

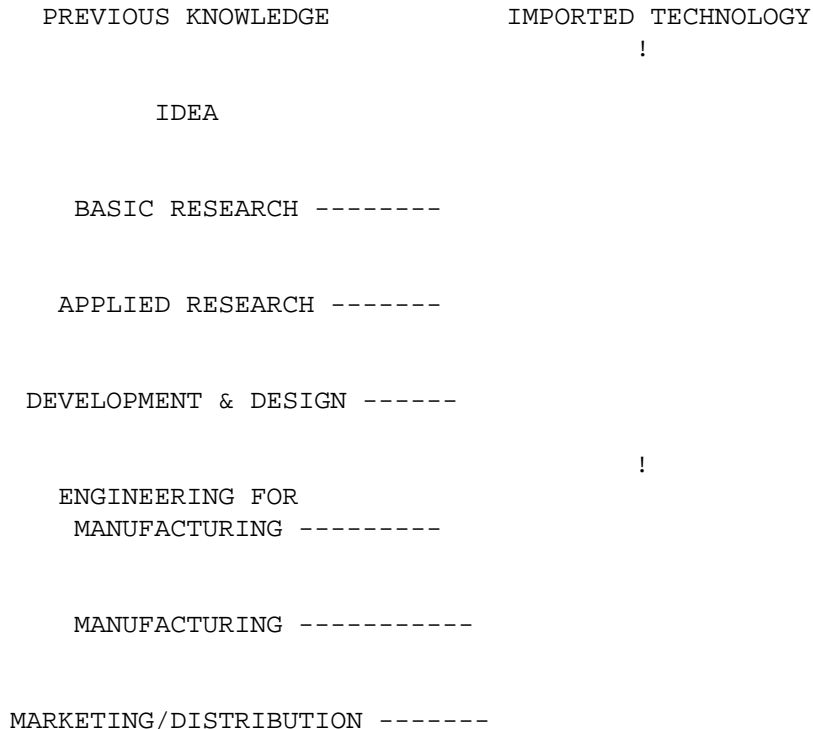
INNOVATION UNDER THE IMPACT OF TECHNOLOGY IMPORTS

INTRODUCTION

Thus far, the innovation chain has been discussed as if technology imports do not occur and the process of innovation is the only way of acquiring new technology. In fact, both industrialized and developing countries import technology, and therefore it is important to understand the impact of technology imports on the process of innovation.

BYPASSING STEPS IN THE INNOVATION CHAIN

The fundamental effect of the import of a technology on the innovation chain for that technology is that the import permits a part of the chain to be bypassed. In other words, by introducing the imported technology at a specific step in the innovation chain, all the prior steps in the process of innovation of that technology are made redundant and unnecessary. For a manufactured product, the imported technology can be introduced at any one of the following stage: (1) marketing/distribution, (2) manufacturing, (3) engineering for manufacturing, (4) development and design, (5) applied research or (6) basic research. One can think therefore of technology imports in terms of a multi-point switch which determines at what step in the innovation chain the imported technology enters the chain.



PRODUCT/PROCESS
IN THE ECONOMY

It is often said that a country acquires know-how when it imports technology. That this is too superficial a view is revealed by the above juxtaposition of the innovation chain and the import of a technology. The representation shows that there are in fact different types of know-how and the setting of the switch determines the type of know-how that is acquired through the import of the technology. In particular, one must distinguish between maintenance know-how achieved through switch-setting 1, manufacturing know-how (switch-setting 2), engineering-for-manufacturing know-how (switch-setting 3), design and development know-how (switch-setting 4), applied research know-how (switch-setting 5), and basic research know-how (switch-setting 6). In addition, one may also include operational know-how which is what the consumer requires to use the product/service.

