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CORNUCOPIA: THE PACE OF ECONOMIC GROWTH IN THE TWENTIETH CENTURY

J. Bradford DeLong

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ABSTRACT

There is one central fact about the economic history of the twentieth century: above all, the century just past has been the century of increasing material wealth and economic productivity. No previous era and no previous economy has seen material wealth and productive potential grow at such a pace. The bulk of America's population today achieves standards of material comfort and capabilities that were beyond the reach of even the richest of previous centuries. Even lower middle-class households in relatively poor countries have today material standards of living that would make them, in many respects, the envy of the powerful and lordly of past centuries.

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Cornucopia: The Pace of Economic Growth in the Twentieth Century

A. Increasing wealth

This twentieth century has been above all the century of increasing wealth.

No previous era we know of has seen anything like the proportional growth in material, economic wealth--in the productivity of workers and the standards of living of consumers--that the twentieth century saw in the industrialized democracies that make up the core of the world economy. No previous era and no previous economy has seen anything like the level of material wealth and productive potential attained by the twentieth century's economy.

Today the average American possesses a degree of material comfort that in many ways outstrips the reach of even the richest humans of previous centuries.[2] Perhaps a billion

people living today are within striking distance of middle-class American productivity levels and living standards. Moreover, even lower middle-class households in relatively poor countries have material standards of living that in many dimensions--access to entertainment and news, public health, variety and extent of diet, potential literacy, materials with which to build shelter--would make them the envy of many of the prosperous of past centuries.

Perhaps the best indicator of the extraordinary level and rate of advance of material well-being and productive potential is that we take it for granted. If in the eighteenth century people began to think of the idea of progress,[3] and in the nineteenth there actually began to *be* visible progress,[4] in the twentieth century we *expected* and today we expect progress. We assume that each generation will live between half again and twice as well in material terms as its parent generation.[5] We find it hard to imagine what it would be like to

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[2] Could the Emperor Tiberius have eaten fresh grapes in January? Could the Emperor Napoleon have crossed the Atlantic in a night, or gotten from Paris to London in two hours? Could Thomas Aquinas have written a 2000-word letter in two hours—and then dispatched it off to 1,000 recipients with the touch of a key, and begun to receive replies within the hour? Computers, automobiles, airplanes, VCR's, washing machines, vacuum cleaners, telephones, and other technologies—combined with mass production—give middle-class citizens of the United States today degrees of material wealth—control over commodities, and the ability to consume services—that previous generations could barely imagine.

[3] See Marie Jean Antoine Nicolas Caritat, Marquis de Condorcet (1793), *Esquisse d'un Tableau Historique des Progrès de l'Esprit Humain* (Paris: Masson et Fils).

[4] Although not clearly so until after the so-called "Hungry [Eighteen-]Fourties." John Stuart Mill could write at almost the midpoint of the nineteenth century that it was doubtful that progress had lightened the burden of toil on humanity; Thomas Carlyle could christen economics the "dismal science" for its predictions that progress would not lighten the burden of toil on humanity. See George Boyer (1998), "The Historical Background of the Communist Manifesto," *Journal of Economic Perspectives* ; Thomas Carlyle (1850), *Latter-Day Pamphlets* http://promo.net/pg/_authors/carlyle_thomas_.html#latterdaypamphlets, downloaded January 31, 2000; John Stuart Mill (1848), *Principles of Political Economy, with Some Applications to Social Philosophy* http://socserv2.socsci.mcmaster.ca/~econ/ugcm/3ll3/mill/prin/, downloaded January 31, 2000.

live in a society not experiencing rapid material progress. And the gulf in material standards of living between the end of the twentieth century and the beginning of the twentieth century is so large that it is hard for us to grasp how large a gulf there is between how we lived and how people lived in previous centuries.[6]

1. Montgomery Ward's prices

One place to begin to begin to measure the gulf is the 1895 Montgomery Ward catalog. At the turn of the last century, Montgomery Ward was the largest mail-order retailer in the

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[5] And a slowdown in economic growth--like the productivity slowdown the U.S. and the rest of the industrialized world experienced between 1973 and 1995--is cause for alarm and a force that shakes political foundations. See Robert Reich (1992), *The Work of Nations* (New York: Vintage: 0679736158).

[6] One attempt to capture the difference is made by the science-fiction writer Walter John Williams in his novel *Aristoi.* His viewpoint characters come across a planet that has deliberately been kept in ignorance of industrial and post-industrial technology as part of a metaphilosophical experiment, and they react with horror:

> ... most work seemed to be done by brute human muscle power alone Primitive firearms existed in large numbers--cannons were picked out on the ramparts of castles and star-forts...
>
> ... open sewers down the middle of every street and open cesspits everywhere... existence, even for the better-off, more than justified Thomas Hobbes's remarks on life being nasty, brutish, and short. Heads were observed stuck on pikes above city gates; bodies that showed signs of pitiless torture swung in cages over city streets. Filthy children slept in gutters while disinterested oligarchs in their finery were carried in chairs over the starving bodies... In the country, wandering families of laborers and gleaners slept under haystacks while those with property largely slept with their animals. Famine seemed fairly commonplace—banditry, much of it under the guise of warfare, even more so...
>
> The cumulative impact of the probes' images staggered the Cressida's crew.... Clancy took refuge in unremitting fury.
>
> "Sadist, did I say?" she said. "De Sade was a piker by comparison! Hitler was a trifle maladjusted, Stalin a blunderer, and Chingiz Khan a mere amateur!"

See Walter John Williams (1992), *Aristoi* (New York: Tor: 0812514092).

United States. It supplied rural and small-town households around the country with goods produced in America's factories. It was one of the few ways the forty percent of Americans living in small towns or on the farm could buy the products of modern industry. The regular arrival of the mail-order catalogues, followed by goods shipped from centralized warehouses proved a boon to rural consumers and a comfortable market niche for companies like Montgomery Ward, willing to supply goods ranging from sterling silver teaspoons to sets of the *Encyclopedia Britannica* to drill presses.

Multiplication of Productivity 1895-2000
Time Needed for an Average Worker to Earn the Purchase Price of Various Commodities

Commodity	Time-to-Earn in 1895 (Hours)	Time-to-Earn in 2000 (Hours)	Productivity Multiple
Horatio Alger (6 vols.)	21	0.6	35.0
One-speed bicycle	260	7.2	36.1
Cushioned office chair	24	2.0	12.0
100-piece dinner set	44	3.6	12.2
Hair brush	16	2.0	8.0
Cane rocking chair	8	1.6	5.0
Solid gold locket	28	6.0	4.7
Encyclopedia Britannica	140	33.8	4.1
Steinway piano	2400	1107.6	2.2
Sterling silver teaspoon	26	34.0	0.8

Source: 1895 Montgomery Ward *Catalogue*[7]

[7] *1895 Montgomery Ward Catalogue,* intro. By Boris Emmett (New York: Dover Books, 1969 facsimile edition: 0486223779). I was made aware of the Montgomery Ward *Catalogue* as a source by William Baumol, Sue Anne Batey Blackman, and Edward Wolff (1989) *Productivity and American Leadership: The Long View* (Cambridge: MIT Press: 0262521636), which contains a nice discussion of productivity growth through this particular lens. Boris Emmett's introduction to the facsimile edition of the *Catalogue* is very well done. Also very well done is W. Michael Cox and Richard Alm (1997), *Time Well Spent* (Dallas: Federal Reserve Bank of Dallas).

Comparing the prices charged in the Montgomery Ward catalog with prices today--both expressed as a multiple of the average hourly wage--provides an index of how much our productivity in making the goods consumed back in 1895 has multiplied.

Consider a one-speed bicycle, costing $65 if ordered from Montgomery Ward in 1895. The price of a bicycle measured in "nominal" dollars has more than doubled over the past century (as a result of inflation). But the bicycle today is much less expensive in terms of the only measure that truly counts, its "real" price: the work and sweat needed to earn its cost. It took perhaps 260 hours' worth of the average American worker's production in 1895 to mount up to enough money to buy a one-speed bicycle. Today a bicycle--the high-tech cutting-edge consumer good of 1895--costs 1/36 as much in labor time today as it did back then. On the bicycle standard—measuring wealth by counting up how many bicycles it can buy—the average American worker today is some 36 times richer than his or her counterpart was back in 1895.

Other commodities tell their--different--stories. A six-volume set of (cheaply made) novels by Horatio Alger costs 1/35 as much in this labor-wage-metric now as it did a century ago. A 100-piece dinner set from Crate and Barrel today costs 1/12 as much in labor time as a set from Montgomery Ward used to. A cushioned office chair has become 12 1/2 times cheaper.

But there are other goods with less of a productivity multiple: a multiple of less than 5 for a solid gold locket, a productivity multiple of only a little more than two for a Steinway piano, and a productivity multiple of 0.8 for a sterling silver teaspoon: it costs more hours to earn the money to buy a silver teaspoon (mail order from Ross Simons) today than it

took back in 1895.[8] There are some commodities for which our productive potential has not increased over the past century.

