ISSUES IN NATIONAL TECHNOLOGY POLICY

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PREFACE

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Beginning of the Third World War.

And within its framework

Beginning of our Second War of Independence.

War against the nexus between the rulers and the financial corporations of the developed countries.

The Swadeshi Jagaran Manch has explained on number of occasions the nature of this War against foreign economic imperialism.

This is a total war on number of fronts, with various economic weapons. To meet this challenge we have to equip ourselves with an integrated view of the national and international economic scene.This necessitates knowledge of all the relevant facts concerning the challenges on all the fronts. With this end in view, the Manch has published, (i) WTO and Our Agriculture and (ii) Foreign Investment: Facts without comments. This third document **"National Technology Policy"** seeks to furnish all the relevant facts concerning the theme of Technology.

True, after the Singapore conference of WTO all the previous contexts, conditions, considerations and calculations have suddently become out-dated. The genesis, the nature and the implications of the new challenge must be understood correctly, bringing fresh mind to bear on the fresh subject. This document furnishes us with all the pertinent facts, and thus equips us to comprehend comprehensively the national and the international scene. But before entering in this new subject, it is essential that

we must know our Swadeshi thinking on Technology so far. Because we will have to workout the solutions to the new problems in the light of our original Swadeshi thinking. For, while the situations are always changing, the guiding principles remain always unchanged. This becomes quite clear from the Annex. I.

Swadeshi Thinking on Technology

As far as Science and Technology are concerned, the technologically advanced countries have now come to feel that the world may have to suffer catastrophic consequences if the direction of scientific progress is not determined. People of the West have experienced this fear at the time of the Second World War. When Robert Oppenheimer, father of the atomic age, first split the atom he had no idea that it would be used for killing innocent people on a huge scale. In his diary, which shows he was not given to destructive thinking, he has written that he made many attempts to split the atom, but they all failed. But the final experiment, which took place in a desert and which he watched from a long distance, was successful, and the terrible scene, on that occasion made him exclaim, "I have become Death, the shatterer of the worlds." This is the English rendering of Sri-Bhagwad Gita's " Kalosmi Lokakshya Krit Pravridduah". It is strange, instead of quoting something from science or the Bible, he quotes Lord Krishna in the Gita. When Oppenheimer's research was used in the world war for man-slaughter on a vast scale, the scientists asked themselves - was this the purpose of Oppenheimer's penance?

Geneticists had stated that by the year 2040 A.D. genetic engineering would be so advanced that it would be possible to make human beings to genetic specifications; but what is the guarantee that it would produce men like Lord Buddha, Jesus Christ or Mahatma Gandhi? What is the guarantee that they would not produce fiends like Altilla, Timur and Chengez Khan? This is

what western scientists have been thinking about. In experiments conducted in Seattle, U.S.A., on the possible achievements of genetic engineering, scientists came to the conclusion that the achievements could indeed be revolutionary, but they could not say if such experiments would release any destructive bacteria. The civic authorities of Seattle asked the scientists what type of bacteria would be released consequent to the experiements and what effect they would have on people if they spread outside. The scientists replied, they could not say anything definitely. Bacteria may be quite innocus; or they may annihilate one-third of mankind if they spread outside. On hearing this, the civic authorities of Seattle banned the experiments, saying that they did not want this type of progress.

The availability of nuclear weapons has made some scientists realise that there would be catastrophe in the world if the direction of scientific advancement is not properly determined. Dr. Wienner, exponent of cybernatics, which is the foundational science of computerisation, says, a scientist may conduct any experiment to ensure that his name goes down in history as a brilliant scientist, - a Nobel prize winner, but what social cost will humanity have to pay for it? Will this cost be terrible! To emphasize their apprehension, such scientists related the famous European tale of "The Monkey's Paw".

Once a tourist came to stay with a family for a day. He had a contraption, he called a monkey's paw. On being questioned about it he said it had the power to fulfil its owner's first three desires, - but there was also some bad omen about it. It can bring great disaster to its owner and his family. Now, the landlord was in need of two hundred pounds. He requested the tourist to hand him over the monkey's paw. The tourist obliged. The landlord thought that as soon as his desire was fulfilled he would throw it away and would get rid of it. The traveller departed and the landlord's son, who served as an engineer in a factory nearby,

went to work there. In the afternoon a man came with a cheque for two hundred pounds. The landlord was happy at this achievement of the monkey's paw, and he asked the bearer about the reason for the draft. He was told his son had died in an accident while working on the machine and the money which, the bearer, had delivered was the first installment of the workmen's compensation.