The different types of know-how can also be ranked on the basis of the extent to which they contribute to self-reliance (which is the capacity of a society to take and implement independent decisions), or conversely, to dependence (which is the situation in which a society's decisions and actions are determined by external societies). In that sense, the types of know-how constitute a hierarchy of levels of self-reliance and of dependence:

RESEARCH KNOW-HOW

DESIGN & DEVELOPMENT KNOW-HOW

DEPENDENCE

ENGINEERING-FOR-MANUFACTURING KNOW-HOW

SELF-RELIANCE

MANUFACTURING KNOW-HOW

MARKETING/DISTRIBUTION KNOW-HOW

The concepts developed above regarding (1) the relationship between technology imports and the innovation chain and (2) the distinction between the different types of know-how can be used to throw light on the Japanese approach to technology imports. Japan has been a major importer of technology over the past four decades and the emphasis has been on purchasing operational and/or maintenance and/or manufacturing know-how. But, these purchases of foreign technology have only been a starting point. The Japanese approach consists of the "four-to-one thumb-rule" according to which, for every \$1 spent on the import of technology, the technology-importing firm/agency then spends \$4 on to acquire engineering-for-manufacturing know-how, design and development know-how, and research know-how for the same technology that has been imported. In other words, the approach is to work backwards through the innovation chain from the step at which the technology is imported -- this why

the approach is sometimes known as reverse-engineering. The Japanese approach -- as is well known -- has been eminently successful with the importing firm/agency often ending up technologically ahead of the foreign firm/agency from which the technology was imported. Quite often, Japanese firms coordinate their technology imports (under the aegis of their (MITI) Ministry of Trade and Industry) so that one firm imports the technology and shares the benefits with other firms in the same field so that the country as a whole advances technologically.

The Indian approach has been very different -- the general tendency and practice (see, however, exception below) has been to import operational and/or maintenance and/or manufacturing know-how and make no attempt to do reverse-engineering. The result is that technology-importing firms/agencies never acquire the engineering-for-manufacturing know-how, design and development know-how, and research know-how for the technology that has been imported. As a result, their technological level remains static and after some time they are so backward technologically that they are forced to go in for another technology import in order to modernize. This is why there are repetitive collaborations (like blood transfusions) at frequent intervals over a period of time. The absence of coordinated imports of technology also leads to repetitive collaborations by a number of firms at one point of time.

Thus, there are sharp differences between the Japanese and Indian approaches to technology imports. Japanese firms look upon technology imports as starting-points for reverse-engineering and make the expenditures for the acquisition of know-how for engineering-for-manufacturing, design and development, and research. In contrast, Indian firms see technology imports as a substitute for reverse-engineering and as a way of avoiding expenditures on the crucial preceding steps of the innovation chain. No wonder that the Japanese approach has proven to be a spring-board for greater self-reliance and the Indian tendency has resulted in increasing dependence upon the technology-exporting countries. It is also clear that the imports of products/services enables Japan to imitate those products/services, adapt and modify them, and finally even improve upon them. India has frequently imitated, sometimes adapted, but very rarely improved upon imported products/services because improvement depends upon competence in the engineering-for-manufacturing, design and development, and research steps of the innovation chain.

There are two very important exceptions to the generalizations made above. Firstly, the small-scale sector of Indian industry often cannot afford the costs of technology imports and therefore this sector has frequently turned for technology development to Indian R & D institutions, particularly, the CSIR. In response to this demand-pull, the CSIR has often been successful in developing technology. In fact, the bulk of the products/services released by CSIR have been to small-scale industry. The situation here is one where self-reliance is strengthened there is no substitute to indigenous completion of the innovation chain and, as a consequence, self-reliance is strengthened

Secondly, there are sensitive technologies for which imports are not possible because, for instance, industrialized countries ban technology

exports in strategic areas. Space and nuclear technologies are well-known examples. In the case of such technologies, India has not been able to import the products/processes. Thus, it has not been able to buy operational and/or maintenance and/or manufacturing know-how. The country has had no alternative except to incur the requisite expenditures to go through the innovation chain for those products/processes. Thus, it has been forced to acquire the know-how for research, design and development, and engineering-for-manufacturing for the technology that could not be imported.

There is an international dimension to this process. Innovative ability, i.e., the ability to complete the innovation chain, is an instrument for achieving self-reliance and development in India, and other developing countries. But, industrialized countries often see their technology exports as an instrument of control over developing countries. They also do not hesitate to use them as ways of undermining self-reliance and increasing dependence. In particular, as soon a developing country is on the verge of achieving self-reliance with respect to know-how for research, design and development, and engineering-for-manufacturing for a technology which it was prevented from importing, industrialized countries rush in to offer hitherto-embargoed products/processes at cut-rate prices along with operational and/or maintenance and/or manufacturing know-how. Unless the benefits of self-reliance are included in the economic calculus, the temptation is to accept the cut-rate offer of technology imports and avoid the expenditures on completing the innovation chain indigenously. If this temptation is succumbed to, the inevitable result is the undermining of self-reliance.

