

Growth in the World Economy, ca. 1870–1990

J. Bradford De Long

NBER and Harvard University

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The twentieth century has seen material wealth grow at a pace unmatched by any previous century. Even the fastest-growing regions over the century from 1750 to 1850--the century economic historians have traditionally called the century of the "industrial revolution"--did not come close to matching the twentieth-century pace of productivity growth in today's advanced industrial economies. In the first section of this paper I try to describe the magnitude of the twentieth century explosion of material wealth, for today we often take too much for granted and lack a sufficient sense of awe and wonder at how extraordinary twentieth-century economic growth has been.

The rapid multiplication of material wealth in the twentieth century has been accompanied by substantial growth in relative inequality across nations. The rich

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have gotten much richer. The poor have also grown richer, but have on average shown no sign of catching up to the rich. For economists this increase in the relative spread of productivity levels and living standards across nations is a surprise. There is a very strong theoretical economic logic that leads us to expect "convergence" of living standards and productivity levels.

Knowledge and use of modern machine technologies are the principal resources that make the industrial west today so rich. For the most part, these technologies are "public goods." The material benefits from taking advantage of the base of technological knowledge developed since the industrial revolution are so enormous that governments and entrepreneurs in poor economies should be straining every nerve to learn how to adapt and use modern machine technologies. As those in poor economies learn to draw on the open storehouse of the technologies that have made the modern west so rich, we should see "convergence" in productivity levels and living standards. But in the second section of this paper I demonstrate that we see few signs of such "convergence" over the past century.

In the third section of this paper I argue that the failure of "convergence" has as its proximate causes the failure of relatively poor nations to on average invest in the imported machinery that embodies much industrial technology and in education to a sufficient extent, and the failure of poor nations to rely sufficiently on market forces in organizing their economies. I argue that low rates of investment in physical and human capital are principal sources of slow growth, and that the forces making for convergence--while strong--have been masked by the inability of poor nations on average to invest on a sufficient scale and to make proper use of market institutions.

I observe in the conclusion that this gives us hope that the future shall see the world's economies draw closer together in productivity levels and living standards. For by and large the proximate causes of slow growth--failures to invest and to make

use of market institutions--can be traced to inappropriate policies and ideologies. Such policies and ideologies were themselves largely derived from a misreading of nineteenth and early twentieth century experience. Thus there is reason to hope that in the future the governments of developing countries will not make the mistakes of the past, and that the economic logic of "convergence" will dominate in the future even though it has been masked in the past.

I. Twentieth-Century Growth

The Multiplication of Wealth

The level of material wealth--economic output per worker²--in the United States in 1991 is nearly eight times what it was back in the middle of the nineteenth century. As measured by historical national income and product accounts, productivity levels and living standards in America over the past century or so have doubled every forty years. This pace of advance in material prosperity is historically unprecedented. Even the century 1750–1850 of the first industrial revolution saw average productivity levels in the British economy at most double. Still earlier centuries saw at best a slow upward drift in productivity: doubling times were measured in centuries or millennia rather than decades, and each century almost as likely to see productivity and living standards fall as rise.

Figure 1

²Output per worker is a more appropriate measure than output per capita. The number of children a family has is for the most part a choice: leaving to one side issues of the distribution of power within the household, does a family really reduce its economic welfare when it chooses to have another child? Adults who are not in the paid labor force are for the most part producing economic goods and services that are not counted in measures of GDP. Their productivity in these activities is sufficiently high that the option of joining the paid labor force does not seem sufficiently attractive.

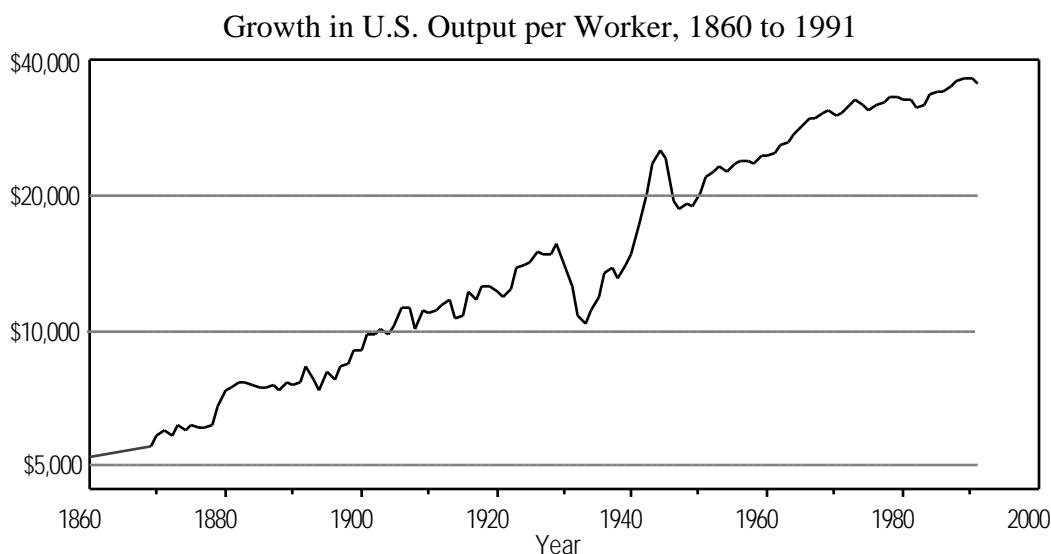


Figure 1 plots estimates of the upward advance of American output per worker, denominated in dollars of 1991 purchasing power, over the past century and a third.³ The pace has been uneven, with output per worker falling in "normal" recessions, in the extraordinary episode of the Great Depression, and after 1945 as America stands down from its mobilization for World War II. But the upward trend has been irresistible: by 1900 material output per worker was twice what it had been in 1860, by World War II it was twice what it had been in 1900, and by 1990 it was twice what it had been in the aftermath of World War II.

Moreover, the United States (along with the other English-language settler economies) was a very rich economy in the nineteenth century, and so has experienced less of a proportional multiplication of productivity levels and living standards than the currently-industrialized nations of Europe. For the twelve non

³The estimates of real national product underlying figure 1 are, for the first half of the period, Romer's (1989) revisions of Kuznets' estimates, and for the second half of the period the official real national product estimates in 1982 prices. Real national product is then divided by the full-employment labor force interpolated through the decade benchmarks given by Maddison (1991), and adjusted for differences in unemployment rates at different decade benchmarks.

English-speaking nations in Maddison's (1982, 1991) sample of sixteen currently-industrialized economies, the multiplication of material wealth over the past hundred and twenty years indicated by historical national income and product accounts has been by a factor closer to twelve than to eight. And Japanese national income accounts suggest levels of output per worker today some twenty-five times those of the mid-nineteenth century.

