The Catch-up Process in a Global Economy: An Analytical Approach

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The diverse growth experience of economies across the globe is perhaps the most intriguing question that the economics profession faces. The economies of East Asia have grown rapidly over the past three decades, while the economic performance of the South Asian and Latin American countries has been relatively mediocre, although better than that of the African countries, where the per capita incomes have been generally declining. Among the developed countries also, there has been considerable diversity of economic performance.

There is no dearth of research on the question, but there is little agreement among economists on what explains the diversity of economic growth experience. One reason for the absence of consensus is that economic growth is a relatively recent phenomenon and we, as economists or social scientists, still do not understand well what factors bring it about. Sustained economic expansion and rise in living standards can be traced back only to the late eighteenth century, i.e., the time when the Industrial Revolution started in Great Britain. This is not to suggest that there had been little social or economic change prior to that epoch. Quite the contrary. Agricultural practices had been improved over time, and there is a rich record of the mastery and ingenuity of artisans all over the world. But such improvements in products and processes as occurred over the period prior to the Industrial Revolution somehow did not become an economic force, leading to a general improvement in the living standards.[1]

The fact that there was little sustained economic growth until the Industrial Revolution also implies that income disparities across nations, hovering around subsistence levels, were very much smaller than what we currently observe. While the per capita income in the richest countries today is more than two hundred times that of the poorest countries, the income disparity was no more than two to one around the late eighteenth century. (Dosi et al 1993) In other words, the sharp income disparities that

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[1] Indeed, if there had been any sustained rise in living standards since (say) the time of Moses, some 5000 years ago, the results would have been truly astounding. Just the investment of one dollar, at a rate of interest of no more than a quarter of one percent a year, would have yielded an income level of well over two hundred thousand dollars today!

we observe across the world are also of recent origin. Prior to the Industrial Revolution, it was still of course possible for some nations or social groups to grow rich—and there are many monuments reflecting the riches of by-one ages—but this was possible only through plundering other nations or exploiting other social classes. What the experience of the last two hundred years has shown is that the increase in the living standards can, in principle, be widely shared, even though the actual record of countries differs very widely.

Three examples stand out in the growth experience of the last two hundred years. First, the experience of Great Britain showed that a sustained increase in the living standards over the long term was a feasible proposition.[2] Later, the Japanese experience after the Meiji Revolution of the late nineteenth century showed that the process of growth could be considerably accelerated and that sustained economic expansion was not solely a European phenomenon.[3] More recently, that is over the last thirty years, the East Asian developing countries have demonstrated that the speed of catch-up with the living standards of the more advanced countries can be compressed to a much shorter time period.

This article attempts to elucidate three propositions that help to explain the growth experience, without attempting to give a comprehensive treatment to the subject. The three propositions are:

* Technological prowess—i.e., the ability to generate and manage technological change—is a critical factor in explaining countries' ability to raise their standards of living.
* The best measure of technological prowess is the growth in labour productivity over time. And,
* The growth in labour productivity—or technological dynamism—is best explained by: (i) investment in physical capital; (ii) investment in human capital; (iii) and investment in the build up of what has come to be called "national technological capabilities".

Technological Prowess

The central importance of technological progress is recognised in the literature on economic growth. With technological progress absent, the

[2] There is, of course, a strong body of opinion that holds that the development of Great Britain, as well as other colonial countries, was brought about through the exploitation of today's colonies. The purpose here is not to open this debate, but simply to state the record of Britain's growth.

[3] Japan until not too long ago was the sole country with a non-European population that was a member of the OECD (Organization of Economic Cooperation and Development).

catch-up in living standards for the lagging countries would be a rather simple matter. All they would need to do is equip labour with ever increasing amounts of capital, which would raise labour productivity. We know that this is not a realistic explanation.

Economic growth is synonymous with an increasing quantity, quality and variety of goods that have become available to mankind over time. It also implies that, thanks to steady improvements in methods of production, physical arduousness of work has declined over time: all the product of technological change. This is, however, not a one-step change, but rather an intrinsically dynamic process, where technological knowledge feeds on itself. Through increasing the range of available products and production processes, technological progress widens and raises the potential for economic expansion. But this process also multiplies the range of possible combinations of known goods and processes, thus opening up new avenues to exploit the available knowledge.