Now, the desire was fulfilled, but at what cost? What will be the social cost of unrestrained and misdirected scientific and technological progress? Would annihilation of mankind be the cost for such advancement? In a drama titled "The Last War", Neil Grant, the author, depicts an international conference of all the animals in the world after the humanity is completely wiped off from the earth because of the Technology? In their speeches these animals criticise, ridicule and condemn human beings for their folly of raising their own Frankenstein.

The humanitarian scientists prefer to think of technology in two distinct parts, technological know-how and technological know-what. Technological know-how tells us how to achieve the given purposes; technological know-what should indicate what purposes are worth being achieved. If technological know-what does not govern technological know-how, all of us would come to grief. They, therefore, suggested the raising of the Technological Ombudsman. But they further made it clear that scientists and technologists should not be a part of such Ombudsman, for in their craze of Nobel prize they may not care about the future of the world. The Ombudsman, they suggested, should consist of sufficiently cultured people who have love for the whole of the humanity.

We do not accept the view that western paradigm is the universal model of progress and development. Each national culture can have its own paradigm. No doubt, as a developing nation, it is our duty to study all the various aspects of their material advancement and scrutinise them for the purpose of

imitation, modification, adaptation or rejection. But we should not be oblivious of the fact that it is not possible to import or imitate foreign technology without imitating or importing simultaneously a part of the culture of the country or countries in which it was evolved. While accepting foreign technology, we will have to be careful to adapt it to our indigenous culture. Conscious efforts must be made to modify everything foreign so as to make it part and parcel of the native culture.

The westerners are homo-centric. Homo-centricism is against the spirit of our culture. Again, they have no time or mind to think of the welfare of distant posterity. They are incapable of long-ranged view of things. Whatever is immediately beneficial to them is accepted and implemented by them without caring for its long-ranged effects on the future generations. They have been continuously abusing their natural environment. They are ravagingly exploiting natural resources. Within a century and a half, we will have completely exhausted stocks of different fuels furnished by nature. Scientists are leaning heavily on the use of nuclear energy. But the world stock of uranium and thorium is not unlimited. How will this affect the welfare of future generations?

Mr. Maurice Strong, who had been assigned the task of oranising the UN conference on Human Environment at Stockhom in 1972, had said that a tendency to link environment with the problem of the affluent countries only is wrong and that environment is equally a concern of the developing, or rather the poor countries. "It is a human problem affecting all the world"

Then, about the production techniques. The west has preference for the techniques of mass production. This has given rise to capital intensive, large-scale industries. Maximum production with minimum number of working hands is their strategy. Is it suited to Indian conditions and requirements? Or we will have to strike a balance between mass production and

production by masses. It should be realised that it is 'large production', and not merely 'large-scale' production which gives both-increasing returns and a progressive down-ward shift in the cost curves; that these techniques are incompatible with the expansion of employment opportunities which is the supreme need of our national economy; that 'mechanisation' can assume variety of forms-some of them being drastically different from the current ones, and that new technological developments like automatic machinery, synthetic alloys, die-casting, samll-scale precision instruments and the developments in power-distribution have reduced the technological disadvantages of small-scale production.

Heavy plants imposed upon, but not integrated with the rest of the economy; production of capital goods not correlated with that of consumer goods; industrial sector running parallel to, but not co-ordinated with agricultural sector; processes of decapitalisation, unmployment, etc., initiated because of the lack of full and comprehensive consideration of the seven M's, i.e. men, material, money, machinery, management, motive power and market; indiscriminate introduction of foreign technology which, under Indian conditions, aggravates the problem of unemployment and, simultaneously, creates the problem of idle capacity, all these present a picture of the lopsided industrial planning, not suited to the optimum utilisation of available resources and fulfilment of national requirements.

In future planning, it is necessary to lay greater stress upon the evolution of characteristically Bharatiya technology which would facilitate decentralisation of the processes of production with the help of power converting home, instead of factory, into centre of production. The new techniques should cause minimum possible decapitalisation of our means of production. Our artisans should not find it too difficult to switch over from the traditional to the new techniques. The available skills competent to manage small-scale industries should not be rendered useless under the

new system. Small investors should not be denied opportunities of investment. Clusters of small domestic savings be channelised into investments in small, village and cottage industries.