Economic historians have identified many powerful and sufficient reasons for this explosion of material wealth to have as its center northwestern Europe.⁴ The development of European science laid key foundations for the creation of industrial technologies. Habits of investment and "ethics of accumulation" derived from European culture and values aided the process of development in Europe. The self-governing European city provided, for the first time in history, a political structure ruled by merchants with the objective of increasing trade and economic activity rather than by nobles or bureaucrats with the objectives of maximizing plunder or rent. Competition among European states, each keenly aware that its success in state-vs.-state competition depended on a strong economy, also played a role. Also important were the concepts of private property and limited jurisdiction that grew out of Roman and feudal legal systems and that greatly restricted the ability of rulers to appropriate wealth.

Economic historians have fewer good explanations of why it was the nineteenth century that saw the "industrial revolution" fuse lit that led to the twentieth century explosion of wealth. Looking back thirteenth- or fifteenth-century Italy, or seventeenth-century Holland, appears in many ways to lay as good foundations for an industrial revolution as eighteenth-century England. I lean toward explanations of England's central role that rely on chance and politics: in

⁴See, for example, Jones (1981), Landes (1969), or Mokyr (1990).

Italy the thirteenth century was followed by the Black Plague, and the fifteenth century was followed by the projection of military power into Italy by the new Spanish and French absolutist monarchies; Holland was drained of resources in the seventeenth and eighteenth centuries by its necessary defense of independence against Habsburg and Bourbon armies; England was an island. But why the industrial revolution was a nineteenth-century phenomenon--and not a seventeenth or a twenty-first--remains an unsettled and very difficult question.

Comparisons

How to put such enormous upward leaps in material wealth in their proper perspective?⁵ One approach is to compare an economy's upward trend over time of income and wealth with its internal distribution of income at a point in time. In the United States today the poorest fifth of the population have approximately one-quarter the average income, and the richest fifth approximately twice the average income. If one is willing to compare incomparables, one way to read figure 1 is as showing that the average American today lives as well in terms of material prosperity as an average upper-class American in the top fifth of the income distribution lived in 1940. The poorest fifth of Americans today live as well--in terms of material prosperity--as the average American of 1900, or as well as an upper-class American of 1860. According to the national income accounts working-poor Americans today are as well off in a material sense as were the Harriet Beecher Stowes and the Abraham Lincolns of the mid-nineteenth century. And the gap between the material living standard of the average American today and of the mid-nineteenth century is roughly the same as the gap between the top and bottom

⁵Still very good as a placing of the long-run into its proper perspective is Keynes (1931).

quintiles of the income distribution.

In at least one dimension, such calculations understate the relative income gap. Both rich and poor today receive the same "public goods": they benefit from the same public health programs--the gap in life expectancy between rich and poor today is much less than the gap in life expectancy between now and then--from the same subsidies to public transport. They benefit unequally from public provision of education, but the distribution of education across wealth classes today much more equal than its distribution across time.

Shifting Relative Prices

Along another dimension, such calculations are simply not possible. They pay no attention to index number problems. Transforming the 1.75 percent per year growth rate of output per worker into a multiplicative factor of eight, and thus claiming that the average American worker in 1860--with an income in 1860 dollars of about \$280 per year had a standard of living equivalent to that possible on \$5,000 per worker today, is a very hazardous exercise. One dollar then would not buy what 17.5 dollars today will buy--it would buy much more of some things, much less of others, and nothing at all of entire classes of commodities we take for granted in day-to-day life. Along with the eightfold multiplication (according to the historical national income accounts) in living standards have come large shifts in relative price structures.

Table 1
Prices 1895–1990, According to the 1895 Montgomery Ward Catalogue⁶

⁶I owe my knowledge of this source, Montgomery Ward (1969) to Baumol, Blackman, and Wolff (1989).

Item	Price 1990	Price 1895	Ratio of Time to Produce in 1895 to 1990	
Hand mirror	\$1.50	\$0.75	60	
Bicycle	\$150	\$66	44	
Watch (inexpensive)	\$15	\$5.22	35	
Dinner set (stoneware)	\$75	\$11	15	
Frying pan	\$8.50	\$1.20	14	
Wooden bookcase		\$60		10
paperback novel, <i>Looking Backward</i>	\$3.50	\$0.33	9.3	
Wool suit (inexpensive)	\$150	\$10	6.7	
Cane rocking chair		\$35		5.7
Baseball glove	\$25	\$0.75	3.0	
Steinway piano	\$23,000	\$600	2.6	
Sterling silver teaspoon	\$70	\$0.63	0.9	
Approximate national product per worker	\$50,000	\$500	1.0	

Table 1 reports the prices of some more-or-less representative commodities then and now. Column 1 reports the price of a commodity in 1990 at the Arsenal Mall in Watertown, Massachusetts.⁷ Column 2 reports the price of the same commodity--or of an approximate substitute--as given in the 1895 Montgomery

Especially worth reading is the introduction by Boris Emmett.

⁷Or another Boston area location when the commodity in question could not be found at the Arsenal Mall.

Prices as given in the Montgomery Ward Catalogue are representative of prices in the turn-of-the-century U.S. At the turn of the century Montgomery Ward was the largest mail-order business in the United States, supplying rural and small-town households around the country with goods produced in America's factories. Montgomery Ward was big business: fully half of Americans then still lived on the farm or in very small towns. The shops and stores of the big cities were much less convenient than the regular arrival of the mail-order catalogues. Shipping by mail from centralized warehouses, companies like Montgomery Ward were willing to supply goods ranging from sterling silver teaspoons to sets of the Encyclopedia Britannica to drill presses.

Prices at the Arsenal Mall are relatively representative of prices in the late twentieth century U.S. The mall is not patronized primarily by high-income urban and suburban groups, but by blue- and white-collar workers from middle-income Brighton and Watertown. The brands of goods it sells are for the most part standard, nationally advertised brands. Lower middle-class malls like the Arsenal Mall do stand in approximately the same position in retail distribution today as did the Montgomery Ward Catalogue at the end of the last century.

Ward *Catalogue*. Column 3 shows the proportional shift in the price using the average worker's daily productivity as numeraire. It answers the question: how much more time did it take an average worker to produce the commodity in question in 1895 than today.

In table 1 products are listed in order of their relative price decline over the twentieth century. For the first item on the list--a hand mirror--the relative price in 1895 is 41.5 times the relative price in 1990 (with the value of an average worker's daily labor power as numeraire). For the last item--a sterling silver teaspoon--the relative price in 1895 is 0.74 times the relative price in 1990: a sterling silver teaspoon (bought through Montgomery Ward) is a smaller proportion of nominal GDP in 1895 than (bought at the Arsenal Mall) it is in 1990.

