

Economia Marche

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- **The Search for the Sources of Economic Growth**
- **The Great postwar catch-up Boom**

THE SEARCH FOR THE SOURCES OF ECONOMIC GROWTH

Lecture "Economía Marche 1992"

I

I want to talk to you today about the shifting, twisting path that economists have followed since World War II in their search for the causes of economic growth. I am not referring now the deeper, underlying causes, the economic institutions, the legal systems that control property relations or the cultural outlook that shapes the values and efforts of people. My concerns are with what one may call the "proximate" sources. John Stuart Mill put the matter in this fashion:

We may say, then... that the requisites of production are Labour, Capital and Land. The increase of production, therefore, depends on the properties of these elements. It is a result either of the elements themselves or of their productiveness.

(Principles, Ashley edition, p. 156)

Mill wrote in 1848, but this was still the view that the economists of 1948 held when, after a long period of neglect, they began again to be concerned with long-term economic growth. The economists' work since then has been governed steadily by Mill's general framework. What is striking, however, is how their emphasis has shifted from one of the elements to another and then back again. Right after the war, the emphasis fell heavily on investment and capital accumulation.

But then the emphasis shifted radically from capital accumulation to what Mill called "productiveness", but which we would now call "technological progress". And now the emphasis is shifting back to capital accumulation, a term whose meaning has now broadened.

It used to include only tangible capital - land, structures, machinery and so on. It now includes intangible capital, which means our cumulative net investment in education, research and similar investment in human skills and knowledge.

The first shift from capital accumulation to technological progress occurred in the late 1950s. It was caused at bottom, I believe, by a growing general impression about the speed of technological change. But for the economists, it followed the publication of articles by myself and by Robert Solow. Our papers appeared within a few months of one another, and they ushered in a long line of work that goes by the name of "growth accounting". Growth accounting aims to decompose the growth of national product into its elements, or "sources", just as John Stuart Mill might have done, and to give to each Source, Labor, Capital (including Land) and their "productiveness" a clear numerical measure.

I cannot go into the derivation of the model that lies behind such calculations. Let me just write down the final equation which is the basis for the empirical and historical work.

$$\frac{\Delta Y}{Y} = \alpha \frac{\Delta L}{L} + \beta \frac{\Delta K}{K} + \frac{\Delta A}{A}$$

This equation says that the relative increase in output during a period, or its growth rate, $\left(\frac{\Delta Y}{Y}\right)$ equals the sum of the growth rates of labor $\left(\frac{\Delta L}{L}\right)$ and capital $\left(\frac{\Delta K}{K}\right)$ when each is multiplied by a weight (α and β). The weights represent the increase in output attributable to a unit percentage increase in labor and capital, respectively. And these effects are measured — so the theory behind the model tells us — by the fractions of total output that come to labor and capital as their earnings — *provided* that their productivity has not changed. So the sum of the first two terms represents the contribution to the growth of total output that is made just by the quantitative growth of labor and capital. But, of course, productiveness does change. The first two terms do not exhaust the total growth of output. There is something left over. That is $\left(\frac{\Delta A}{A}\right)$. We now call it "total factor productivity", but a better name is just the Residual.

Needless to say, the basic equation can also be transformed to decompose the growth rate, not of aggregate output, but also

output per capita or output per worker (or per hour), that is, labor productivity. In the case of labor productivity, to which I refer later, this is the way it looks:

$$\frac{\Delta Y}{Y} = \alpha \frac{\Delta L}{L} + \beta \left(\frac{\Delta K}{K} - \frac{\Delta L}{L} \right) + \frac{\Delta A}{A}.$$

This says that the growth rate of output per worker equals the growth rate of capital per worker multiplied by capital's share of total income — plus, of course, the Residual.

Now when Solow and I came to make our calculations, we got very closely similar results. They seemed to show that over periods of over half a century — at least in the USA, at least in the present century — the combined per capita input of labor and capital accounted for only 10 percent of the growth of per capita output. Total factor productivity, or the Residual, appeared to be responsible for the remaining 90 percent. In terms of labor productivity the Residual accounted for about 80 percent, and the growth of capital per worker for only 20 percent.

All this was a surprise to me and, it seems, to most economists. After all, capital accumulation was a great subject in economics. In a vague way, we all thought it must play a large part in explaining growth, not just a small supporting role. So I thought we had hit on something new and substantial. But what exactly was it?