Caveats

Or has it? A farm household ordering a few silver implements back in 1895 was presumably seeking flatware that would not corrode rapidly. They did not know how to mix chromium atoms with iron and carbon atoms to make corrosion-resistant flatware. We do. Thus our everyday utensils are made of stainless steel: our silver is reserved for when (and who) wants to set a glittering table. Is the right comparison to make that of the price of a sterling silver teaspoon then with a sterling silver teaspoon now, or of a silver teaspoon then with a stainless steel teaspoon now? It matters a lot. For those who think that the important characteristic is that it is made up of silver, it is indeed 25 percent more expensive now than it was back then when you could pick the silver up off of the ground in Nevada. But for those who think that the important characteristics is that it does not rust, a teaspoon today costs only one-fiftieth as much in terms of labor time as it did a century ago.

Or consider the *Encyclopaedia Britannica.* Today its print version costs $1,250--in labor hours one quarter as much as it cost back in 1895. But the *Encyclopaedia Britannica CD 2000* costs $49.95--a drop in labor-time price of a factor of 100, if the CD is taken as an

[8] See http://www.ross-simons.com/

equivalent product. And the *Concise Columbia Electronic Encyclopedia* can be accessed over the internet for free.[9]

Even comparing commodities made in 1895 with the like commodities made today is not quite straightforward.

[Picture: commodities in the table above]

The Index Number Problem

The answer to the question "how much wealthier are we today than our counterparts of a century ago?" depends on which set of commodities you view as central and important. If you care only about personal services—having a butler around to answer the door and polish your silver spoons—then you would find little difference in national average wealth between 1895 and 1990: an hour of a butler's time then cost about an hour's worth of the time of an average worker; an hour of a butler's time today costs about the same; on the butler-hiring standard we are no richer off than a century ago. But suppose you care a lot, instead, about your ability to by mass-produced manufactured goods—like bicycles. Then the multiple is 36.

[9] See http://www.encyclopedia.com/. Most more comprehensive encyclopedias--including *Britannica*--charge about $5 a month for access to their online editions.

This divergence is the index-number problem.[10] It is ultimately unresolvable:[11] there is no single, unique, correct index that will tell you how much higher wealth of productivity is: it all depends on what you value, and what set of weights you choose to evaluate the different production possibilities of different eras. Thus it depends in a very real sense on just who you are. If your tastes, needs, and desires are different, the appropriate measure of economic growth will be different too.

2. Long-Run Estimates of GDP per Worker

Nevertheless the government arrives at a single, consensus, official or semi-official estimate of the pace of long run economic growth. It publishes the time series of real (that is, inflation-adjusted) *GDP*--gross domestic product--in *Historical Statistics of the United States.*[12] You can construct a picture of long-run economic growth by taking the time series for real GDP from *Historical Statistics,* splicing the series onto contemporary estimates of current GDP, and then divide GDP by the number of workers in the American

[10] See, for example, R.G.D. Allen (1975), *Index Numbers in Theory and Practice* (Chicago: Aldine Publishing Company: 0202060713). The classic source is Irving Fisher (1922), *The Making of Index Numbers* (Boston: Houghton-Mifflin: 1851962328).

[11] Economic research has focused on doing as well as possible: constructing so-called "superlative" index numbers that are extremely close local approximations to a true cost-of-living or quantity-of-valued-output index. See W.E. Diewert (1976), "Exact and Superlative Index Numbers," *Journal of Econometrics* 4:2 (May), pp. 115-45. But a good local approximation is not much use when one is concerned about global changes, and when a key source of uncertainty is the question of exactly whose utility one is trying to measure.

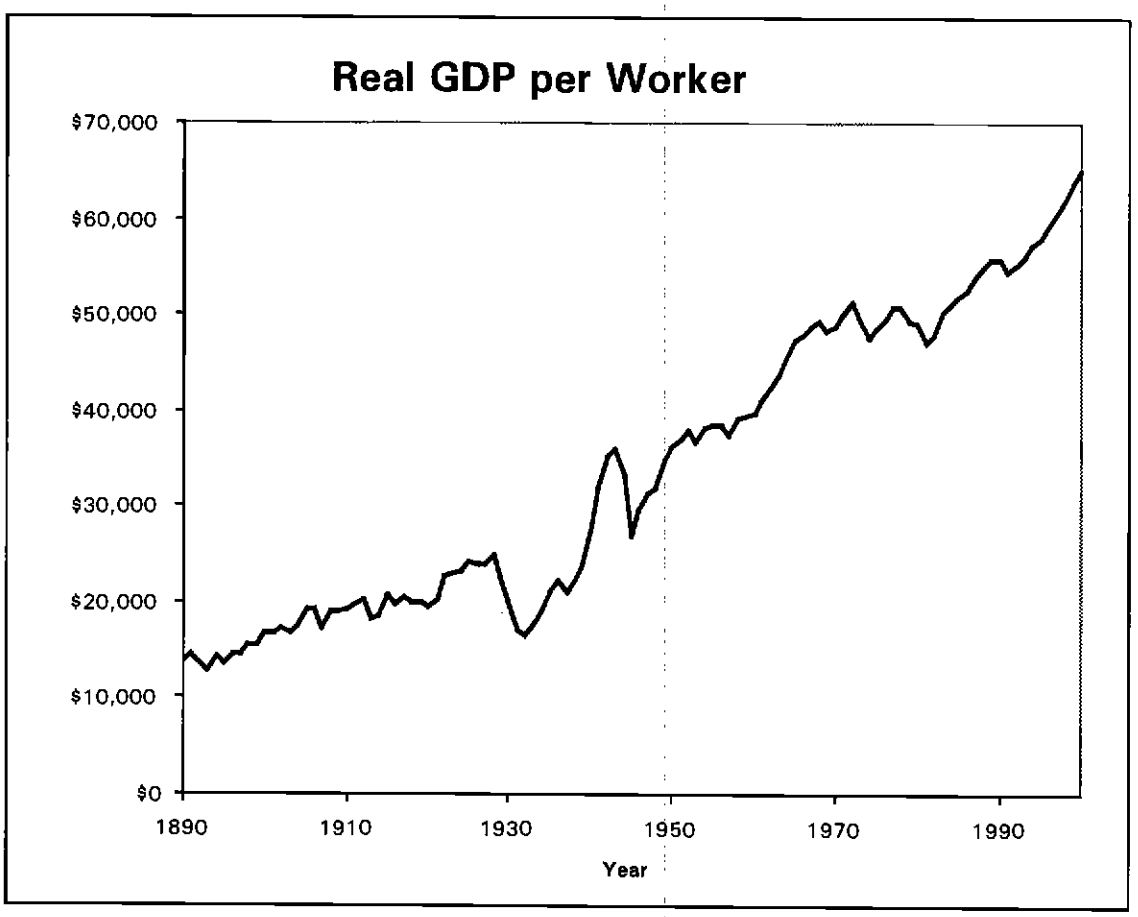
[12] (1997) *Historical Statistics of the United States* (Cambridge: Cambridge University Press: 0521585414). How created. Forthcoming millennial revision. Carter and Sutch.

economy to arrive at an estimate of how the economy's per-worker productive potential has changed over time.[13]

What is this "GDP" that is the standard measure of economic output? Annual GDP is a measure of all the final goods and services produced in a country in a year. It includes all those consumption goods and services produced--those bought by households for their own use. It includes all investment goods purchased by businesses to expand their stocks of productive capital.[14] And it includes goods and services purchased by the government, and used by the government to accomplish its tasks.

[13] Why the focus on "per worker"? Because GDP is a measure only of economic activity that passes through the market. As the share of the American adult population in the paid labor force has risen, so measured GDP has risen, even though part of what has been going on has been the shifting boundary between categories of work that used to be outside, but are now inside the market. So divide real GDP by the size of the American *labor force* (not by the population) to attempt to control for the shifting boundary between market and non-market work, and still arrive at a measure of material well-being and prosperity.

[14] Note that GDP includes not just the production of investment goods that add to businesses' stocks of productive capital, but also the production of investment goods that replace worn-out or obsolete pieces of capital as well. This is a conceptual flaw: a better measure would be *net* domestic product, which is equal to GDP minus those investments that simply replace already-existing pieces of capital that are retired from production. But the Commerce Department's Bureau of Economic Analysis has no confidence in its ability to estimate capital consumption, and prefers to focus on a statistic--GDP--that it can estimate with more confidence. The BEA thinks that NDP is something like 11 percent less than GDP.



As of the end of 1999, forecasts of U.S. GDP in 2000 put it at $9,300 billion, which with 142 million workers (employed plus unemployed) comes to an annual real GDP per worker (measured in dollars of the year 2000's purchasing power) of $65,540. Back in 1890, a little more than a century ago, the spliced-together time series from the Bureau of Economic Analysis tells us that GDP in 1890 (at the year 2000's prices) was $300 billion. With an 1890 labor force of 21.8 million that translates into an annual real GDP per worker in 1890 of $13,700.

The semi-official time series tells us that material standard of living and potential economic productivity at the start of the third millennium was nearly five times what it had been only

110 years before: a rate of per-worker real economic growth of 1.4 percent per year. And if we adjusted for the decline in the working year since 1890, we would find a six to sevenfold increase in measured per-work hour real GDP. According to these estimates, an American household with six times the median family income back in 1890--a household as wealthy and as high up in the relative income distribution then as a household with an income of $300,000 today--was no better off *in measured material welfare* than the average American household today.