Near the top of table 1 is a one-speed bicycle, costing \$65 if ordered from Montgomery Ward in 1895. This sum is approximately 13 percent of national product per worker in 1895: it took about 1 1/2 months of the average American worker's labor power in 1895 to buy a one-speed bicycle.⁸ Today a bicycle of somewhat higher quality can be bought for \$150, only 1/3 of one percent of total national product per worker in 1990. On the bicycle standard--measuring wealth by counting up how many bicycles it can buy--Americans today are not 8 but 44 times as rich as their predecessors were even at the end of the nineteenth century.

Other commodities would tell a different story. Measured by the yardstick of Steinway pianos, output per worker today is only two and a half times what it was in 1895. To the extent that one's reference bundle of goods contains a large proportion of mass-produced manufactures, the eightfold multiplication in measured real GDP per worker since the mid-nineteenth century understates the

⁸Note that wages are approximately one-third smaller than national product: a bicycle thus cost 1 1/2 months' worth of an average worker's production, and approximately 2 1/4 months' worth of an average worker's wages.

growth of material wealth. To the extent that one's reference bundle of commodities is weighted toward services--measures wealth by how many butlers one can hire or the how many products made by skilled craftsmen one can buy, the eightfold multiplication overstates the growth of material wealth.

Wealth and Power

We economists should perhaps take valuations that place high weight on services more seriously than we tend to. Economists by and large reject the belief that the best use of wealth is hiring butlers--that at bottom wealth is the power to command *people*, and not the power to purchase commodities or to manipulate nature. But many others do believe that the principal use of wealth is to exact deference and obedience from others. And from a viewpoint that focuses on the ability to exact deference and obedience from others, the increases in wealth of the twentieth century seem less important.

A small detail from George Orwell's *The Road to Wigan Pier* (1936) is revealing. Orwell is arguing that the capitalist system has failed Britain's middle as well as its working class. In Orwell's view, the British system has failed the middle class because by depriving them of their capability of consuming the traditional services that mark them as members of the British elite. Orwell writes, as a member of what he calls the "lower upper-middle class," that in Britain after World War I:

[Y]our gentility was...theoretical.... [Y]ou knew all about servants and how to tip them, although in practice you had one or, at most, two resident servants. Theoretically you knew how to wear your clothes and how to order a dinner, although in practice you could never afford to go to a decent tailor or a decent restaurant.

Orwell believes that such a "shabby-genteel" household--unable to employ more than two live-in servants--has "far more consciousness of poverty than...any working-class family above the level of the dole."

From today's perspective Orwell's point of view seems alien: why should people feel themselves impoverished because they can only afford to employ two live-in servants? But Orwell does feel impoverished. The long-run rise in the relative wage of unskilled labor means that he and his class cannot command deference, obedience, and subservience from the unskilled on the scale they believe it is necessary for English gentlemen to do. Orwell in 1936 can acquire and make use of any number of new and relatively cheap industrial commodities that his grandparents could not, but from his perspective this is less important than the loss of the ability to command respect and deference by employing the unskilled as servants.

As the prices of mass-produced manufactured goods have fallen much, much more than the prices of goods that require the time and effort of skilled workers, the distribution of consumption has shifted toward goods largely made by machines, and away from craft goods and necessities. In 1850 there were approximately two farmers for every non-farming family in the United States. Today there is only one farm for every thirty non farm households. The balance between production and distribution has changed as well. Today the United States has more people employed selling cars than making them. Assembly-line workers are a smaller part of the total automobile production and distribution workforce than are the employees of the distribution channel.

Perhaps most important of all, the balance between work done within and without the household has also undergone a profound shift. A secular reduction in fertility and an expansion of household technology--microwaves, dishwashers, washing machines, dryers, vacuum cleaners, improved chemical cleansing

products, and so on all--imply that less of total social work has to be devoted to within-household tasks. Maintaining a nineteenth century, high-fertility household was much more than a fulltime job. Large reserves of labor--overwhelmingly female--that had in the nineteenth century and before been tied to the household is today free for other uses.

Such large shifts in the sectoral patterns of production and consumption make it impossible to come up with unambiguous and certain estimates of the multiplication of material wealth. The eightfold multiplication shown by the national income and product accounts is an average. But it is hard to have much confidence that the appropriate average really is an eightfold, and not a fourfold or a twentyfold, multiplication. And for methods of comparing wealth then and now that rely on linked intermediate comparisons it is hard to have much confidence that one's evaluation is insensitive to the particular intermediate links chosen.

New Types of Commodities

Along yet a third dimension, the eightfold multiplication found by compounding growth rates from national income accounts is almost surely a significant underestimate. The past century has seen not only dramatic reductions in prices of existing commodities but the invention of completely new types of commodities. The historical national income accounts cope reasonably well with increases in the productivity of those making standard, traditional commodities. But they do not adequately capture increases in wealth arising from the invention of radically new commodities.

For one example of such a "product" innovation that largely escapes measurement, consider a passage from Edward Bellamy's (1887) *Looking Backward 2000-1887*, perhaps the most influential Utopian novel of late nineteenth-century

America. Bellamy gives only one example of the technological marvels of his Utopia, devoting one-thirtieth of his book to a description of listening to music in the year 2000. His protagonist, a visitor from the long-dead world of 1887 in the society of 2000, is surprised to find his guide "merely touched one or two screws [and the room was] filled with...music.... 'Grand!' I cried.... 'Bach must be at the keys of that organ; but where is the organ?'" His host replies that the music is played in one of four "music rooms...connected by telephone with all the houses of the city....[A]ny one of the four pieces now going on... you can hear by merely...connect[ing] your house [telephone] wire."

Bellamy's observer is stupefied:

It appears to me..." he 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...

"The limit of human felicity" is attained by the ability to receive any one of four audio channels--not even in stereo--over a speakerphone. This is Bellamy's touchstone for the technological marvels of Utopia, one that he believes will be a significant improvement in the quality of human life. But when we read this passage from Bellamy, we are no impressed but amused: compared to the capabilities and powers that we have as products of our entertainment industry today, Bellamy's Utopia appears able to provide pitifully little.

Edward Bellamy was not an unimaginative man: he was a writer of Utopian novels. In Bellamy's day the experience of listening to performances by professional musicians was an expensive luxury. The extension of the capability of consuming this luxury to the population at large was, for Bellamy, a major improvement in

human welfare. But in our civilization listening to the performances of professional musicians is almost as cheap and common as breathing air, or drinking water.