When I asked myself that question, I had no clear answer. What was this Residual, that seemed to hog the whole show? Technological progress was, of course a part of the Residual, and the Residual's large role fitted in nicely with a common intuition that such progress was an important source of productivity growth. Economists, therefore, has a tendency at first to identify that large Residual with the advance of technology. I had seen at once, however, and my paper had pointed out, that this Residual was a cover for many sources of growth besides technological advance, and some were clearly significant matters. So the Residual was really a grab-bag (*una mescolanza*).

For this, there were several big reasons. One was that the measure of factor inputs was incomplete. The whole intangible side of total capital accumulation — education, on-the-job training and

research and development — was neglected. So also were the productivity gains attributable to better allocation of resources and to economies of scale. And all these missing elements were unmeasured and difficult to measure but still embedded in the Residual. With all this in mind, I called that big Residual a "measure of ignorance". This was a phrase that attracted a great deal of attention, and for years afterward, economists set themselves to reduce our ignorance by measuring some part of what the big Residual covered up. Some progress was made. The big contributor was Edward Denison.

He found ingenious ways to measure the contributions of education and of other changes in labor quality. And he went further. He measured the gain from the shift of workers from low productivity farming and from nonfarm self-employment to higher productivity nonfarm wage jobs. And he estimated the gains from the enlargement of scale. So in the end, he reached a final Residual that accounted for, not 80 percent of labor productivity growth, but only 44 percent.

And yet, the unmeasured Residual, though smaller, remained far more important than any other single source; it was seemingly several times more important than the growth of capital per worker, and it accounted for almost half of labor productivity growth. So the question remained: what is this Residual that still hogs such a large part of the show?

Denison gives an almost definite answer. He calls his smaller Residual "the Advance of Knowledge Incorporated into Production and not elsewhere classified". In short, he means "technological progress", and it is this interpretation of the now-refined Residual that has, until very recently, fixed itself in the minds of most economists who study growth in the contemporary world. So it is this interpretation that I want to challenge in the rest of my talk. My plan is first to tell you in general terms what I think the problem is, and then go on to take up two historical developments that illustrate the trouble to which the common interpretation leads.

II

The trouble is really quite simple to state.

Standard growth accounting is based on the notion that the several proximate sources of growth which it identifies operate independently of one another. The implication of this assumption is that the contributions attributable to each one can be added up. And if the contribution of every substantial source other than technological progress has been estimated, then whatever of growth is left over, whatever is not accounted for by the sum of the measured sources, is the presumptive contribution of technological progress. That is Denison's view, and, as I say, it was also the view of most other economists, at least until quite recently.

Once this is understood, the limitations of the standard growth accounts and of many regression studies based upon the same model stand out baldly. After all, 80 years have already passed since Schumpeter's *Theory of Economic Development* argued that net capital accumulation would fall to zero in the absence of invention and innovation. So he was saying that capital accumulation was itself dependent on technological progress. And surely there can be few economists who do not sense that there are two-way connections between technological progress, economies of scale, tangible capital accumulation and human and other intangible capital accumulation.

If one accepts the proposition that the various proximate sources of growth — those that we find in the growth accounts — are really interdependent — if, for example, capital accumulation supports technological progress, and if technological advance supports capital accumulation — we cannot proceed as growth accounting does. We cannot measure the contribution of technological progress to labor productivity growth by first estimating the contribution of capital per worker, as if this were an independent source of labor productivity growth, and then seeing how much is left over.

This point is, of course, not entirely new. It was raised in the 1960s by Robert Solow and Richard Nelson in connection with the so-called "embodiment" process. They showed how a speed-up of capital accumulation, by reducing the age of capital equipment will, for a time, raise the rate at which more advanced equipment is actually incorporated into production, even if it does not increase

the rate at which knowledge itself advances. And in very recent years, the so called "new growth theory" — (Robert Lucas, Paul Romer and others) tries to make the advance of knowledge itself a function of the rate of capital accumulation. In these more recent models, capital accumulation is given a very broad meaning including not only tangible capital but also intangible capital, that is, the cumulative stock of investments in education and in research and development (I shall mention these theories again later on).

But I want to go back to the other direction of causation — *from* technological progress *to* capital accumulation. This is a theme that Paul David and I developed in paper we published jointly in 1973 and then in separate papers in later years. Our basic proposition, going back to J.R. Hicks' early work, is that capital-using technological progress, that is, progress which increases the marginal productivity of capital more than that of labor, increases the demand for capital relative to labor and so tends to raise the growth rate of the capital-labor ratio. And it also tends to increase capital's share in total income. So technological progress raises capital's apparent contribution as this appears in the growth accounts, for two reasons.

