The Changing Institutional Requirements for Technological and Economic Catch up

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INTRODUCTION

The central question of development economics is, or ought to be: "How have and how can countries that are significantly behind the technological and economic frontier catch up?". As posed, the question divides into two parts, one involving study of the past, and the other a look into the future. Today's policy questions obviously relate to the latter. However, the design of policies that will work today depends, I would argue, on achieving a satisfactory understanding how Korea, Taiwan, before that Japan, still earlier Continental Europe, and the United States, successfully caught up with the technological and economic leaders of their era, and reflecting carefully on what is similar and what is different about the present conditions.

I propose as a basic premise that catching up requires gaining access to and mastery of the technologies used by the leading countries of an era, and this means that mechanisms of technological learning need to be studied as a central part of the catch up story. However, I take a broad view of what technologies are, defining the term as encompassing the wide range of productive techniques for meeting needs that human kind has developed over the years, from sophisticated product designs, to procedures used in productive agriculture, to air traffic control systems, to effective public health practices, and capabilities to build and protect water supply for a growing urban population. I note that the capabilities towards the end of this list involve a lot more than

what engineers tend to mean when they talk of technology. While some aspects of these activities are indeed structured by or embodied in machines or other physical artifacts, they also involve centrally modes of organizing, coordinating, managing activities. There is good reason to believe that these organizational and managerial aspects of operating a technology often are much more difficult to master than the engineering aspects.

More generally, it is important to recognize that most technologies are operated through organizations, and learning to master the needed organizational structures and modes of management is an essential part of the catch up process. In turn, firms and other organizations are dependent upon a nation's education and training systems, labor and capital markets, competition and regulatory policies, programs of support of infrastructure, and the ability of government more generally to provide a context for rapid sustainable economic development. Thus, while the perspective I propose has the processes of technological learning in the foreground, the background involves many different facets of a nation's institutional structures. Building new institutions, or adapting old ones to new purposes, may be the most difficult part of the catch-up process.

One way of posing the central question is this. What have been, and what presently are, the kinds of policies and institutional structures that facilitate technological learning and mastery, across the broad front needed for sustainable economic development? There is no presumption of uniqueness here. The quest is to identify certain elements that, while they can take on different form in different countries and different eras, seem to provide the key. And of particular importance of course, the quest is for the policies and institutions that are needed under present conditions.

This way of posing the central development question seems so compelling that one might expect that it has been at the center of attention of the development economics community. But this is not the case. Understanding differences across countries in their level of economic development and the reasons for economic backwardness was of course a central concern of the great classical economists, particularly Adam Smith. But these questions gradually moved to the periphery of the field.

The question came back into focus after World War II. That the development problem was a catch up problem was put forth explicitly in Alexander Gershenkron's "Economic Backwardness in Historical Perspective" (1951), which considered the policies and new institutions of the states of continental Europe during the mid and late 19th century as they strove to catch up with the U.K. , and reflected on the present day relevance of this experience. However, few contemporary development economists have much paid attention to the processes of catch up per se, because most of prevailing economic growth theory has seen the principal reason for low productivity and incomes as low levels of physical and human capital, as contrasted with inadequate access to or command over technologies and other practices used in high income countries. Relatedly, imitation of technologies, and practices more generally, that are in use in advanced countries generally has been viewed as relatively easy, if there are no barriers like intellectual property rights, and the needed inputs, particularly physical and human capital, are available.

The proposition I stress here is that learning to do what others already have done often is not easy, even if there are no particular barriers, but often involves a difficult learning process. I also want to highlight that, while the term "catching up seems to connote that the country catching up in effect copies more or less exactly the practices of the more technologically advanced countries, what is achieved usually diverges in certain

ways from practice in the countries serving as a model. In part the divergence here reflects that exact copying is almost impossible, and that attempts to replicate at best get viably close. In part it reflects deliberate and often creative modifications aimed to tailor practice to local conditions. As I have suggested, the needed special tailoring almost surely is greater for the institutional aspects of catch-up than for the purely technological.

Moses Abramowitz' propositions about the institutional and political conditions needed for successful catch up (1986) clearly had this orientation, and generated a small research tradition specifically on the processes of catch-up. However much of the research stimulated by Abramowitz rather quickly came to concentrate on regression analysis of country level variables. Some of this research has been quite illuminating. Thus scholars like Fagerberg, and Bernardes and Albuqurque, have shown that in recent years countries that have caught up rapidly have tended to focus their higher education systems on engineering training, and have developed indigenous research efforts. However, by and large the variables in these kinds of analyses are defined at a level of aggregation too high to permit analysis of many of the relevant factors.

