Technology and Development in Asia

Frank Harrigan writes that advances in physical technology and the capabilities that are required to master and use technology purposively are the foundation for material economic progress. Harnessing the benefits of technology requires more than acquiring technological hardware and the capabilities to use it. It is the demand for and the returns from adopting modern technology that will determine the assimilation, adoption, adaptation, and innovation of new technology.

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ERD POLICY BRIEF NO. 49

Technology and Development in Asia

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June 2007

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Technology and Wealth Creation

Until the scientific revolution of the 18th century, global material wealth had increased at a snail's pace. Then a burst of knowledge and innovation ignited economic growth in a way never before experienced. This revolution followed two centuries of painstaking scientific discovery and trial and error that began around the time of the European renaissance. DeLong (1998) estimates that it took 15,000 years to double per capita income from hunter-gatherer levels to where it stood around 1750. Global per capita income then quickly gained altitude, fueled by relentless scientific learning and discovery. Just 250 years later, global per capita income has ascended by 73 times what it was in hunter gatherer societies.

Unquestionably, the supply of new ideas and physical technologies is the locomotive of economic growth. Yet, without effective demand for technology (and knowledge), material progress may falter. If circumstances are such that there are few gains to be had from mastery over new technology, investment in learning and improved capabilities will be low and opportunities bypassed. There are some striking examples of how circumstances that contrived to depress the returns to new activities and technology trapped countries, causing reversals or stagnation.

Five hundred years ago, North America was poorer than many parts of Asia (notably India), but relative incomes have since been decisively reversed. Institutional structures based on private property and that engaged entrepreneurs, landowners, and artisans in cooperative relationships better prepared North America for the new technologies then being spawned by the industrial revolution. In other outposts, colonial powers maintained or introduced institutions that reinforced elites and were designed to extract and export agricultural surpluses. Failure of these extractive and parasitical institutions to adapt to the requirements of a new industrial age spelled subsequent stagnation (Acemoglu, Johnson, and Robinson 2002).

Reversals in the Soviet Union provide an even starker illustration of why scientific knowledge and the availability of technological hardware is not enough to sustain growth. Despite considerable technical accomplishments, the Soviet Union's central planning arrangements could not cope with the complexity of emerging economic and social demands. There were no exit mechanisms for moribund activities, no incentives for innovation, and ultimately no Schumpeterian gales of "creative destruction." The system came unhinged, failing to produce and distribute the right goods and services in the right way. A sclerotic economy helped set the conditions for the Soviet Union's demise.

Consider the situation facing developing countries today. Billions remain poor despite an expanding global stock of technological knowledge and opportunities. Advanced technological hardware is widely available and barriers to knowledge transfer are falling (though they certainly have not been eliminated). Constraints on the supply of complementarity factors, such as educated and skilled workers, could be obstructing opportunities. But as Pritchett (2004) has shown, increases in the supply of schooling do not automatically elicit productivity gains. The fact is that in many poor countries, technology delivers low returns not just because of low capabilities but also because of a lack of profitable investment opportunities—opportunities that ultimately drive the demand for technological modernization. In these circumstances, low levels of technology are as much a symptom of economic backwardness as a cause.

So what can countries do to enhance their technological capabilities, thus expanding opportunities for future growth? Though issues about investment in capabilities remain highly relevant, it is equally important to ask how demand for better technology emerges. As technological improvement is rarely disembodied, the demand for technology is likely to be closely linked to the forces driving the birth of new activities and structural change.

Of course, there are other facets of technology that are vital to development that lie outside this framework. Policies that befit economic growth may not deliver on environmental goals, for example. But, given space limitations, the focus in this essay is squarely on the role on technology as an input to economic growth, with the policy spotlight turned largely on industry.