In the rest of my talk, I shall try to show you how this influence of technological progress on capital accumulation worked out in history — first in connection with tangible capital, and then, if I have time, in connection with human capital, i.e. with the rise of education. My history refers to the USA, but I think you will see that it has a more general application.

III

I first encountered the problem in the course of a study of long term growth in the United States on which Paul David and I embarked sometime in the mid-Sixties.

Our plan involved a comparison of the pace and character of growth in the nineteenth and twentieth centuries. The data needed, at least for an account of aggregate growth in the twentieth century, were available in Kendrick, Denison and later writers. Paul David himself undertook to put together the data we needed for the

nineteenth century. These data permitted David to construct a growth account for the nineteenth century, the results of which were presented in the papers we published jointly in 1973 and in several later papers by David alone.

David's nineteenth century growth account again held a surprise: the nineteenth century sources of growth were quite different from the twentieth century results. His account found that the growth of the capital-labor ratio, not total factor productivity, was the major source of labor productivity growth (about 70 percent). It was also the apparent main source of the large acceleration of labor productivity growth between the first and second halves of the nineteenth century (again about 70 percent). Finally, the rates of total factor productivity growth, i.e. the Residual, were very low throughout the century (less than 0.15 percent a year in the first half, less than 0.35 percent in the second half). These numbers are no more than a quarter or even a tenth of the figures that appeared later in the present century.

These results, for the nineteenth century present us with a dilemma. If we think that labor quality, rural-urban migration and, still more, the scale economies from a rapidly growing aggregate output in an increasingly unified economy made any positive contribution, there is no room for technological progress itself. Or if we feel we must preserve some space for technological progress, even for the minuscule apparent rate in the post-Civil War years, there is no room for education, better resource allocation and scale.

What are we to make of all this? Was technological progress really so unimportant in the nineteenth century? Of course, the underlying data may be in error. But David and I do not think that this is where the trouble mainly lies. We do believe that there was a real difference between the two centuries. The difference, however, is probably not so much in the pace of technological progress, although there may well have been such a difference. It lies rather in a difference in the character of technological advance or, as economists would say, in the bias of technological advance. It is this, we think, that caused tangible capital accumulation to emerge with such a large role in aggregate growth accounting calculations for the nineteenth century and a much smaller role in the twentieth

century accounts; and unless one takes account of that difference, one cannot understand this and other major features of American — or, more generally, of modern economic development.

The particular difference in the character of technological progress that concerns us here will hardly sound strange; it is simply this. In the nineteenth century, technological progress was heavily biased in a *physical* capital-using direction. It could be incorporated into production only by the agency of large additional investment in physical capital per worker. And I attribute the dominant importance of nineteenth century capital accumulation as a source of productivity growth in a standard growth account to this fact. In the twentieth century, however, the physical capital-using bias weakened; it may have disappeared altogether. The bias shifted in an intangible capital-using direction and produced the substantial contribution of education and of other intangible capital to this century's productivity growth.

How do we know? The quantitative evidence is not conclusive, but it is good enough to create at least a presumption in favor of the case. As regards the nineteenth-century bias towards physical capital, the key statistic is capital's share of income. Had the growth of the capital-labor ratio been caused by an increase in the supply of saving alone, with technology and scale unchanged, the rate of return to capital would have declined relative to the return to labor. The income shares, however, depend on how fast the relative return to capital declines per unit increase in the capital-labor ratio. In technical terms, the share depends on the elasticity of substitution. And estimates for both the twentieth century and the nineteenth tell us that the elasticity has been far below unity. If technological progress had been neutral, the income share of capital, the fast growing factor, would have declined. In the nineteenth century, however, capital's share rose substantially — by 19 percent during the second half, a 41 percent increase overall. It is this result that creates, as I say, at least a presumption that technology was advancing, not in the neutral fashion that the growth accounts assume, but in a capital-using fashion.

Behind the growth of capital's income share was a series of powerful forces. Each was manifestly connected with technological

progress. First, the great expansion in the total size of the American domestic market and its increasingly unified character encouraged production on a larger scale and supported heavier investment in the application of steam power and in more specialized capital equipment generally. This, indeed, is the message of all the great economists of the nineteenth and early twentieth centuries in a line stemming from Adam Smith and stretching to Allyn Young. But these men did not see the economies of scale as a source of growth separate from technological progress itself. Rather, they thought of the great technological advances which they saw under their own eyes as scale-intensive, as a form of invention that required heavy capital investment and needed large-scale operation to make that investment economical.