India did not succumb to such temptations in the case of the rocket propellant which it ultimately developed indigenously. A counter example is liquid-crystal-display technology where the imports of foreign technology on "attractive" terms destroyed India's LCD capability just when it was maturing. A similar situation is developing in the case of C-DOT technology for electronic exchanges where several powerful telecommunications multi-nationals are competing. Another example is monsoon prediction where offers to predict our monsoons just when the country's capability is growing in this area.

SOME HISTORICAL FEATURES OF SCIENCE & TECHNOLOGY IN INDIA

INTRODUCTION

The descriptions of science and technology and innovation in India have thus far been ahistorical. They tend to give the impression that things have and will remain the same. But, there is a dynamic in every situation. And everything has a history.

A clue to the dynamic can be obtained by looking at how the cumulative number of foreign collaborations have changed since independence. Figure 1 shows that one can demarcate three main phases:

- (1) the import-substitution phase from 1956 to about 1962 when there was an enormous growth in the number of foreign collaborations,
- (2) the intermediate phase between 1962 and around 1979 during which there was a "trough" in the number of foreign collaborations, and
- (3) the current modernization phase which began around 1979.

The first and third phases were the result of definite declared governmental policies, but the intermediate phase was not so much the result of explicit policy as of a conjunction of factors that were of course policy-related.

THE IMPORT-SUBSTITUTION PHASE

Indian independence corresponded to the growing determination of Indian industry to assume political power and control the home market. In particular, because manufacturing and selling is often more profitable than being distributing agents for foreign products, Indian industry sought to launch the import-substitution phase around 1956 to acquire operational, maintenance and manufacturing know-how. This involved the import of a large number of technologies corresponding to the requirements of the Indian market. Since these imports took place through foreign collaboration agreements, there was a large increase in the number of such agreements.

The entire exercise was greatly facilitated by the 2nd and 3rd five-year plans based on the Mahalanobis strategy of development involving a rapid growth of capital goods and the infrastructure. With this thrust, available foreign exchange was to be used largely for imports of intermediate goods and of technology. This meant that foreign exchange was not available for the import of consumer goods as was the case before. Also, many capital goods could not be imported. As a result, there was a market for consumer goods and for many capital and intermediate goods. Both of these markets were met largely by foreign collaboration tie-ups. The policies were quite successful -- from a country which during the 1930s imported almost all manufactured products (except a few such as textiles) India started manufacturing almost all its requirements.

THE 1962-79 INTERMEDIATE PHASE

The 2nd and 3rd Plans largely ignored foreign exchange bottlenecks as well as agriculture and wage consumer goods. Both these shortcomings became significant as a result of the 1962 war and the droughts of 1965-67 -- the available foreign exchange had to be used now for food and other essential and defence-related imports. The resulting strain on foreign exchange reserves meant a cutting back on technology imports. In addition, the failure of the Mahalanobis strategy to make the economy/industry self-sustaining meant that the demand for consumer and capital goods became easily saturated. The mid-60s recession aggravated the situation.

It is natural to wonder how in a country with a population of about 400 millions in 1956 the market could get saturated within the short span of about six years from 1956-62. The answer lies in the fact that India is a "dual society" in which only the richest 15% of the population can afford to buy the output of the manufacturing sector. The poorest 85% are in a sense outside the market economy because they do not have the requisite purchasing power to articulate their demands. India in 1956 was for all practical purposes a market consisting of only about 60 millions. Once this small market was saturated, demand declined.

Thus, a combination of foreign exchange constraints and recession-demand saturation led to a decline in the number of foreign collaboration agreements between 1962 and 1969.

The beginnings of the Green Revolution in agriculture in 1969 can be associated with a resurgence of industrial growth and aggregate investment. This is what probably accounts for the a spurt in foreign collaboration agreements between 1969 and 1975- 6. The similarity between the 1962 and 1975 peaks suggests that 1969-75 spurt in foreign collaboration agreements corresponds to a replacement of the old technologies, i.e., repetitive collaborations, imported during the previous spurt in 1956-62 -- but this suggestion has to be corroborated by detailed examination of which technologies were imported between 1969 and 1975.

