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DETERMINANTS AND CONSEQUENCES OF INDIGENOUS TECHNOLOGICAL ACTIVITY

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Our basic premise is that to the extent that any one dimension is "key" to the successful application of technology in the development context, it is the quality of indigenous technological activity that counts the most. Moreover, though demonstrably more difficult, we hope to be able to maintain this premise even as we descend from generalities to address the more specific linkages with other dimensions of the complicated technological "ball of wax."

Section I will present some definitions and suggest one way of viewing the key relationships among the many concepts floating about the literature. Section II will focus on the supply and demand side determinants of indigenous technological activity. Section III, finally, will discuss the potential and actual consequences for LDC societal objectives of putting indigenous technological activity in its proper place and briefly summarize the policy implications of this view.

I. Indigenous Technological Activity: Definitions and Relationships

The profession, as well as most real world actors, needs little convincing today--in contrast to the situation in the early post-war era--that the black box labelled "technology" contains all variety of "goodies" which, if we could just unlock it and sort it out, is more likely to make the

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difference between success and failure than most other prescriptions, certainly including those relying heavily on the brute force of capital accumulation, with or without an assist from the outside.

It is our contention that "the" basic key to unlocking that box is the twin recognition that i) the co-existence with more advanced countries and more advanced country technologies--in both product and process dimensions--represents an overwhelmingly important dimension of an LDC's dimenment--for better or worse and whether we like it or not--and that ii) the nature and extent of indigenous technological activity will, in fact, determine whether it indeed is "for better" or "for worse"--or, at least for "not as good as it should be."

The first part of this contention is based on the premise that, no matter how "closed" or "self-reliant" the developing economy, the existence of a backlog of accumulated knowledge on "how" to produce and on "what" (attributes) to produce, across countries and across time, dominates all technological activities. Thus "technological dependence" in the broadest sense of that much abused term is an incontrovertible and inescapable fact of life. The second part of the assertion is based on the premise that nothing can ever be efficiently transferred to a particular place at a particular time without having to be modified to make it fit the always peculiar local circumstances; this applies as much to essentially turn-key projects as to the "rediscovery" of old ways of doing things within the developing country itself. In other words, the wheel cannot be imported as is and it cannot be "reinvented" either; to some extent it has to be adapted or modified if it is going to fit in with always different and ever changing local circumstances.

It is the capacity to make those changes continuously, rather than to invent something emerging full-blown "from the brow of Zeus," which constitutes, we believe, most relevant technological activity. In these terms all technological activity is indigenous almost by definition; but it is the quality of an LDCs' indigenous technological capacity which determines how "well" or "appropriately"--in terms of a changing endowment--technology choices, adaptations and modifications are being made on a continuous routinized basis.

Unfortunately, the stock of indigenous technological capacity can only be identified in its use; thus, as with entrepreneurship, it is difficult to define capacity independent of the occurrence of indigenous technological activity. As a consequence, one is forced to settle for tangible evidence of demonstrated indigenous technological activity appearing in association with presumably relevant dimensions of capacity.

Demonstrated indigenous technological activity may be defined in three related ways: one refers to the initial choice of the technology as embodied in blueprints, salesmen's handbooks, machinery patents and commodity tradeworks, foreign or domestic; a second refers to the required modifications of that technology for effective local application; a third focusses on the diffusion of best practice, with appropriate modifications, across agricultural and industrial establishments. Add to this the fact that the accumulated storehouse of human knowledge--i.e. the potential "shelf" or technology space--is constantly being added to as a consequence of the march of science and technology in the mature industrial countries, and we begin to see the outlines of the formidable conceptual tiger we have by the tail.

The quality of the indigenous technological activity actually observed is thus partly a function of the capacity to choose wisely (and cost effectively) from among the shelf technologies, partly a function of the capacity to tinker and adjust, and partly a function of the capacity to channel and diffuse. While these capacities are clearly neither fully independent in concept nor empirically identifiable in isolation, e.g. the capacity to diffuse relevant information and the capacity to tinker are usually closely associated, it is nevertheless worthwhile to try to distinguish among them. They may well depend on somewhat different human and/or organizational and institutional abilities on the supply side and be critically affected by different dimensions of the economic environment determining the demand side. Together they add up to a certain quality of indigenous technological performance the level of which has to be assessed in terms of the system's total responsiveness to the economy's underlying endowment conditions as well as its flexibility to changes in those conditions over time. We intend to take a closer look at these underlying supply and demand side determinants of indigenous technological activity in what follows.

