

A Historical Perspective on the New Economy

J. Bradford DeLong
delong@econ.berkeley.edu
<http://www.j-bradford-delong.net/>

June 2001

The essence of the "new economy" is quickly stated. By the end of the 1950s electronic computers had largely replaced mechanical and electromechanical calculators and sorters as the world's automated calculating devices. Back then there were roughly 2000 installed computers in the world: machines like Remington Rand UNIVACs, IBM 702s, or DEC PDP-1s. The processing power of these machines averaged perhaps 10,000 instructions per second. Today, talking only rough orders of magnitude, there are perhaps 300 million active computers in the world with processing power averaging several hundred million instructions per second. 2,000 computers x 10,000 instructions/second is 2 million. 300,000,000 computers x, say, 267,000,000 instructions/second is 800 quadrillion--a forty-billion-fold increase in the world's raw automated computational power in forty years, an average annual rate of growth of 84 percent per year.

How does this compare to past economic "revolutions," past "new economies"? The hundred and fifty years from 1650 to 1800 or so saw land productivity in British agriculture double and British food production triple in order to support a growing population: a rate of growth of food production of less than one percent per year. Yet this British agricultural revolution has been at the heart of economic historians' analyses of the preconditions for the industrial revolution. The fifty years from 1800 to 1850, the core of the industrial revolution itself, saw British textile output multiply tenfold, British iron output multiply fivefold, and the coming of the railroad as steam and automation were applied to the economy's leading sectors: this industrial revolution saw a growth rate of nearly five percent per year in its leading sectors. The fifty years after the invention of electricity, 1880-1930, say, saw an increase in the mechanical horsepower applied to U.S. industry of perhaps a hundredfold: an annual growth rate of nearly ten percent per year. All of these transformations--the British agricultural revolution, the British industrial revolution, and the second industrial revolution of the U.S. gilded age that brought with it the electrification of industry, among other changes--had growth rates in the economy's leading sectors that far from match the past generation's growth in data processing and data communications.

All three of these earlier transformations revolutionized their industries and their societies, and definitely created "new economies." 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.

The consequences of the industrial revolution were obvious: For the first time the standard of living of the average person underwent a sustained rise. First Britain and then the whole world shifted from an agriculture-heavy to a manufacturing- and services-heavy economic structure. The application of iron and steam to production changed what people's jobs were, how they did them, and how they lived more completely than any previous economic shift save possibly the invention of agriculture, and the discovery of fire.

And the economic transformations of the second industrial revolution of the Gilded Age, itself largely driven by the electrification of industry were almost as far reaching: without electricity, no mass production. Mass production in its turn brought the large joint-stock corporation, the continent- and then world-wide market in staple manufactured goods, the industrial labor union, and--in the United States--a significant edge in productivity levels and standards of living vis-a-vis the world's other industrial economies that has so far endured for a century.

Now it is important to note that all revolutions in productivity in individual sectors, even extraordinary revolutions in productivity, do not bring with them a "new economy." Consider the history of artificial illumination. 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 over the past two centuries. According to Nordhaus, accurately measuring the falling price of illumination contributes seven percent to the growth of real wages over the nineteenth and twentieth 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 perhaps 1/2 of 1 percent of its income on illumination, and receives vastly more artificial light than 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. Even though the productivity of illumination-producing technology has increased enormously, its impact on the economy and on society has been limited because demand has not kept pace with falling prices. Thus the total share of illumination in total spending, and thus in the share of the economy used to produce it, has shrunk. Its economic salience has declined.

Now some--more than the number a year and a half ago--believe that the information technology revolution will likewise have limited economic impact, that the microprocessor and the fiber optic cable will be more like the incandescent or the fluorescent light bulb than like the steam engine and the electric motor.. They believe that improvements in data processing and data communications technology will soon run into diminishing returns, and that even though the productivity of these leading sectors will rise and the costs will shrink, the share of information technology in total GDP will shrink as well and its economic salience will diminish.

This scenario is not totally implausible: of the four microprocessors currently dedicated to my personal use, two are off right. The other two? Each is running, but each is running at about 5% of its possible load. We have built a computer system that vastly outstrips the imagination of science fiction writers of previous generations, and we use it to play games of solitaire by the billions. We have worldwide communications bandwidth unimaginable even a generation ago, but as Henry David Thoreau asked of the telegraph, how much do we really have to say? Investments in information processing and communications technology may be subject to diminishing returns that set in rapidly, which would mean that 10,000 computers are only a little better than one.

Fifteen years ago such skepticism about the long-run economic implications of our data processing and data communications technologies was the conventional wisdom. Even though it is still an active current of thought, it is no longer the conventional wisdom. Instead, the history of the past generation appears to tell us that diminishing returns do not set in rapidly and that the information technology share of the economy does not diminish, but rises over time. For at least in the past each upward leap in computer processing power has brought with it a new dimension of capabilities and uses.

Consider: The first computers produced tables useful for calculating artillery trajectories. The next generation were used not to make sophisticated calculations, but to make the extremely simple calculations needed by the Census, and by the human resource departments of large corporations. The next generation of computers were used to stuff data into and pull data out of databases in real time--airline reservations processing systems, insurance systems, inventory control.

Computers came to the American office as wordprocessors and what-if machines, devices to answer questions like "what if this paragraph looked like that?" or "what if this cash flow growth rate were only half as fast?" More recently computers have become embedded into objects as sensors and controllers, and have reached outward to become windows to access the worldwide library that we are now building. For paralleling the revolution in data processing capacity has been a similar revolution in data communications capacity.

