Technological Implications of New Growth Theory for the South

BY STEVE DE CASTRO

A wide audience in the South needs updating on the new growth theories, especially on technological policy aspects. In simplest terms, these theories hold that the engine of growth is technological innovation, and economies which reward innovators grow faster. However, globalization raises many complications for technology policy-makers, so much so that a nation can become a passive backdrop for transnational flows. Author Steve De Castro, from the Department of Economics of the University of Brasilia in Brazil, has done technology policy and economic studies in several industries and a government in the Caribbean, as well as research in several Northern countries.

IN THE LATE 1980s, growth theory returned to the center stage of economic research after being neglected for nearly two decades. Today, some of the most productive macroeconomists have turned to the study of why such a large proportion of the world's population still lives below some decently defined poverty line. In this century of so many technological innovations, it is a paradox and certainly a tragedy that income disparities within and across nations have become such an outstanding feature of world history.

Despite this return to growth theory, the textbooks used in the South are still dominated by the ideas and theories from the first flowering of the topic in the 1950s and early 1960s. Thus, a wide audience in the South needs updating on the new growth theories, especially on technological policy aspects in the broadest sense. Here the word *growth* will mean an increase in average income per person in the economy. Some authors refer to this as intensive growth

A wide audience in the South needs updating on the new growth theories, especially on technological policy aspects in the broadest sense.

and reserve the qualifier "extensive" to mean growth in total income or gross domestic product (GDP). If an economy grows by 3 per cent a year in GDP, it actually is not growing if its population is also increasing at 3 per cent per year.

OLD GROWTH THEORIES

Perhaps the first coherent growth theory which was stimulated explicitly by the increasing spread of incomes per person across countries was Arthur Lewis' two-sector model. It portrayed growth as a transfer of labor from a traditional sector, mainly but not exclusively agricultural, to a modern sector grouping relatively new processes such as plants and factories. Lewis claimed there was excess labor in the traditional sector because it operated in a precapitalist mode of family enterprises and farms which used more labor than necessary.

If all the surplus labor transferred to the modern sector, the productivity of all workers would rise to the new level, and the economy could then grow in a more market-oriented manner. But how to explain that several developed economies, such as France, Germany and Japan, continued to support a large, family-based agricultural labor force even after the second world war? According to Lewis, large parts of these economies would still have been in a mode where market forces are suppressed—an unlikely situation.

The dominant paradigm for three decades was Robert Solow's neoclassical theory, a general one that could apply to any economy, rich or poor. The basic assumption was that all economies had access to the same global technology in the form of a single production function which transformed labor and capital into GDP or total income. This does not mean they all had the same "mix"; some, with more capital per worker, would tend to use more capital-intensive techniques. In each economy, agents would save part of their income which, when invested, would increase the stock of capital. If capital grew faster than labor, then GDP would also grow faster than labor, and income per worker would rise. In our language, there would be growth.

Solow's reasoning had a dramatic conclusion: no matter where any economy started in the process of capital accumulation, no matter how high its saving rate, and no matter how low the growth rate of its labor force, each would eventually end up in a state of zero growth. GDP would continue to grow, but only at the rate of growth of the labor force, thus leaving income per worker constant. This happens because Solow supposed that if capital accumulates faster than labor, its productivity will fall, and each additional unit of savings will yield less extra output. Savings will eventually be sufficient to supply each new worker only the same amount of capital as current workers get.

The only way an economy could break out of this stagnation is technological progress—new methods and know-

how which enable given amounts of capital and labor to yield more output and hence higher incomes. However, new growth theorists criticise this way out of stagnation. Under Solow's assumption that all markets function in perfectly competitive fashion, businesses and firms would as usual pay labor its market wage and capital its normal rate of return, but then have no revenue left over to pay innovators, inventors, researchers and the like. Not only did the technical progress come from outside the economy, but the theory could not find a way to pay for it. If all economies eventually must grow only at the rate of technical progress, which comes from outside each economy, then all would eventually grow at this common rate. This is the famous convergence hypothesis which has now been tested with postwar data (see "Econometric history" below).

NEW GROWTH THEORIES

In Solow's work, growth is exogenous because the technical progress which drives it does not use any of the economy's own resources. In contrast, the new theories separate out the activities which produce innovations, the cause of technical progress. These activities divert labor and capital from normal production to research and development (R&D). The more resources devoted to R&D, the faster the rate of arrival of innovations and the higher the growth rate. Growth becomes endogenous.

