task—a rate of technological progress of 10 percent per year sustained across half a century (Freeman and Louca (2001)).

These earlier transformations revolutionized their economies' leading industries and created "new economies." They changed the canonical sources of value and the process of production. The industrial revolution itself triggered sustained increases in median standards of living for the first time, a shift to a manufacturing- and then to a services-heavy economic structure, changed what people's jobs were, how they did them, and how they lived more completely than any previous economic shift, save the invention of agriculture and the discovery of fire. The economic transformations of the second industrial revolution driven by electrification and other late nineteenth-century general-purpose technologies were almost as far reaching: mass production, the large industrial enterprise, the continentwide and then worldwide market in staple manufactured goods, the industrial labor union, the social insurance state, even more rapid sustained increases in median living standards, and the middle-class society.

But consider another extraordinary wave of innovation that did not create a "new economy." William Nordhaus (1997) has analyzed the real price of light—how much it costs in the way of resources and labor to produce a fixed amount of artificial illumination—and has found that the real price of light has fallen by a thousandfold during the past two centuries. A middle-class urban American household in 1800 would have spent perhaps 4 percent of its income on illumination: candles, lamps, oil, and matches. A middle-class urban American household today spends less than 1 percent of its income on illumination, and consumes more than a hundred times as much artificial illumination as did its predecessor of two centuries ago.

Yet, we do not speak of the "illumination revolution," or of the "new economy" generated by the existence of exterior streetlights and interior fluorescent office and store lights. The productivity of illumination-producing technology has increased enormously, but its impact on the economy and on society has been limited. Demand has not grown rapidly enough to offset falling prices. The total share of illumination in total urban spending, and, thus, the share of illumination production in the urban economy, has shrunk. Our artificial illumination technologies are an enormous boon and source of value—Nordhaus (1997) believes that it has contributed 7 percent to the growth of real wages during the nineteenth and twentieth centuries—but its economic salience has been limited.

In standard growth accounting we can measure the contribution of technological progress in one sector to economywide productivity growth by multiplying that sector's share in total demand by the rate at which the costs of production (measured relative to an index of the costs of factors of production) in that sector are falling. Total productivity growth π will be a function of the rate at which costs fall in the leading sector, π_L, the rate at which costs fall in the rest of the economy, π_R, and the share σ that the products of the leading sector have in total expenditure:

$$\pi = \sigma (\pi_L) + (1\text{-}\sigma)(\pi_R) \qquad (1)$$

As time passes, the share σ of the leading sector in total expenditure changes. If the income elasticity of demand for the leading sector's products is less than one, then increases in real wealth will make *s* shrink. If the relative price elasticity of demand for the leading sector's products is less than one, then the rapid relative fall in the prices of the leading sector's products produced by the fact that π_L is greater than π_R will cause σ to shrink as well. And as the share *σ* of the leading sector's products in total expenditure shrinks, overall productivity growth π will shrink as well, approaching the rate of growth π_R in the less dynamic rest of the economy. This is Baumol and Bowen's (1966) "cost disease" scenario: The pace of economic growth slows because demand shifts to those goods where technological progress is weak.

However, if the income elasticity of demand for the leading sector's products is greater than one, increases in real wealth will make σ grow. If the relative price elasticity of demand for the leading sector's products is greater than one, the rapid relative fall in the price of the leading sector's product produced by the fact that πL is greater than π_R will cause *σ* to grow as well. As the share σ of the leading sector's products in total expenditure grows, overall productivity growth π will rise as well. If this continues and the share *σ* of the leading sector's products in total expenditure approaches one, the overall rate of productivity growth will rise to approach the rate of growth πL in the dynamic leading sector.

Such an acceleration of productivity growth is, in fact, what happened in the 1980s and 1990s, until the cyclical slowdown of the past year. A year ago in this room, Chairman Greenspan said that it was "difficult to find credible evidence in the United States that the rate of structural productivity growth has stopped increasing ... after stripping out the significant impact on productivity acceleration of the recent shape of the business cycle, the second derivative of output per hour still appears to be positive." We are not yet able to separate the trend from the cycle component of productivity during the current slowdown. It is certainly possible—if not probable—that when U.S. growth resumes, trend productivity will grow as fast or faster than it did in the late 1990s. The elasticity of demand for high-tech products, and the share of income attributable to the information-technology capital stock are likely to keep rising. It is a property of exponential growth that equal proportional increments translate into larger arithmetic increments over time, and, thus, that even a slower proportional rate of growth within the high-tech sector itself is likely to translate into a larger contribution to the growth of the economy as a whole.