Our technologists must study thoroughly and assimilate industrial technology all over the world, locate and introduce such parts of foreign technology as are suited to Indian conditions; and devise, for the benefit of artisans, reasonably adaptable changes in the traditional techniques of production, without incurring the risk of increase in unemployment, wastage of the available managerial and technical skills, and complete decapitalisation of the existing means of production.

Dr. Sehumacher pleaded for the technology that should reconcile optimum utilisation of available capital and labour with the economic facts of capital scarcity and huge unemployment, the technology that would increase the employment potential of each rupee of industrial investment by many times without increasing cost per unit of output. The technology, according to him, should be capable of reconciling growth in employment with industrial efficiency. For this purpose, it was necessary to conduct research in certain aspects of the problem. For example, in how many cases it would be feasible to scale down the size of plants without reducing their efficiency? Is it practicable, on the basis of the new technology, to locate new industries in small towns and villages, utilising local capital, local labour, local raw materials, local managerial skills and local entrepreneurial talents? Can such industries become self-supporting with the help of efficient marketing organisations, provisions for appropriate infrastructure, and revival of the swadeshi spirit? Is it practicable and advisable to have fresh spatial planning?

We had demanded evolution of the National Technology Policy on four points (i) what portions of foreign technology should be adopted; (ii) what other portions can be adapted with suitable modifications; (iii) in what areas foreign technology

should be completely banned and, (iv) in what areas our own indigenous Bharatiya technology should be evolved.

And this should be done on the basis, not of academic or theoretical thinking, but of practical experiments and trial and error methods. It is advisable to select, in the first place, a few specific industries, such as, leather, ceramics, etc., for this purpose and assess probable impact of Schumacher's appropriate technology upon their future. Such study can open new avenues, offer fresh stimuli, and pave the way for the development of characteristically indigenous technology appropriate to particular factor endowment of our economy. Though it is true that the quantum of capital per employed worker cannot be the same in all branches of production and, even within the same industry no single technology in the sense of one single capital-labour ratio may rule profitably. Different levels of technology may rule side by side. But the emphasis should be on the development and progressive utilisation of Bharatiya technology, with the object of securing an increase in employment at rising levels of incomes.

To sum up, indiscreet transplantation of western technology and structure will convert us into a Western State without Bharatiya nationhood. What is imperative today is thinking, free and fearless thinking, original thinking, hard thinking. The culturists of this generation will have to shoulder this responsibility, since our fashionable radicals are suffering from intellectual inertia and western type of obscurantism. This has been the Swadeshi thinking on Technology so far. In its light, and in consonance with it, we will have to strive to seek solutions to new problems, - to meet ever-new challenges from the hegemonistic economic imperialists. The following document, "National Technology Policy" will equip the readers adequately for this purpose.

D. B. Thengadi

I. TECHNOLOGY AND DEVELOPMENT :

A Historical Perspective

Research carried out over last two decades has empirically established that technology is a major determinant for the economic growth of a country. Actually technological change is an important input for change in productivity levels and thereby a source of change in wealth of nations. Several authors have emphasised the importance of indigenous R&D efforts for development.

Most probably, Friedrich List, was among the first few social scientists to recognise the importance of national R&D efforts, in his book, "The National System of Political Economy" (1841). Explaining the ideas of List, Christopher Freeman in his latest book, "Technology, Globalisation and Economic Performance" (1997), suggests that, "the main concern of List was with the problem of Germany overtaking England and, for underdeveloped countries (as Germany then was in relation to England), he advocated not only protection of infant industries but a broad range of policies designed to accelerate, or to make possible, industrialisation and economic growth". It was thanks to the advocacy of List and like minded economists as well as the long-established Prussian system, that Germany developed one of the best technical education and training system in the world. E. Hobsbawn in his book, "Industry and Empire" (1968), has mentioned that, this system not only was one of the main factors behind Germany overtaking Britain in the latter half of the nineteenth century, but to this day is the foundation for the superior skills and higher productivity of the German labour force in many industries. The United States was even more successful than Germany in overtaking Britain in the second half of the Nineteenth century and List had learnt a great deal from his residence in the United States. The wide spread promotion of

education was even more remarkable in the United States than in Germany. However, the abundance of cheap, accessible materials, energy and land, together with successive waves of immigration, imported to the U.S. national system some specific characteristics without parallel in Europe. The pro-active role of the state was greater in Germany while foreign investment played a greater role in the US, basically because of immigrants.