This is perhaps the most impressive and wonderful aspect of twentieth century economic growth. Goods and services that once took immense labor and resources to provide are now so cheap as to be commonplace background. If Bellamy could see us today, he might see us more or less as we would see a society where each household has goods we regard as rare and expensive--bushel baskets filled with gem-quality diamonds, room-temperature superconductors, or life-prolonging pharmaceuticals--stored in basements because no one can think of a use for them. We can imagine such a society: we would think of it as one with wealth in quantities unlimited for all practical purposes. So those alive in the mid-nineteenth century would think if they could see us.

One way to try to quantify how much wealth has been increased not by cheaper but by new types of commodities is to value not a bundle of commodities but one of "capabilities":⁹ while the price of a Steinway piano has fallen only in half in relative terms over the past century, the cost of at least one of the major capabilities a piano was purchased to produce--the capability of hearing piano music in one's living room--has fallen by a factor more like 500, comparing the cost of a piano (and of training a pianist) now to the cost of our music-playback systems today.¹⁰

⁹See Sen (1987).

¹⁰The analogy is not exact. A CD player can do much more than play piano concertos. And the experience of listening to live is not the same as that of listening to recorded music. The capabilities are not identical.

In addition, some see drawbacks to the ability of the relatively poor today to consume "cheap luxuries." George Orwell, for example, is disquieted because he thinks that the poor are being exploited: the system is taking advantage of the relatively poor by enabling them to consume commodities that they think are luxuries, but that in fact are no longer so. While "whole sections of the working class...have been plundered of all they really need," there was little protest because they had been "compensated...by cheap luxuries which mitigate the surface of life": fish and chips, artificial-silk stockings, tinned salmon, cut-price chocolates, movies, radio, tea." Orwell is in the last analysis not pleased but upset by the fact that "the youth...for two pounds ten on [installments]...can buy himself a suit which...at a...distance looks...tailored on Saville Row. The girl can look like a fashion plate at

Thus a "capability"-based analysis would provide a much larger estimate of growth in material wealth than one based on the prices of bundles of commodities. But even an analysis that confines itself to the cost today of providing the capabilities of the mid-nineteenth century will be an understatement. Perhaps one-quarter of my waking hours are spent using commodities that provide me with capabilities it would have been impossible, or overwhelmingly costly to even approximately duplicate in any previous century.

The factor of eight suggested by the historical national income accounts--which suggest that a dollar in 1850 had, taking a rough balance of changes in relative prices, 17.5 times the purchasing power of a dollar today--is a considerable underestimate. I know that it would require considerably more than \$2,500 a year to make me think that a citizen of 1850 had "the same" material standard of living as is provided by my Harvard salary of \$45,000 a year today. But when I introspect, I find that I value the new capabilities that living at the end of the twentieth century has given me so much that I cannot determine what, or if any, level of wealth a century in the past would give me "the same" material standard of living.

II. Inequality Across National Economies

We are on shaky ground when we try to quantify the pace at which wealth has grown over the past century. We are on somewhat firmer ground when we attempt to assess relative degrees of inequality across countries in the world distribution of income at a single point in time. Differences in relative price structures are smaller.

an even lower price....[I]n your new clothes you can stand on the corner, indulging in a private daydream of yourself as Clark Gable or Greta Garbo..." It makes tolerable what Orwell believes should not be tolerated: that the upper class has too large a share of the pie.

Questions of relative wealth at a point in time have answers that are less ambiguous.

The Logic of "Convergence"

Economists tend to think--but perhaps the better word is "hope"--that differences in relative wealth levels across countries will decline over time. Consider John Stuart Mill (1848), writing in the middle of the nineteenth century. Mill looked out on a world where the industrial revolution had opened huge relative wealth gaps between northwest Europe and the rest of the world. But he hoped and expected this wealth inequality to be transitory. The spread of democracy, education, and liberalism would soon make the cruel and inefficient tyrannies that kept much of the world impoverished things of the past. Population pressure would cease to be an important cause of human misery with the spread of birth control. Resource scarcities would lose their significance with the advance of technology.

As Mill saw it, the wealth of England in the middle of the nineteenth century was based on its institutions and its technologies, and its political-economic institutions and industrial technologies were not private property: they were "public goods." Anyone literate could read about, and anyone could observe the workings of the processes that made the industrial west rich. The right metaphor to use in thinking about the sources of industrial wealth was not the metaphor of a secret recipe for prosperity, but the metaphor of a storehouse, at least potentially open to all, of technologies and techniques that had been and were being developed.

The material benefits from tapping this storehouse of industrial technologies and organizational techniques were and are enormous. Economists like Mill thought--and economists today think--that the benefits are so great that businessmen and governments in developing nations should be straining every

nerve to learn how to tap this open storehouse. Thus the economic logic behind the proposition that the world's economies should draw together in productivity levels is very powerful. Some economies are today better than others at adding to the store of technologies and techniques. And some are better than others at using the storehouse. But all should be trying very hard to learn, and as they learn their productivity levels will draw closer to those found in the world's industrial leaders.

In many ways, this optimistic forecast of "convergence" was correct. We can see the partial working-out of the process over the past century. The industrial revolution did give northwestern Europe an enormous edge in terms of productivity and technology. The technologies of the industrial revolution did diffuse (Pollard, 1982). Americans traveled to Britain, hired technologically-skilled workers, spied out factories, and successfully copied British textile technologies in their own factories in Pawtucket, Waltham, and Lowell. The flows of ideas, organizations, and machines across national boundaries, and the rises in productivity generated by this diffusion of technology have been principal features of twentieth century economic history.

Yet the distribution of the world's wealth between nations appears more unequal today than when John Stuart Mill wrote. This is not to say that poorly-performing economies have stagnated in absolute terms. Argentina, for example, has been one of the world's economic disappointments in the twentieth century. But in Argentina national product per worker today is perhaps three times what it was in 1900; only relative to growth achieved in today's in other countries has Argentina been a disappointment.