This is, in fact, what happened in the original industrial revolution: As the dynamic modern sector grew to encompass the bulk of the economy, overall productivity growth accelerated (see Crafts (1985)). The heroic age of double-digit annual productivity increase within the steam-power and textile-spinning sectors of the economy ended before the nineteenth century was a quarter over. Yet, the major contribution of steam power and textile machinery to British aggregate economic growth took place in the middle half of the nineteenth century. Thus, historians of the British industrial revolution, like Landes (1969), focus on the late-eighteenth century, while macroeconomists and sociologists focus on the mid-nineteenth century: The lag in time between the major innovations and fastest proportional growth of the leading sector on the one hand, and its major influence on aggregates on the other, are likely to be substantial.

Elasticities of substitution and general-purpose technologies

What determines the income and price elasticity of demand for high-tech products? The more high-tech products are seen as "luxury" goods, and the greater is the number of different uses found for high-tech products as their prices decline, the larger will be the income and price elasticities of demand—and, thus, the stronger will be the forces pushing the expenditure share up, not down, as technological advance continues.

All of the history of the electronics sector suggests that these elasticities are high, not low. Each successive generation of falling prices appears to produce new uses for computers and communications equipment at an astonishing rate.

The first, very expensive, computers were seen as good at performing complicated and lengthy sets of arithmetic operations. The first leading-edge applications of large-scale electronic computing power were military: The burst of innovation during World War II that produced the first one-of-a-kind hand-tooled electronic computers was totally funded by the war effort. The coming of the Korean War won IBM its first contract to actually deliver a computer: the million-dollar defense calculator. The military demand in the 1950s and the 1960s by projects such as Whirlwind and SAGE (Semi-Automatic Ground Environment)—a strategic air defense system—both filled the assembly lines of computer manufacturers and trained the generation of engineers that designed and built.

The first leading-edge civilian economic applications of large—for the time, the 1950s—amounts of computer power came from government agencies such as the Census Bureau and from industries such as insurance and finance, which performed lengthy sets of calculations as they processed large amounts of paper. The first UNIVAC computer was bought by the Census Bureau. The second and third orders came from A.C. Nielson Market Research and the Prudential Insurance Company. This second, slightly cheaper, generation of computers was used not to make sophisticated calculations, but to make the extremely simple calculations needed by the Census Bureau, and by the human resource departments of large corporations. The Census Bureau used computers to replace its electro-mechanical tabulating machines. Businesses used computers to do the payroll, report-generating, and record-analyzing tasks that their own electro-mechanical calculators had previously performed.

The still next generation of computers—exemplified by the IBM 360 series—were used to stuff data into and pull data out of databases in real time—airline reservations processing systems, insurance systems, inventory control. It became clear that the computer was good for much more than performing repetitive calculations at high speed. The computer was much more than a calculator, however large and however fast. It was also an organizer. American Airlines used computers to create its SABRE automated reservations system, which cost as much as ten airplanes (see Cohen, DeLong, and Zysman (2000)). The insurance industry automated its back-office sorting and classifying.

Subsequent uses have included computer-aided product design, applied to everything from airplanes designed without wind tunnels, to pharmaceuticals designed at the molecular level for particular applications. In this area and in other applications, the major function of the computer is not as a calculator, a tabulator, or a database manager, but is instead as a "what-if" machine. The computer creates models of "what-if" would happen if the airplane, the molecule, the business, or the document were to be built up in a particular way. It, thus, enables an amount and a degree of experimentation in the virtual world that would be prohibitively expensive in resources and time in the real world.

The value of this use as a "what-if" machine took most computer scientists and computer manufacturers by surprise. None of the engineers designing software for the IBM 360 series, none of the parents of Berkeley UNIX, nobody before Dan Bricklin programmed Visicalc had any idea of the utility of a spreadsheet program. Yet, the invention of the spreadsheet marked the spread of computers into the office as a "what-if" machine. Indeed, the computerization of Americas white-collar offices in the 1980s was largely driven by the spreadsheet program's utility—first Visicalc, then Lotus 1-2-3, and finally Microsoft Excel.

For one example of the importance of a computer as a "what-if" machine, consider that today's complex designs for new semiconductors would be simply impossible without automated design tools. The process has come full circle. Progress in computing depends upon Moore's Law; and the progress in semiconductors that makes possible the continued march of Moore's Law depends upon progress in computers and software.

As increasing computer power has enabled their use in real-time control, the domain has expanded further as lead users have figured out new applications. Production and distribution processes have been and are being transformed. Moreover, it is not just robotic auto painting or assembly that have become possible, but scanner-based retail, quick-turn supply chains, and robot-guided hip surgery as well.

In the most recent years, the evolution of the computer and its uses has continued. It has branched along two quite different paths. First, computers have burrowed inside conventional products as they have become embedded systems. Second, computers have connected outside to create what we call the World Wide Web: a distributed global database of information all accessible through the single global network. Paralleling the revolution in data processing capacity has been a similar revolution in data communications capacity. There is no sign that the domain of potential uses has been exhausted (see Cohen, DeLong, and Zysman (2000)).