II. Supply and Demand Side Determinants of Indigenous Technological Activity

Activity of any kind is based both on the capacity to carry it out, a supply side concept, and on the desire to carry it out, a demand side concept. Indigenous technological activity is no exception. While a division into supply and demand factors is necessarily at times somewhat artificial, it remains useful for expositional purposes. Accordingly we intend to discuss the various ingredients of each consecutively, bringing to bear the relevant evidence as appropriate to the case.

The most obvious and yet also the most important ingredient of indigenous capacity resides, of course, in the quality of the human resources available to the developing society. The qualities which affect the nature and direction of the process of search among "known" core techniques and product choices and the qualities which affect the process of modification and adaptation may not be precisely the same but they are very likely to be closely related, i.e. to have their roots in differing or the same combination of formal and informal learning experiences to which the economically active population has been exposed.

Economic historians and historians of science have been puzzled for some time about the precise origins of a basic technological capacity embedded in a society's entrepreneurial population at large. Such capacity is obviously related to some extent to general literacy, especially in the agricultural sector,[1] and very likely also to the extent of the overall primary educational system's emphasis on general cognitive processes and on empirical problem solving capacity using locally informed cases. Historically, the U.S., for example, borrowed heavily from England in the last half of the 19th century, but the key to her subsequent success resided in the mechanical engineering industries which facilitiated new production with interchangeable parts and was based on a wide-spread tinkering capacity. As Rosenberg saw it, the Americans borrowed freely and extensively, with very little genuine inventive activity of their own, even during the colonial period. The role of widespread general education provided for a substantial measure of technical literacy at all skill levels and created a substantial problem solving capacity

[1]For example, see Christopher Colclough, "The Impact of Primary Schooling on Economic Development: A Review of the Evidence," World Development, March 1982, ("The evidence....from studies of farmer productivity suggests that individual behavioral changes that result from schooling are stronger when literacy is widely spread.")

which undoubtedly helped the U.S. to be both "highly discriminating in borrowing patterns and highly selective in the uses to which imported technologies were put." While the U.S. produced few contributions to frontier science and even frontier technology the improvement of imported technology in a labor saving direction as part of the "American system" responsive to the more labor scarce endowment situation a la Habakkuk, required not only engineers who had at least a grounding in "high technology" and its use but also large numbers of polytechnic level technical personnel imbued with an extremely pragmatic attitude towards technology. The U.S. as a frontier society with virtually unlimited natural resources and therefore not inclined to invest heavily in indigenous basic innovations stands in some contrast to Germany, the other beneficiary of England's loss of technological leadership. In the U.S. infrastructural investments by government, in education as well as in agricultural research and extension services, helped create a broadly based technological literacy to improve and diffuse technology; natural resources poor Germany, in contrast, focussed on goverment supported basic science and science intensive industries and a much more elitist general as well as technical educational structure.

Most contemporary developing countries find themselves in situations with a natural resources endowment likely to be much less plentiful than that of the 19th century U.S. and a skilled human resources endowment much less plentiful than that of Germany. The reliance on the embodiment of unskilled but literate labor is thus likely to be much more important. Historical Japan, with her poor natural resources but abundant human resources endowment, in fact, might be viewed as the most relevant for LDCs. After early Meiji government mistakes in attempting to apply Western style, land abundant methods in agriculture, mainly developed for wheat, to a small scale, land scarce, rice economy--and similar errors in industry via importing inappropriate "turn-key technology" for use in public sector plants--it took the Japanese relatively little time to recognize the importance of selecting imported technology relatively carefully and then adapting it substantially to local conditions. Both in agriculture and in industry, trial and error led to greater reliance on private sector decisions regarding technology choice. The enhancement of indigenous technological capacity through education, through demonstration farms and extension, and through the efforts of travelling veteran farmers, had their counterpart in more informal private diffusion activities in the nonagricultural sector. The empirically based response of Japanese industrial as well as agricultural actors to the changing availability of a technology potential would not have been possible without a strong and well dispersed educational base, both general and technical, which has been a part of the Japanese scene from the very beginning.