I won't say whether this particular leap forward in technology is larger than in the past--bigger than the steam engine or the automobile. How could I? What metric would we use? In their day television, or the internal combustion engine, or the railroad, or the steam engine were technological leaps that transformed the economy and society as well. You only have to begin thinking about the problems of measuring changes in economic structure and changes in rates of economic growth across structural transformations before you conclude that the problems of measurement are unsolvable.

I also can't say whether the pessimistic conventional wisdom of fifteen years ago or the more optimistic recent point of view is more correct. In the macroeconomic universe where I usually dwell, the answer to this question depends on the shape of the aggregate production function. But in reality there is no such thing as an aggregate production function, and no such thing as the diminishing-returns-to-scale parameter that determines how much extra production is generated by larger investments in communications and computer capital. There are only industries and sectors--and whether the computer

revolution will unleash a new economic golden age depends on what happens industry-by-industry, sector-by-sector. Whether the pessimistic or the optimistic view is correct depends on the details--on whether these technologies do amplify productivity industry by industry.

It is clear that claims that we are in a "new economy" are less strident than a year ago. However, current opinion is in danger of becoming overpessimistic. That there are recessions, that unemployment rates can rise, that the stock market sometimes fluctuates downward as well as upward--these facts are not relevant to the important and interesting structural issues. As Steve Cohen, John Zysman, and I wrote two years ago, the "new economy" is "not about... smooth growth, permanently rising stock prices... or permanently low rates of unemployment, interest and inflation." Instead, the "new economy" is about whether the ongoing technological revolutions are doing for information processing and organizational control something like what the technological revolutions of the nineteenth-century industrial revolution did for materials processing and transportation.

And we think that we can see the imprint of ongoing technological revolutions in macroeconomic variables in the United States--in the patterns of trends and fluctuations exhibited by aggregate indicators like real GDP, the unemployment rate, and inflation. According to Jorgenson and Stiroh, as well as Oliner and Sichel, Nordhaus, and a growing number of others, the information technology revolution has almost surely driven the recent acceleration in American productivity growth. As Dale Jorgenson presented this afternoon, there is very good reason to believe that United States trend productivity growth will continue at its current, higher rate for at least a decade.

A likely important 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 is hard to envision without the productivity speedup, which is largely driven by the technological revolutions in data processing and data communications. A possible macroeconomic consequence of the computerization of American business is a decline in the inventory fluctuation-driven component of the business cycle. Already the decline in aggregate inventory-to-shipments ratios in manufacturing is substantial. However, we have not yet seen whether theoretical predictions that a leaner inventory chain means a smaller business cycle come true.

Nevertheless, do not overestimate the macroeconomic changes. The past hundred and fifty 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. In 1959 Arthur Burns confidently predicted that better macroeconomic policy and structural change meant that "the business cycle is unlikely to be as troubling or disturbing to our children as it once was to our fathers." However, the best available evidence is that Burns was more wrong than right. We hope that better macroeconomic policy has eliminated the risk of another Great Depression, but it is difficult to find any large reduction in the size of the business cycle comparing the pre-Depression to the post-World War II period.

So the most important effects of the new economy are likely to be structural. And here I have no answers, but just two questions--the same two questions everybody else has.

First, we don't know yet how to make the intellectual property system work for the coming e-economy. Back a century ago, in the Gilded Age, say, intellectual property was not such an important factor. Industrial success was based on knowledge, yes. Industrial success was based on knowledge crystalized in dedicated capital. Lots of people knew organic chemistry. Few companies--those that had made massive investments--could make organic chemicals.

Today it seems that intellectual property is rapidly becoming a much more important source of value. And the political system's response seems to be to tighten up on intellectual property rights. To reinforce the rights of "owners" at the expense of the freedom of "users." 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. But with information goods the social cost of distributing information is close to zero. What will be the right intellectual property system for tomorrow? We do not yet know.

Second, the governmental foundations underpinning the market system necessary to make it function well are not fixed in stone. As technology and society change, what the government needs to do in order to make the market function changes as well.

Consider again the three examples of "new economies" I mentioned back at the start of my talk: the British agricultural revolution, the British industrial revolution, and the second industrial revolution associated with the end of the nineteenth century Gilded Age in the United States.

The British agricultural revolution of the hundred and fifty years before 1800 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.

So 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.

Similar lessons come from the Gilded Age in the United States: the age that saw the coming of mass production, the large corporation, the continent-wide 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 today's standpoint we can look back and say that in the United States at least the coming of the large corporation required four things:

- Limited liability and the stock market.
- Investment banking.
- A common market.
- An antitrust policy.

You needed legal and institutional changes--limited liability and the growth of an investment banking industry--to assemble the capital to build factories on the scale needed to serve a continental market. You needed political changes--antitrust policies--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. You needed institutional changes 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 preemption 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 at least gave us some malefactors of great wealth. It gave us the core endowment of at least one major west coast university (as ex-governor of California Leland Stanford used a sweetheart deal between the Central Pacific Railroad he promoted and the construction company he and his three partners owned to divert a lot of British investors' money into his own pockets--crony capitalism at its finest). 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.

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 a poorer place.

Because North 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 said.

Now these potted lessons from economic history are oversimplified: reality was much more complicated. But they are thought provoking. They lead us to ask what changes in the government-constructed underpinnings of the market are needed for e-business to flourish? 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 underway?