Moreover, aggregate data show that the economic salience of the high-tech sector has been rising over time. Federal Reserve Board staff economists Steven Oliner and Daniel Sichel (2000) have calculated that in the 1980s, information technology capital—computer hardware, software, and communications equipment—accounted for 3.3 percent of the income earned in the economy, and contributed 0.5 percent per year to economic growth. By the late 1990s, according to Oliner and Sichel, information technology capital accounts for 7.0 percent of income earned in the economy and contributed 1.4 percent per year to economic growth.

Another way to put it is that modern semiconductor-based electronics technologies fit Bresnahan and Trajtenberg's (1995) definition of a "general-purpose technology"—one useful not just for one narrow class but for an extremely wide variety of production processes, one for which each decline in price appears to bring forth new uses, one that can spark off a long-lasting major economic transformation. So far, there are no good reasons to believe that the economic salience of high-tech industries is about to decline, or that the pace at which innovation continues is about to flag. And there are good reasons to believe that the economic salience of high-tech industries will increase. Because of the general-purpose nature of the technology, it has an enormous number of potential uses, many of which have surely not yet been developed. There is room for computerization to grow on the intensive margin, as computer use saturates potential markets such office work and e-mail. But there is also room to grow on the extensive margin, as microprocessors are used for tasks such as controlling hotel room doors or changing the burn mix of a household furnace that few, two decades ago, would have thought of.

The Nasdaq crash and the "new economy" III.

If the future of the "new economy" is as bright as the previous section suggests, then why have high-tech stock market values fallen so far in the past year and a half? There is a strand of today's conventional wisdom that holds that the crash of the Nasdaq reveals that the "new economy" was smoke and mirrors. It was the irrational exuberance that often breaks out at the peak of a boom, not any deeper or permanent change in the economy. But it is more likely that the crash of the Nasdaq was the result of the realization by investors that the "new economy" was, in most sectors and for most firms, likely to lead not to large quasi-rents from established market positions but to heightened competition and reduced margins.

The exuberance that pushed the Nasdaq so high in 1999 and early 2000 rested on the belief that technological leap forward in data processing and data communications technologies had created a large host of winner-take-all markets in which increasing returns to scale were the dominant feature. An information good—a computer program, a piece of online entertainment, or a source of information—the work only needs to be done once and then it can be distributed to a potentially unlimited number of consumers for pennies: Producing at twice the scale gains you nearly a 50 percent cost advantage. Moreover, information goods produced at larger scale are more valuable to consumers. The version with the largest market share becomes the standard. It is the easiest to figure out how to use, the easiest to find support for, and the one that works best with other products (which are, of course, designed to work best with it).

In that part of the new economy dominated by supply-side economies of scale and demand-side economies of scope, a firm that establishes a market-share lead gains a nearly overwhelming position. Its products are most valuable to customers. Its cost of production is the least. Unless its competitors are willing to take extraordinary and extraordinarily costly steps—like those Microsoft took against Netscape, pouring a fortune into creating a competitive product and then distributing the competing Internet Explorer for free—the first firm to establish a dominant market position will reap high profits as long as its sector of the industry lasts.

But increasing returns to scale and winner-take-all markets are not the only or even the primary consequence of high-tech's technological revolution. It is at least as likely that innovations in computer and communications technologies are competition's friends. They are the frictions that, in the past, gave nearly every producer in the economy a little bit of monopoly power. They enable swift searches that reveal the prices and qualities of every single producer, while, in the past, such information could only be acquired by a lengthy, costly, painful process. In the past, you could comparison-shop only by trudging from store to store. In the present, you can use the World Wide Web.

Thus, in the "new economy," more markets will be contestable. Competitive edges based on past reputations, or brand loyalty, or advertising footprints will fade away. As they do so, profit margins will fall: Competition will become swifter, stronger, more pervasive, and more nearly perfect.

Consumers will gain and shareholders will lose. Those products that can be competitively supplied will be at very low margins. The future of the technology is bright; the future of the profit margins of businesses—save for those few that truly are able to use economies of scale to create mammoth cost advantages—is dim. Is it really possible for anyone to acquire significant economies of scale by writing a single suite of software that will cover the heterogeneous purchasing requirements of millions of businesses seeking to streamline their operations by using the Internet? Is it really possible for anyone to acquire significant economies of scale by using the Internet to distribute information about groceries? The Nasdaq crash was the result of the marginal investor's realizing that the odds were heavily against. But the Nasdaq crash tells us little about the future of the underlying technologies or about their true value.

Perhaps the best analogy is an old topic that was a puzzle to the classical economists of three centuries ago: the difference in price between water and diamonds. Water is absolutely essential to sustain life, and, thus, immensely valuable to every consumer. Yet, (at least in wet northern Europe and the eastern United States) water is very cheap indeed. By contrast, diamonds have been and remain very expensive. The gap in price between water and diamonds does not tell us that diamonds are useful and valuable and water is not, but that it has, so far, proved much easier to maintain market power and high margins in the diamond business than in the water business.