Neither 19th century U.S. or Japan were thus pioneers either in science or in basic technology, but they both developed a definite capacity to absorb science and imported technology as a basis for their own very substantial achievements. The capacity of each to respond successfully to very different endowment conditions is related to the nature and reach of the educational system as well as to the quality and strength of other infrastructural interventions.

No actions of government can, of course, legislate "against" the basic, drastically different, initial endowments. They can, however, play an important role in the educational and institutional sphere to overcome supply-side constraints on indigenous technological activity. The substantial adaptations on top of imported technology in Japanese industry as well as the almost instantaneous diffusion of the improved technology in both industry and agriculture in 19th century Japan are but a case in point. The emphasis on primary education, the role of the agricultural extension service, the land policy and the expansion of the railroad and rail repair network played a similar role in the U.S. The engineering intensive technology which was adapted to the wide open spaces of the United States is hardly less relevant than that of Japan which took a more capital stretching path.

The causal direction does not, of course, always run from science to basic and then to applied technology. As Kuznets, among others, has pointed out, technology continuously gives rise to as many puzzles which require a further response by the scientific and technological community, as the other way around. Thus the U.S. and Japan, over time, built their own science capacities partly in response to such demands, partly because they could increasingly afford a scientific establishment marching to a different (longer term) drummer. But at an earlier stage relevant, say, to most contemporary African societies, the capacity to utilize or modify international technology and adapt it to different environments depends on the extent to which tinkering can become routinized within a substantial proportion of the entrepreneurial and engineering cum polytechnic population.

The capacity to pick intelligently from an international shelf in full awareness of the costs of search, adaptation etc. may be more of a white collar task of information gathering plus R&D activity, while the capacity to solve puzzles and adapt further is likely to be a mix of white and what might be called blue collar R&D and information diffusion capacities. It takes a certain amount of wisdom, for example to choose initial foreign technology to be at least in the "vicinity" of a system's domestic capacity so that it acts as a stimulus to the problem solving capacities of the indigenous population, not as a discouragement. It takes a somewhat different set of talents to make the crucial adaptations to meet peculiar local conditions. Whether these are equally dependent on general literacy or on more formal engineering education, is beyond my ken. What seems clear is that the second capacity needs to be much more widely diffused throughout the population and may be very much related to the existence of a capital goods industry, especially in mechanical engineering, repair shops etc. in developing countries. Such a capital goods sector undoubtedly plays a very special role in determining indigenous capacity in the sense that it provides a given quality of human resources a chance to have a multiple impact. We are dealing here not only with so called "compulsive sequences," i.e. new ideas at one processing stage forcing appropriate changes in techniques and attributes up or down the line, but also in terms of the simple proposition that "tinkering" requires complementary resources which must themselves be adjusted and modified in the course of development. The extent to which simple repair and mechanical engineering industries are developed is bound to have a wider multiplier effect in terms of the ability to modify products and processes in a wide range of client industries. This has been demonstrated through the examples of blacksmiths in Sri Lanka, tube well repair shops in the Punjab and metal-mechanic industries in Peru.

Other supply side dimensions affecting indigenous technological activity, of course, relate to the organizational/institutional infrastructure which the public sector may or may not create, or may or may not channel in appropriate directions. We have in mind here the extensive science and technology institutional infrastructure which often favors export cash crops while discriminating against food crops in agriculture while focussing on the relatively advanced end of the science and technology spectrum and giving short shrift to more modest support of problem solving capacities in the engineering, metal working industries and their customers. We all know too well the small allocation of global R&D in the developing world as a whole, in Africa in particular. This makes the frequent allocation of very scarce budgetary and human resources to essentially "white elephant" activities which tend to respond to irrelevant reward and value systems even more painful.

It is, of course, difficult to fashion hard and fast decision rules which might tend to eliminate any frontier type, publicly funded research activity, whether it is basically science or technology oriented; but the burden of proof clearly should be on the allocation of very scarce budgetary and human resources in that direction, when the most elementary private sector adaptation and diffusion capacities are relatively underdeveloped and could be given substantial assists through modest public sector contributions. There can be little doubt, for example, that a society's information gathering and adaptation capacities need to be viewed as of one cloth, even though we may differentiate them conceptually.