Note that this broad upward sweep in measured output per worker is *the* central feature of the figure above. On this scale, the business cycle-centered concerns of newspaper financial pages are barely visible.[15] The recessions and depressions and the transitory booms that make headlines are by and large hard to see. The 1970 and 1991 recessions are small ripples. The 1974 oil shock and the 1982 inflation reduction depressions are small notches. They had little effect on the volume of production. They are only minor interruptions in its upward march.[16]

There is one exception. Between 1929 and 1950 the U.S. undergoes the Great Depression, the immense boom of World War II, and then the process of reconversion from the total war economy of 1942-1945 to a peacetime economy. %he Great Depression of 1929-1941 temporarily annihilated a generation's growth in incomes. It saw

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[15] Save for the Great Depression, which alone is of large enough scale to be clearly visible as a major feature of the record of twentieth century GDP per worker growth. Caution that the welfare costs of business cycles are (perhaps) at least an order of magnitude larger than their costs in terms of output per worker. Cite to David Romer (), *Advanced Macroeconomics* (). Cite to Rebecca Blank and Alan Blinder.

[16] Recessions are in fact *not* feared because they significantly reduce the volume of production. They are feared because of the distribution of the losses that they create. Most people are unaffected, but many the people lose their jobs and nearly all their income, and a few of the rich lose nearly all their wealth. It is this fear that you will be one of the unlucky whom a recession hits terribly hard that accounts for much of the salience of recessions in American minds.

unemployment peak at a quarter of the labor force. Unemployment remained above ten percent and production per worker remained below its 1929 level. until the beginning of World War II. The Great Depression provoked fears that the run of economic growth that had commenced with the industrial revolution had played itself out, and that "secular stagnation" had set in.[17] But the Great Depression was unique. It has not been repeated.[18] Neither has the extraordinary military mobilization of World War II.

Moreover, this upward jump of productivity and wealth has not been confined to the world economy's industrial core. Even as early as 1987, 97 percent of households in Greece--not usually considered one of the world's industrial leaders--owned a television set. In Mexico in that same year there was one automobile for every sixteen people, one television for every eight, one telephone for every ten.[19]

Thus *Historical Statistics* produces an estimate of the multiplication of economic wealth over the past century in the range given by the prices in the century-old Montgomery Ward *Catalogue.* A six to seven-fold multiplication is more than our increasing power to make some of the commodities listed (Steinways, solid-gold lockets) and less than our increasing power to make other commodities (bicycles, chairs, and books).

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[17] See Alvin Hansen ().

[18] At least it has not yet been repeated. But the economic stagnation of Japan in the wake of the late-1980s collapse of its "bubble economy" is rapidly approaching Depression size in terms of lost production and foregone economic growth. The current majority opinion is that the Great Depression required that uniquely large shocks hit the global economy at a time of uniquely great structural vulnerability. Hence many people are willing to bet real money that the Great Depression will not be repeated. See Peter Temin (), *Lessons from the Great Depression* (Cambridge: MIT Press); Barry Eichengreen (1997), *Globalizing Capital* (); Christina Romer (1999), "Changes in Business Cycles: Evidence and Explanations," *Journal of Economic Perspectives* ().

[19] (1990), *The Economist Book of Vital World Statistics* (New York: Times Books: 0812918770).

3. Alternative Answers

But the set of calculations underlying the numbers reported in *Historical Statistics* are only one way of calculating increasing wealth. The time series of *Historical Statistics* is, mostly and roughly, what economists call a *Laspeyres* index.[20] It corresponds to a certain conceptual experiment. Suppose that we took a representative sample everything produced in some year in the past, stuffed it into a time machine, moved it forward to today, and sold it; how much would it be worth? That is what the "2000 prices" in the statement "GDP per worker in 1890 was some $13,700 a year at 2000 prices" means. And the resulting estimate of long-run economic growth compares the value at today's prices--$13,700--of the commodities produced by an average worker then to the value at today's prices--$65,000--of the commodities produced by an average worker today.

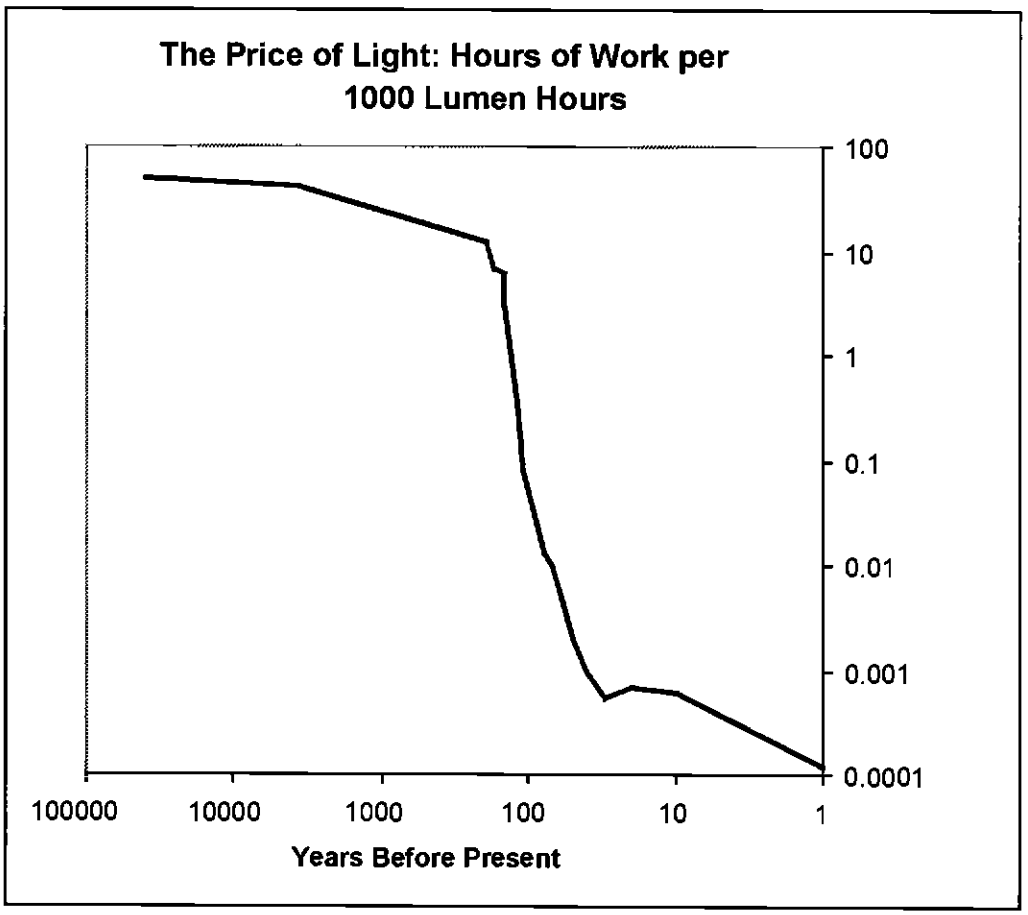
A little thought will convince you that this is a significant understatement of the extent and magnitude of economic growth. When we hear that "average GDP per worker in 1890 was equal to $13,700 at 2000 prices," we think that the material standard of living *then* was about what we could obtain *now* if we had $13,700 to spend to support us for a year. But that is not the case: the material standard of living *then* was roughly what we could obtain *now* if we had $13,700 to spend, *and were required to spend it* all *on commodities that have been around for more than a century.* People then could buy wrought-iron fences, bicycles, books by Horatio Alger, cushioned chairs, flour meat, and a primitive telephone. They could not buy modern entertainment or communications or transportation

[20] Laspeyres index footnote.

technologies, no modern appliances, no modern buildings, no antibiotics, no air travel. An income of $13,700 today that must be spent exclusively on commodities already in use in the late nineteenth century is, for all of us, worth a lot less than $13,700.

The argument that our commodity-focused price indices miss most of the real action—that price indices focusing on the *services* provided would produce vastly greater estimates of long-run economic growth—is made most powerfully by William Nordhaus in his study of the economic cost of light.[21] Nordhaus attempts to construct a consistent series of the real labor-time cost of illumination from the dawn of civilization until today. He concludes that the past hundred years have seen a ten thousand-fold decline in the real price of illumination. Yet commodity-based price indices have only captured a ten-fold decline in this real price.

[21] William Nordhaus (1997) "Do Real Output and Real Wage Measures Capture Reality?: the History of Lighting Suggests Not," in Timothy Bresnahan and Daniel Raff, eds., *The Economics of New Goods* (Chicago: University of Chicago), pp. 29-66. Also worth reading is the insightful comment by Charles Hulten, pp. 66-70. For a somewhat different methodology—an attempt to calculate the total consumer surplus generated from a single innovation, the CAT scanner—see Manuel Trajtenberg (1990), *Economic Analysis of Product Innovation: The Case of CT Scanners* (Cambridge: Harvard University Press: 0674225406).



Nordhaus guesses that the *Historical Statistics* estimates of economic growth have understated true economic growth since 1800 by between 0.5% and 1.4% per year—an amount that cumulates to a multiplicative factor of between 3 and 15 over the past to centuries, and to a conclusion that real wages since 1900 have multiplied by a factor between 20 and 100.