The analogy to the Internet, the "new economy," and the crash of the Nasdaq is straightforward. Even Internet Explorer, which today has as dominant a position in the browser market as anyone could wish, is not (or is not yet) a source of profits: Barring the creation of some essential function that Explorer can serve that competing browsers cannot, our modern computer and communications technologies simply make it too cheap and too easy to distribute a competing product.

The macroeconomy and the "new economy" IV.

What are the macroeconomic consequences of the "new economy"? One, at least, is clear: In the past half decade, we have seen the impact of the information technology revolution in the recent acceleration in American productivity growth. The others remain more speculative.

As Martin Baily will discuss later, one possible macroeconomic consequence of the acceleration in productivity growth is the improved labor market and reduced NAIRU that we are seeing today. The high-pressure economy, tight labor market, and gratifyingly low unemployment rate of the past half decade are hard to envision without the productivity speedup, which is largely driven by the technological revolutions in data processing and data communications. A second possible macroeconomic consequence of the computerization of American business is a decline in the inventory fluctuation-driven component of the business cycle. The decline in aggregate inventory-to-shipments ratios in manufacturing during the past two decades has been substantial. And, as Michael Woodford will discuss later, the changes in the macroeconomy brought about bring changes in the way that monetary policy should be conducted as well. All of these have the potential to be substantial boons.

Nevertheless, in our view at least, the macroeconomic changes may not be as pronounced as we hope. The past 150 years have seen the world's advanced industrial economies shift from primarily agricultural to primarily industrial and now primarily service economies. They have seen repeated technological revolutions, as one leading sector after another—chemicals, electricity, autos, aircraft—has taken the lead in productivity acceleration. They have seen the rise of sophisticated systems of consumer credit that allow households to smooth their spending over time. They have seen the rise of the modern social insurance state to serve as a sea anchor for the economy by virtue of the large relative size of its spending programs. They have seen the rise of systems of deposit insurance to reduce the probability of a massive chain of bankruptcies and, thus, a full-fledged financial panic. They have seen the government take on responsibility for managing the macroeconomy.

Yet, in spite of all these structural changes, the business cycle in the second half of the twentieth century has looked remarkably like the business cycle in the last quarter of the nineteenth century. It is remarkably difficult to trace causal links from structural changes in the economy to changes in the business cycle and in macroeconomic policy (see Romer (1999)). Indeed, Romer (1999) traces the major changes in the business cycle over the past 100 years not to any of the major structural changes in the economy, but to changes in how the Federal Reserve has thought about issues of macroeconomic management.

Moreover, there is one dimension along which the "new economy" is a source of macroeconomic danger. With the possible exception of the 1990s, the decade in the past century that saw the fastest productivity growth and the greatest degree of structural change was the 1920s. And the booming 1920s were followed by the disastrous 1930s.

There was no necessary reason that a decade as good as the 1920s had to be followed by a Great Depression. As John Maynard Keynes (1931) put it at the start of the Depression, while "some part of the investment which was going on [in the 1920s] in the world at large was doubtless ill judged and unfruitful," there could be no doubt that "the world was enormously enriched by the constructions of the quinquennium from 1925 to 1929; its wealth increased in these five years by as much as in any other ten or twenty years of its history. ... I see little sign of any serious want of balance such as is alleged by some authorities. ... A few more quinquennia of equal activity might, indeed, have brought us near to the economic Eldorado where all our reasonable economic needs would be satisfied." And it was "an extraordinary imbecility that this wonderful outburst of productive energy should be the prelude to impoverishment and depression." In Keynes's view, the source of the Great Depression was "not in the high level of investment which was proceeding up to the spring of 1929, but in the subsequent cessation of this investment."

But Keynes was both right and wrong. The end of a period of high euphoria and extravagant boom will inevitably bring a reduction in investment in the economy's leading sectors. This reduction will not, by itself, bring about a Great Depression—or even more than a period of "readjustment"—as long as other sources of demand are present and able to absorb the slack in productive resources created by the end of high euphoria. However, managing this expenditure switching is a very delicate macroeconomic task.

Moreover, a euphoric boom is a period during which people stop thinking as intensely about problems of macroeconomic management and the business cycle. Ironically, it is precisely during euphoria that countercyclical policy becomes less important. But it is in the aftermath of euphoria that countercyclical policy becomes more important than at any other time. For example, nobody in Japan in the late 1980s paid any attention to problems of business cycle management. Few in Japan in the early 1990s paid sufficient attention to the business cycle. And the Japanese economy and the world economy today are suffering from that lapse.

Thus, the largest short-run impact of the "new economy" may be that it increases the stakes at risk in macroeconomic management.

The microeconomy and the "new economy" V.

It is more likely that the principal consequences of the "new economy" will be found in the microeconomy, and that they will be accompanied by important changes in the underpinnings—property rights, institutions, "rules of the game"—that governments must provide if market economies are to function well.