We saw earlier that if producers of normal goods operated in perfectly competitive markets, they would have no revenue left over to pay for innovations. The new theories argue that, for an economy to innovate and thus to grow, some form of imperfect competition must be present. Growth comes from profit-seeking behavior of producers and innovators, but, more important, they are seeking monopoly profits and not just the normal rates of return of competitive industry. Put like this, the obvious question is, didn't many previous economists say all this ages ago?

The new twist of the theory is to show how monopoly power drives growth. Monopoly power can emerge in a number of ways: producers form a cartel, for example, or government cedes operating rights for a particular activity to only one person or firm. However, if the monopoly derives from the creation of an innovation, the economy will grow. The monopoly may cause maldistribution of incomes. After all, the monopoly owners will receive a higher return. But this income effect clearly is considered the lesser evil.

Perhaps the simplest way to explain how the new theories differ from the old is to show how they would regard investment. In the older theories, accumulation of capital was seen as the engine of growth. The more Keynesian economists tried to understand how investment was determined, but economists like Arthur Lewis and Nicholas Kaldor concentrated on how to generate increased saving to

finance the required investment, which was taken for granted as an obvious suppressed demand in the South. Poor economies were seen as savings-constrained. Kaldor in particular saw the link between the level of saving and the distribution of income. Since the richer households were likely to have higher saving rates, it was probable that a distribution skewed in favor of the rich would generate more savings than an equitable one.

The low saving ratios of the US and certain other developed economies should certainly cause some deeper thought. Some would want to argue that this may be the cause of the relatively low growth rates of the US economy in recent times. Others may claim it is the social and technical efficiency of its investments, which do not require high saving rates to generate growth. For example, 40 per cent of US investment is in computers, not a sector one associates with high capital intensities when compared to, say, petrochemicals or electric power generation.

Looking at this debate between the Keynesians and the development economists, the new growth theorist would, first, say that the fundamental determinant of all investment, whether in physical or human capital, is the flow of innovations in the economy; and second, claim that these innovations are not exogenous but motivated by profit-seeking.

To illustrate, the new growth theorist would not regard replacement of an old machine by a new one, almost identical, as innocuous, without links to any innovation. If the new machine, however lacking in new features, were not capable of yielding productivity increases and thus higher profits, the owner would not replace the old one. The fact that the new one is not radically improved would indicate, for the theorist, that the particular industry had a low rate of innovation. If this is symptomatic of all the sectors in an economy, then it would have a low growth rate, no matter how high the investment and saving rates may be. The engine of growth is technological innovation, and economies which overcome the difficulties of rewarding innovators for their efforts would grow faster.

In the postwar period, some high growth economies, especially the Asian "tigers", have exhibited very high saving ratios, at times over 30 per cent of GDP, accompanied by very low spending on R&D. The new theories would suggest that either they are imitating, copying or buying the innovations of other economies, or there is a problem in their growth accounting.

ECONOMETRIC HISTORY– THE STYLISED CONCLUSIONS

Everyone agrees that the innovations associated with Britain's industrial revolution were the inspiration for the growth which eventually led to high incomes for some countries. However, it is now believed that other innovations,

in agriculture and in cottage industry, were occurring in some economies both before and concurrently. Research on Japan before Meiji (1868), for example, indicates that its income per head was already probably at the level of Britain's, even before its late industrialization after Meiji. Some other countries (Australia, Argentina) achieved high incomes by mid-century without significant industrial activity. Industrialization may not have been the true mother lode for growth, but rather only one form that innovations can take.

Since around 1950, data are much improved, allowing the convergence hypothesis implicit in Solow's work to be tested and found false. However, convergence seems to be occurring in western European countries and Japan, partly through a technological catch-up with US labor productivity; and also in some middle-income countries, such as Venezuela, Chile, Argentina, though not in income per head, because investment did not keep up with population growth. Why is this only happening now in western Europe and Japan, five decades after the second world war? Some economic historians suggest it has taken them this long to master the US structure of corporate capitalism and large bureaucratic oligopolies, as opposed to the competitive markets of owner-driven factories as in 19th century Britain. The argument, however, is yet to be tested formally.

Again, empirical work with the Asian "tigers" produced no common, clinching feature to explain their performance. True, they all emphasise exports and education, but even those policies differed considerably across governments. In Korea, for example, higher education was almost completely a private initiative, while exports had heavy government intervention.

As for econometric testing of new growth theories as formal hypotheses, perhaps the most damaging is a study by Charles I. Jones [1995]. It showed that, despite exponential growth in the number of scientists and engineers engaged in R&D in recent decades in the US, France, Germany and Japan, their growth rates have not experienced any concomitant permanent increases.