'Globalisation' and National Systems

It has been argued in the previous section that a variety of national institutions have powerfully affected the relative rates of technical change and hence of economic growth in various countries. The variations in national systems which have been described are of course extreme contrasting cases. Nevertheless, they have certainly been important features of world development in the second half of the twentieth century and they point to uneven development of the world economy and divergence in growth rates. Moreover, differences in national systems are also very important between Japan, the United States and the EU and between European countries themselves. The comparative study of Ireland and other small countries by Mjoset (1992) also demonstrates this point and the comparison between Denmark and Sweden by Edquist and Lundvall (1993) shows that big differences exist between neighbouring countries which superficially appear very similar in many ways. Moreover, Archibugi and Pianta (1992) have demonstrated the growing pattern of specialisation in technology and trade and Fagerberg (1992) has shown the continuing importance of the home market for comparative technological advantage.

However, the whole concept of national differences in innovative capabilities determining national performance has been recently challenged on the grounds that transnational corporations (TNCS) are changing the face of the world economy in the direction of globalisation. For example, Ohmae (1990) in his book," The

Borderless World", argues that national frontiers are 'melting away' in what he calls the ILE (inter-linked economy) the Triad of USA, EU and Japan, now being joined by countries from South East Asia. This ILE is becoming 'so powerful that it has swallowed most consumers and corporations, made traditional national borders almost disappear, and pushed bureaucrats, politicians and the military towards the status of declining industries' (p. xii). As against this, Michael Porter (1990, p. 19) in, has argued that competitive advantage is created and sustained through a highly localised process. Differences in national economic structures, values, cultures, institutions and histories contribute profoundly to competitive success. The role of the home nation seems to be as strong or stronger than ever. While globalisation of competition might appear to make the nation less important, instead it seems to make it more so. With fewer impediments to trade to shelter uncompetitive domestic firms and industries, the home nation takes on growing significance because it is the source of the skills and technology that underpin competitive advantage.

In addition to Porter's argument, Lundvall (1993) points out that if uncertainty, localised learning and bounded rationality are introduced as basic and more realistic assumptions about macroeconomic behaviour, rather than the traditional assumptions of perfect information and hyperrationality, then it must follow that local and national variations in circumstances may often lead to different paths of development and to increasing diversity rather than to standardisation and convergence.

At first sight, the activities of multinational corporations might appear to offer a powerful countervailing force to this local variety and diversity. The largest corporations in the world, whether their original domestic base was in Europe, the United States, Japan or elsewhere, have often been investing in many different new locations. This investment, even though initially it may have been in distribution and service networks, or in production facilities,

has more recently also included R&D. Whilst the greater part of the 1980s' investment has been within the OECD area itself and in oil producing countries and could be more accurately described therefore as 'Triadisation' rather than 'globalisation', it has also flowed, even though very unevenly, to other countries of the Third World and there is now a small trickle to the former socialist group of countries.

Even in the case of consumer goods where it might be reasonable to suppose that there would continue to be wide variations in consumer tastes, we are all sufficiently familiar with such products as Coca-Cola and such services as those provided by McDonald's to recognise the reality of such global production and distribution networks, offering standardised products and services worldwide. Is it not realistic to suppose that an ever-larger proportion of world production and trade will take this form? Supporting such a view are not only the obvious examples of hotel chains, soft drinks, canned beer, tourist agencies and credit cards but theoretical economic arguments based on static and dynamic economies of scale in production, advertising, marketing, design and finance, as well as the ability of large multinationals to take advantage of surviving differences between nations in costs of capital, labour, energy and other inputs.

However, it would be unwise to assume that these tendencies are the only or even necessarily the strongest tendencies within the world economy. Nor are they so unequivocally desirable that they should be promoted by both national and international economic policies. In fact, the arguments for preserving and even encouraging diversity may sometimes outweigh the shorter-term advantages of the scale economies derived from standardisation and their propagation through transnational companies, free trade and free flows of investment. In fact, the two processes (global standardisation in some areas but increasing diversity in others) co-exist.