Inventions largely commercialized and diffused in this century include late-nineteenth century inventions like the monorail, the telephone, the microphone, the cash register, the phonograph, the incandescent lamp, explosives, the electric train, linotype printing, the steam turbine, the gasoline engine, the streetcar, movies, motorcycles, automobiles, concrete-and-steel construction, electric appliances of all kinds, inflatable tires, radio,

aspirin, x-rays, taxicab meter. Twentieth-century inventions include the espresso machine, plastics, airplanes, helicopters, hydrofoils, the zipper, the traffic light, heat-resistant glass, television, bulldozers, antibiotics, highways, jet engines, radar, insulin, photocopiers, nylon, transistors, integrated circuits, computers, fiber-optic cables, videotape, oral contraceptives, lasers, CT scanners, catalytic converters, and genetic fingerprinting.[22] A rough cut is that roughly 45% of the value of what middle-class consumers in rich industrial countries use at the start of the third millennium is in commodities that were not invented or that were not in widespread use at all in the last years of the nineteenth century.

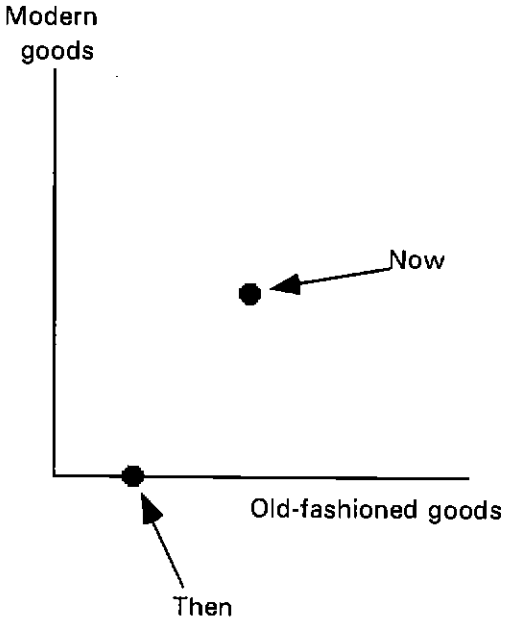
[Figure: collage of commodities invented in the twentieth century]

Measuring economic growth as the Laspeyres index does means that we value goods produced in the past at their current prices, and so understates economic growth as it produces an estimate of a six to sevenfold improvement in material standards of living in the past century. What if we were to turn it around, and calculate economic growth valuing goods and services not at their prices as of 2000, but at their prices as of 1890? The figure below shows one of the standard diagrams of introductory economics. Along the horizontal axis of the diagram we plot the amount produced per worker of "old fashioned" goods that were invented and were in use in 1890. Along the vertical axis of the diagram we plot the amount produced per worker of "modern" goods. The point labeled "then" shows what annual per-worker production was back then in 1890: $13,700 worth (at today's prices) of old-fashioned goods and $0 of modern goods. The point

[22] See *Smithsonian Historical Timeline of Inventions*

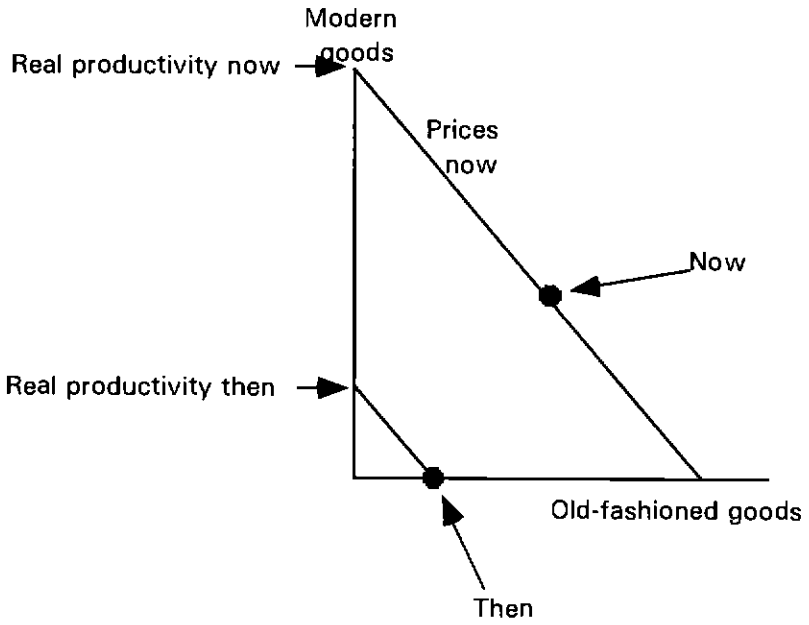
labeled "now" shows what annual per-worker production is today: (roughly) $35,000 worth (at today's prices) of old-fashioned goods and (perhaps) $30,000 worth (at today's prices) of modern goods.

Production of Modern Goods and Old-Fashioned Goods



In this oversimplified and stripped-down way of looking at it, production "then" and production "now" are each two dimensional quantities: you simply cannot compare them--say that one is X times larger than the other--without imposing more structure.

Relative Real Productivity Levels: Using Today's Prices



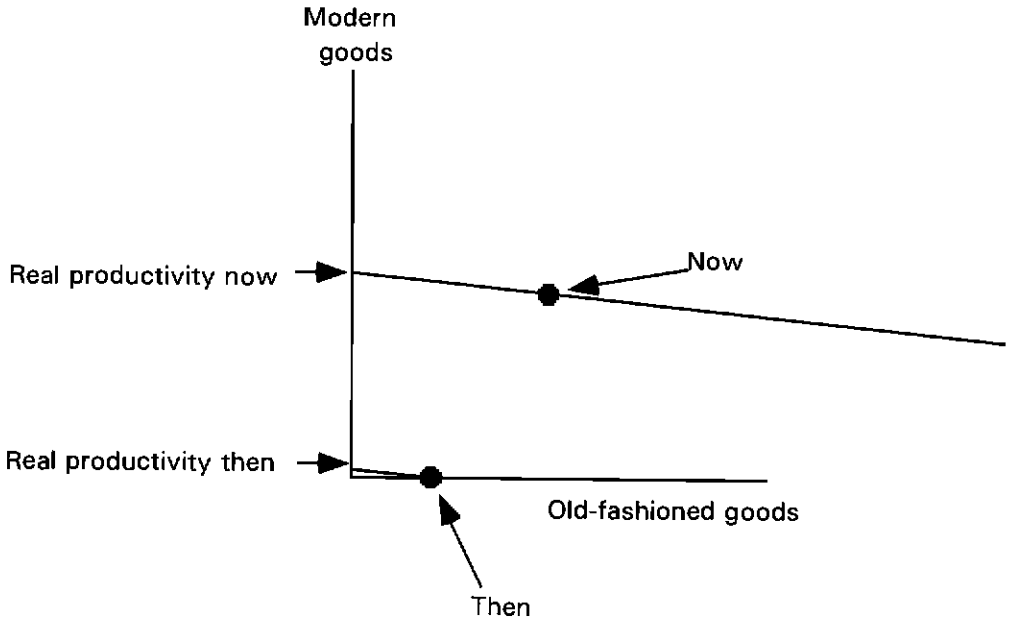
One way to proceed--the way that *Historical Statistics* more-or-less proceeds--is to use the fact that $1 worth of modern goods buys $1 worth of old-fashioned goods today, and to look not at the points showing what is actually produced but at all the possible combinations of goods that could be purchased (at today's prices) with the income needed to buy per-worker production either then or now. Draw, as in the figure above, the *price line* showing how dollar-for-dollar one could at today's prices buy more of modern and less of old-fashioned goods. Compare the positions of the lines that show the resulting sets of available choices.

Because the two lines are parallel, the ratio of their relative distances from the bottom-left corner shows the ratio of the today's-dollar value of production "now" to production "then." This is what the Laspeyres index does: it uses the metric provided by today's prices to make a *single* numerical comparison between the value of goods produced "now" and the value of goods produced "then."

But what if we took some other set of prices? Instead of taking a representative sample of everything produced in 1890, stuffing it into a time machine, bringing it forward to today, selling it; suppose we took a representative sample of everything produced today, stuffed it into a time machine, took it back to 1890, and sold it then at the prices that then prevailed?

Then we would have a very different answer, for a large chunk of what is produced now was unavailable back in 1890. It has a very high--in many cases an infinite--price. Drawing the 1890 *price line* showing the terms at which old-fashioned goods were then exchanged for modern goods produces a nearly horizontal line. And the relative distance between the two lines is very large, much larger than the six to sevenfold increase in output per work hour calculated from *Historical Statistics.*

Relative Real Productivity Levels: Using Past Prices



We would then conclude that, measured in the metric provided by prices in the past, that economic growth over the past hundred years has been nearly infinite: even all of the resources of the economy of the past would have been unable to produce even an infinitesimal fraction of some of the goods we make today. We are nearly infinitely better at producing the floating-point arithmetic operations, or airplane flights, and antibiotics that we take for granted--because they are so cheap--today.

4. Credible Answers

Are such large estimates of the rate of economic growth and improvement in material welfare over the past century credible? The answer is both yes and no.

A credible answer to the question of how much material prosperity has multiplied over the twentieth century might look like the answer to one of the following two thought experiments:

- Take a household with income per capita today equal to the economy-wide average. What multiple of average income per capita a century ago would be required for that household to feel equally well-off in a material sense, if it were transported back in time?