The ability of nations to take advantage of these opportunities is crucial in determining their capacity for economic growth. It is one thing to be able to put together a product or master a particular production process—taking advantage of the existing knowledge—but quite another to be able to make product and process improvements, and add to technological knowledge. The former variety of skill or knowledge acquisition of course cannot be ignored in a discussion of policies for economic growth, it is often the first necessary step to developing the capability of generating technological change. But, equally, this first step is not a guarantee for technological dynamism. It is not uncommon that the state-of-the-art industrial plants are established in developing countries, but (depending on the speed of technological advances elsewhere), these plants become out-of-date and uneconomic fairly quickly.

The capabilities to generate, and then manage technological change depend on a culture of problem-solving: identifying a problem, and then systematically looking for an answer. This in turn is a product of a general environment of intellectual curiosity and inquisitiveness about natural and physical phenomena. The birth of this environment of scientific inquiry explains better than anything else the timing and location of the Industrial Revolution. As noted by Abdus Salam, the famous physicist:

...there centuries ago, around the year 1660, two of the greatest monuments of modern history were erected, one in the West and one in the East: St. Paul's Cathedral in London and the Taj Mahal in Agra. Between them, the two symbolise...the comparative level of architectural technology, the comparative level of craftsmanship and the comparative level of affluence and sophistication the two cultures had attained at that epoch of history. But at the same time, there was also created—and this time only in the West—a third monument, a monument still greater in its eventual import for humanity. This was Newton's *Principia* published in 1687." (1989, p. 5)

There has been considerable discussion on how such an environment comes to be created. Essentially, there are two sets of explanations: those that attribute it to religious or ethnic factors (such as Protestant ethics to explain the European advances, or Confucianism to explain the Japanese performance) and those that hold "necessity is the mother of invention". While the role of either cannot be denied, they are inadequate as sole explanations. If the former is accepted, the question arises why technological dynamism took root at a given point in history, considering that Protestantism or Confucianism (or any other set of beliefs) predate the incidence of the Industrial Revolution by many centuries. Similarly, while it is true that a large number of technological advances are responses to some real economic need, this is not a satisfactory explanation since there is no evidence of a correlation between the pressure of wants and technological dynamism. Certainly, the countries in deep penury are not usually technologically the most dynamic.

One thing, however, seems to be clear: the capabilities to generate technological change are manmade, and different places at different times have shown themselves to be technologically dynamic. It is in this respect that the experience of Japan and other East Asian economies is very relevant to developing countries: Each of these countries was dismissed not too long ago as incapable of making rapid economic progress. The following quote is perhaps typical of the perception about East Asia at the end of the Second World War: "Forty-three years ago an influential government report in an important developing country observed that labour today shunned hard, productive jobs and sought easy, merchant-like work. The report showed that workers' productivity had fallen, wages were too high, and enterprises were inefficient and heavily subsidised. The country had virtually priced itself out of international markets and faced a severe competitive threat from newly industrialising China and India. It was overpopulated and becoming more so. This would be the last opportunity, concluded the Prime Minister in July 1947, to discover whether his country would be able to stand on its own two feet or become a permanent burden for the rest of the world. That country was Japan." (World Bank 1991, pp. 13-14) There is considerable empirical evidence that countries that invested in bringing about technological change (e.g., through R&D expenditures) were better able to grow rapidly and catch up with the more advanced countries. (See, e.g., Dosi *et al* 1990). Fagerberg (1998) concluded from his statistical results that "...to catch up with the developed countries...semi-industrialised countries cannot rely only on a combination of technology imports and investments, but have to increase their national technological activities as well." (p. 451)

The Measurement of Technological Progress

Economists have essentially employed two measures of technological progress: the growth in the so-called total factor productivity (sometimes also called multi-factor productivity) and growth of labour productivity. Productivity of capital is normally not considered to estimate technological change, since the nature of output as well as capital can change with technological change. Empirically, the output-capital ratio is found to be rather stable over time, reflecting that increased output is associated with greater reliance on capital.

Total factor productivity (or TFP), as its name implies, measures the improvements in productivity of all factors taken together. In order to measure it, some assumptions have to be made to aggregate various outputs and inputs, which are often questionable. TFP at any given time is equal to:

$$\frac{X_1}{X_{\underline{1}}},$$

where X_t and Y_t represent, respectively, outputs and inputs aggregated on the basis of given weights.

Solow (1957) is credited with a method of estimating TFP growth, using the standard Neo-Classical production function and retaining the assumption that factors earn rewards equal to the value of their marginal products. This approach allowed him to separate the *shifts* in the production function over time. His starting point was that, in the absence of technological change, a constant returns to scale production function would fully exhaust the value of output if factors earned rewards equal to their marginal products, and this will hold true for variations in the use of factors as well. Technical progress will have occurred if there is a residual of output left over after the factors of production have been paid their rewards equal to their marginal products. That is:

$$\text{TFP Growth} = \frac{\Delta X_t}{X_t} \; \Sigma\beta_i \; \frac{\Delta K_i}{K_i},$$

where K_i represents factor input i and β_i represents that factor's share in the output based on its marginal product.