We also know that there exist startling gaps in knowledge about existing technological choices, domestic and foreign, within any given developing country, along with the well known absence of the capacity to make the necessary modifications. Thus the best network for diffusing information, while probably in the private sector, can be helped by government actions, e.g. by utilizing the same resources now in traditional science and technology institutes to support a network with built-in information cùm problem solving capacity available to the crucial private actors in both the agricultural and non-agricultural sectors. We are not referring here to "question and answer" services which usually don't make too much sense because of the unlikely ability of the final customer to be able to formulate the proper question, but rather to public sector support for an essentially private network which permits information and problem solving capacities to be combined and enhanced by encouraging "doing" and gaining confidence by "doing."

The specific public policy changes required for such an information/diffusion/adaptation network can not, of course, be spelled out, certainly not for all country types and stages of development. But once we recognize that these capacities are indeed of one cloth and must be accessible to a large number of small blue collar actors we can examine such possibilities as rural industrial extension services along the lines of the more successful farmer association experiences in the developing world, as well as introducing such a capacity into decentralized credit institutions such as development or commercial banks equipped with substantial numbers of rural branches. There often is a need in such cases for this particular function to be at least initially subsidized, preferably on a declining scale over time. To a modest extent a change in the reward system within the so-called science and technology institute community can also be of help by focussing scarce entrepreneurial scientific and intellectual energies in the direction of a strengthened indigenous technological capacity,rather than the ability to participate in the invisible college of the international engineering and scientific establishment.

There are undoubtedly important institutional and organizational choices which affect the quality of a society's indigenous technological capacity over time. One of these clearly includes the issues of subcontracts vs. more integrated firms in industry,as well as the related issue of how soon modern inputs produced outside of agriculture replace traditional inputs. The simple minimum cost choice answer may not include the dynamic effects in terms of encouraging indigenous technological competence outside the large firms. The Japanese record of doing a good deal of industrial subcontracting early on and enforcing enhanced quality standards by encouraging quality as well as price competition among a number of would-be suppliers is a case in point; the cultivation firm phenomenon in contemporary post-labor surplus Taiwan agriculture is another. We are not suggesting the encouragement of subcontracting via subsidization or any other selective government policy actions, only that a policy of at least even-handedness with respect to the allocation of infrastructure to rural areas would seem to constitute an important supply side action to strengthen the opportunity for a more decentralized growth of indigenous technological capacity. Most often the existing LDC allocation of public overheads in the industrial sector positively encourages the integration alternative, e.g. power rates are often lower in the large cities, and the construction of roads and other overheads tends to favor industrial concentration. This is also true in the agricultural sector where irrigation and other overhead allocation in favor of local elites is often quite blatant as a consequence of the relative weakness of decentralized rural organizations, both public and private, in most of the developing countries.

Another organizational dimension relevant to the supply side of the indigenous technology capacity canvas refers to the choice between batch and continuous production lines which may have differential dynamic consequences which are often not included in private sector calculations. Episodal accounts certainly seem to indicate that, very much in the vein of the modern Volvo story, a batch production process encourages the search for product and process change much more so than the continuous assembly line. Such dynamic dimensions would, of course, have to be weighed against static comparative cost calculations, but sensitizing the private sector to such issues, including incorporating this dimension within the information plus R&D capacity enhancement network, which might be partially encouraged by public sector action (see above), should be included in the consideration of how to strengthen supply side factors.