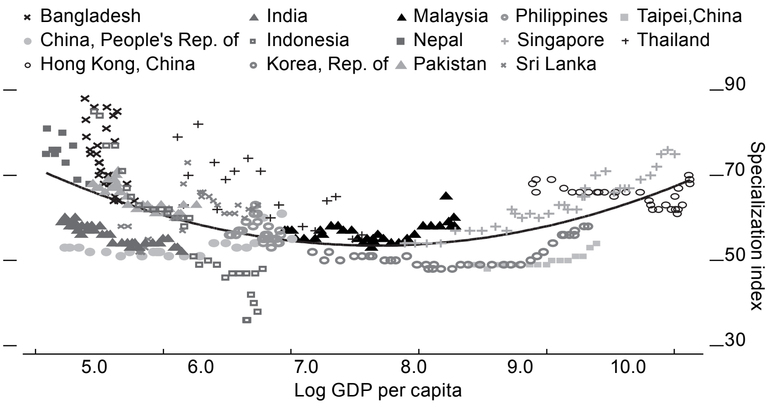
Growth, Technology, and Structural Transformation in Asia

Rising prosperity occurs through cumulative economic change. There is nothing particularly novel or controversial about this observation. At the dawn of the industrial revolution, today's industrial countries were largely agrarian. They followed a path of population migration from countryside to town; resources moved from agriculture into industry and services; and they changed what they produced, where they produced, and how they produced. The celebrated "logistic model of growth" (Kuznets 1966 and 1971) captures these ideas but in a way that suggests the transformation is almost automatic. But in a world where agents have to explore, learn, and adapt to an unfolding and unpredictable environment, economic modernization is hardly preordained. Businesses have to know about and then master physical technologies before they can use them purposively.

Imbs and Wacziarg (2003) have added an intriguing and significant twist to this story. They observe that as countries scale the path from low to high incomes, their economic structures initially become more diversified. Specialization eventually follows diversification but only once incomes have become quite large. Rodrik (2004) and others interpret this to mean that success in climbing the income ladder requires mastery over an increasingly diverse range of activities at comparatively low levels of income. Does this story fit the experience of income growth and change in developing Asia? The special chapter of the Asian Development Bank's *Asian Development Outlook 2007* publication (ADB 2007), on which this essay is based, provides some answers.

Figure 1 plots a specialization index for manufacturing industry against per capita income levels (at market exchange rates) for a range of Asian developing countries over the period 1970–2005. Just as in Imbs and Wacziarg's data, increasing diversification occurs at low income levels, with a tendency toward specialization following only at middle- and high-income levels. Much of the variation along this arc appears to be due to the fact that country sizes differ, and large countries can be expected to show greater diversification for a given income.

Figure 1. Specialization Index of Developing Economies in Asia: Manufacturing Value-added



Note: The estimated regression line is:
Specialization = 203.653 – 39.163 GDP per capita(log) + 2.554 (GDP per capita(log))
t-stat: (17.78) (-12.39) (12.13)

R^2: 0.30; No. of observations: 387

Source: Staff estimates.

It would also appear that as countries navigate the transition to greater diversity and eventual specialization, the technology and scale intensity of what they produce steadily rises. Republic of Korea (henceforth Korea); Singapore; and Taipei,China, each of which followed distinct strategies toward the acquisition of technology, exemplify successful transitions. Countries that have grown slowly have typically exhibited much less technological vigor and have focused on activities with low economies of scale.

Evidence of the importance of the link between complexity and economic growth can also be detected in the evolution of exports. Those countries that have grown most quickly are those that have been most successful in exporting goods that rich countries also export. As Hausmann, Hwang, and Rodrik (2005) aptly put it, “what you export matters.” Support for the idea that export quality (and by extension, technological efficiency and sophistication) boosts growth emerges from Asia’s experience. Tests show that this link runs from export quality to growth, not the other way round (ADB 2007).

Finally, the technological escalator is moving faster. Today, both the People's Republic of China (PRC) and India produce a much more technologically advanced range of goods than did Malaysia at comparable income levels. Likewise, for given income levels, Malaysia's output basket manifests greater technological sophistication than Korea's. This acceleration in technological modernization is most apparent for those countries that are participating intensively in global supply chain activity.