There is still more. The unification of the national market was itself created by a most dramatic example of scale-intensive and capital-using technological progress. I mean the steam railroads. Indeed, Simon Kuznets' estimates of national wealth tell us that by 1890, the cumulative net investment in the structure and equipment of the railroads was greater than that in all non-agricultural industry put together.

Next, there is the rise of the cities about which I shall say only this. Scale-intensive and capital-intensive production viewed broadly involved a large increase in urban activity in trade, finance, business and professional services as well as in much of manufacturing itself. And the urban concentration that responded to these requirements was another capital-intensive development. It required heavy investment in structures for housing, trade, finance, government and schools and, especially in its early stages, for streets, water supplies, sewage disposal and urban transport.

I come back now to the main current of my argument. The implication of all I have just said is that, in a growth accounting framework, the undoubtedly large contribution of technological progress to nineteenth century growth is to be found, not primarily in the growth-accounting Residual, but rather hidden inside the technology-dependent rubrics of capital accumulation and economies of scale.

When we turn to the present century, there is a substantial

change. The income share of conventional capital declined and declined substantially. Measured in gross terms, capital's share of gross product in the private domestic economy fell by over 40 percent between the end of the last century and the 1960s. In net terms the decline would have been even larger. The implication is that the physical capital-using bias of technological progress was, at least, weakening.

IV

All this has to do with tangible capital. The present century, however, has seen an enormous increase in intangible capital — mostly for formal education, on-the-job training and research and development. I do not have time to develop this theme. Let me just say this:

- In 1900, hardly any American workers had had even a secondary school education. By 1988, 85 percent of workers had a secondary school diploma and 45 percent had had some university level education. The annual cost of schooling, including the earnings lost by students, amounted to 20 percent of conventional Gross Domestic Product. It exceeded gross private tangible investment by 35 percent.

In spite of this great increase in the ratio of human capital to uneducated labor, the relative earnings differentials between workers with different levels of schooling have not declined.

Obviously, there must have been a great increase in the economic demand for educated workers. The economy absorbed a great increase in supply without a decline in price.

I attribute this great increase in demand largely to a new human capital-using technological progress. And I believe that the change was caused, in the first place, by a very large relative increase in the jobs that commonly require long years of education. This shift in the occupations of people was connected with two things:

1) The relative increase of the Service sector compared with Industry and, still more, with Agriculture. This shift was due, of course, in part to changes in consumption associated with higher incomes. In large part, however, it was due to an increase in "Business Services", that

is, in those functions that are needed to operate a technology that is capital-intensive and scale-intensive and concentrated in urban communities. I mean wholesale and retail Trade, Finance, Insurance Engineering, Accounting, Law and Government itself - including, of course, the Schools.

2) The second cause of the shift of occupations is the increase of Service functions within Industry and Agriculture, as well as in the production of Services. Firms that operate on the increasingly large scale characteristic of the present century now devote a very large part of all their workers to management, administration, accounting, finance, legal services, purchasing, sales, worker-training, etc...

These shifts in jobs account for about half the increase of the educational level of the American workforce over the century. The other half is a rise in the educational level of workers who hold the same general type of job. I cannot speak confidently about that side of the change. Some of it, however, perhaps a great deal, is due to changes in the nature of machinery and to the size of business firms, which demand some degree of schooling in almost every kind of job. And some is due to a change in the curriculum of the schools, which now are much more concentrated on teaching skills and subjects that are of commercial interest and are able to do so in a more scientific and sophisticated way.

V

So now I can try to come to a conclusion - or, at least, to an end. My general theme has been the interdependence of what we have come to call the "proximate sources" of growth. My historical examples support the view that we cannot gain a truly meaningful idea of the contribution of technological progress by first estimating the contributions of tangible and intangible capital accumulation, and of the other (apparently measurable) sources, and then seeing what is left over.