Industrialization may not have been the true mother lode for growth in the 19th century, but rather only one form innovations can take.

Either the theory is false, or there must be some mechanism in these economies which is not allowing the increase in R&D to be passed on, through innovations, to the growth rates. One possibility is a fall in the productivity of their research. Another idea is being pursued in the present author's research. The idea is that a second process is present in any economy, from the consumer's side rather than the

producer's, which can resist or retard the rate of adoption of innovations because it may be too fast for social efficiency. If this is true, then despite high R&D rates, certain countries may not exhibit high growth rates because gains from innovations have dissipated through delays in adoption caused by various consumer-side checks, directly or through the government. Institutions in the US like the Environmental Protection Agency, the Federal Drug Administration and numerous consumer-side pressure groups all come to mind. Neither hypothesis has been tested.

In the South, the proportions of GDP spent on R&D are generally minute. Some econometric studies have substituted education levels, literacy rates and so on. From these, there is some indication that low educational enrollments are a substantial impediment to growth there.

TECHNOLOGICAL ASPECTS OF THE NEW THEORIES

Since growth is about the whole economy, care is needed when analyzing the technological effects on a particular sector or industry. Before reaching for conclusions about whether or not the innovations in a sector are generating growth in the overall economy, it is essential to do the complete set of accounts. This caution is important because innovation can have unintended effects. One effect is reflected in the popular refrain that it will put people out of work. Another effect, more subtle, is that innovations can affect the prices of certain commodities—for example, food—so much that they cease to be significant generators of income and employment in a modern economy. Agriculture, perhaps the most known case of this phenomenon, can be used to sketch how we need to do complete, more general, social accounting in order to study growth.

Agriculture ties together the two sides of the argument in a more complex way than usual. When an innovation enters a sector, costs of production and hence prices will fall, which should normally increase demand for goods from that sector. This may sometimes compensate any loss of jobs directly caused by the innovation. However, this may not happen; there may be a net loss of employment in the sector, and yet the economy can continue to grow at full employment. Agriculture, the dominant sector in almost all economies when growth began, today hardly employs 5 per cent of the labor force and yields about the same percentage of GDP in the richer countries. Yet any unemployment existing in such economies has long ceased to be attributed to changes in their agricultural sectors. In fact, their manufacturing sectors have been undergoing a similar transformation, with falling proportions of employment and GDP in most countries for decades, e.g. the US. They are becoming or have become post-industrial. Yet these economies have continued to exhibit growth, and at seemingly full employment most of the time. New

goods and services which did not exist before are being introduced continually.

We saw earlier that, although many economists spotted profit-seeking as the driving force in market economies, few were able to show clearly how this competitive behavior could lead to growth of the whole economy. The competition could lead to a situation where, loosely speaking, each agent's competitive strategies exactly cancel out the other's, leaving the economy standing still. Schumpeter was probably one of the earlier economists to perceive that competition alone was not enough, and that some form of monopoly profits had to be introduced to get growth. He also perceived that each monopolist, earning super-profits with a new good or technique, would attract other innovators. Seeking such profits in turn, they would try to better the technique or good and so destroy the base of the previous monopoly, but replace it with another. Schumpeter dubbed this a process of creative destruction, an oxymoron if there ever was one.

The contributions of the new theory were, first, to formalize how this apparent contradiction could generate growth, even though each innovation destroyed the one which came before it. Second, it helped us understand under what conditions the growth it generated can be socially efficient and not just enhancing of the profits of a monopoly. This second point is especially of interest to a poor economy, desperate for growth no matter the cost.

The growth rates generated by untempered profit-seeking can be too fast or too slow from the point of view of social welfare, because each innovation is won at a cost to society. Resources had to be diverted to its development, sometimes by formal research institutions and firms, but other times by quite informal or hidden ways—subsidies, protection from foreign competition, even burning the midnight oil. Now, the innovation must repay these social costs during its useful life. If it is killed off too early by a subsequent innovation, then this could generate a growth rate which, on an economy-wide scale, is too fast. Consumer-side resistance here would increase social welfare. On the other hand, if its life is prolonged beyond repaying its social costs, just so it can yield super profits to the monopolist who introduced it, then scaled up to the economy-wide level, this would yield a growth rate which is too slow by a social welfare measure.

All this sounds rather abstract, but it comes down to its most practical level with the following simple question: what should be the optimal life of a patent? A patent is protection granted by the society, to an individual agent or firm, of a monopoly right to exploit a discovery for a fixed period of time. The longer the period, the greater the incentive to the innovator. The shorter it is, the lower the cost to consumers who would have been paying the monopoly price for the product.