There are several quite detailed studies of particular countries that have been successful in catching up that do delve into the key processes and institutions involved. There are several fine studies that have examined how firms in developing countries have caught up in particular industries. However, these kinds of studies have not been brought together in a systematic way.

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This presentation is more a laying out of a research agenda, plus conjectures as to what that research is likely to show, than a report of completed research. In the following section I propose several different elements that have been present in successful efforts of

catch up. I then turn to how the context for catch up has changed, and some of the implications of those changes for developing countries today. I conclude by proposing that research in universities and public laboratories is likely to play a much more important role in the innovation systems of countries that catch up during the 21st century than in the past. I have little evidence to support this conjecture. My purpose in making it is to stimulate thought, argument, and research.

ELEMENTS OF THE CATCH UP PROCESS

My reading of prior relevant research leads me to propose that, in the past, all successful cases of catch up have involved the following elements.

First, considerable cross-border flow of people, with a combination of citizens in the then backward country going to learn abroad and then returning, and people from the advanced country coming as advisors or, in some cases, to establish themselves in the developing country. Thus the core of British textile manufacturing methods was brought over to the new United States by British technicians, who stayed. Sidney Pollard has detailed the flow of British to northern Europe in the early 19th century, who came with the objective of setting up business on the continent. The development of Japanese industry in the late 19th and early 20th century was helped by technical advisors from abroad, as well as by Japanese returning home after studying Western methods. The Korean and Taiwanese electronics industries were developed largely by men who had studied, and often worked, in the United States.

During the twentieth century companies came to play an increasing role in this cross national learning and teaching process. The new Japanese automobile and electrical equipment companies established close interactions with companies in the United States

and Europe that served as their mentors. The development of Singapore was largely driven through the establishment branch operations by Western multinationals. Michael Hobday has documented in detail how Korean and Taiwanese companies developed increasing competence working for American and Japanese electronics companies as Original Equipment Manufacturers

Over the last quarter centuries an important part of the transnational flow of people in the catch up process has involved university study abroad in the relevant fields of engineering and applied science. University faculty in the successful developing countries has to a considerable degree been based on nationals who received their training abroad. While this development has been particularly visible in recent years, it should be noted that up until World War II a good fraction of Americans taking advanced training in chemistry and various sub fields of physics did so in Europe. I believe that this university mediated trans national conduit of learning will be of particularly great importance during the 21st century for countries seeking to catch up. This certainly will be so regarding agriculture, public health and medical care, as well as regarding manufacturing technology.

While the benefits of such transnational learning may seem apparent, governments in countries trying to catch up often have tried to hinder some of the key activities involved. Thus the outflow of young talent from a developing country to study or work abroad often is seen as a "brain drain". In some cases concerns about brain drain turned out to be well justified; the emigrants did not return. It is important to learn more about what processes and conditions make such people flow advantageous to developing countries.

A second important element in countries that successfully caught up with the leaders during the 19th and 20th centuries was active government support of the catch up process, involving various forms of protection and direct and indirect subsidy. The guiding policy argument has been the need of domestic industry in the industries of the day judged critical in the development process for some protection from advanced firms in the leading nations. Alexander Hamilton's argument for infant industry protection in the new United States was virtually identical to that put forth decades later by Friederich List regarding Germany's needs. The policies and new institutions used in Continental Europe to enable catch up with Britain are documented in Alexander Gershenkron's famous essay. The same story also fits well with the case of Japan, and of Korea and Taiwan somewhat later. In many countries these policies engendered not successful catch up but a protected inefficient home industry. However, they also were the hallmark during the 20th century of all the countries that have achieved their goals of catching up. Again, we need to learn more about the circumstances under which infant industry protection leads to a strong indigenous industry, and the conditions under which it is self defeating.

These policies obviously angered companies in the leading countries, and their governments, particularly if the supported industry not only supplied its home market but began to invade the world market. While the case made after World War II for free trade was mostly concerned with eliminating protection and subsidy among the rich countries, and at that time there was sympathy for the argument that some infant industry protection was often useful in developing countries, the international treaties that have been made increasingly have been used against import protection and subsidy in countries seeking to catch up from far behind.

My belief is that Hamilton and List were right that successful catch up in industries where international trade is considerable requires some kind of infant industry protection or other forms of support. The challenge is to find effective means under the new conditions.