- Take a household with income per capita a century ago equal to the economy-wide average then. What fraction of average income per capita today would be required for

that household to feel equally well-off in a material sense, if it were transported forward in time?

However, these two questions will not have identical--or even close--answers. It is clear that the answer to the first question suggests a very large increase in material prosperity over the past century. Given the absence in 1890 of modern innoculations, modern antibiotics, and other technologies of the past century, it is hard to argue that anything less than an astronomical income back in 1890 could compensate. J.P. Morgan could not go to the movies, or watch football on television. He has no VCR. To travel from New York to Italy took a week, not a night. Was he better off in a material welfare sense than an average inhabitant of the U.S. today? Perhaps, but it is not clear. The answer to the first question is very large indeed.

Personally I have no problem at all with the first answer's conclusion that *Historical Statistics* vastly understates growth: my household's income today is roughly $200,000 a year—about three times average GDP per worker. Suppose that you stuffed me and my family into a time machine, sent us back a century to 1890, and then gave us an income equal to eighteen times that of 1890 average GDP per worker—an income that would put us at the same place in the relative income distribution then as some $1,200,000 a year would today. We would not be among the 500 or so richest families in the country that might be invited to the most exclusive parties in the mansions of Newport, Rhode Island; but we would be among the next outer circle of 5,000 or so.

Would we be happy—or at least not unhappy—with the switch? Our power to purchase some commodities would be vastly increased: we would have at least three live-in servants, a fifteen-room house (plus a summer place). If we lived in San Francisco we

would live on Russian Hill, if we lived in Boston we would live on Beacon Hill. If we lived in New York we would live on Park or Fifth Avenue.

But the answer is surely that we would *not* be happy. I would want, first, health insurance: the ability to go to the doctor and be treated with late-twentieth-century medicines. Franklin Delano Roosevelt was crippled by polio. Nathan Meyer Rothschild—the richest man in the world in the first half of the nineteenth century—died of an infected abscess.[23] Without antibiotic and adrenaline shots I would now be dead of childhood pneumonia. The second thing I would want would be utility hookups: electricity and gas, central heating, and consumer appliances. The third thing I want to buy is access to information: audio and video broadcasts, recorded music, computing power, and access to databases.

None of these were available *at any price* back in 1890.

I could substitute other purchases for some. I could not buy a washing machine, but I could (and would) hire a live-in laundress to do the household's washing. I could not buy airplane tickets; I could make sure that when I did travel by long distance train and boat I could do so first class, so that even though travel churned up enormous amounts of time it would be time spent relatively pleasantly. But I could do nothing for medical care. And I could do nothing for access to information, communications, and entertainment technology save to leave the children home with the servants and go to the opera and the theater every other week. How much are the central heating, electric lights, fluoridated

[23] See David S. Landes (1998), *The Wealth and Poverty of Nations: Why Some Are So Rich and Some So Poor* (New York: W.W. Norton: 0393040178), citing Derek Wilson (1994), *Rothschild: A Story of Wealth and Power* (London: Mandarin).

toothpaste, electric toaster ovens, clothes-washing machines, dishwashers, synthetic fiber-blend clothes, radios, intercontinental telephones, xerox machines, notebook computers, automobiles, and steel-framed skyscrapers that I have used so far today worth—and it is only 10 A.M.?

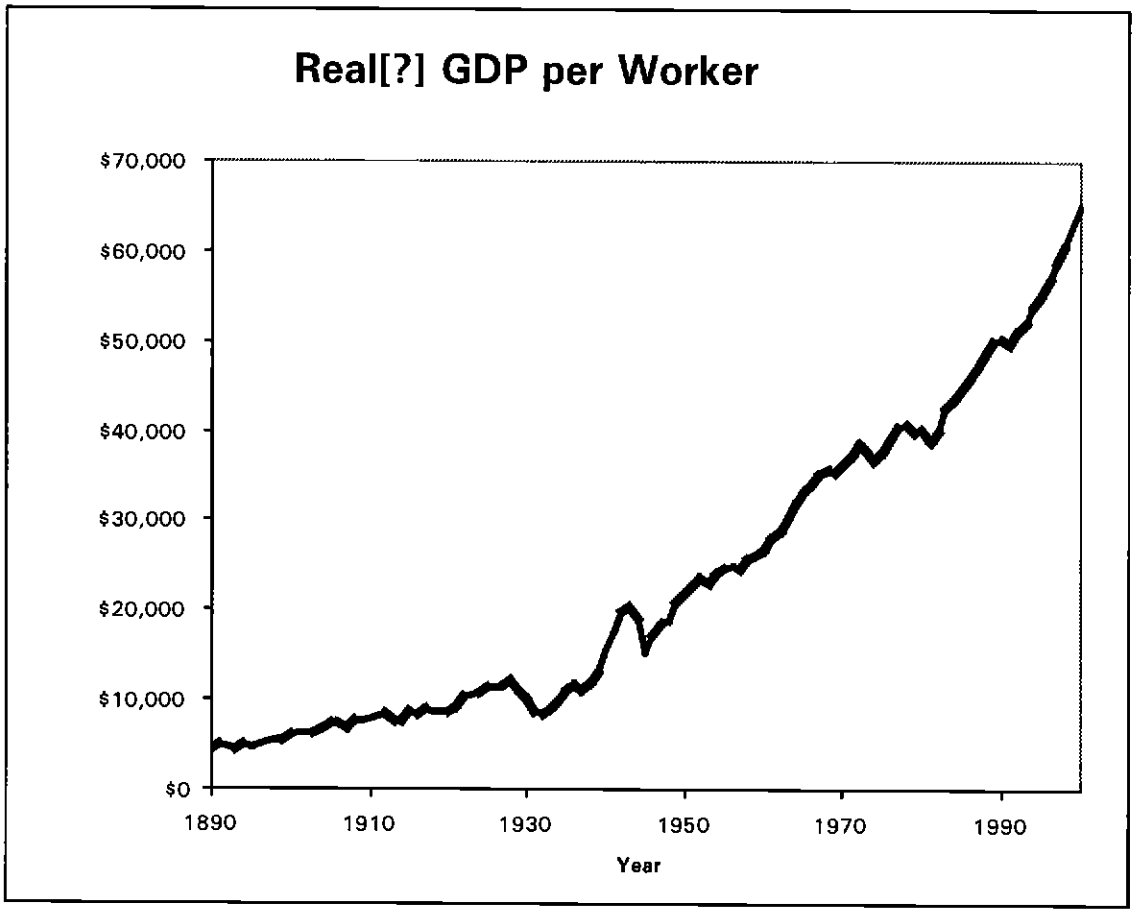
I would not be satisfied with my attempts to substitute using late nineteenth century technology. First of all, I would be dead. Second a very large chunk of my-high-material standard of living is the broad range of commodities newly-invented over the course of the past century that I can choose to purchase, and that I *do* use because they give me capabilities that were simply not possible a century ago.

By contrast, the answer to the second question suggests a smaller increase in material prosperity--perhaps a factor of ten. Someone with an income of $5,000 a year in the U.S. today has much better access to medical care and mass entertainment than a middle-class household of a century ago, and better transportation and clothing. He or she has better winter vegetables, but perhaps a worse overall diet. And he or she has worse housing, worse access to non mass-media forms of entertainment, and a much lower ability to purchase goods that are currently fashionable. The comparison of the poor today with the middle class of a century ago produces an estimate of the pace of economic growth not too dissimilar from that produced by *Historical Statistics*. The comparison of the middle class today with the rich of a century ago produces an estimate that is much much larger.[24] So how much economic growth is worth to you depends on where you sit: for those near the bottom of the income distribution in industrial economies growth looks much less

[24] This difference should not surprise us. Only if consumption patterns are what economists call *homothetic*—only if a proportional increase in income leads to a proportional increase in the purchase of *all* commodities—will the answers to these two thought-experiments be the same. There is no good reason to believe in such homotheticity Homotheticity footnote.

impressive, in large part because many of the new commodities invented over the past century are of no use if you cannot afford them.

So do we shrug our shoulders and accept the *Historical Statistics* answer that we today are eight times as rich as our counterparts of a century ago? (And that the gulf is larger if we care about manufactured goods; and smaller if we care about personal services, and some kinds of luxuries?) No, I do not think that we accept this answer, because the *Historical Statistics* answer is the *least* of the possible answers we could arrive at: we know that it provides a lower bound to "true" growth. It provides a lower bound because the calculations that underlie it leave out the many things we make today that were not made back in the 1890s.



If we must put forward one number, we will probably due the least damage to reality if we take the Boskin Commission's guesstimate that unmeasured improvements in quality and the invention of new goods and new types of goods have led standard measures to understate true economic growth (from a first-world middle-class perspective at least) by 1% per year. Such an assumption leads to a conclusion that economic output per worker has multiplied sixteen-fold since 1890.

5. The Limit of Human Felicity

However, in the end the quantitative estimates of the pace of economic growth--and the wide range of such estimates generated by the unresolvable index number problem--is in some ways less interesting than a picture of the qualitative difference twentieth century economic growth makes. We can see the magnitude of the contribution that the changing set of commodities we can produce makes to our wealth by reading *Looking Backward,* Edward Bellamy's turn of the last century utopian novel.[25] In *Looking Backward* the narrator—thrown forward in time from 1895 to 2000—hears the question, "Would you like to hear some music?"