It is not easy to answer this question, even for a single industry, much less at

the level of the whole economy when trying to assess whether the result induces efficient growth. Medicines provide a dramatic example of the conflicts. For many decades in this century, an international treaty required governments not to grant any patents, nor to protect other countries' patents, for medicines. The rationale was that medication can be a matter of life or death and such producers' monopolies should not be given protection by the society, a view now questioned.

The insertion of an innovation into an economy, then, may very well cause disruptions in its sectoral balance. Some sectors may increase their contribution to total income and employment, while in others the opposite may occur. The ambiguity disappears if one is convinced that the increased productivity an innovation generates in one sector would make all real incomes grow by reverberating onto other sectors, through increased demand for all goods, both old and new. Any accompanying unemployment would be seen as temporary, in some cases even voluntary, as workers may seek retraining to take advantage of the higher wages paid by the new technologies.

In all this apparently strong defense of the benefits of the free working of markets, we have largely avoided so far a major issue in the new theories—that technological innovations have many attributes of what economists call a public good, and public goods are treated as serious sources of market failure, at least in introductory texts. The clue to the dilemma is obtained from the following innocent question about patents: if the innovator really has a new and superior product or technique, why does it need protection from a patent? Monopolists, even in societies committed to laissez-faire like the US, are not tolerated highly. Anti-trust laws and regulatory bodies are examples of institutions set up to temper monopoly power, not to create it, much less with such an instrument as a patent.

The answer lies in the ability of other producers to copy or imitate the product or technique without having to pay the innovator. For many innovations and unlike normal goods, inventors are unable to establish property rights over their inventions. Whereas it may be obvious that it is socially efficient to help consumers of durables maintain their property rights, it is not so clear in the case of innovations. For new growth theory therefore, innovations cannot be treated like physical capital goods. The issue is still in progress, and no final answers are available. Romer [1994] has argued that new knowledge must be treated more like a public good because each innovation can be utilized simultaneously by many producers at no extra cost to the innovator. Public goods can be financed by markets, but the legal and transactional framework required is substantially more complex, and the mechanism may well be socially inefficient.

IMPLICATIONS FOR TECHNOLOGY POLICIES IN THE SOUTH

Since the main focus of the new theory is technological progress, anything useful which can be said now must relate to the microeconomic aspects of innovations, taking for granted their contribution to growth. Scholars examining the technological implications of the new theory quickly descend to the sectoral level. The key argument is whether such sectoral innovations contribute to, or are socially efficient generators of, growth in the global economy. Outlining a few ideas and views will help to guide a policymaker through the debate.

One extreme view is that economic agents who contribute to advances in knowledge have found myriad ways to appropriate the fruits of their labor, to the extent that the advance is clearly attributable to them. Even when this is not possible, such workers, it is claimed, group themselves into institutes, research centers, laboratories, firms even, such that their collective benefits can be shared efficiently. This position was held by Ronald Coase, who defended the idea that certain positive externalities generated by some economic activities are recognized as such by their beneficiaries, who are usually willing to pay the perpetrators. The example is often used of beekeepers whose bees pollinate farmers crops and increase their yields; a study found that farmers paid the beekeepers, and in amounts closely related to the values of their extra yields.

However, the most insightful comment on Coase is the prediction that such externalities would not be observed often. They would be grouped by agents into a single organization—a research center or firm—where spillovers from one subgroup to another can be managed equitably and efficiently. In a correct application of the idea, the R&D organization should be a profit maximizer, and not some other entity such as a university institute or nonprofit foundation.

In the notion of globalization lurk complications for technology policy-makers.

A more balanced approach would seem to be to try to separate R&D into two types: fundamental research, as in the natural sciences and pure mathematics; and applied research, more linked to specific marketable goods and services. Unfortunately, this dichotomy has largely broken down in the last decades, and both public and private funds are found in the budgets of research outfits in both categories. Sometimes these declare themselves to be nonprofit, other times not.

Further complications for technology policy-makers lurk in the notion of globalization. It has been argued that globalization is not simply trade liberalization, but rather a process by which firms and nations become exposed internationally to a series of intangibles such as know-how, synergies, and generalized informa-

tion flows, few of which are formally traded like goods. Some of these transnational or globalized flows are so strong in certain sectors and regions of national economies that they have led to the emergence of a mosaic of sub-national poles. Each pole is so strongly linked to the others internationally, through their product-based, technological learning systems, that the nation becomes a passive backdrop for them.