Very Long Run Patterns

Some idea of the increasing relative spread of output per worker levels--of the

growth in cross-country inequality--can be gained by figure 2, which plots estimates of 1870 levels of log GDP per capita and 1870–1989 growth rates of GDP per capita for thirty of the countries analyzed by Maddison (1989).¹¹ The estimates are approximate only, and must be taken with a great deal of salt.¹²

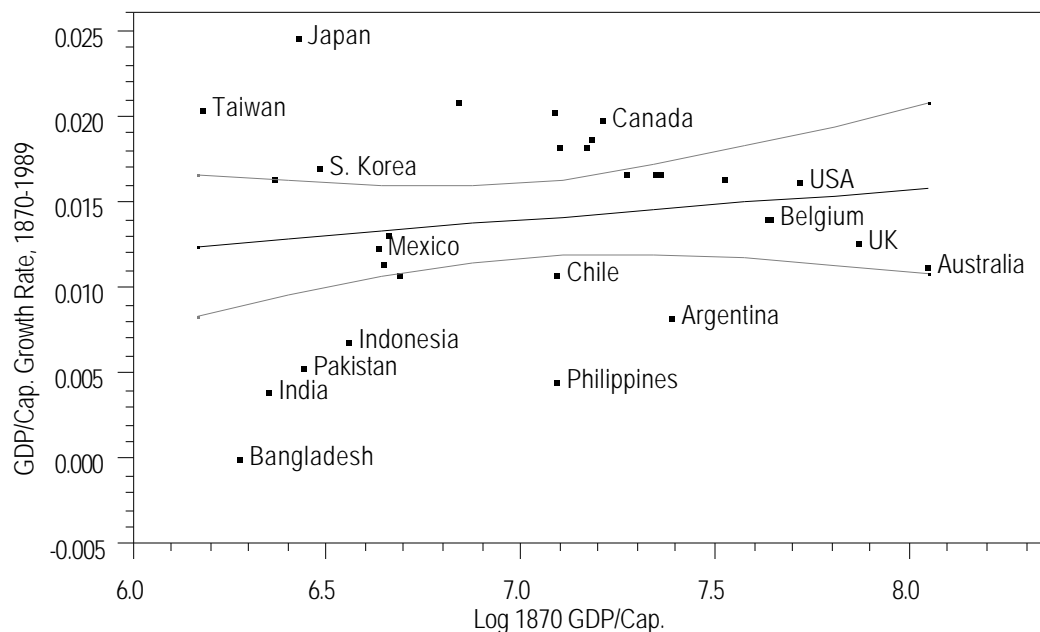
Nevertheless, the estimates in figure 2 show no sign of systematic "catch up": rather than the poor tending to close the relative income gap vis-a-vis the rich, the rich have tended to grow slightly faster than the poor. The regression line of 1870–1989 growth on initial 1870 levels has an upward slope, although as figure 2 shows the slope is not statistically different from zero.

Another way of reaching the same conclusion is to examine the standard deviation of log GDP per capita: approximately 0.52 in 1870, yet 0.97 today. There has been an approximate doubling of the relative spread of output per capita levels over the past century, at least in this sample and according to this set of estimates.

Figure 2
1870–1989 GDP per Capita Growth Rates Plotted Against Estimates of 1870 GDP per Capita Levels

¹¹Estimates are of output per capita and not output per worker because estimates of labor force for some observations are very uncertain.

¹²Estimates of GDP per capita and growth rates from Maddison (1989 and 1991), with growth from 1870 to 1900 for countries not included in Maddison's (1991) sample of sixteen currently-industrialized economies estimated from a preliminary regression of cross-country pre-World War I output growth patterns on export volumes. See Hanson (1980, 1991).



Note that convergence fails to appear even though figure 2 includes no countries that underwent the bloody twentieth-century experiments of communist rule. The human cost of such régimes is well known. The narrow material cost in terms of foregone production and growth can be gauged by looking across the borders of what used to be the communist sphere at neighboring economies that were similar before communist rule. Comparing Western to Eastern Germany, Austria to Hungary, Greece to Bulgaria, the Philippines to Vietnam, Taiwan to China, or South Korea to North Korea, suggests that communist rule destroys somewhat more than seventy-five percent of potential wealth. And few claim today to know what steps to take to quickly repair the damage. Over the course of the twentieth century communism has been a major factor making for divergence: making nations that were relatively poor poorer even as the rich industrial economies have grown richer.¹³

¹³Bergson (1961) remains the foundation for work attempting to quantify the pace of growth under Stalin and his successors.

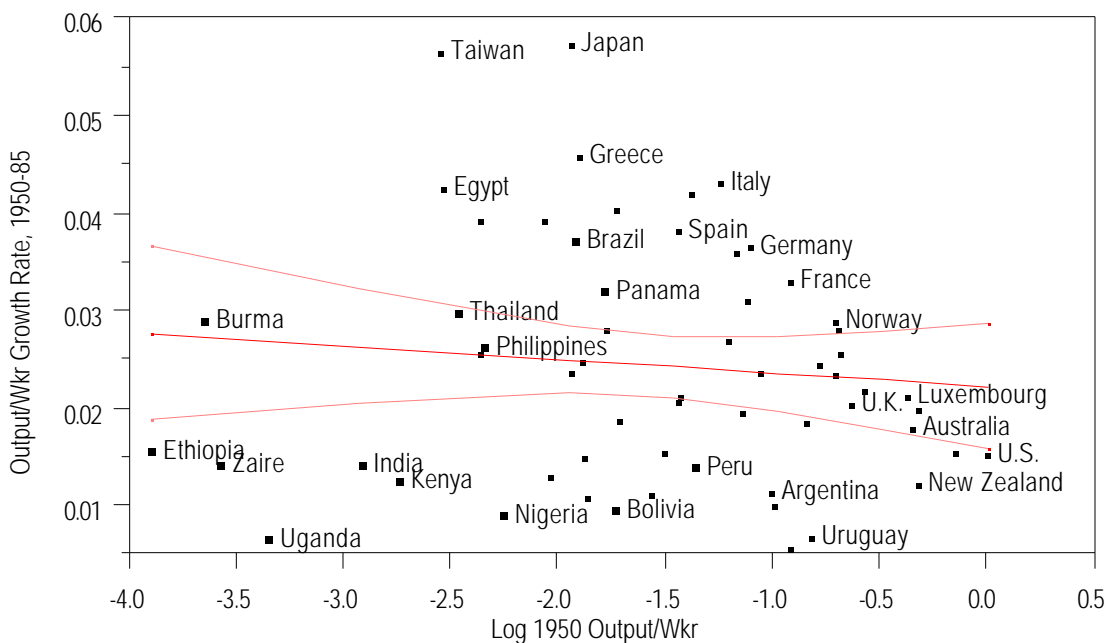
The failure of figure 2 to suggest convergence is especially striking because the methods by which estimates of 1870 relative productivity levels were constructed almost guarantees a bias toward convergence. Past estimates of productivity levels are derived by backward extrapolation from present-day benchmarks using growth rates. Any errors in measuring growth rates thus appear as equal and opposite errors in levels estimated for the distant past.