Third, during the 19th and early 20th century, many developing countries operated with intellectual property rights regimes which did not restrict seriously the ability of their companies to in effect copy technologies used in the advanced countries. There are many examples where licensing agreements were involved, but I believe that for the most part these were vehicles through which technology transfer was effected for a fee or other considerations, rather than instances of aggressive protection of intellectual property by the company in the advanced country.

Like infant industry protection and subsidy, conflicts tended to emerge largely when the catching up company began to encroach onto world markets, or even to export to the home market of the company with the patent rights. Increasing instances of this clearly were a major factor in inducing the treaty on Trade Related Intellectual Property Rights. But this treaty makes vulnerable to prosecution not just companies in developing countries that are exporting, but also companies that stay in their home markets.

The increased tendency of companies in high income countries to enforce their intellectual property rights is having consequences regarding agricultural development, and the workings of the public health systems in developing countries, as well as regarding manufacturing development. Patented seed varieties are playing an increasingly important role in modern agriculture. And patented pharmaceuticals are key elements in the attack on a number of diseases that devastate poor countries. The arena of intellectual property is almost sure to become one of considerable international

conflict in the immediate future. Developing countries need to learn to be able to cope with this new problem.

CHANGING CONDITIONS

I already have begun to lay out a number of aspects in which how the current and future development environment for countries trying to catch up is different from what it has been. International treaties have changed the environment for catch up in important ways. Firms in the advanced countries are likely to press hard for access to markets and in many cases the rights to establish branches abroad. Protection and subsidy of domestic industry is likely to be met by legal and other punitive action on the part of the advanced countries, and hence will have to be more subtle, involving support of sectoral infrastructure, training, and research. Firms in advanced countries also are likely to be far more aggressive and effective in protecting their intellectual property rights, and hence firms and governments in developing countries will have to develop new strategies for access on reasonable terms.

The new legal environment has come into place in a context where both business and finance are operating on a more global frame. Foreign direct investment has played a significant role in the catch up processes of some successful countries, and is likely to play an even greater role in the future than in the past. So too partnerships between firms in developing countries and companies that possess advanced know how. At the same time, firms in developing countires can aspire realistically to sell on a world market if their wares are good enough.

Less well noticed, scientific and technical communities in different countries also are now more connected than they used to be. I believe this latter development is very important.

It is important because another major development over the past half century has been that technologies increasingly have become associated with fields of applied science or engineering dedicated to achieving scientific understanding of the principles that are operative, to providing training for professionals who will work with the technology, and to building a scientific basis for efforts to move the technology forward. Included here are such older fields as chemical and electrical engineering, and modern fields such as computer science, biotechnology, and immunology. In recent years these fields of science have become increasingly open to those who have the training and connections to get into the relevant networks.

The implications for catch up can be profound. On the one hand, in technologies with strong scientific underpinnings, advanced training in the field has become a prerequisite for ability to understand and control; simple working experience no longer will suffice. This fact clearly challenges the capabilities for education and technical training in countries seeking to catch up. But on the other hand, I believe that a strong science base significantly reduces the importance of operating apprenticeship abroad, or tutelage by foreign industrial experts. This is not to argue that advanced formal training in a field suffices for mastery. However, in many fields it provides a substantial basis for learning by doing. Moreover, having a domestic base of good scientists provides the basis for breaking into the international networks where new technologies are being hatched.

As a result of these changes, certain avenues that were open to follower nations in the 20th century now are closed, or at least more difficult to follow in the 21st, but on the other hand certain avenues are more open.

THE INCREASED IMPORTANTANCE OF INDIGINOUS CAPABILITIES IN SCIENCE AND TECHNOLGY

Christopher Freeman has proposed that Friederich List had something like a National Innovation System in mind when, in the mid 19th century, he was writing about what Germany needed to do to catch up with Great Britain. However, the modern conception of a National Innovation System was developed to be useful in thinking about the key institutions involved in technological advance in countries at or close to the frontier. It would seem evident that, if the concept is to be useful for orienting policy in countries significantly behind the frontier and striving to catch up, some significant reorientation is needed from the standard format. Lundvall and colleagues, Albuquerque, and Viotti, among others, have attempted to highlight some of the needed reorientations.

I propose that a suitably reoriented concept of an Innovation System can be a useful tool for considering policies and institutions needed for effective catch-up in the new context. In the first place, it calls attention to the fact that the process of catch up involves innovation in an essential way. The innovating that drives the process of course differs from the innovating that has been the central focus of research on technological advance in advanced economies. The new technologies, practices more generally, that are being taken on board, while new to the country catching up, generally are well established in countires at the frontier. And much of the innovation that is required is organizational and institutional. But what is going on in catch up most certainly is innovation in the sense that there is a break from past familiar practice, considerable

uncertainty about how to make the new practice work effectively, a need for sophisticated learning by doing and using, and a high risk of failure, as well as a major potential payoff from success. These aspects of catch up tend to be denied or repressed in the standard economic development literature.