A quite distinct dimension of the supply side infrastructure that may assist in the development of indigenous technological capacity is related to the legal side. As we have already noted, in the more successful developing countries we witness a good deal of so-called blue collar R&D activity, with problem solving going on in unconventional locations and carried out by unconventional actors. Such "minor" innovative activity can be encouraged through worker incentive systems, suggestion box approaches etc., as traditionally in Japan, but also through the legal device of establishing a so-called utility model or "petty patent" as an alternative and supplement to conventional patenting legislation. Such an alternative, interestingly enough, exists in both Japan and Germany, the latecomer countries, as well as in some of the more successful contemporary developing countries. The system encourages application for the protection of smaller innovations with a lower "novelty" requirement, protected at lower financial and bureaucratic costs, in exchange for a shorter period of protection, i.e. 5 to 7 as opposed to 15 years. In such contemporary LDCs as South Korea and Brazil, petty patents seem to be granted primarily to nationals and individuals in contrast to regular patents which go predominantly to foreign corporations. The history of the Japanese textile industry, for example, indicates that, historically, such utility models were very important, especially in weaving, which relied heavily on domestic innovations based on traditional handlooms, improved with the help of imported Batten and Jacquard related ideas. Petty patents played a lesser role in cotton spinning which relied more heavily on adaptations from fully developed inventions "embodied" in imported machinery. It is, moreover, interesting to note that petty patenting seems to have been concentrated in mechanical engineering activities.

Moving beyond the utility model, the patent system as a whole, including design patents, trade marks, licensing systems etc. has not been carefully examined in this century with respect to its encouragement or discouragement of indigenous technological activity. We are all aware of episodal evidence to the effect that foreign patents introduced into LDCs are often used for blocking rather than transfer of technology purposes and that licensing payments often do not reflect the technology content of the transaction.

It is quite possible that a fuller reconsideration of the trade-offs between the appropriability of private gains function of patents and its function as a conveyor of information, if utilization can be enforced could point the way to substantially enhancing indigenous technological activity, given a certain level of human and institutional/organizational capacity within the LDC.

In addition to typological differences in the initial conditions among countries, e.g. size, resource endowment, etc., policies crucially affect the intensity of the search for indigenous technological activity on the part of individual actors, both in the public and private sectors. A developing country in early transition growth, for example, typically adopts a policy environment for purposes of primary import substitution industrialization which is typically unfriendly to indigenous technological activity. This is in general a period which focusses on "getting things done," providing a warm environment for a new industrial entrepreneurial class including obtaining the necessary physical tools or technologies from the outside. It is a period which emphasizes physical accumulation as opposed to efficiency and places much less heavy emphasis on the refined calculus of choosing appropriate technologies, either in terms of the careful search of international shelves or in terms of the effort necessary to make the appropriate adaptations or modifications domestically.

These regimes, in other words, discourage the coming into play of substantial indigenous technological activity, partly because they typically distort product and factor prices away from the endowment picture and because they usually create windfall profits for the private entrepreneurial class which make them much less interested in seeking out indigenous technological opportunities. It is, of course, also a period which typically encourages free entry of foreign capital goods while protecting intermediate as well as final goods via the normal cascading of tariffs,which policy may have a long term deleterious effect on the establishment of an indigenous capital goods sector, so often an essential ingredient, as we have seen, for the construction of indigenous technological capacity on the supply side. When government interventions especially favor, as in the India of the 1950's, Ghandian khadi and its associated traditional technology, on the one hand, and Mahalanobis steel mills based on imported technology, on the other, what is squeezed out is the vast array of indigenous technological activity likely to be most appropriate to her changing endowment conditions.

The problem of distorted relative factor and product prices is too well known to require much attention here. Underpricing capital, imports, and skilled labor, and overpricing unskilled labor of course affects static technology choices. For our purposes even more important is how it affects the nature of the search for new technologies over time. This is also a subphase of transition during which, for a number of reasons, great expectations abound with respect to the power of the imported process and of the internationally specified product, which apparently every developing country seems to go through, although the extent, severity and length of the import substitution policy syndrome of course vary substantially.

Perhaps more important than the relative factor price and relative product price dimension is the intensity with which normal entrepreneurial functions are likely to be carried out. The more scarce entrepreneurial energies are spent on playing the controls game, obtaining the slips of paper required for assuring oneself of the windfall profits available in various controlled markets. the less energy left for concern with indigenous technological activities. One can find this to be true in the agricultural sector where prices are often set artifically, as well as when there exist restrictions on entry and on access to scarce resources for new and small entrepreneurs in nonagricultural activities. This typically leads to "invisible handshakes" between elitist capitalists and elitist workers and a narrow growth path which excludes the majority of potential entrepreneurs who could substantially contribute to a successful search for indigenous technological activity.