The examples I have offered, however, trace only one line of dependence, the dependence of both tangible and intangible capital accumulation on the pace and character of technological progress. In truth, however, the interdependence of the proximate

sources runs both ways. i have been arguing that technological progress, actual and prospective, supports capital accumulation. But tangible and intangible capital accumulation also influence technological progress - in the shorter term, through the embodiment process, in the long-term by intangible investment in research and development, through learning-by-doing and by-using, and by the contribution of education to the absorption of new products and processes and through other channels. My talk has had to leave all that aside. It is these lines of influence, however, from capital accumulation to technological progress, that are the heart of the "new growth theories" associated with Robert Lucas, Paul Romer and their associates. Their almost total concentration on that line of influence, however, seems to me to be overdone. It calls for qualification. The nineteenth century physical capital-using bias of technological progress and the present century's intangible - capital - using bias were not the consequence, certainly not the exclusive consequence, of cumulative investment. There is far too much that we do not understand about the evolution of applied science and technology and about the political and economic institutions and the kinds or organization on which the discovery or acquisition of technology depend. We cannot reduce the actual advance of technology in use to a stable function of capital accumulation alone. Capital accumulation and the advance of knowledge each arise partly from independent or poorly understood sources, and partly from interaction with each other. They work together to produce joint effects. And that is the moral of this sermon.

My talk, I believe, leads to two conclusions. One is merely technical - of interest to economists. Until we can learn a great deal more about the interdependence of the sources of growth - of capital accumulation, both conventional and human, with the economies of scale and technological progress, the growth accounts will be misleading, and the regression studies that have the same object will be confused. I am arguing that in order to handle such problems, we must take account of the character of technological progress - its biased nature - not just its pace.

More, however, depends on the character of technological progress than these problems of measurement. I have suggested

that the great rise of education, with all its political and social consequences was connected with the nature of technological progress in the present century. If I had had the time, I could have made a similar suggestion about the entry of women into paid employment outside the home. And this is another development that brings with it far-reaching consequences. Many are very good in my opinion, others more problematic. These historical examples should lead us to face a serious question for the future. What kinds of basic political and social developments are embedded in the technology that is even now emerging in the western world?

THE GREAT POSTWAR CATCH-UP BOOM

Lecture given for honorary membership of University of Ancona

I

Let me start by saying that I am very pleased and very proud to become an honorary member of your University. My pleasure is twofold. One part is the simple pleasure that any scholar takes in the fact that his work has won some recognition and is found worthy of some praise. Like actors in the theater, what scholars crave most is a little applause. And I value very highly the approval of this University.

There is, however, a second reason. The proceedings this afternoon are, in a sense, an outgrowth of a connection between Ancona and me personally and between Ancona and my University Which began 30 years ago and which has become stronger with the years. If one goes back to the beginning that connection began because John F. Kennedy, after he became president in 1961, became disturbed by two economic developments that had recently become prominent. One was that Western Europe and Japan appeared to be growing much more rapidly than America. The other was that the US balance of payments had come to be cronically in deficit and the dollar was under pressure in the foreign exchange markets. The US was losing gold, and the Bretton Woods international monetary system was in danger. Kennedy urged the Ford Foundation to organize a study of international differences in growth rates, and the foundation asked Simon Kuznets, that great student of economic growth, who later won a Nobel Prize, to lead the study.

Kuznets' plan was to organize a series of parallel studies of postwar and longer-term growth in seven countries - five European countries, Japan and the US. Since I was working in Paris that year

- it was now 1963 - Kuznets asked me to find the European collaborators. Italy was one of the countries, and it was very fortunate that in Italy I found Giorgio Fuà. So that was the beginning of the long and pleasant collaboration and the warm friendship between Professor Fuà and myself and between the Economics Departments of Ancona and Stanford. Professor Fuà brought the whole group of collaborators to Ancona for one of these conferences, I made other visits to Ancona, Professor Fuà came to Stanford; and he began to send his students and young faculty members to Stanford. They did some work with me but much more with my colleagues. We are very happy to have them and these connections have continued until the present time.

It is altogether fitting, therefore, that the brief lecture which I shall now present is an outgrowth of that old study of growth and of that old collaboration of Kuznets and Fuà and me with our associates in other countries. In my talk I want to give my impressions about one of the main forces behind the remarkable growth experience of the industrialized world since the end of World War II.

By the "industrialized world," I mean, at least in this talk, the advanced, capitalist countries in Western Europe, North America, Australia and Japan - 16 countries in all. I now refer, therefore, not only to the seven countries of our collaborative studies, but to a larger group which includes all the countries of Western Europe from Italy in the south to Scandinavia in the north. But I shall not be talking about the less developed countries of Latin America, Asia and Africa, or about the collectivized countries of Eastern Europe or the Soviet Union.

There are three striking aspects of that experience that we have to take into account.

The first is the extraordinarily rapid growth of the first quarter-century following the War, say, from 1948 or 1950 until 1973. The best way to express that growth for comparative purposes is in terms of labor productivity, which is what I shall use throughout. In 15 countries other than the US, the average growth rate was 4.6 percent a year, which was two and one-half times as fast as during any comparably long period before the War, going back as far as 1870. It was a rate that tripled output per man in 25 years.