The Post-World War II Era

One possibility is that the horrible political history of the twentieth century is a principal cause of the failure of convergence. One might expect a general era of peace and growth to see technology and capital flow to poor and labor flow to rich areas, even if such a process of diffusion broke down in eras of war and depression. Figure 3 provides some evidence that this is not the case: there is no more "convergence" in the relatively peaceful post-World War II era than over the twentieth century as a whole.

Figure 3 plots growth in GDP per worker from 1950 to 1985 against the log of 1950 GDP per worker, using Summers and Heston's (1991) estimates of relative productivity levels in common prices corresponding to the average of those found in the world in 1985. In figure 3 there is a very small tendency for the poorer economies to grow faster than and "catch-up" to the richer, but even if this tendency works undisturbed it appears so weak that it will take a thousand years for the poorer nations to catch up to the richer.

Figure 3
Output per Worker Levels in 1950 and Growth, 1950–85



Growing relative inequality across nations is not yet cause for despair: as best as Summers and Heston can measure, average material living standards in even poorly-performing countries are for the most part still growing from generation to generation at a pace faster than that of any century before the nineteenth. But the failure of convergence to take hold is certainly cause for dismay. And for economists it is cause for puzzlement: the logic of convergence is as clear in theory as its failure to take hold is clear in practice.

III. Proximate Determinants of Post-World War II Growth

One possible reason for "convergence to fail is that the forces working toward convergence--while strong--have been outweighed by other factors that have been unfavorable with respect to growth in relatively poor economies over the past

century. A second possibility is that convergence fails because the forces tending to generate it are weak. Perhaps the metaphor of the open storehouse of industrial technologies and techniques is misleading. Perhaps effective use of modern industrial technologies is impossible without a large number of tacit skills that can only be gained by experience working with modern technologies, and thus are only found in relatively rich nations.

Over the past century as a whole we lack the quantitative base of data to sort out which of these two possible reasons is in fact correct. In the post-World War II era, however, there is strong evidence supporting the first possibility: convergence fails because relatively poor nations have devoted on average small shares of national product to investment, and have on average made insufficiently strong commitments to education.

Growth, Machinery Investment, and Schooling since World War II

Table 2 reports cross-country regressions of GDP per worker growth over 1960–85, using Summers and Heston data, on the initial 1960 gap in output per worker vis-a-vis the United States--which measures the extent of the productivity gap to be closed through technological diffusion and convergence--and on four other proximate determinants of growth: the rate of investment in machinery and equipment as estimated by De Long and Summers (1992), the "human capital investment proxy"--enrollment in secondary school education--that Mankiw, Romer, and Weil (1992) used to argue that there was a strong relationship between education and growth, the growth rate of the labor force, and the rate of non-machinery investment.¹⁴

¹⁴Of all the estimates of the proximate growth factors, use of the secondary school enrollment rate as a proxy for human capital accumulation is surely the least satisfactory. This is the most distressing and

Table 2
Regressions of 1960–85 Output Growth on the Productivity Gap vis-a-vis the U.S., and
Proximate Determinants of Growth

Productivity Gap vis-a-vis U.S.	0.052 (0.010)	0.052 (0.012)	0.032 (0.008)	0.008 (0.009)
Machinery Investment Share	0.262 (0.051)		0.342 (0.049)	
Secondary School Enrollment	0.027 (0.009)	0.048 (0.010)		
Non-Machinery Investment Share	-0.002 (0.031)	0.009 (0.035)	0.048 (0.028)	0.117 (0.032)
Labor Force Growth Rate	0.148 (0.159)	0.205 (0.183)	0.018 (0.161)	-0.019 (0.201)
n	79	80	89	89
R ²	0.519	0.348	0.454	0.139
SEE	0.011	0.013	0.013	0.016

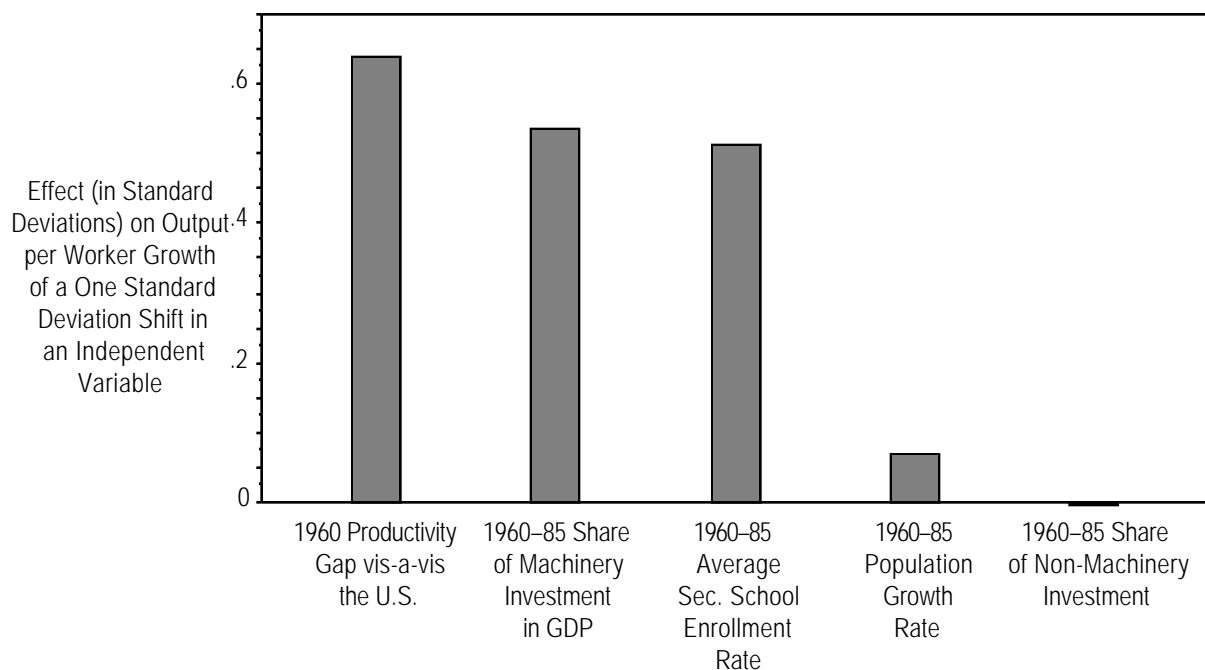
Table 2 shows that the gap in output per worker in 1960 (relative to the U.S. level, as a share of U.S. output per worker in 1960) is significantly associated with 1960–85 growth in GDP per worker when either the average share of GDP devoted to machinery investment over 1960–85 or the secondary school enrollment rate (or both) are also taken into account. A ten percentage point increase in the 1960 GDP per worker gap vis-a-vis the United States is associated with an acceleration of one-half a percentage point per year in the rate of output per worker growth. Over the twenty-five years 1960–85, this acceleration cumulates to a thirteen percent increase in 1985 output per worker.

damaging hole in our knowledge of the cross-country pattern of growth and its proximate determinants since World War II. Barro and Lee (1992; in preparation) are attempting the construction of better cross-country estimates of human capital accumulation rates.