If and when the society does shift from domestic market oriented import substitution into an export oriented regime via substantial reform in the various relevant policy areas the chance for a larger role played by indigenous technological activity is substantially enhanced. We have certainly observed this in the East Asian cases which graduated from import substitution to export substitution in the early 1960s. When such graduation does not take place, however, and countries persevere in import substitution, as in most of the Latin American countries and some of the ASEAN countries, an accelerated tendency for the noncompetitiveness and satisficing rather than maximizing behavior inimical to the demand for indigenous technological activity must be noted.[1]

Countries like those in Sub-Saharan Africa, still largely in early import substitution, are of particular interest here. They still have a fateful choice before them, i.e. whether to persevere in import substitution, shifting from primary to the more technology and capital intensive secondary type, or to shift into an export oriented policy stance.

The size of a developing country represents an important demand side typological characteristic quite aside from its effect on the availability of particular human and physical endowments already referred

[1] For some concrete examples see the author's: "Industrial Sector Labor Absorption", EDCC (April 1973) as well as "International and Domestic Determinants of LDC Technology Choice," (with G. Saxonhouse) in <u>Technology Choice and Change in Developing Countries: Internal and External Constraints</u>, Barbara Lucas and Stephen Freedman eds. Tycooly International Publishing Ltd., Dublin, 1982.

to. Among other reasons such size determines the relative importance of domestic versus international markets regardless of the policy regime in vogue at a particular time. In other words, even in the most successful case we would expect the domestic market insulated from international prices to be much more important in the large than in the small country case. In the case of smaller countries, the pressure for maintaining one's competitive edge by finding new labor using products and processes will come relative more from abroad. For larger LDCs it will come mainly from the demands of a broadly based balanced growth process in domestic markets. In that connection we should remind ourselves that the demand for indigenous technological activity has two components: one focussed on the continued search for more appropriate processes, the other on more appropriate products. Successful technological activity of the process type is likely to be more relevant to the export sector, with its emphasis on price competitiveness in international markets, while success in the search for appropriate technological activity on the product attribute side is likely to be more important with respect to the domestic blade of successful development, i.e. via balanced growth in domestic markets. Thus, assuming that supply side elements are well dispersed across the country, depending on its size and the dispersal of its population, the contribution of indigenous technological activity to each of these major blades of development will depend very much on the policy mix determining the intensity of the demand.

The important typological dimensions thus include size, the extent of labor surplus etc. as well as the initial geographic density of the population, the kind and extent of the existing transportation system, the level of initial agricultural productivity, which together indicate the ideal static degree of industrial decentralization for any given product mix. While we must assume that such initial characteristics setting the parameters for demand as well as supply side elements are not readily amenable to policy, the factors which determine the strength of the motivation of the individual entrepreneurs can be directly influenced by policy. LDC governments can affect the extent of the monopolistic or oligopolistic control of industries by internal measures as well as by the extent of effective protection etc. permitted to persevere with respect to competition from the outside. A reasonably workably competitive environment is the best insurance for creating the requisite demand side pressure for indigenous technological activity. Without a shift from satisficing to maximizing behavior on the part of individual economic actors there is very little chance much indigenous technological activity will be in evidence. Exclusive attention to the supply side is very much like pushing on a string. If millions of individual decision makers don't have the "bit in their teeth" little else will follow.

It is, of course, true that the rest of the world can also be very helpful or harmful in terms of the environment for indigenous technological activity in a given developing country context. Foreign aid, for example, to the extent it is tied to particular commodities or sources of technology, clearly provides an obstacle instead of an assist. On the other hand, by inducing a country to shift its policy mix it can also be of important help in the creation of a better environment for indigenous technological activity. It can do this both by helping create supply structures, a good example being the CIGYAR organization in agriculture, an international network of supply side information on food crop technology choices, as well as by encouraging a shift to more endowment responsive policies and the erosion of windfall profits, on the demand side. Similarly, with respect to multi-nationals, greater willingness to participate in a flexibly phased development program rather than obstructing it by export prohibitions, cartelization and market sharing arrangements may make an important contribution to the domestic environment in which indigenous technological activity can flourish. The already referred to use and misuse of patents for transferring technology rather than obstructing market access is another case in point, as is the willingness to unbundle various components of the multi-national package. Public policy can affect MNC behavior at least by making the provision of subsidized investment guarantees, surveys, tax benefits etc. discretionary rather than automatic or dependent only on financial flow criteria.