He expects his host to play the piano—a social accomplishment of upper-class women around 1900. To listen to music on demand then, you had to have—in your house or nearby—an instrument, and someone trained to play it. It would have cost the average worker some 2400 hours, roughly a year at a 50-hour workweek, to earn the money to buy a high-quality piano, and then there would be the expense and the time committed to piano lessons.

But today, to listen to music-on-demand in your home, all you need is a CD or a tape player—or in a pinch, if you are willing to let others choose your music for you, a radio. The labor-time value of a Steinway piano may have only halved when measured in average worker-hours. But if what you value is not the piano itself but the capability of listening to music at home, the cost has fallen from 2400 average worker-hours a century ago to 10

[25] Edward Bellamy (1887), *Looking Backward* (New York: New American Library: 0451524128). Paragraph on the importance of *Looking Backward* viewed in its context.

hours today (240 dollars for the boom-box plus 10 dollars for the CD). So when we calculate the increase in material wealth, do we count the halving of the labor-time price of the *commodity* (which is what *Historical Statistics* does); or do we count the 240-fold decrease in the real labor-time price of the *capability* of listening to piano music? And whose piano playing do you *really* want to listen to?

After answering "yes" to the question "would you like to hear some music?" Bellamy's protagonist is stupefied to find his host "merely touched one or two screws," and immediately the room was "filled with music; filled, not flooded, for, by some means, the volume of melody had been perfectly graduated to the size of the apartment. 'Grand!' I cried. 'Bach must be at the keys of that organ; but where is the organ?'"

He learns that his host has called the orchestra on the telephone—for in Bellamy's utopia you can dial one of four orchestras, and then put it on the speakerphone. Bellamy's protagonist then says that:

> if we [in the nineteenth century] could have devised an arrangement for providing everybody with music in their homes, perfect in quality, unlimited in quantity, suited to every mood, and beginning and ceasing at will, we should have considered the limit of human felicity already attained...

To Edward Bellamy—a self-described utopian visionary, a late-nineteenth century minister's son from western Massachusetts—a radio that could tune into any of four stations is "the limit of human felicity..." What if someone were to take Edward Bellamy to Tower Records? Or Blockbuster Video? His heart would stop. Yet we do not think of our modern ability to cheaply listen to high-fidelity go-anywhere listen-to-anything music as a remarkable or even a notable part of our economy. We do not daily give thanks for

our cassette players and genuflect in front of our CD collections. We do not reflect that they have brought us to the limit of human felicity.

The technological inventions of the past century have transformed experiences that were rare and valued luxuries—available only to a rich few at great expense at relatively rare performances of the symphony or the opera—into features of modern life that we take for granted. Bellamy's view of us might be somewhat analogous to our view of a civilization in which everyone had several boxes of gem-quality diamonds sitting in their basement, ignored because no one could find a use for them, and in which no one thought of these boxes as in any way interesting.

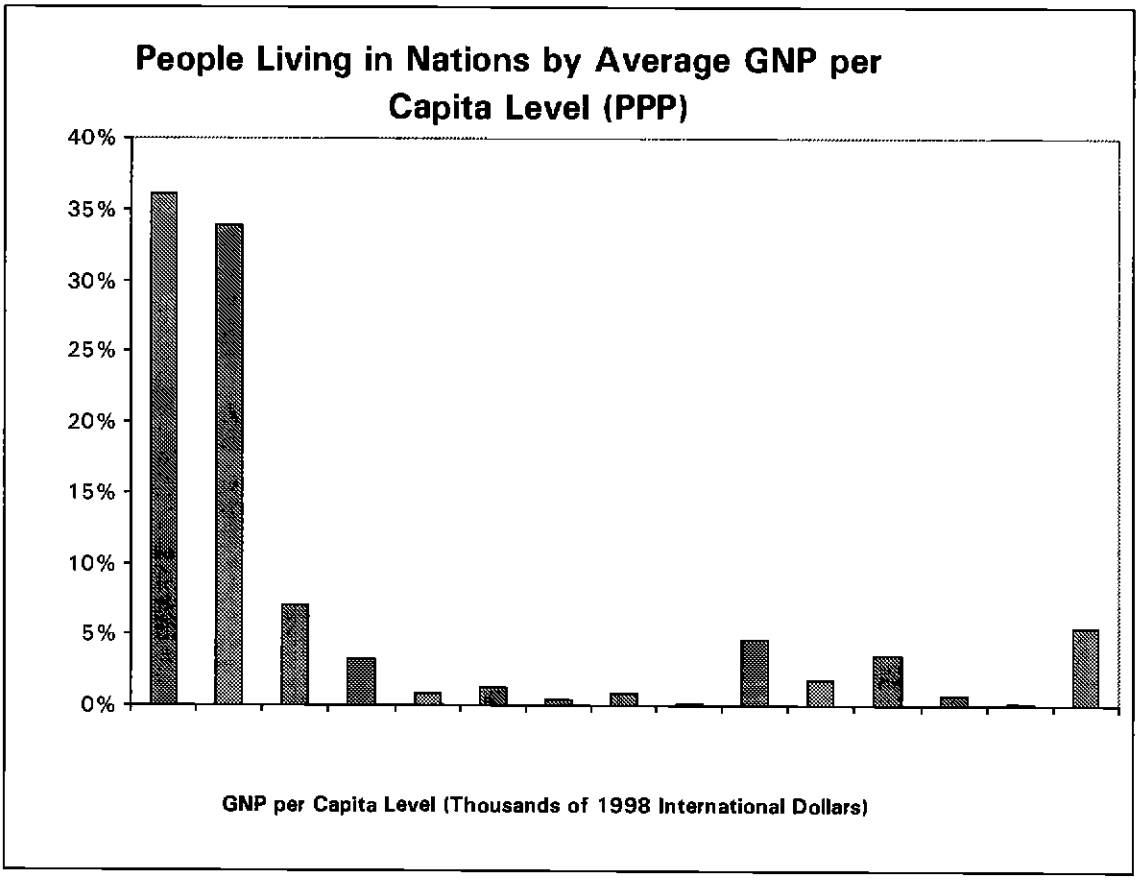
If you asked Edward Bellamy--or any other nineteenth-century or earlier sketcher of utopias--whether we here today have the knowledge of technology and of productive organization needed to provide at least the *material* abundance needed to build a utopia, they would all say "of course." And they would in turn ask of us why we do not recognize that those of us in the middle and upper classes of the industrial economies have, in material well-being at least, reached the limit of human felicity.

B. Economic Growth in Long-Run Perspective

1. Before and Since the Commercial Revolution

The world as a whole has not had the sixteen-fold multiplication of its material prosperity that our third-millennium middle-class standpoint sees in the United States over the past century. It is a mistake to claim that growth and development over the course of the past century has been confined to the United States, or to the United States and western Europe, or to the United States, western Europe, and Japan. It is true that only twelve percent of the world's population lives in countries where GDP per capita at the start of the third millennium is more than $20,000 per year: the world distribution of income today is skew to a remarkable extent.

But comparing cross-national estimates of material productivity measured at exchange rates that equalize purchasing power across countries to our guesses about the pace of long-term economic growth above suggests that the average inhabitant of Thailand of Tunisia today has three times the productive potential of the average inhabitant of the United States in 1900; and the average inhabitant of Argentina, Botswana, Uruguay, or Mexico has five times the material productive potential of the average inhabitant of the U.S. in 1900. (However, unequal income distributions within nations make such estimates misleading as guides to economic welfare, even leaving aside the heroic and shaky assumption that comparisons across countries today can be related to comparisons across time within a country.)



Perhaps 36% of the world's population in 2000 lives in a country with a level of material output per capita less than that of the United States in 1900. But even in such poor countries today, most inhabitants are living much better than their predecessors. Angus Maddison estimates that world per capita GDP at the end of the twentieth century is five times what it was at the century's start--and Maddison's estimates are (in concept at least) Laspeyres estimates that make insufficient allowance for technological change and the invention of new commodities.[26] Making half as great an allowance for the impact of new

[26] See Angus Maddison (1995), *Monitoring the World Economy, 1820-1992* (Paris: OECD: xxxx).

commodities and technologies produces an estimate of a ninefold increase in world GDP per capita over the twentieth century.

Thus not just in the United States, but worldwide, the twentieth century is unique in its pace of economic growth. Such rapid growth in standards of living has never been seen before, anywhere. The nineteenth century saw perhaps a doubling of measured material standards of living in the United States—perhaps a tripling once proper account is taken of the impact of new technologies like the railroad and the telegraph, and the expanded range of technological capabilities.[27] Nineteenth century growth was itself remarkably fast: people christened the nineteenth century the "industrial revolution" because it was remarkable compared to what had happened before. And before the nineteenth century growth was even slower. The standard of living in the Netherlands, probably the richest economy in the world at the end of the eighteenth century, might (or might not) have been some fifty percent higher than it had been three centuries before, at the time of the Renaissance.[28]

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[27] The effects of new technologies are likely to have been less in the nineteenth century because of a slower overall pace of technological change, and because a larger share of nineteenth-century technological change took the form of new types of *capital* goods that made production easier but did not greatly change people's style of life. The spinning jenny and the power loom made cloth cheap: but it was still the same cloth. More nineteenth century inventions were like the differential gear, the locomotive, the dynamo, the combine harvester, the hydraulic jack, the telegraph, or nitroglycerine; fewer were like canned food, the gas stove, the bicycle, kerosene, or linoleum. See *Smithsonian Timeline of Inventions.*

The standard source is—and by virtue of his industry and thoroughness will long remain—Angus Maddison (1995), *Monitoring the World Economy, 1820-1992* (Paris: OECD: 9264145494). See also his 19 *Phases of Capitalist Development* (New York: Oxford: 0198284519), and Paul Bairoch's speculative (but I have no better speculations) "Main Trends in National Economic Disparities since the Industrial Revolution," in Paul Bairoch and Maurice Lévy-Leboyer, eds. (1981), *Disparities in Economic Development since the Industrial Revolution* (London: Macmillan).