Together, these observations suggest the existence of a powerful link between technological upgrading, structural change, and economic growth.

Technology and Industrial Policy

Lall (1997) offers a helpful typology of policies that might directly or indirectly mold national technological capabilities. He distinguishes between policies that act at the levels of incentives, markets, and institutions. Lall also differentiates between policies that are functional, or enabling, and those that are selective.

At an enabling level, macroeconomic stability (incentives) and access to credit (markets) are clearly important, as is an environment that supports contract enforcement (institutions) and scientific, technical, and vocational education (markets). Selective policies usually seek to influence incentives and include direct public expenditure support, or subsidies and tax breaks for research and development (R&D) (incentives); patent and intellectual property protection (institutions as well as incentives); or measures targeted at the development of specific sectors (incentives). It is of course possible to add other elements to these lists.

Lall observes that Asia's technological leaders have followed different paths. Singapore's approach, based on foreign direct investment, technical training, and process capabilities, has paid off, as has Korea's approach based on technological licensing, national investments in heavy industry (supported by access to bank credit). and product branding. Taipei,China, another technological leader, followed a route based largely on high quality, public sector technological extension services aimed at indigenous small- and medium-scale enterprises. When it comes to the nitty-gritty of technology policy, there seems little basis for generalization.

However, in terms of broader strategic principles there are important lessons. Technology policies in successful countries have embedded within them, strong incentives and performance standards, which in many ways have been tied to exporting but sometimes to domestic competition as well. Trade in technology has been a conduit for knowledge and learning, promoting product diversity and the birth of new activities; and ultimately, success in international markets has been the litmus test of performance (Westphal 2001). This has been true for call centers and back office operations as for the producers of electronic parts and components. Though government interventions did not always work, failed experiments were usually abandoned or modified on the basis of market feedback. These experiences can be contrasted with India's technological push in the 1960s and 1970s, which focused on the development of indigenous capabilities but in ways that were largely closed to foreign ideas and competition. Though small islands of technological excellence did emerge at a national level, India's planning efforts ended largely in failure.

A second broad lesson is that approaches need to be attuned to a country's level of development. The acquisition of technological capabilities is cumulative and is contingent on what has gone before. For example, it is simply not possible to leapfrog from producing simple radio transformers to global positioning systems. Knowledge and know-how are highly specific and accumulate through experience. Between radio transformers and global positioning systems, there will inevitably be many technological stepping stones.[1] Typically, mastery over technology involves small hops, not big leaps. For low-income countries, strategies should be directed at enabling assimilation, adoption, and adaptation of physical technologies that are essentially of foreign origin. Investments in education need to focus on mass literacy and numeracy, as well as on basic technical and scientific skills. Investments in basic physical infrastructure will also be important. Not until quite sophisticated capabilities have already been acquired does it make sense to invest in R&D aimed at innovation on an international level. But once countries have reached

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[1] For one company in Taipei,China, the intermediate steps involved the following sequence: production of transformers and coils for radios, transceivers, citizen band transceivers, audio stereos, cordless telephones, power supply units, desktop computers, portable computers, telecommunications equipment (including mobile telephones and fax machines), and then eventually global positioning systems (Westphal 2001).

this point, public and private investments in advanced scientific and technical education will be needed, and countries should have high quality institutions that, among other things, offer protection to intellectual property.

Throughout this essay, the observation has been made that improved capabilities need to be matched by a demand for improved technology. Absent demand, rates of return on new, more productive activities will be low and progress will falter. Lall's "functional" or enabling policies operate through this channel, acting on the incentives, institutions, and information needed to encourage and reward enterprise and investment in new economic activities.