Strong transnational flows—for example, in telecommunications, pharmaceutical research and computer software—make the nation into a passive backdrop.

There are certainly one or two sectors where the extreme situation seems already a reality. Telecommunications come to mind at once. Another is pharmaceutical research, where the discovery and testing of new medicines is being spread out over several countries in a complex mix of privately and publicly funded activities. A third is the area of computer software and programming. To the extent that production of knowledge becomes an industry, and that industry comes to dominate an economy, as several authors claim is the case for the US and some others, then public policy about R&D activities can truly be said to be in a mess.

In the face of these dilemmas, it is only prudent to suggest that governments in the South, referring to national ones while they continue to exist, ought to concentrate on fostering public, mass, general education to as high a level as the economy will bear. If knowledge production is becoming an industry, then education cannot but be a major input to it, and may well be threatened with industrial status in the process.

This may seem an innocuous suggestion. But it appears to be a tall order for many administrations, especially as the education system grows and becomes dominated by the more expensive, secondary and tertiary levels. Entrenched positions on how to finance these should be avoided. Education always has an element of income redistribution, taking from the relatively better off to finance the development of the children of the not so well off, a public sector activity which clearly requires the most delicate of political skills. This may be because education, in many ways, is not a public good at all. Most of its benefits, especially at the higher levels, are appropriated by the individuals who receive it, in the form of better paid jobs. Since almost all states accept the task of providing some fraction of perceived educational demands, one explanation may be that there could be some market failure involved with the financing of each individual's schooling. Another reason may be precisely the redistribution effects which are sought rather than social efficiency. This too, like so many others, has become a topic for specialists.

Another practical suggestion is for governments to avoid sector-specific policies, especially notions of fostering industrialization, a task dear to the hearts of the first generation of development professionals. Even middle-income countries now have more than half their GDP in the tertiary sectors, and this proportion is growing. Looking for the mother lode of growth in any one sector is not likely to be a successful endeavor. As for governments which, for lack of theoretical criteria, have tried to spot and foster sub-sectors which can be technological winners, the empirical results have shown this to be largely a hit-and-miss affair, even for Japan's much admired MITI, and one which can be very costly.

In the face of these dilemmas, it is prudent to suggest that governments in the South…ought to concentrate on fostering public mass, general education to as high a level as the economy will bear. If knowledge production is becoming an industry, then education cannot but be a major input to it….

However, whenever a potential non-rival innovation is identified, whose benefits are clearly not appropriable by its possible developers, a government should not hesitate to set up publicly funded research and extension services for its creation and diffusion. The best known historical example is the US federal and state governments' creation in the late 19th century of land-grant colleges focused on agricultural research and extension. It is not a perfect case, because much of this research can be and is now done by profit-seeking firms. The intensity or scope may not of course be at the right levels for social efficiency, if its gains are not fully appropriable.

This article at times has been so equivocal that I am reminded of the story of a prime minister in the South, who longed for the day when he could have as an advisor, what he called an one-handed economist, not given to such phrases as "on the other hand..." which left him as baffled as before, about the correct policy to adopt. Without apologies, this article, at least in its policy suggestions, was written with two hands. One can only hope it will not leave prime ministers baffled. ■

Further reading on economic growth

An insightful world economic history, which finds growth episodes as early as the Sung period, is Eric Jones [1988]. For after 1800, see Easterlin [1996] who, unlike Jones, finds growth only after "the scientific revolution." A creative introduction to current theory is Paul Romer [1994], who says knowledge should be treated like a public good, not physical capital. The only textbook that

covers new theory is Barro & Sala-i-Martin [1995], who use lots of mathematical models and econometrics meant for specialists. Peter Howitt (ed) [1996] specifically covers the technological issues of the new theory, treating some sectors (telecommunications) and one country (Canada) interestingly.

References

- **Eric Jones** (1988), *Growth recurring: economic change in world history*. Clarendon Press-Oxford. Richard Easterlin (1996), *Growth triumphant: 21st century in historical perspective*. University of Michigan Press.
- **Paul Romer** (1994), "The origins of endogenous growth." *Journal of Economic Perspectives*, 8(1), Winter: 3-22.
- **Charles I. Jones** (1995), "Time series tests of endogenous growth models." *Quarterly Journal of Economics*, 110 (May): 495-525.
- **Robert Barro & X. Sala-i-Martin** (1995), *Economic Growth*. McGraw-Hill.
- **Peter Howitt** (ed) (1996), *The implications of knowledge-based growth for microeconomic policies*. University of Calgary Press.