Two of the proximate other determinants, the machinery investment rate and the secondary school enrollment rate, also have strong partial associations with growth. The associations of the three variables with growth are all approximately equally strong: figure 4 shows the relative power of these different factors calibrated in terms of standard deviations. A one standard deviation shift in the 1960 productivity gap vis-a-vis the United States is associated with an 0.64 standard deviation rise in output per worker growth; a one standard deviation shift in machinery investment carries with it an 0.54 standard deviation rise in output per worker growth; and a one standard deviation rise in secondary school enrollment carries with it an 0.51 standard deviation rise in output per worker growth.¹⁵ All three factors--the "catch-up" of productivity to levels of the rich nations, the rate of investment in machinery (and thus of the acquisition of the capital goods that embody much of modern industrial technology), and the rate of investment in formal education (and thus in the skills to handle modern literacy-requiring technologies)--are of roughly equal importance in accounting for differences in output per worker growth rates.

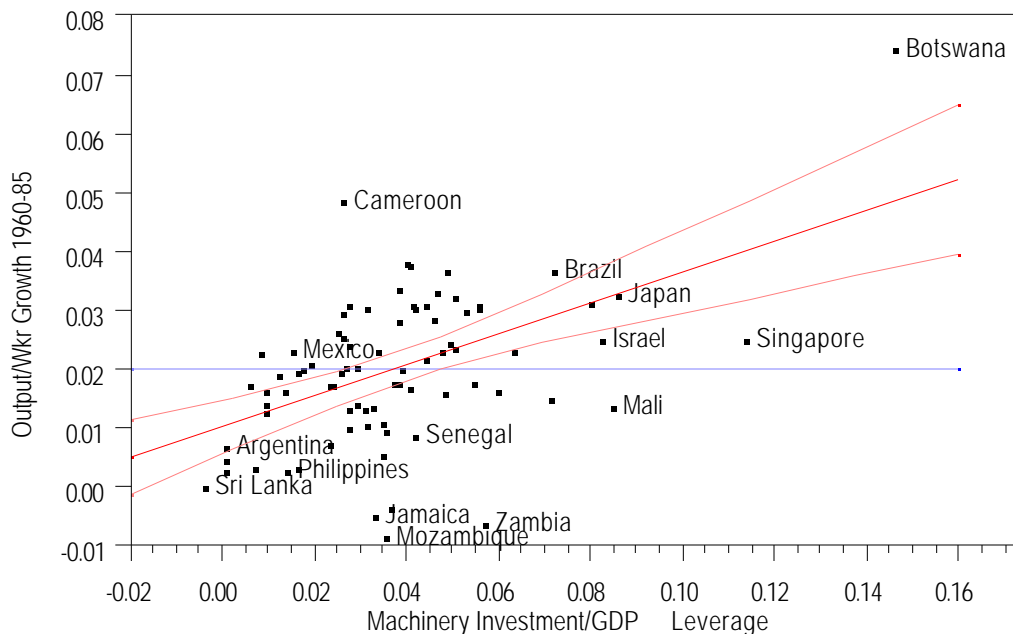
Figure 4
Effects of Different Growth-Related Factors, Calibrated in Standard Deviations

¹⁵The other factors in the regression--non-machinery investment and labor force growth--have little partial association with output per worker growth, controlling for the productivity gap, for machinery investment, and for school enrollment.



Figures 5 and 6 show the partial scatters of output per worker growth over 1960–85 on the one hand, and machinery investment (for figure 5) and secondary school enrollment (for figure 6) on the other. That is, the figures show the difference between machinery investment (or secondary school enrollment) and the value that one would expect given the values of the other independent variables, and the difference between the growth rate and the value one would expect given the other independent variables. The figures show not so much whether growth was high or low, machinery investment high or low, or secondary enrollment high or low. They show the "surprising" component of growth, investment, and enrollment given the values of the other independent variables not shown in the figures.

Figure 5
Partial Scatter of 1960–85 GDP per Worker Growth and Machinery Investment

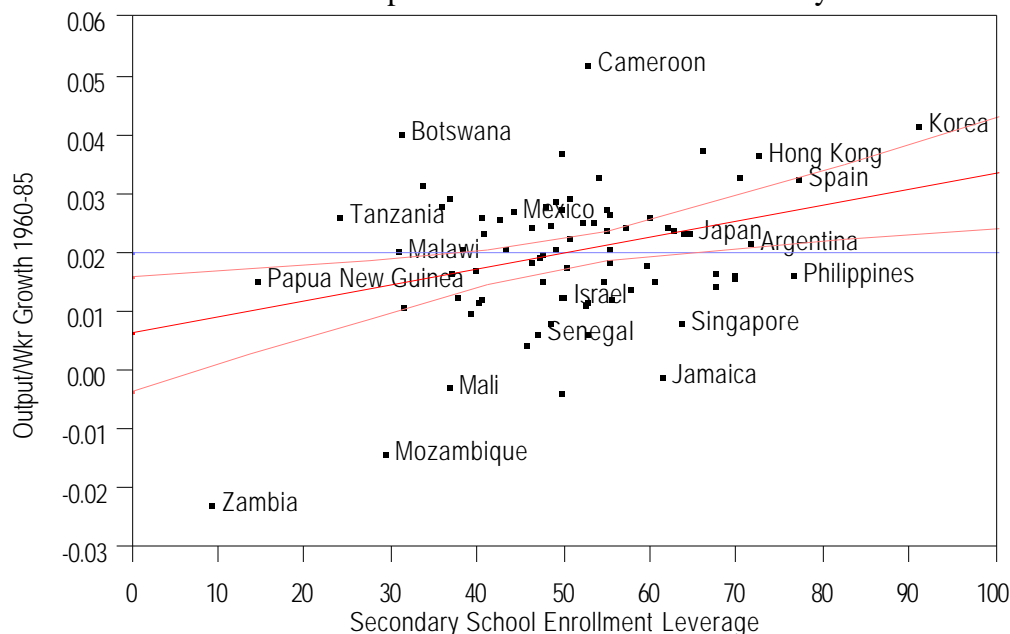


These partial scatter plots show point-by-point the influence of the observations generating the regression coefficients plotted in the first column of table 2. Important observations in producing a positive estimated association of machinery investment and output per worker growth include Botswana, Singapore, Japan, Israel, and Brazil--all with high machinery investment rates and high growth rates--and India, Sri Lanka, Argentina, Chile, Uruguay, and the Philippines with low growth and low rates of machinery investment.