It is a principal characteristic of the new economy that my consumption of a good does not necessarily detract from your consumption of it. If I am wearing my shoe, you cannot be wearing my shoe. But if I am informed, if I have access to software, you can also be informed, you can also have access to that software. Thomas Jefferson put it best: "He who receives an idea from me, receives instruction himself without lessening mine; as he who lights his taper at mine, receives light without darkening me." A world in which the information-technology sector is salient is one in which more of the goods that are produced will have the character of pharmaceuticals or books or records, in that they involve very large fixed costs and much smaller marginal costs. It is one in which positive network effects will be much more pervasive. A single lonely fax machine is a hunk of metal that is best used as a doorstop. Yet, 100,000 fax machines make possible 10 billion different one-way connections. This is Metcalfe's Law: The number of connections that are possible, and, thus, the utility of the network, rises not proportionately with the number of nodes that are connected but by more—as much as the square of that number.

The greater salience of these characteristics has crucial implications for business and for the functioning of the economy as a whole. The "new economy" will have more examples of very high fixed costs and very low marginal costs. Such a pattern can produce positive feedback: Rising demand will often produce higher efficiency and higher returns, drives, and lower prices, leading to yet higher demand. The old economy is driven by negative feedback: Rising demand leads to higher prices, which leads producers, when prices rise, to produce more and consumers to buy less, which restores and equilibrium at a lower level of demand. By contrast, in an information economy, in that sense, if the agricultural and industrial economies were "Smithian," the "new economy" is "Schumpeterian."

There is a wide range of potential implications. In finance, as Andrei Shleifer will discuss, our ongoing technological revolutions are drastically lowering transactions costs and increasing the flow of information, while, at the same time, they may be overwhelming the filters that used to separate the news from the noise. The quantity of "information" rises, while the quality of information may fall. As Hal Varian will discuss, the "new economy" raises the salience of and the stakes at risk in issues of market structure and market regulation that must all now be rethought.

The extent of the market

High initial fixed costs and low, even zero, marginal costs pose difficult questions but also open up enormous opportunities for economic policy. In a "new economy," the canonical industrial structure will be more like what we have seen in pharmaceuticals, publishing, or the recording industry than in the corn-production or textile or steel industry. The opportunity is that growth should have a greater potential to snowball. Success may have greater potential to become self-perpetuating, as growth leads to rapid declines in prices, and so to further expansion in the market and further growth. We see aspects of this today: Orphan drugs cost much more than drugs with a larger market, and bestselling books cost much less than academic monographs that very few people may read.

This reality points up the importance of making sure that we function with as large markets as possible. When a market is driven by a positive feedback, its efficiency will be directly related to its size. Larger networks and larger production lines over which to amortize high initial fixed costs will generate cascading benefits. Thus, government policies that expand the size of markets in any way—through reducing trade barriers, through improved infrastructure, through the removal of other barriers to market access—become that much more important and that much more worthwhile. Ever since David Ricardo, economists have focused on comparative advantage as the most important reason that trade should be free. But it may well be that we are moving into a future in which these benefits are less important than those of increasing returns to scale and the extent of the market.

If so, this means that openness to the international economy will become an increasingly critical requirement for economic growth in the future, especially for relatively small economies.

Monopoly

An industry with high fixed costs and near-zero variable costs has another important characteristic: it tends to monopoly. The rule of thumb in high technology has been that the market leader makes a fortune, the first runner-up breaks even, and everyone else goes bankrupt rapidly. In such an industrial structure, the only sustainable form of competition becomes competition for the leading position in the next generation market that is growing up now—for competition in already established markets with high fixed and low variable costs is nearly impossible to sustain.

Good public policy in such an environment should make sure that the monopoly profits from the provision of things that become essential services are not too large (although they need to be large to reward all the past investments, successful and failed, in the market). Good public policy in such an environment needs to make sure that producers with a near-monopoly position in one generation's market do not use that position to retard innovation and the growth of the next-generation market, or to guarantee themselves a large head start in the race to establish a leading position in the next-generation market. But good public policy also needs to make sure not to take steps that artificially limit the market shares of the most efficient producers of this generation's products, for large market shares go with low costs and (relatively) low prices charged to consumers.

It is far from clear how such policies can be designed, or how close policy can get to its ideal, given the blunt instrument that is our legal system.

Distribution

Technology does provide Americans with remarkable opportunities, but they are not there for those who lack the knowledge and skills to take advantage of them. It has been estimated that in America today, a child born of a single teenage mother who did not finish high school has an 80 percent chance of living in poverty at the age of ten. Male life expectancy in Washington, D.C., is several years below that in Mongolia or Belarus.