What is interesting is the post-1970 demand from several groups (particularly those that had established indigenous manufacturing capability) to ban technology imports during a period when the number of foreign collaboration agreements were rising. A cry of self-reliance was raised. Many mechanisms were established to screen proposals for foreign collaborations.

But, the cry of self-reliance was articulated in unfavourable context of an economy slowly coming out of recession. The self-reliance slogan increasingly fell on deaf ears. The number of foreign collaboration agreements started increasing from around 1970 and rose to a peak around 1975-76.

OPTIONS FOR GETTING OUT OF RECESSIONS

However much recessions favour the demand for self-reliance by reducing technology imports, they are considered by the industrial sector as unfavourable to growth.

There are three options in the Indian context for getting out of the crises of recessions:

Option 1: raising the incomes of the poorest 85% of the population so that they also become part of the market which thereby becomes significantly enlarged;

Option 2: adopting the strategy of export-oriented growth; and

Option 3: modernization based on diversifying the product-mix of the manufacturing sector so that the richest 15% can buy new types of goods.

The problem with Option 1 is that the bulk of the poorest 85% of the population lives in the rural areas, and their poverty is mainly because of inadequate control/access over the crucial assets of land, water and capital.

The redistribution of assets (particularly land and water) is a necessary condition for raising their incomes. But, redistribution is too radical a solution for the vested interests in rural areas. Hence, Option 1 is rarely chosen in developing countries.

The "success" economies of South Korea, Taiwan, Hong Kong and Singapore are usually cited when Option 2 is recommended. But, there are several problems with Option 2. Firstly, the export-led growth of these four economies has been sponsored by the industrialized countries via their multi-national companies and is under their aegis. Secondly, a necessary condition for the success of the export-led strategy is the absence of trade barriers and protectionism in the industrialized countries. Thirdly, indigenous technology is of the 1950s vintage and is therefore too old and inferior for the manufactures from such technology to compete in the international export market. So, Option 2 requires massive imports of technology and the blessings of the industrialized countries and the multi-national companies.

The case for Option 3 is based on the fact that the richest 15% of the population was starved of consumption goods for about 25 years (from about 1955-80). In particular, their craving is for foreign consumption goods because their philosophy seems to be: "all that is rural is bad, all that is urban is better, and all that is foreign is best!" Now, the richest 15% in India is small in percentage terms, but very large in numbers -- around 1981, they constituted about 103 millions which is roughly the same as Japan's population of about 120 million. If therefore production can be oriented towards their desires, then there is an enormous market waiting to be exploited.

But, in order to tap this market, firstly, the elementary- minimum-needs bias of goods/services that has characterized production since the 1950s must be abandoned/minimized, and secondly, the consumption patterns of the

industrialized countries must be brought in even though these westernized consumption patterns are oriented towards luxury consumption (TVs, VCRs, private transportation (cars and two-wheelers), kitchen gadgets, etc.). But, for this new luxury thrust in the pattern of consumption, the technologies available indigenously are quite inadequate. Hence, the corollary of westernization of consumption patterns is a massive import of technologies.

Such massive imports are possible only if the barriers to the free import of technologies are removed. In other words, all the institutional mechanisms for rigorously assessing whether technology imports are really necessary have to be dismantled. In other words, Option 3 requires the so-called "liberalization" of the economy. The elimination of controls (such as licensing) becomes imperative even though these controls may have been responsible for the careful husbanding of resources and the good housekeeping which together kept India out of the debt trap into which so many developing countries had fallen.

The real problem with Option 3 is that the technology imports have to be paid for which means that once the previously accumulated surpluses are exhausted the only way of making the payments is with exports. So, Option 3 requires a simultaneous adoption of Option 2, i.e., combination of Option 2 and Option 3 becomes obligatory.

THE CURRENT MODERNIZATION PHASE

Such a strategy of export-led modernization was mooted as far back as the 1970s with the visit of a group of US businessmen led by Orville Freeman. This visit was followed by the general promotion by the World Bank of its export-led strategy. By the time India applied for an IMF loan, an export-led strategy and economic liberalization were laid down as conditions for the grant of the loan.