The second remarkable aspect of that growth experience - still referring to the growth boom of the first quarter-century after the War - was that no great acceleration occurred in the leading country, the USA. The growth rate there was only 2.4 percent a year; which was fast for that country, but no faster than in still earlier decades. So the difference between the levels of productivity in the US and in the countries that were behind was greatly reduced. There was a pronounced "catch-up". This was a new thing because in the long period from 1870 to 1950, America had been growing faster than the average of the other (laggard) countries and by 1950 a big gap in productivity levels had developed.

There was something more. The postwar catch-up proceeded in a systematic way. There was an almost perfect rank correlation between countries' initial levels of productivity and their subsequent rates of growth. The poorer the country at the beginning, the faster it grew thereafter. Productivity levels within the group came closer together; there was rapid convergence.

This convergence was not an entirely new thing. There had been a tendency to convergence ever since 1870, but it had proceeded far more slowly than after the War.

And then after 1973, everything changed again. Growth in all the industrialized countries became much slower. This was the third outstanding aspect of postwar growth experience. There was a long persistent slowdown which plagues us all to this day. Catch-up continues, but far more slowly and convergence has stopped. The variance of productivity levels no longer declines.

My thesis is that all three aspects of our growth experience are connected. In particular, the rapid growth of the first quarter-century after the War was the result of a set of forces that give the laggard countries, that is countries with low levels of productivity, a growth advantage over those that are further ahead and, of course, an advantage over the leading country itself. These are the forces that tend to produce catch-up and convergence. And if the leading country itself enjoys fast growth, as the USA did after the War, the whole group of countries will tend to enjoy very fast growth. In that sense, the convergence process helps explain the growth boom. But the catch-up and convergence process has another

implication. It is self-limiting. It becomes weaker as the process goes on. So an eventual slow-down is inherent in the catch-up process itself.

This, of course, is a very simple and unqualified statement. You can see, however, that if I am to make my thesis persuasive, I must explain why and under what circumstances there is a convergence process. And I must also explain why it was that convergence proceeded more slowly in earlier times. Why was catch-up absent before the War? How is it that the US established a productivity lead by 1900, and why did it become even larger during the first half of this century?

My answer to these questions is that before the War, the convergence process was held back by a combination of constraints that, in some degree, always limit its operation. These constraints became weaker over time, however, and after the War a special conjuncture of circumstances, combined with new economic institutions and public policies worked together to produce the strong convergence of the postwar boom and, therefore, the rapid growth of those years. Many of the elements of this conjuncture, were, however, self-limiting. They were undermined by the convergence and catch-up they had supported; others that might perhaps have continued, nevertheless, weakened or disappeared. The weaker convergence and catch-up and the slower growth of the last 20 years followed.

II

This is my thesis. It proceeds from a view about two sets of conditions that govern the strength of convergence: one that governs the relative potential of different countries to raise their productivity, and a second that influences their ability to realize their potential.

First, as to potential itself. Consider two countries, otherwise similar, but one is a productivity leader, the other has lower productivity, it is a laggard. There are at least four reasons why the laggard will tend to have a stronger potential for productivity growth than the leader.

First, as the leader's capital turns over, its technological

progress is limited by the advance of knowledge over the lifetime of its capital instruments. But a laggard can make a larger leap by replacing modern, state-of-the-art equipment for instruments that were obsolete even when originally installed.

Secondly, laggards typically suffer from relatively low levels of capital per worker. On this account, as well as because new capital means a large technological leap, the prospective rate of return to investment tends to be strong. So there is a potential for rapid progress by capital accumulation as well as by speeding the application of best-practice technology.

Thirdly, in laggards one usually finds a relatively large fraction of partially or wholly redundant workers attached to farming and petty trade. This is an opportunity for relatively large gains from the better allocation of labor. Here in Italy, you are familiar with the gains you have made by the migration of Southern agricultural workers to urban jobs in the north.

Fourthly, the chance for rapid productivity advance along all these channels means a chance for rapid growth in aggregate output and size of markets, which brings a productivity bonus from the economies of scale.

This is the simple core of the tendency to convergence. And if that were all there was to it, we should expect to see laggards "always and everywhere" advance faster than a leader. Rates of productivity growth across countries in any period would be an inverse function of their initial levels of productivity, and national levels of productivity would converge towards the leader's. By the same token, as the process of convergence went on, the gaps separating laggards from leaders would become smaller, and rates of growth would decline. The opportunity for rapid growth by modernization would be self-limiting, weakening steadily as catch-up proceeded.