In the "new economy," it is clear that human capital is a strong complement to physical capital and intellectual capital. The return on investment in human capital has been rising so that it is now quite possibly the highest that it has ever been (see Goldin and Katz (1999)). It is, thus, doubly important to ensure that children receive the best education possible. If investments in factories were the most important investments in the industrial age, the most important investments in an information age are surely investments in the human brain. Investments in human capital also have the potential to bring the promise of equality of opportunity closer to reality. The middle-class society of mid-twentieth century America was, in large part, created and sustained by America's early twentieth century commitment to mass high school education. Policies to generate a similar commitment to mass higher education for the information age have the promise of producing not just a richer society but one of more widely distributed opportunity as well.

Moreover, the demand-side consequences of the "new economy" for distribution promise to be as important as the supply-side consequences for the value of education. For most of the past century, price discrimination—charging one price to one set of consumers and a very different price for a nearly identical product to another set of consumers—has been viewed by most as an unmixed evil. It has been seen as a way that those with monopoly power can further increase their monopoly profits. But price discrimination has another face as well: It is a way that businesses can extend their market and make their product of more value to consumers. An information good-providing firm that successfully engages in price discrimination can still make a profit by charging high prices to its relatively well-off core market, and can add to that profit and greatly increase the social utility of its product by charging low prices to those who are relatively poor. It may well be that in the information age, our attitude toward price discrimination should shift.

There are many cases—of which the provision of pharmaceuticals to people living in poor countries is only the most critical and obvious—in which good public policy should focus on making it easier for companies to charge wildly different prices to different groups of consumers. The reason that pharmaceutical companies charge high rather than low prices to customers in poor countries is relatively small: Their major fear is that of the reimportation of low-priced drugs into the rich first world. The loss in profits they suffer from charging an inappropriately high price to customers in poor countries is small change relative to the gray-market reimportation risks that they believe they face. Yet, the cost in lost lives in poor countries is unacceptably high. Effective ways of segmenting the market more completely, so that rich country customers could pay the fixed costs while poor country customers paid close to marginal cost, has the potential to create an enormous addition to world welfare.

Innovation and intellectual property

The most critical issues, however, are those that revolve around intellectual property. It is a fact that we today simply do not know yet how to make the intellectual property system work for the "new economy." Back in the Gilded Age, intellectual property as such was not such an important factor. Industrial success was based on knowledge, but on knowledge crystalized in dedicated capital. Many people knew organic chemistry. Few companies—those that had made massive investments—could make organic chemicals.

Today, it appears that intellectual property is rapidly becoming a much more important source of value. One response would be to reinforce the rights of "owners." The underlying idea is that markets work because everything is someone's property. Property rights give producers the right incentives to make, and users the right incentives to calculate, the social cost of what they use. It is clear that without strong forms of protection of property rights, a great many useful products would never be developed at all. This principle applies as strongly to intellectual as to other forms of property.

But with information goods, the social marginal cost of distribution is close to zero. One of the most fundamental principles of economics is that prices should be equal to social marginal cost. In this case, strong intellectual property rights have the potential to decrease economic efficiency by driving prices away from marginal social costs.

Thus, different economic principles cut in different directions. If information goods are to be distributed at their marginal cost of production—zero—they cannot be created and produced by entrepreneurial firms that use revenues obtained from sales to consumers to cover their costs. If information goods are to be created and produced by businesses that face the right incentives to explore new paths, they must be able to anticipate selling their products at a profit to someone. If the government is to subsidize the creation of information goods, the government needs mechanisms to determine in which directions the subsidies should flow, and government bureaucracies have never been able to choose and assess the directions of applied research and development very well. Mainstream academic economics has long underestimated the importance of Hayekian insights into market competition as a discovery mechanism, of the entrepreneurial advantages of private enterprise, and of the administrative defects of overly rigid systems of top-down control that come with centralized funding (see Scott (1998)).

We know that markets and the spur of competition are the best producers of applied knowledge. But we do not know how to use markets and competition for this purpose, as far as information goods are concerned, and still satisfy the economic principle that final consumers should pay no more than marginal cost.

At the same time, we also know that the Lockeian belief that property rights are good, that intellectual property is a form of property like any other, and, thus, that stronger intellectual property rights are very good is simply wrong. In the "Smithian" economy, property rights are good because they (a) force buyers to pay prices for goods, and, thus, to approximately internalize in their own decision-making the effect of their actions in reducing the ability of others to use scarce, rival goods, and (b) allow for the decentralization of economic decisions and, thus, for entrepreneurship. In the "new economy," with non-rival goods, property rights that force buyers to pay prices above very low marginal cost do not contribute to but detract from economic efficiency and lead not to decentralization but to a greater degree of centralization in economic decision-making in the hands of the owner of the intellectual property rights.