All these trends coming under the general rubric of modernization were initiated around 1980. They have gathered tremendous momentum since 1985. Imports of technologies have been liberalized, and as a result, there has been a tremendous increase (Figure 1) in the number of foreign collaboration agreements. Multi-national corporations have been welcomed. There has been an proliferation of luxury goods to satisfy the cravings of the richest 15%. Whether it is two-wheelers, TVs, VCRs, or kitchen gadgets, foreign collaboration agreements have led to a large number of manufacturers of each item, i.e., repetitive collaborations have been liberally permitted.

India has accumulated a great deal of experience with regard to how technology imports should and should not be used to acquire technological capability and know-how. Despite this, the approach to such imports in the 1980s has not differed in any meaningful way from the imports of the 1950s. The emphasis continues to be on the import of operational and/or maintenance and/or manufacturing know-how without subsequent attempts to do reverse-engineering. In fact, in the current phase, there is a great deal of what be called "screw-driver technology", i.e., the import of equipment, particularly electronics, in a completely-knocked-down (CKD) condition, the

assembly of the equipment with a screw-driver, culminating with the claim that the equipment has been indigenously manufactured. With the persistence of this approach, it is clear that technological levels are unlikely to rise -- technology-importing firms/agencies will never acquire the know-how for engineering-for-manufacturing, design and development, and research for the technology that has been imported.

THE NRI PHENOMENON

One of the distinguishing features of the current modernization phase is the importance given to NRIs (non-resident Indians) particularly from the USA.

Indian immigrants into the USA are in many ways unique among that country's immigrant community. They have not immigrated because of religious or political persecution; most of them landed in the US as highly trained professionals; they occupy key positions in the professions; they are affluent; they retain strong cultural and economic links with India. As a result, they are in a position to offer from the US massive amounts of capital and technology.

Such offers were received with alacrity by the new leadership in India for several reasons. Firstly, this leadership was unconstrained by the ties with the leaders of the scientific establishment that the previous leaderships had built over decades. Secondly, the new leadership felt that the Indian science and technology establishment (except for space and atomic energy) had failed to deliver self-reliance and indigenous technology capability in frontier areas. And for that matter, they had not even delivered technologies for the rural poor. In this context of disappointment with the local S & T establishment and attraction to the NRIs, the NRIs came in with attractive offers of capital and technology from key positions in the USA.

With such unassailable credibility, their offers were not easily refused. A few dissenting voices were raised. Was it not distorting values to downgrade the professionals who had returned from the USA in the 1960s and 1970s? Was it not more profitable for the NRIs to invest in India than in the US because of the higher interest rates in India? The NRI offers also came with a large number of demands for liberal tax and customs concessions, house sites, land, etc. Also, barring rare exceptions, the NRIs were not prepared to pack their belongings in the US and come home to link their fortunes with those of the mother country.

The honeymoon with the NRIs did not last too long. The crass commercial motivations of the NRIs became obvious, and the economic price of tying up with NRIs started becoming apparent.

THE NEXT PHASE?

Already, several problems with the current export-led modernization strategy have come to the surface. Firstly, the bills for modernization/liberalization have started coming in. The balance-of-payments situation is deteriorating rapidly. Debt problems are mounting, and it is

even becoming difficult to service the debt by making interest payments. But, all this is no news at all to other developing countries such as Brazil and Mexico which embarked upon the same course. Secondly, product diversification was a way out of recession for a short period during which the appetite of the richest 15% could be satisfied with luxury goods. But, the market for even these goods must quickly get saturated, and that is what happened in the case of two-wheelers, many kitchen gadgets, TVs, etc. It looks that the number of foreign collaboration agreement will peak for the third time (see Figure 1) and then start declining to the accompaniment of the self-reliance slogan. Thirdly, all is not well on the exports front because the export strategy is coming up at a time when the industrialized countries are raising trade barriers and protectionist policies to solve internal problems such as unemployment. Coming on to the stage of history much later than South Korea, Taiwan, Hong Kong and Singapore, can their success play be reenacted by India even when the favourable conditions have disappeared? Or, will political problems and their economic roots force Option 1 involving raising the incomes of the poorest 85% and having a huge and expanding internal market? Will it become essential to explore a development-oriented approach as distinct from the growth-and-trickle-down strategy that has been followed all these years?