[28] Jan de Vries and Ad van der Woude (1997), *The First Modern Economy: Success, Failure, and Perseverance of the Dutch Economy, 1500-1815* (Cambridge: Cambridge University Press: 0521578256).

[Figure: the countryside: Roman Italy, circa 0; Netherlands, circa 1500; U.S. midwest, circa 1900; U.S. midwest, today]

And before that? Between the invention of agriculture and the commercial revolution that marked the end of the middle ages, wealth and technology developed slowly indeed. Medieval historians speak of centuries and half-millennia when they speak of the pace at which key inventions like the watermill, or the heavy plow, or the horse collar diffused across the landscape. And improvements in technology relatively quickly led to increases in population, until the human population once again reached a new Malthusian steady state in which births were held in checks by death. For most of human history before the industrial revolution, increases in technological capability led to increases in the population that could be supported on a given natural resource base, with little if any appearing as an improvement in the median standard of living.[29]

So slow was the pace of change that people, or at least aristocratic intellectuals, could think of their predecessors of a thousand years before or more as effectively their contemporaries. And they were not far wrong. Marcus Tullius Cicero, a Roman aristocrat and politician of the generation before the Emperor Augustus, might have felt more or less at home in the company of Virginia planter Thomas Jefferson. The slaves outside grew different crops. The plows were better in Jefferson's time. Sailing ships were much improved. But these might have been insufficient to create a sense of a qualitative change

[29] Or so I read the history at least. See Abbott P. Usher (1922), *A History of Mechanical Inventions* (New York: Dover: 048625593X); Michael Kremer (1993), "Population Growth and Technological Change: One Million B.C. to 1990," *Quarterly Journal of Economics* 108:3 (August), pp. 681-716; Massimo Livi-Bacci (1992), *The Concise History of World Population* (London: Blackwell: 0631204555).

in the order of life for the elite. And at bottom being a slave of Thomas Jefferson was probably a lot like being a slave of Marcus Tullius Cicero.[30]

[Figure: Slaves at Monticello—Slaves working the fields of ancient Rome]

Overall, however, the differences in standards of living and in technologies used to manipulate the world were small, or at least "small" relative to the pace of change in the nineteenth and twentieth centuries. Even the first century of the industrial revolution produced more "improvements" than "revolutions" in standards of living. With the railroad and the spinning and weaving of textiles as very important exceptions, most innovations during the first century or so of the industrial revolution proper were innovations in transportation, in how goods were produced, and in new kinds of capital but not consumer goods. Improvements in productivity--in the first half of the nineteenth century at least--were concentrated in a few relatively narrow sectors rather than spread throughout the economy.[31]

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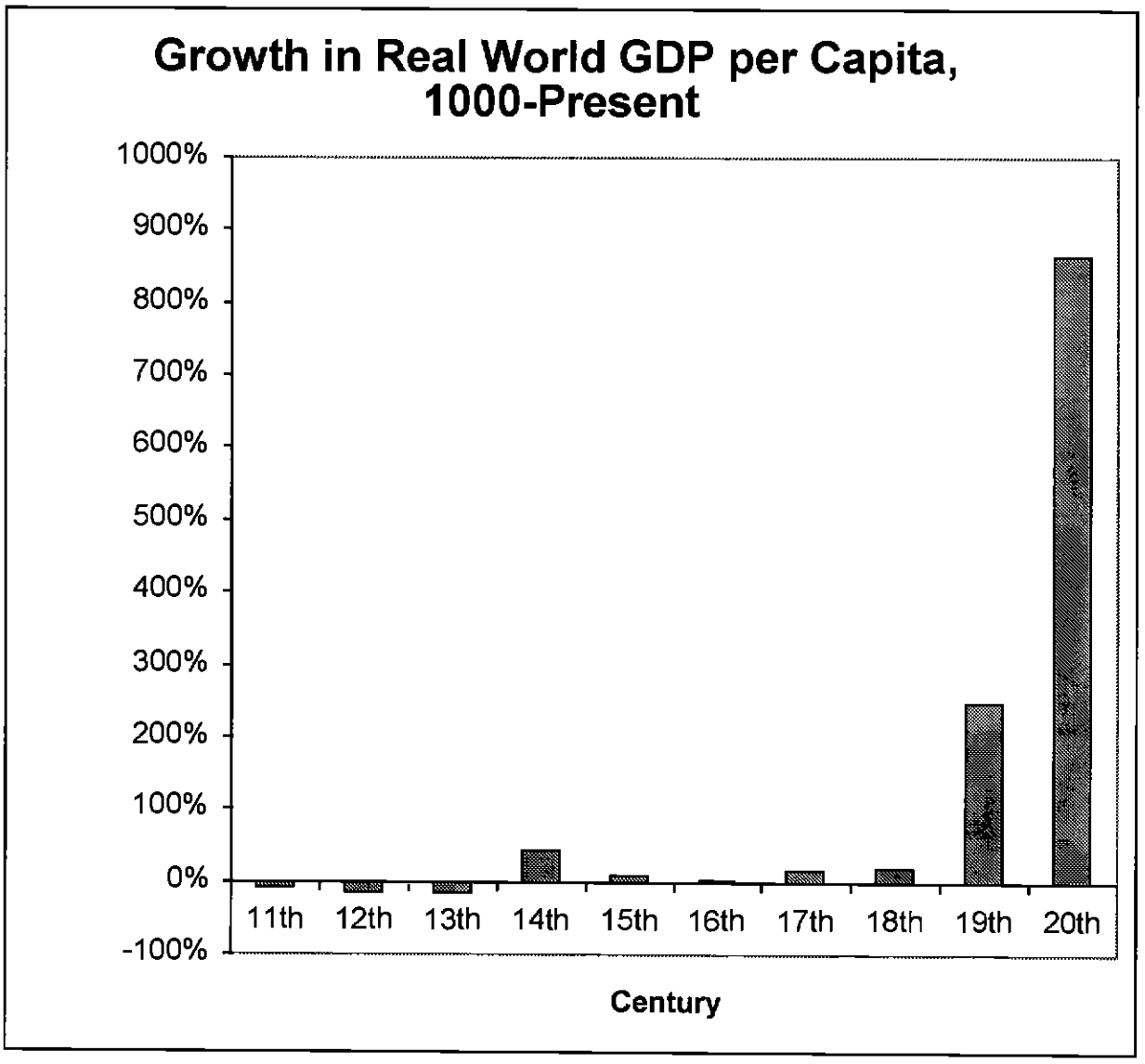
[30] See Moses Finley (1985), *The Ancient Economy* (Berkeley: University of California Press: 0520024362). One change between his day and Thomas Jefferson's might well have struck Cicero as amazing and wonderful: printing. Printing technology might have been enough to create a sense of a qualitative change in the order of life. For Cicero acquiring one copy of one book involved two months' worth of copying labor by a literate slave, an amount of labor that we would value at perhaps $4,000 dollars compared to the $10 price of a trade paperback book today; we today find the real price of books in terms of human labor to be 1/400 of what it was for Cicero, and even in Jefferson's day the real price of books had already fallen to perhaps 1/50 of what it had been at the beginning of the Roman Empire. See Elizabeth Eisenstein (1993), *The Printing Revolution in Early Modern Europe* (Cambridge: Cambridge University Press: 0521447704). Printing made possible macrohistorical events like the Reformation and the Scientific Revolution. It also made it possible for a person to earn a living as an author: see Lisa Jardine (1995), *Erasmus, Man of Letters: The Construction of Charisma in Print* (Princeton: Princeton University Press: 069100157X). And it made it possible for individuals to own enough books to construct their own virtual reality chamber. See Niccolo Machiavelli to Francesco Vettori, December 10, 1515, in James Atkinson, ed. (1996), *Machiavelli and His Friends: Their Personal Correspondence* (David Sices, trans.) (Chicago: Northern Illinois University Press: 0875802109).

[31] So C. Knick Harley and N.F.R. Crafts have persuaded economic historians. See N.F.R. Crafts (1985), *British Economic Growth During the Industrial Revolution* (Oxford: Oxford University Press:



So slow was the pace of improvement that literary intellectuals in the first half of the nineteenth century debated whether this industrial revolution was worthwhile. Was it an improvement or a degeneration in the standard of living? And opinions were genuinely

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0198730675). Peter Temin, however, has cast some significant doubt on this conclusion. See Temin's 1997 "Two Views of the Industrial Revolution," *Journal of Economic History* 57:1 (March), pp. 63-82.

divided, with as optimistic a liberal as John Stuart Mill coming down on the "pessimist" side as late as the end of the 1840s.[32] The figure above shows—approximately—the relative pace of economic growth in productivity levels and material wealth for the world as a whole over the past ten centuries. The estimates are rough and approximate only. But the figure does not do violence to the *qualitative* picture of relative rates of economic growth over the past ten centuries. And in the leading-edge economies of Europe (plus the European-settled North American economies) the acceleration of growth into the twentieth century was an order of magnitude faster still.