Complicating the issues still further, the most important innovations that we see today are built on progress in basic science—everything from group theory to quantum theory. If one asked what research had made the most important contribution to the navigation of ships since the 1600s, a good case could be made that it was pure mathematics. Pure mathematics built the tools used by James Clerk Maxwell to construct his equations describing the behavior of electromagnetic fields. Without Maxwell's equations, we would not have radios. We know from long experience that basic science is best diffused broadly, so production must be supported from the outside. That is why a crucial component of public policy at this time must be strong support for basic research.

Moreover, basic research must be widely disseminated because basic research and applied research are cumulative enterprises. There is a good chance that heavy restrictions on the dissemination of intellectual property will do less to create incentives for research and development and more to destroy the web of scientific and technical communication that make research and development effective (see Gallini and Scotchmer (2001)). Isaac Newton said that the only reason he was able to see farther than others was that he stood on the shoulders of giants. Whenever we consider the importance of property rights over ideas in giving companies incentives to fund research and development, we need to also consider the importance of free information exchange and use in giving researchers the power to do their jobs effectively. Traditional discussions within economics have focused on the length of patents. Yet, it may well be that the depth and breadth of patents are at least as important determinants of economic progress.

New institutions and new kinds of institutions—perhaps even some that have been tried before, like the French government's purchase and placing in the public domain of the first photographic patents in the early nineteenth century (see Kremer (1998))—may well be necessary to achieve the fourfold objectives of (a) price equal to marginal cost, (b) entrepreneurial energy, (c) accelerating the cumulative process of research, and (d) providing appropriate financial incentives for research and development. The work of Harvard economist Michael Kremer (1998, 2000), both with respect to the possibility of public purchase of patents at auction and of shifting some public research and development funding from effort-oriented to result-oriented processes (that is, holding contests for private companies to develop vaccines instead of funding research directly), is especially intriguing in its attempts to develop institutions that have all the advantages of market competition, natural monopoly, and public provision.

It will be no surprise to you that at least one of the authors has been thinking very hard about the role that heavily endowed non-profit educational institutions have to play in attempting to resolve the dilemmas of innovation and intellectual property in the new economy.

Conclusion VI.

The balance of probabilities is that our modern data processing and data communications technologies are, indeed, creating a "new economy." It is likely that they are producing profound change with continuing powerful impact. These are seismic innovations, ranking with electric power. Even if they are not likely to have profound impact in reducing cyclical volatility, they will have profound microeconomic effects that we do not yet fully understand. We already know that the competitive paradigm is unlikely to be fully appropriate, but we do not yet know what the right replacement paradigm will be. We know that property rights become a central question. We know that some market practices—such as price discrimination—that have traditionally been looked at with some skepticism should perhaps be re-evaluated.

It cannot be an accident that Soviet-style communism, planning ministries throughout the developing world, and large corporations run by command and control all ran into a brick wall in the same decade and had to be restructured. Increasingly, the balance of economic advantage has tilted in favor of systems in which economic power and opportunities are more decentralized—and the skills and ideas of the individual are given greater weight. At the level of individual businesses and national economies, flexibility is winning out over rigid controls. And the capacity to respond to change is winning out over the capacity to dictate it. Whether the NBER looks back three years from now and concludes that the U.S. economy went through a small recession in the past year or so or not, the structural changes that we call the "new economy" are ongoing.

Moreover, as the economy's structure changes, desirable government policies change as well. If we step back a bit, we can see that the governmental foundations underpinning the market system necessary to make it function well are not fixed in stone. As technology and society have changed in the past, what the government needed to do in order to make the market function changed too.

Consider, for example, the British agricultural revolution of the 150 years before 1800. It was, in the judgment of many historians, an essential prerequisite for the industrial revolution itself. In the absence of the British agricultural revolution, Britain in 1800 would have been dirt-poor and British labor dirt-cheap, as very low labor productivity in agriculture would have diminished urban wages as well. With low wages, where would the middle-class demand to buy the low-end textiles, ironware, and railway tickets that were the products of the British industrial revolution have come from? With low wages, how much innovative activity would have been directed toward building cranky and temperamental machines when workers desperate for anything and willing to do any task by hand were abundant? Both supply-side and demand-side arguments that the British agricultural revolution was an essential prerequisite for the British industrial revolution have always seemed very plausible.

But the British agricultural revolution would not have taken place without the enclosure movement: the extinguishing of traditional manorial common rights to the use of land, the replacement of the open-field system of arranging cropland in long, narrow, unfenced strips by enclosed-fenced fields. The distributional consequences of enclosures were horrible. The efficiency benefits appear to have been large. The enclosure movement provided improving landlords and farmers with the incentive to experiment with new, potentially more productive techniques. And the enclosure movement created the organizational form needed to make such experimentation possible: Unanimous consent of the thirty heads of household in a village to experiment with patterns of agricultural practice different than those time-honored by custom was not going to happen, and under the open-field system unanimous consent was needed. The old, pre-modern institutional arrangements and forms of British agriculture were, in the judgment of many historians at least, incompatible with the agricultural revolution. Had institutions and laws not changed, that particular economic transformation would have been badly hobbled.