The TFP measure, however, is fraught with serious conceptual and practical problems. The idea of deriving a quotient of general efficiency of input use is obviously appealing, but strong and unrealistic assumptions have to be made to derive the estimate. If the production function is not constant returns to scale or if the factors of production do not get paid according to their marginal productivities, the Solow procedure breaks down. Furthermore, being in the nature of a residual, the measure of TFP growth contains all the measurement errors, which in the case of physical and human capital can be particularly serious. (Haque 1995) When the estimate refers to national efficiency, the sectoral biases in production can influence it. For all these reasons, it has been aptly called a "measure of our ignorance". TFP estimates certainly have their uses, but as indicators of technological progress they are quite unsatisfactory.

Labour productivity growth, as an indicator of technological advance, is also seriously deficient, but it does have the merit that conceptually it is relatively straight-forward. Notwithstanding the differences in the types of labour, measuring output per unit of a more or less homogenous input presents less serious conceptual or practical problems. It too faces some serious measurement problems, but at least conceptually its meaning is quite clear. The main weakness of labour productivity as a measure of technological sophistication is that it can rise simply by equipping workers with more capital: this may just represent a *movement* along a given production function, rather than reflect its *shift* over time. However, to the extent that more capital intensive techniques represent more advanced technologies, an increase in labour productivity would mean greater technological sophistication. It is seldom, if ever, the case that more capital intensive techniques simply mean more of the same capital good being employed per head of employed person. (Two shovels instead of one per labourer is not a more efficient technique). Thus, in fact, it is quite impossible to distinguish between the movements along a production function and its shifts over time, except by adopting strong assumptions, such as those required for deriving TFP estimates.

From the point of view of long term growth, labour productivity has an appeal for two reasons. One might say that labour productivity growth is twice blessed:

It is the main determinant of the rise in living standards over time; and

Labour productivity growth is a key determinant of a country's ability to compete in the world market, thereby ensuring that economic growth is sustainable over time.

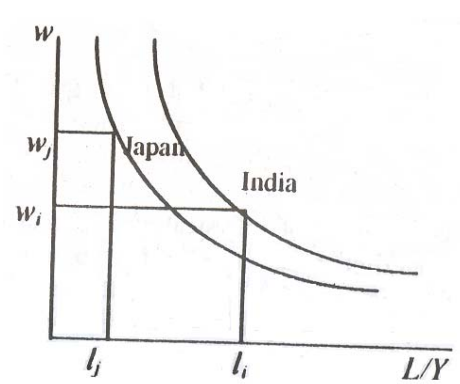
The relationship between living standards and productivity growth is quite straight-forward: per capita income is simply equal to the product of labour productivity, the employment rate, and the proportion of the population in the labour force:

$$\frac{Y}{P} = \frac{Y}{L}\ \frac{L}{N}\ \frac{N}{P}$$

where *Y, P, L,* and *N* stand for national output, population, employed persons, and active population, respectively. If the above equation is converted into growth rates, it shows that the growth in per capita income is equal to the sum of growth of labour productivity *(Y/L)*, the rate of change in the employment rate *(L/N)*, and the rate of change of the proportion of population in the active labour force *(N/P)*.

Although, the employment rate can fluctuate widely in the short term, it displays little change in the long term. Economies have a tendency to hover around a long term rate of employment. The size of the active population does change over time, because of demographics (birth and death rates influence the size of the working-age population) or social change (participation of women or children in the work-force). However, there is no definite trend that the proportion of active population may follow, and some of the changes may be off-setting each other (e.g., as child labour declines, a greater number of women may enter the labour force). In short, if in the long term, there is little or only a modest change in the employment rate and the proportion of active population, the growth in per capita income will be quite close to the growth in labour productivity. To put it differently, it is impossible in the long term to raise living standards without raising labour productivity.

Figure 1



Economic growth and a rise in living standards cannot be sustained in an open trading environment if the country's balance of payments is not viable. Although countries may rely on foreign financing for a number of years, ultimately the viability of the balance of payments depends on export growth. Exports must rise rapidly enough to prevent the trade balance from becoming so large that it cannot be financed. The growth in labour productivity is an important factor in determining export growth.