A somewhat different set of economies are important observations for generating the close partial association of education with growth: Spain, Hong Kong, and Korea have higher than expected education rates and rapid growth, while African economies like Zambia, Mozambique, and Mali that have failed to achieve high rates of education have experienced low growth. Thus there appear to be two roads to relatively rapid (or relatively slow) growth: one requiring high (or low) machinery investment rates, and the other high (or low) rates of schooling.

Figure 6

Partial Scatter of 1960–85 GDP per Worker Growth and Secondary School Education Rates



Interpretation

It is tempting and natural to attribute a causal role to all of the important right hand side variables in the cross-country regressions shown in table 2. Education provides people with the literacy and the skills they need to be productive in modern industrial economies. Machinery investment is important as a way of giving workers the tools they need to achieve high productivity, and is perhaps more important as a carrier of embodied technology. And the larger the gap between a country's productivity level and the world's best practice, the faster it can grow as it acquires and adapts industrial technologies. Moreover, all three factors appear to be of roughly equal importance.

De Long and Summers (1991) argue that the partial association between growth and machinery investment does arise because high machinery investment caused rapid growth. The most convincing argument is simple supply-and-demand. If fast growth driven by other factors were the cause and a high rate of machinery

investment were the effect, it would be because fast growth raised the prospective profits of investing firms and thus increased firms' demand for machinery. If fast growth is the cause and high machinery investment the effect then fast growth, high machinery investment, and high machinery *prices* should all go together.

On the other hand, if a high rate of machinery investment is the result not of high demand but favorable supply and thus high machinery investment is cause and not effect, then rapid growth and high machinery investment would go not with high but with low machinery prices--as they in fact do. The pattern is consistent with the belief that machinery investment is a key factor in economic growth: the post-World War II cross-country pattern is consistent with the belief that investments in machinery--not necessarily other kinds of capital--yield social benefits by helping to increase the skills of workers and ability of firms to handle modern technologies that may amount to three times or so the extra private profits received by firms that invest in machinery and equipment.

The causes of high rates of machinery investment are for the most part straightforward. High machinery investment economies have a high rate of private savings, and for the most part offer savers reasonable returns. Their governments on average run surpluses or at worst small deficits, so as not to pull capital that would otherwise be devoted to investment into financing current government-funded consumption. Capital goods are relatively cheap and easy to purchase--and since even in rich economies a large proportion of capital goods are imported, low prices of capital goods are generally found only where tariffs are low and there are few non-tariff barriers restricting trade. Import barriers and export limitations have tremendously deleterious effects on machinery investment, either directly by making it difficult to acquire machinery from abroad, or by making it difficult to acquire the hard currency with which to purchase modern capital goods from the

industrial core.¹⁶

Powerful instruments for estimating the cross-country causal influence of education on growth are harder to find. But a large number of microeconomic studies suggest rates of return in the range of ten to twenty percent per year for individuals (Schultz, 1992). If such increases in private wages reflect social benefits from increases in education, then it is straightforward to interpret the partial relationship between education and growth shown in figure 6 as due to the causal influence of increased education rates on economic growth.

IV. Conclusion

If the twenty-first century sees an explosion of relative wealth as great as the twentieth century, our descendants a century hence will have a remarkable amount of power and wealth. Instead of GDP per worker levels of \$40,000 or so in whatever countries then comprise the core of the world economy, think of GDP per worker levels of \$300,000 or so. That \$300,000 will not buy much more than \$40,000 today buys of many commodities: it is difficult to believe that the prices of a barber's time, an oceanfront property, or a silver spoon will do anything other than rise at the rate of nominal income growth over the past century.

But the prices of the manufactured goods on which we spend such a large proportion of our incomes today will continue to fall. And incomes a century hence will allow the purchase of new types of commodities that will give our descendants capabilities as extraordinary in our vision as our consumer electronics industry

¹⁶See Lee (1992) and Warner (1991) for analyses of the very high share of machinery and equipment that is imported.

today would be in the eyes of Edward Bellamy. And expect those in my place a century hence to say that a factor of eight is insufficient to describe the multiplication of wealth in the twenty-first century--and that \$300,000 in 1990 would not give them a material standard of living equal to that enjoyed by the average worker in 2090.

This is in the way of an extrapolation, not a forecast. It assumes the future will be like the past in rates of change. While exponential growth in wealth is one possibility, it is not the only possibility. We can all imagine scenarios according to which the world at the end of the twenty-first century will be little if any better off than the world today.

If the regressions in table 2 can bear a causal interpretation, they suggest good news for the possibility of "convergence" over the next century. Governments that establish and maintain strong educational systems, and that support and encourage investment--especially in machinery--by entrepreneurs have found themselves with fast-growing economies in the past. The larger the productivity gap vis-a-vis the developed economies of the first world, the faster growth. The failure of convergence over the past century appears to reflect not so much the difficulty of acquiring modern technologies as the absence of the appropriate educational infrastructure, the presence of economic policies that discouraged investments in machinery (especially in imported capital goods that embody so much of modern industrial technologies), and the replacement of market-based by central planning-based economic systems.

The lack of educational infrastructure is slowly being made good. And the prospects for economic policies in developing countries that will rely on market institutions and encourage machinery investment are equally good. In large part, governments over the past fifty years have by mistake pursued policies based on central planning, on the closing of their economies to trade and capital goods

imports from outside, and on the premature establishment of protected heavy capital goods-producing industries.¹⁷ The major mistake has been the basing of policies on ideologies that themselves spring from misinterpretations of nineteenth and early twentieth-century experience.

Today such ideologies have much less of a hold than they did in the past. Few now point to the Great Depression, predict its imminent return, and argue that a policy of immediate import substitution is necessary. Few hold that the construction of capital goods-producing industries regardless of comparative advantage is a forward step in development. Few count the Soviet industrialization experience a success. And few believe, as Karl Marx (1867) did in the nineteenth century, that market economies are incapable of generating upward trends in real wages.

Governments in the future will no doubt make their own economic policy mistakes. But they will do so without the ideological support that has smoothed the path toward central planning, high tariffs, and an unwillingness to import capital goods in the past. We can perhaps look forward to a future in which developing economies devote more effort to machinery investment and education than they have in the past. Thus John Stuart Mill's relative optimism may be justified for our future even though his forecasts of his future were overoptimistic.

¹⁷See Bates (1981) for a very insightful study of the political economy of economic policy in sub-Saharan Africa.

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