But things are not so simple. Leading and lagging nations are not "otherwise similar". The low productivity of laggard countries is not, in general, an accidental development. It arises from conditions that have limited their past growth and that may continue to limit their ability to make the technological leaps that the convergence hypothesis envisages.

There are two broad classes of constraints. The first has to do with what I call the limitations of technological "congruence". Such limitations arise because the frontiers of technology do not advance evenly in every direction. They advance, rather, along parts that are adapted to the resource availabilities, the scale of markets and the consumer tastes of the leading countries, those that have been operating at the technological frontiers. Their technological paths, however, may not conform well to the resources, scale and tastes of lagging countries. So the laggards cannot just take over and employ the best practice of the leaders; not all of that practice may be really relevant to the circumstances of the laggards.

Second, there is a more vaguely defined class of matters that I call "social capability". This refers to matters that almost every student has to allow for. It is a class that covers countries' levels of general education and technical competence, their commercial, industrial and financial institutions, which bear on their abilities to finance and operate modern, large-scale business, and their political and social characteristics that influence the risks, the incentives and the personal rewards of economic activity.

These then are the elements of countries' relative Potential for productivity growth. Beyond that there are a group of factors that govern the ability of countries to Realize their potential in particular periods of time. Here one has to consider the facilities that laggard countries have for learning about more advanced methods, for appraising them and for acquiring them. Next, there are the issues that arise because long-term, aggregate productivity growth requires change in the nature and location of jobs. So the determinants of resource mobility, particularly labor mobility, are important. And finally there are the macroeconomic conditions that govern levels of employment and business activity, the intensity of use of resources and the volume of investment activity. They influence the rate of capital accumulation and, therefore, the pace at which more advanced technology is incorporated into production. And they affect the choices between presents and future that control the research, development and investment horizons of business.

III

So that is the framework of ideas within which I interpret our historical experience. And now here is the interpretation to which it leads. First, why was the postwar convergence and catch-up so much stronger in the advanced capitalist world during the postwar quarter-century than it had been for comparably long periods back to 1870? My answer is that after the War, the laggard countries faced a stronger potential for growth relative to the US than they had done in earlier decades and enjoyed better conditions for the realizations of the potential.

The stronger potential of the laggards stemmed, first, from the enlarged productivity gaps separating them from the US. The enlargement of the gaps had taken place in two steps - the first and larger step between 1870 and 1913, when America was forging ahead, and the second, another substantial step, during the 1940s as a result of World War II.

The fact that a part of the enlarged gaps arose from the War gave an impulse to growth greater than the numbers themselves might suggest. Relatively small investments to repair or replace bridges, marshalling yards or damaged machinery or to rebuild stocks of materials made it possible to bring large quantities of capital back into operation.

The potential of postwar productivity growth and convergence was stronger than the enlarged gaps might suggest for other reason as well.

The first reason was an improvement in what I have called "technological congruence". Differences in natural resources had become less important. In the late nineteenth and early twentieth centuries, the US enjoyed abundant and relatively cheap supplies of food and raw materials. America had those supplies because it had a rich endowment of resources, which it developed early. The resources lay directly in the part of this Westward expansion, and it had the social capability - the incentives and institutions - to exploit them. The cheap supplies were the basis for the resource-intensity of American technology, and other countries, for whom raw materials were more costly, could not easily follow the American technological path.

This advantage, important in the last century, became less important as transport costs fell and as additional sources of food, material and energy were developed throughout the world. Think what the substitution of cheap middle eastern oil in place of coal meant for Italy.

When the postwar period opened, technological congruence in Europe and Japan was stronger for other reason as well. In the late nineteenth and early twentieth centuries, technology, besides being resource-intensive was also scale-intensive and capital-intensive. This was the message of all the great economist of the time, and there is now quantitative evidence to support that view. But these again were tecnological paths that America could follow more easily than most other countries. It had an advantage in market scale which was especially important because international trade was smaller than it later became. So these differences in the congruence of countries with the emerging path of technological opportunity were an obstacle in the earlier 1900s both to catch-up with the US and to convergence within the group of countries.