2. Massive and colossal productive forces

In 1848, in the middle of the nineteenth century, before the industrial revolution proper had spread far from its original homes in Belgium and in the British midlands, a young German philosopher-turned-political activist marveled at the extraordinary pace of economic growth in his day. He saw it as a new historical epoch that was only a century old, and yet was opening wide the door to utopia. He saw the epoch as equivalent to that of Prometheus, the mythological Greek demigod who defied the chief god Zeus, brought knowledge of fire to humanity, and transformed humanity's condition.

[32] See George Boyer (1998), "The Communist Manifesto in Historical Perspective," *Journal of Economic Perspectives*. The fact that there can be a debate over whether the median standard of living rose or fell in the first half of the nineteenth century tells us that the pace of economic growth then must have been much slower than is has been since, either in Britain or elsewhere. There is no "standard of living debate" for the late nineteenth-century U.S., for mid twentieth-century Italy, or for late twentieth-century South Korea.

The young Karl Marx wrote that the economically ruling class—the capitalist class, the entrepreneurial class, the business class, the *bourgeoisie*—of this epoch was:

> ...the first to show what man's activity can bring about. It has accomplished wonders far surpassing Egyptian pyramids, Roman aqueducts, and Gothic cathedrals; it has conducted expeditions that put in the shade all former Exoduses of nations and crusades....
>
> [It has], during its rule of scarce one hundred years...created more massive and more colossal productive forces than have all preceding generations together. The subjection of nature's forces to man, machinery, the application of chemistry to industry and agriculture, steam-navigation, the railways, electric telegraphs, the clearing of entire continents for cultivation, the canalization of rivers, the conjuring of entire populations out of the ground—what earlier century had even a presentiment that such productive forces slumbered in the lap of social labor?

Karl Marx was dumbfounded at the pace of the economic transition he saw around him in the middle of the nineteenth century. Yet compared to the pace of economic growth in the

twentieth century, all other centuries—even the nineteenth century that so impressed Karl Marx—were standing still.[33]

[33] Karl Marx and Friedrich Engels (1848), *Manifesto of the Communist Party,* in Robert Tucker, ed., *The Marx-Engels Reader* (New York: W.W. Norton: 039309040X).

MEASURED REAL GDP PER WORKER

Year	Real GDP per Worker (2000$)
1890	13738.355
1891	14644.5276
1892	13669.0583
1893	12937.5563
1894	14181.8993
1895	13523.1137
1896	14490.2359
1897	14465.6027
1898	15412.8386
1899	15471.7483
1900	16861.4535
1901	16722.0454
1902	17200.3528
1903	16662.1965
1904	17600.2181
1905	19295.2626
1906	19200.0017
1907	17309.301
1908	19050.7212
1909	18896.4562
1910	19177.2424

1911	19670.9182
1912	20092.5419
1913	18204.3009
1914	18399.5885
1915	20606.4618
1916	19742.725
1917	20539.4018
1918	19930.068
1919	19878.4804
1920	19456.3087
1921	20284.3461
1922	22591.8576
1923	22875.1653
1924	23068.4126
1925	24172.0508
1926	23999.559
1927	23897.778
1928	24917.6593
1929	22198.6028
1930	20003.1108
1931	17124.5741
1932	16569.6418
1933	17637.2288
1934	18874.4947
1935	21305.2734

1936	22120.5391
1937	20900.6967
1938	22288.8411
1939	23766.9552
1940	27675.9101
1941	31956.7392
1942	35355.9812
1943	36010.2234
1944	33386.9019
1945	26779.4605
1946	29588.0454
1947	31199.5106
1948	31680.2439
1949	34863.5452
1950	36161.2036
1951	36994.8257
1952	37873.1038
1953	36792.5043
1954	38217.6335
1955	38406.0935
1956	38455.5642
1957	37566.7052
1958	39147.3771
1959	39392.4435
1960	39783.5604
1961	41197.5659
1962	42147.4061

1963	43673.3701
1964	45418.9074
1965	47243.0487
1966	47772.7888
1967	48912.4276
1968	49268.1325
1969	48298.5652
1970	48821.7682
1971	49918.6476
1972	51148.4694
1973	49538.7886
1974	47642.4325
1975	48651.992
1976	49592.9508
1977	50859.6237
1978	50754.118
1979	49349.616
1980	48979.1276
1981	46971.8951
1982	47863.0903
1983	50278.6464
1984	51120.1566
1985	51726.7783
1986	52615.0628
1987	53732.8151

1988	54874.3128
1989	55824.1065
1990	55582.0345
1991	54453.972
1992	55286.803
1993	55913.7448
1994	57211.1134
1995	57859.8766
1996	59145.2009
1997	60751.4333
1998	61814.2835
1999	63782.5085
2000	65034.965

REAL[?] GDP PER WORKER

Year		Real GDP per Worker (2000$)
1890	4573.10112	13738.355
1891	4923.73171	14644.5276
1892	4641.95103	13669.0583
1893	4437.692	12937.5563
1894	4913.4014	14181.8993
1895	4732.24796	13523.1137
1896	5121.64171	14490.2359

1897	5164.32086	14465.6027
1898	5557.79163	15412.8386
1899	5635.10439	15471.7483
1900	6202.98209	16861.4535
1901	6213.5223	16722.0454
1902	6455.48329	17200.3528
1903	6316.35605	16662.1965
1904	6738.9983	17600.2181
1905	7462.26961	19295.2626
1906	7500.05512	19200.0017
1907	6829.44893	17309.301
1908	7592.07513	19050.7212
1909	7606.28136	18896.4562
1910	7796.88491	19177.2424
1911	8077.97574	19670.9182
1912	8334.04304	20092.5419
1913	7626.72007	18204.3009
1914	7786.0082	18399.5885
1915	8807.50947	20606.4618
1916	8523.14215	19742.725
1917	8956.19148	20539.4018
1918	8777.83283	19930.068
1919	8843.10236	19878.4804
1920	8742.28305	19456.3087
1921	9205.94491	20284.3461

1922	10356.2433	22591.8576
1923	10591.5005	22875.1653
1924	10788.3221	23068.4126
1925	11418.0683	24172.0508
1926	11450.5235	23999.559
1927	11516.5541	23897.778
1928	12128.7269	24917.6593
1929	10913.8142	22198.6028
1930	9933.25087	20003.1108
1931	8589.27656	17124.5741
1932	8394.46211	16569.6418
1933	9025.12127	17637.2288
1934	9755.30779	18874.4947
1935	11122.328	21305.2734
1936	11663.9927	22120.5391
1937	11131.5397	20900.6967
1938	11990.1581	22288.8411
1939	12913.7958	23766.9552
1940	15188.8615	27675.9101
1941	17714.4925	31956.7392
1942	19795.7561	35355.9812
1943	20364.6974	36010.2234
1944	19070.901	33386.9019
1945	15450.4047	26779.4605
1946	17242.3818	29588.0454
1947	18364.187	31199.5106
1948	18834.556	31680.2439

1949	20935.4048	34863.5452
1950	21932.8786	36161.2036
1951	22664.0067	36994.8257
1952	23435.2477	37873.1038
1953	22995.3986	36792.5043
1954	24126.167	38217.6335
1955	24488.8064	38406.0935
1956	24766.7839	38455.5642
1957	24437.4834	37566.7052
1958	25721.6596	39147.3771
1959	26142.805	39392.4435
1960	26667.718	39783.5604
1961	27893.0952	41197.5659
1962	28822.9845	42147.4061
1963	30166.696	43673.3701
1964	31687.6965	45418.9074
1965	33291.6137	47243.0487
1966	34003.2533	47772.7888
1967	35164.3051	48912.4276
1968	35776.0069	49268.1325
1969	35424.4356	48298.5652
1970	36168.0554	48821.7682
1971	37352.3053	49918.6476
1972	38657.1816	51148.4694
1973	37816.8954	49538.7886

1974	36734.7731	47642.4325
1975	37890.2094	48651.992
1976	39011.1968	49592.9508
1977	40409.68	50859.6237
1978	40731.1338	50754.118
1979	40002.0212	49349.616
1980	40100.7181	48979.1276
1981	38843.8377	46971.8951
1982	39978.6136	47863.0903
1983	42418.325	50278.6464
1984	43561.7239	51120.1566
1985	44521.6507	51726.7783
1986	45741.3382	52615.0628
1987	47182.5394	53732.8151
1988	48669.1495	54874.3128
1989	50009.1401	55824.1065
1990	50292.7046	55582.0345
1991	49767.1832	54453.972
1992	51036.1516	55286.803
1993	52133.6301	55913.7448
1994	53879.3975	57211.1134
1995	55038.0171	57859.8766
1996	56826.0844	59145.2009
1997	58955.9571	60751.4333
1998	60590.2787	61814.2835
1999	63147.8619	63782.5085
2000	65034.965	65034.965