The relationship between productivity growth and export performance can be demonstrated easily through Figure 1, where the locus of labour cost, as the main element of variable costs, has been traced, indicating that the share of labour costs can either be reduced by means of reducing wages or by increasing labour productivity (the inverse of *L/Y*). Thus Japan with its higher wages than India's ($w_j > w_i$) can remain more competitive than India simply because of higher labour productivity ($l_j < l_i$). There are, of course, other factors that can influence a country's ability to compete in the world market (quality of products produced, timeliness and quality of service, etc.) but labour productivity is in some sense a fundamental factor. There is considerable evidence that countries with higher labour productivity growth also tend to be more successful in increasing their shares in the world market. (See Haque 1995)

There are also some interesting policy implications of the relationship between productivity and export performance. In Figure 1, India could become as competitive as Japan by means of reduced wages (through, for example, a devaluation of the Indian rupee). If, however, the goal is to improve the standard of living over time, then productivity improvement measures will have to be the focus of development strategy. The success of the East Asian tigers (Korea, Taiwan, Singapore, and Hong Kong) lay precisely in remaining internationally competitive while their standards of living rose.

Determinants of Technological Dynamism

Recent advances in the so-called new growth theory show that technological differences are the main explanation for differences in growth experience. Since technology in these analyses is equated with knowledge, which is held to be more or less universally available, the models place emphasis on the accumulation of physical and human capital (especially the latter). The two together make the access to and use of the growing technological knowledge possible. The empirical estimates of the impact of human capital are indeed very impressive. They consistently show a major and statistically highly significant impact of human capital on economic growth. (See e.g., Barro 1991, Baumol 1989, and World Bank 1993)

The usual measures of human capital accumulation—i.e., the school enrolment rates—do not, however, capture the countries' technological sophistication and dynamism. Education and engineering skills are of course prerequisites to achieving technological mastery, but they do not by themselves determine the pace at which technologies are improved and put to work in productive activities. The experience of the centrally-planned economies shows that educational, scientific, and even engineering achievements can fail to materially affect economic perfo0rmance. There are also many developing countries (e.g., India, Pakistan, and Bangladesh) where despite the low supply of educated and skilled labour and technical expertise, there is unemployment among the available stock of engineers, scientists, and medical doctors, many of whom ultimately migrate to other countries.

Technological dynamism requires investment in building technological capabilities, and creating a culture of intellectual curiosity, a drive to innovate, and a certain motivation for making small incremental improvements within individual firms (what the Japanese call "kaizan"). This requires governments dedicated to economic growth and private enterprise committed to national development. This seems to suggest that there is a sort of virtuous circle involved here. Just as Nurkse several decades ago drew attention to developing countries being caught in the trap of low investment, low growth, and low savings, the same could be true of technological dynamism.

While the evidence on the relation between human capital and innovative effort and productivity growth has been found to be strong, there could also be a reverse causation. As Nelson (1981) points out: "Just as a high rate of capital formation and a well-educated work force stimulate technological advance, so technological advance stimulates a high rate of capital formation and motivates young people to acquire formal education." (p. 1055)

To this virtuous circle of investment, human capital accumulation, and economic growth should also be added the openness of the economy to world trade. Although foreign trade can have a negative impact on the domestic economy, competition in the world market feeds technological dynamism. This happens through domestic producers being exposed to different products and approaches to production, skill improvement from usage of imported goods, and not least the buyer-seller contacts which often yield technological improvements in products and processes.

Competing in the world market obviously requires exploiting a country's existing strengths, but countries have constantly to be searching for new areas of competence in order to sustain rapid growth. This is not a passive pursuit, but rather requires deliberate strategy to stay abreast, if not ahead of technological developments elsewhere.

Conclusions

The vast income disparities that we observe today in the world are of relatively recent origin. These disparities have arisen out of the differing pace of economic expansion of different countries and regions observed over the last two hundred years. A major factor that explains the differences in economic performance is technological dynamism, which is, on the one hand, determined by human capital and technological prowess, and, on the other, by the exposure of domestic producers to the world market. However, openness to international trade needs to be accompanied by deliberate promotion of capabilities to search, evaluate, adapt and develop technologies to enhance a country's competitiveness.

The rapidly growing economies of East Asia evidently overcame the hurdles to the virtuous circle of trade-technology-competitiveness, and started to catch up with the developed world. How they did it is obviously a subject of much discussion and research, but two things appear to be conspicuous in their experience: a national commitment to economic development and pragmatism in their national strategies and government policies.

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