These earlier American advantages became less important as development proceeded. Domestic markets became larger as incomes rose, and the composition of demand changed. Europeans and Japanese became able to afford the automobiles and other durable consumer goods whose mass production, America had pioneered. With the decline of transport cost and the liberalization of trade between 1880 and 1913, it became easier for Europeans and Japanese to find the advantages of scale by exporting to foreing markets. Continental Europe and Japan, finally, were also developing in their experience with large-scale enterprise and in the effctiveness of their capital markets. For all these reasons, then, the laggard countries were becoming technologically more congruent with the US and with each other. And on this account I have speculated that a strong catch-up and convergence process might well have appeared in the Nineteen, Twenties, Thirties and Forties. But, of course, that possibility was foreclosed by the wars, by the trade and financial disturbances that followed and by the Depression of the Thirties. So instead of a catch-up boom after World War I, Europe and Japan fell further behind, and the boom took place after World War II.

So much for the greater postwar Potential for catch-up and convergence. The supports for the rapid Realization of potential were also greater after the War than they had been in earlier decades. There is much to say about all this, particularly about the new facilities for the diffusion of technology, and about labor supplies and labor mobility. But I shall discuss just one matter now, and that is why investment rates were so high after the War and why the macroeconomic background for capital accumulation and investment was particularly favorable.

Part of this strength came, of course, from the enlarged productivity gaps, from the potential for growth by modernization itself. Part of it came from the side of savings. The unexpected rapid income growth left households, business and governments with large amounts of unspent income. The matter I want to emphasize, however, has to do with the international monetary regime and the supply of money.

That posed a problem. In the regime of fixed exchange rates instituted by Bretton Woods, that meant that countries needed larger reserves of gold and short-term dollar claims. But when the War ended, the existing monetary gold stock was largely in the US and short-term claims on dollars were small. Money growth throughout the world, therefore, required a redistribution of the US gold stock and an increase of US short-term liabilities.

The problem was solved partly by deliberate US policy - the Marshall plan and other governmental loans and transfers. Mostly, however, it was solved by catch-up itself. The unexpected, rapid catch-up of productivity in Japan and western Europe, caused the currencies of those countries to be undervalued at the exchange rates fixed in 1949. As a result, the US could not sustain a sufficiently large current account surplus to offset its unilateral transfers and private foreign investment flow. By 1970, therefore, the US had lost \$13.5 billion in gold to other countries, \$2.5 billion in other reserves and accepted some \$41 billion of additional short-term liabilities.

We can say, therefore that the chronic US balance-of-payments deficits and the Bretton Woods monetary system provided for the necessary expansion of the World's money supply. The American losses of gold and the cumulating short-term claim against the dollar

however, were a threat to dollar-gold convertibility which became greater from year to year. The Woods system was pushed over the edge by the OPEC oil shock of 1973. But the underlying cause of the breakdown was the catch-up process itself. It was productivity catch-up that produced the American deficit, and without the American deficit the necessary redistribution of gold and international monetary reserves would not have occurred. But a chronic deficit of the size needed meant that dollar-gold convertibility could not be maintained indefinitely. In the end, the Bretton Woods system was destroyed by this contradiction.

IV

That is my story of the postwar growth boom. The hallmark of the boom was a great acceleration in the growth rates of countries whose productivity levels had - over a period of 80 years - fallen increasingly far behind that of the US. The acceleration itself was based on a rapid adoption of the advanced technology and organization that had already come into being. These methods had been developed over many decades by the USA and other productivity leaders. But their adoption in many countries had been restricted - by lack of domestic natural resources by small domestic markets, inadequate capital markets and deficient managerial experience with large-scale organization and operation, and finally, by the wars, the protectionism and the business and financial disturbances of the years between 1913 and 1950. Some of the more difficult obstacles, however, had become less important over the years and the remainder were removed or reduced by the institutional reforms and the more enlightened domestic economic policies of the postwar period. The result was the strong convergence and catch-up process of the postwar years and the great growth boom which the release of that long pent-up process constituted.

In principle I should now go on to tell you why the growth boom has been followed by a period of much slower growth that has now persisted for 20 years and is with us still. But that would be another long story. I shall say just two things.

First - although many factors have been involved, the common

central force behind the slowdown has been the convergence process itself. I mean its self-limiting character. In the nature of things, rapid growth based on catch-up cannot continue at the same rapid pace indefinitely.

Secondly - a consoling note on which to end this talk - even at the slower pace of the last two decades, European and Japanese growth rates on the average but not those in the USA, remain distinctly higher than they had been before the War and before 1913. They have raised the material levels of living by 60 percent even during the last two decades of slower growth, and, if they can be maintained, the next generation of Europeans, when they grow up will be 80 percent better off materially than are the young adults of the present time. That's not bad. I wish I could say as much for my own country.