The thorny issue remains of what types of selective policies countries might consider following to promote technology. It is at this point that technology and industrial policies intersect most closely. Most countries in East and Southeast Asia have at one point or another intervened selectively to favor particular activities (like exporting or foreign direct investment) or sectors (like car manufacturing, biotech, or information and communications technology). Even Hong Kong, China with its almost unique noninterventionist approach heavily supported infrastructure development. Indeed, in seeking to influence the shape and rate of transformation of their economies, there are few countries (developed and developing alike) that have not tinkered with incentives. Whether or not interventions have worked, can be usefully copied, and are still permissible (within World Trade Organization rules) is an entirely different matter. Successful strategies would appear to lie in designs that provide strong performance-based incentives and avoid featherbedding of inefficient activities.

Rodrik (2004) provides a perspective on industrial policy that emphasizes the importance of demand for new economic activities. Rodrik prefers the term "discovery" to "innovation" as low-income countries typically do not come up with new goods or processes on their own, rather, they latch onto physical technologies developed in other countries. But from the perspective of the adopting country, the product will be novel and the technology modern. When Kodak entered into a joint venture in 1982 with the PRC to produce slide projectors in Shanghai, the technology and product were hardly cutting-edge, but represented technological advances for the PRC.

The rationale for policy intervention is straightforward: "discovery activities" can have high social returns but low private returns. Two factors drive a wedge between private and social returns. First, entrepreneurs that "discover" a profitable new activity may not be able to collect adequate returns as these are skimmed off by copycats who do not incur "discovery costs." Or if discovery is costly and unprofitable, entrepreneurs bear the costs themselves. Essentially, there is an information externality as discovery costs are revealed only after the event. Second, new activities cannot easily emerge from an environment where upstream or downstream infrastructure, which may have high fixed costs, is lacking. This is a classic coordination problem in which if all investments occurred simultaneously they would be profitable, but in isolation they are not.

Not all market failures lend themselves to fixing. Certainly, government alone may not have the information, capabilities, instruments, or fiscal resources to improve outcomes. But, if private returns to new activities are low compared to potential social returns, a hands-off approach could tax dynamism and growth. In these circumstances, it is a practical rather than philosophical matter whether policy can engineer improvements.

For Rodrik, the solution lies in approaches that embed private initiative in a framework of public action. As the public sector may have less information than the private sector as well as limited capabilities, institutional arrangements must engage both, balancing public sector autonomy with private self-interest. Malaysia's National Economic Consultative Council and Industry-Government Group for High Technology are examples of mechanisms that seek to generate information and knowledge, bridging public and private interests. Similar consultative arrangements that bring together chambers of commerce, industry groups, and government exist in many other countries in East and Southeast Asia. Such arrangements are most effective in resolving coordination failures when they are inclusive, transparent, and publicly accountable. To facilitate technological transfer and the expansion of productive activities in the private sector, public support for R&D, technical training, and extension services could be considered.

Rodrik also advocates selective interventions, but emphasizes that subsidies or other forms of financial support (e.g., start-up capital, credits, guarantees, or even prizes) should be targeted only at substantially new *activities* (and, then, only those with spillover benefits). There is no basis for supporting existing activities or sectors, as their discovery processes will have been largely completed. To ensure that public sector resources are not siphoned off and diverted to unintended uses, financial support must come with conditions. Ensuring that the government-supported portfolio generates positive fiscal returns as well as social benefits will require credible performance-based incentives, sunset clauses, and shutdown conditions. Though the policy space open to developing countries in Asia may have been narrowed by multilateral disciplines as well as by bilateral and regional free trade agreements, there is still ample scope for supporting discovery, and by extension, technological modernization, through financing and other arrangements.

Conclusion

Advances in physical technology and the capabilities that are required to master and use technology purposively are at the foundation of material economic progress. But harnessing the benefits of technology requires more than acquiring technological hardware and the capabilities to use it. Though these are clearly vital, it is equally vital that there is a demand for modern technology. As technology is rarely disembodied, modernization is likely to go hand in hand with a country's success in generating new activities and diversifying its economy. As such technology policy is necessarily tied to greater efforts to widen the productive opportunities of countries. Asia's experience, though diverse, confirms that incentives, effective and adaptable institutions, and market-based performance tests are essential ingredients of successful operational approaches.

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