It was obvious from early in the nineteenth century that the British industrial revolution was an extraordinary economic transformation that would transform politics and society, as well as production and distribution. Throughout the second quarter of the nineteenth century, politicians, journalists, novelists, technologists, and revolutionaries made pilgrimages to Manchester, England, to examine the extraordinary productive power of steam-applied-to-textile production, and to meditate on the "new economy" then being created.

Few in Manchester, however, even noticed that the British government was not building schools for children of workers migrating in from the countryside to the jobs in the new factories. Yet, lack of an educated workforce meant that the post-steam-engine technologies of electricity, metallurgy, and chemistry found themselves much more at home in late nineteenth century Germany—where investments in schools had been made—than in late nineteenth century Britain. The failure of Britain to evolve the institutions—to provide the education, training, public health, and infrastructure needed to support not current but evolving and future technologies—meant that its mid-nineteenth century industrial leadership could not be sustained. And so, Britain entered the twentieth century and its half-century death struggle with anti-democratic German regimes, having already squandered a very large initial edge in technology and productivity.

Or consider the U.S. Gilded Age toward the end of the nineteenth century. The Gilded Age saw the coming of mass production, the large corporation, the continentwide market, and electric power to the United States. You needed more than the improvements in production technology that made possible the large-scale factory in order to arrive at the large industrial organization and the high-productivity, mass-production economy. From our viewpoint today, we can look back and say that in the United States, this economic transformation rested on five things:

- Limited liability.
- The stock market.
- Investment banking.
- The continentwide market.
- The existence of an antitrust policy.

Legal and institutional changes—limited liability, the stock market, and an investment banking industry—were needed to assemble the capital to build factories on the scale needed to serve a continental market. Without limited liability, individual investors would have been unwilling to risk potentially unlimited losses from the actions of managers they did not know and could not control. Without the stock and bond markets, investors would have been less willing to invest in large corporations because of the resulting loss of liquidity. Without investment banking, investors' problem of sorting worthwhile enterprises from others would have been much more difficult.

Moreover, political changes—the rise of antitrust—were needed for two reasons. The first was to try to make sure that the enormous economies of scale within the grasp of the large corporation were not achieved at the price of replacing competition by monopoly. The second was the political function of reassuring voters that the growing large corporations would be the economy's servants rather than the voters' masters.

Last, institutional changes were needed to make sure that the new corporations could serve a continental market. For example, think of Swift Meatpacking, subject of an ongoing dissertation at Berkeley by Gary Fields. Swift's business was based on a very good idea: mass-slaughter the beef in Chicago, ship it dressed to Boston, and undercut local small-scale Boston-area slaughterhouses by a third at the butchershop. This was a very good business plan. It promised to produce large profits for entrepreneurs and investors and a much better diet at lower cost for consumers. But what if the Massachusetts legislature were to require, for reasons of health and safety, that all meat sold in Massachusetts be inspected live and on the hoof by a Massachusetts meat inspector in Massachusetts immediately before slaughter?

Without the right system of governance—in this case U.S. federal pre-emption of state health and safety regulation affecting interstate commerce—you wouldn't have had America's Chicago meatpacking industry (or Upton Sinclair's *The Jungle*). That piece of late nineteenth century industrialization wouldn't have fallen into place.

The Gilded Age industrialization of the United States gave the country some impressive displays of crony capitalism, some "malefactors of great wealth" in President Theodore Roosevelt's phrase. It gave us the core endowment of at least one major West Coast university, derived from ex-governor of California Leland's sweetheart deal between the Central Pacific Railroad he promoted and the construction company he and his partners owned outright. It also gave the average American the highest standard of living and the most productive industry in the world in the first half of the twentieth century.

By contrast, in Europe there was no continental market because of national tariffs. Without the continent-spanning market, fewer of the possible economies of scale could be attained. In Britain, with next to no pre-World War I development of investment banking, you didn't get assembly of the pools of capital to build the large factories in the first place. British businesses stayed smaller and much less efficient than their American counterparts (see Chandler (1994)). In Germany, with no antitrust policy worthy of the name, there was no brake on the cartelization of modern industry. Political theories that German industrial cartels poisoned Germany's politics in the first half of the twentieth century are now out of favor, but surely cartel-driven output restriction made the average German household poorer and Germany's distribution of wealth more skewed.

Because American institutions changed to support, nurture, and manage the coming of mass production and the large-scale business enterprise chronicled by Alfred Chandler—and because European institutions, by and large, did not—it was America that was on the cutting edge of the future at the start of the twentieth century. It was America that was "the furnace where the future was being forged," as Leon Trotsky once said.

What changes in the government-constructed underpinnings of the market economy are needed for it to flourish as the economic changes produced by computers take hold? How should governments deal with their possibly large distributional implications? And what failures to change or what changes made in support of vested interests would hobble the transformation now under way?

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