Second, the Innovation System concept focuses attention on domestic institutions involved in science and technology. While in earlier eras such a focus may not have been warranted, my proposition is that it is an important one in the twenty first century. Perez and Soete, and Pavitt and Bell, argued this point some time ago, as did I in my essay with Carl Dahlman. But I think it fair to say that standard development economics still is mostly blind to this possibility.

I believe that an important part of the national strategies needed to effect catch up will involve strong support of scientific and technical training. In particular, I propose that indigenous universities and public laboratories will play an increasingly important role as vehicles through which the technologies and organizational forms of the advanced countries come to be mastered in the developing ones, as partially an organizing structure for and partially a substitute for international people flows. Indigenous universities will play a key role as the source of students who take advanced training abroad, and as the home of faculty who have been trained abroad. On the other hand, domestic universities must do the bulk of the training of people who will go to industry and other economic activities needing well trained technical people.

And I want to argue that the research capabilities of universities and other public institutions will play an important role in catch up in the 21st century. Indeed, while ofen overlooked, indigenous research long has been an important element of catch-up in certain important fields. This is especially so in agriculture and medicine. An important

part of the reason is that in these areas developing countries often could not simply copy technology and practice in countries at the frontier, but needed to develop technologies suited to their own conditions. Soil and climate conditions tended to be different. The prevalent diseases were different. There is every reason to believe that the importance of having the capability to do effective research and development in these fields will be even greater in the future.

In contrast, while in manufacturing the technologies used in advanced countries may not have been optimal, at least they worked in the new setting with often modest modification, and they generally were available at no great expense. The experience of countries that have successfully caught up in manufacturing over the past half century testifies to the importance of a nation's education system in providing a supply of trained engineers and applied scientists to manufacturing firms catching up. And an important part of the catch up process has involved firms learning to do R and D on their own. However, while there are exceptions (electronics in Taiwan seems to be one) it is not clear that research per se in universities and national labs has played an important role in catch up in manufacturing, beyond its role in the training function.

But circumstances may have changed. In the new regime of stronger protection of intellectual property, it is going to be increasingly important that countries trying to catch up develop their capabilities to revise and tailor manufacturing capabilities relatively early in the game. First of all, this can help companies to develop and employ technologies that avoid direct infringement of intellectual property that is likely to be enforced aggressively. Second, over the longer run the development of an intellectual property rights portfolio by firms in a developing countries can provide bargaining weight in the complex cross licensing arrangements that mark many manufacturing industries.

More generally, achieving competence in many areas of manufacturing requires staying up with a moving target. Further, as the frontier is approached, the lines between sophisticated imitation and creative design of new products and processes becomes blurry. A strong R and D capability becomes essential. To a considerable extent the R and D needs to go on in firms. However research in universities and public laboratories can play a strong supporting role.

I also want to note here the important roles that universities have played over the years in training private and public managers. This role is likely to become increasingly important.

It is a mistake, I believe, to view a nation's system o public research and high level training as monolithic. The roles of public sector research and he institutional structures clearly differ between manufacturing, where engineering schools and a few departments of applied science, like computer science, and in some cases specific technology oriented public laboratories are involved, and medicine and public health, where the key actors are medical schools and disease related public research laboratories, and agriculture, where still a different set of institutions are involved. And by and large schools of business and of public administration have their own identity.

Thus it is a mistake to view the policy challenge as simply to strengthen university research, without attending to the areas where the priority is high, and to the often quite specialized needed institutional structures. Indeed it needs to be recognized that many existing university systems, or parts of university systems, operae more or less in isolation from the firms, farms, hospitals, that need to learn about and come to master superior ways of doing things if economic development is to proceed effectively. For the

training and research done at universities and other public institutions to contribute to economic development, there needs to be effective linkages between those institutions and the organizations and sectors involved in the production of goods and services. Existing university structures in some cases may be as much a barrier as a potential vehicle for the development of an effective system of public research and training. Achieving an effective system of public research and training is no mean challenge.

I note again, I highlight, that most of what I propose above is conjecture. I have very little evidence to back it up. If I am right, careful research on issues like these should be a high priority subject. I hope these notes have stimulated interest in the subject. Roberto Mazzoleni's essay, to be presented later in this conference, will carry these ideas further.