III. Indigenous Technological Activity: Consequences and Policy Conclusions

Obviously it thus takes both favorable supply and demand conditions to evoke adequate levels of indigenous technological activity. The question we may still want to ask ourselves is what difference does it really make in terms of the underlying development performance indicators we are most familiar with, including some combination of growth, employment and equity, with the diminution or elimination of conflict among these objectives a high priority. In other work comparing the performance of East Asian and Latin American NICs[1] we have been able to conclude that, in fact, it is possible to avoid seemingly inevitable conflicts between employment and

[1] G. Ranis, "Challenges and Opportunities Posed by Asia's Superexporters: Implications for Manufactured Exports from Latin America," in Export Diversification and the New Protectionism edited by W.Baer and M. Gillis, NBER,1981.

growth, on one hand, and the distribution of income, on the other, mainly by affecting the way in which growth is generated. This work, moreover, indicates that the extent a society's own changing endowment is effectively utilized in the course of transition represents the most important single ingredient of that performance. This, in turn, is, by definition, in large part determined by the society's ability to fully harness its indigenous technological capacity as it moves through various subphases from infant industry dominated import substitution to an export substitution subphase characterized by much greater market orientation.

It is by now well known that the East Asian countries such as Japan historically and Taiwan and Korea more recently have done much better than the Latin American cases such as Mexico or Colombia, in terms of this ability to husband indigenous technological activity to the development process. This, we believe, is directly related to differences in supply conditions as well as the different courses taken by the two systems, i.e. the perseverance of import substitution in Latin America, and the shift to export substitution in East Asia. Different income distribution performance along with growth result directly from the differential role of indigenous technological activity in determining product and process mixes.

While there is no need here to present the details of the differential performance in terms of the mopping up of labor surplus, growth rates, Gini coefficients, etc. in the two types of NICs as a demonstration of the point being made, it is possible to assert that the favorable distribution of income in the context of rapid growth in a place like Taiwan was related not only to an initially favorable distribution of assets, particularly land, but also to the fact that substantial indigenous technological activity was in evidence, making small farm holdings more productive, inducing land to be used more intensively for such labor intensive crops as mushrooms and asparagus, activities which attracted especially the poorest or smallest farmers and thus simultaneously improved the distribution of income.

Similarly, with respect to non-agricultural activities, both rural and urban, the decentralized nature of the industrial structure, made possible by the equitable allocation of public sector infrastructure on the supply side, as well as the relatively mild form of primary import substitution plus an early shift to export substitution on the demand side, led to an industrial structure which was highly decentralized and labor intensive in technology both from the product and process points of view. The fact that 50% of rural families' incomes was generated in non-agricultural activity represents an important ingredient of the demonstrated large role of indigenous technology activity. Such decentralized industrialization provides higher employment and higher incomes for the same poorest families; at the same time urban infrastructural requirements are lower and equilibrium market areas reflecting a compromise between economies of transport costs and economies of scale move in favor of relatively smaller market areas. This, in turn, favors output bundles permitting more scope for indigenous technological activity of the product as well as of associated labor intensive process variety. With the poorest families often profiting from the by-employment opportunities offered by decentralized rural industry and services, such a combination of appropriate goods and processes leads to an extraordinary absorption of unemployed labor hours in an efficient fashion, making a substantial contribution to the improvement rather than the deterioration of the distribution of income during rapid growth.

Indigenous technological activity contributes to the efficient labor intensity of agricultural and non-agricultural production in the labor surplus economy. While the functional distribution of income does not tell the full story of the family distribution of income, it makes a substantial contribution to it, as we have explored elsewhere.[1] We can, for example, point to the sharp gap between the typical relative share of labor in Latin American industry, i.e. .4 falling to .3 over time and that of the East Asian case, .6 and rising to .7, as one indication of the differential level of indigenous technological activity. A growth strategy which permits the relatively greater penetration of foreign markets by labor intensive nondurable consumer goods is much more able to induce indigenous technological activity by permitting the absorption of workers and the forging of a strong link between indigenous technological activity and the improving distribution of income. In Latin America, on the other hand, the much lower resort to labor intensive technology and output choices caused by the perseverance of import substitution policy had the important consequence of resulting in continued high levels of income inequality that we are now observing in places like Mexico and Brazil. There can be little doubt that how output is generated and what growth path is selected is the single

[1] J. Fei, G. Ranis, S. Kuo, "Growth and the Family Distribution of Income by Factor Components," Quarterly Journal of Economics, Feb. 1978.

most important consequence of the quality of indigenous technological activity. In the East Asian case increased sensitivity to changes in factor endowment permitted indigenous technological activity to come to full bloom and incorporate its results in what is being produced and how. In the case of the Latin American growth path the veil between endowments and prices has thickened, while entrepreneurial energies have been ever more focussed on obtaining a favored place in the queue for directly allocated goodies rather than deploying indigenous technological activity in the search for the construction of the "better mouse traps." The search for indigenous technological activity, we must remember, is also a function of the requisite human capacities as well as the extent of help from information and network capacities created by public sector actions. As Rosenberg put it, "economic forces and motives do not act in a vacuum but within the changing limits and constraints of scientific and technical knowledge."[1]

The conclusions for public policy which follow from all this are sufficiently self-evident. The combination of supply and demand conditions must be rendered sufficiently favorable for indigenous technological activity of the requisite quantity and quality to take place. In such an event we can be quite confident that it will produce the desired effects in terms of the bottom line, the society's development objectives.

[1]Nathan Rosenberg, "Science, Invention and Economic Growth," Economic Journal, March 1974.

Levels of overall competitiveness and specifically the impact of macro policies which distort price signals have the effect of inhibiting the demand for appropriate technology and may be viewed as the most serious obstacle to the generation of adequate indigenous technological activity. On the supply side the sine qua non is the joint or separate capacity to pick from the full storehouse of human knowledge that which is appropriate and to modify it at the same time. The high private search costs involved in this effort can be assisted by public sector contributions to the educational and institutional network to enable tinkering to take place across the entire landscape. Constraints on patenting, licensing and trade marks from outside must be reexamined. Current R&D allocations must be directed to enhancing the capacity via government extension services or selective subsidies on a declining basis through private banking channels. The role of the Japanese style trading company or the trade association case on the model of the Japan Cotton Spinners' Association which assisted the almost instantaneous diffusion of new technology should also not be underestimated.

In general, given our review of the determinants and consequences of indigenous technological activity, it is clear that the emphasis must be on the functioning of an internal decentralized network and the capacity to sustain it rather than on the transfer of hardware from the outside. While we are not arguing for the preservation of outdated handicrafts we are arguing for the recommendation that indigenous Z goods industries perhaps in disuse for some time may provide the basis for modernized efficient production activities based on indigenous technological capacity.

It must be emphasized that we are dealing here with the generation of alternative modern production processes in search of new attribute combinations, not the artificial preservation of outmoded techniques and products. Nor is the latest technology always inappropriate, or the most basic good invariably appropriate; but the gap between the social and private calculus can be reduced, if not eliminated, with the help of changes in macro policies. Thus the most important resource of all, namely broad based entrepreneurial and innovative capacities, can be harnessed.

A society's full participation in experimentation and tinkering lies at the heart of the required confidence to make appropriate technological choices. Such increased confidence should not take the extreme form of tending towards technological autarky since, as we have pointed out above, the presence of advanced country technologies will continue to be overwhelmingly important as a stimulus and as a point of departure. Developed countries, whether they like it or not, will continue to make key catalytic inputs, both on the human and on the physical resources side, in helping to develop and enhance a science and technology capacity which permits individuals to ask the right questions, to choose more appropriately, and to adapt more effectively.

In some instances, however, it may also mean that less developed countries may have more to learn from each other than from the more advanced countries. The center of gravity for inducing indigenous technological activity clearly rests with the mobilization of thousands of nonspectacular adaptive responses and modifications of modern processes across a vast number of applications and landscapes. Given both differentiated endowments and objectives, the individual actors in the typical developing country must be given the widest physical opportunity to choose among alternatives and to have the maximum pressure, combined with the fullest possible information, to achieve the objective of a diminished conflict between growth and distribution by virtue of their active pursuit of indigenous technological activities.