Whilst there are certainly some products and services, such as those already mentioned, where there is indeed a demand which is 'global' in nature and where local variations in taste, regulation, climate and other circumstances can be largely or wholly ignored, there are far more products and services where such variations certainly cannot be ignored without dire consequence and innumerable examples leap to mind where climatic conditions affect the performance of machines, instruments, vehicles and materials and even more examples are obvious in relation to variations in national standards, specifications and regulations. Whilst it is true that international standardisation is a countervailing force through the activities of the International Standards Organisation (ISO) and many other bodies attempting to achieve harmonisation of technical standards, it is also true that the experience of the European Union over the past twenty years demonstrates the extreme difficulties attending this process in many areas (as well as the feasibility in others). And all this still does not, take into account the cultural aspects of the problem which deeply affect such areas as food, clothing and personal services.

So far we have been discussing mainly the case of established products and pointing to some factors which limit global standardisation even in the simplest cases. Advocates of a strong globalisation hypothesis would of course accept most of these points, although they might argue that some of them will tend constantly to diminish as the media, travel, education and international organisations all exert their long-term influences. Rothwell (1992) has pointed to the 'electronification' of design as an important factor facilitating the internationalisation of design and R&D. It can be argued further that local variations can easily be dealt with inside the framework of the global strategies of the multinational corporations. Indeed, globalisation of R&D has already led to local adaptation and modification of products to meet national variations, as a normal and almost routine activity

of TNCS. Companies such as Honda go one step further and claim to have a strategy of diversity in worldwide design which goes beyond the simple modification of a standard product to the idea of local variation at the design stage in several different parts of the world. However, the vast majority of Japanese-based TNCs remain essentially Japanese companies with international operations rather than truly international companies and the same is true of US and most other MNCs in relation to their home environment (Hu, 1992). Most R&D 'activities of MNCs are still, overwhelmingly conducted in the domestic base of the company and are heavily influenced by the local national system of innovation. Moreover, ownership and control still remain overwhelmingly based on the domestic platform.

The statistics are rather poor but analysis of all the available data and cross-checking with the patent statistics (Patel and Pavitt, 1991) suggests that the R&D activities of US companies outside the USA amount to less than 10 per cent of the total, whilst those of Japanese companies are much lower - less than 2 per cent - though gradually rising. The picture in Europe is more complex both because of the development of the European Community and the Single European Market, and because of the existence of several technically advanced small countries where the domestic base is too small for the strong MNCs which are based there (Netherlands, Sweden, Belgium, Switzerland). A larger part of national R&D activities in these countries and most other parts of Europe is undertaken by foreign multinationals and their 'own' TNCs perform much more R&D abroad than is the case with the USA or Japan. Only a small part of total world R&D is conducted outside the leading industrial countries and only a very small part of this is financed by TNCs.

Qualitative analysis of the transnational activities of corporations shows that most of it is either local design modification to meet national specifications and regulations or

research to facilitate monitoring of local science and technology. The more original research, development and design work is still' overwhelmingly concentrated in the domestic base, although there are important exceptions in the drug industry and electronics industry where specialised pools of scientific ability play an important role.

As long as we are dealing with a static array of products and discussing only minor variations to adjust to local consumer tastes and environments, then the standardisation arguments, the globalisation arguments and even some of the simplifying neoclassical assumptions about perfect information are at the borderlines of credibility and usefulness. But once we leave this world and enter the dynamic world of radical innovations, both technical and organisational, and of extremely uneven and unequal access to new developments in science and technology, then the whole picture is transformed. More realistic assumptions and a more realistic vision are essential if economic theory is to be of any help in policy-making.

Lundvall (1993) points out that, even in the case of continuous incremental innovation in open economies, the drive towards standardisation is limited. Geographical and cultural proximity to advanced users and a network of institutionalised (even if often informal) user-producer relationships are an important source of diversity and of comparative advantage, as is the local supply of managerial and technical skills and accumulated tacit knowledge. He gives several examples of such localised leaming generating strong positions in the world market. Whilst he accepts that TNCs might locate in such 'national strongholds' in order to gain access to the fruits of this interactive leaming process, he points out that it is not always simple to enter such markets because of the strength of the non-economic relationships involved. Competing standards for the global market may be important weapons in such situations as well as other forms of product differentiation and quality improvement.

When it comes to radical innovations the importance of institutional variety and localised learning is even greater. Posner's (1961) theory of technology gaps and initiation lags is of fundamental importance here. It may be many years before imitators are capable of assembling of skills, the work organisation and other institutional changes necessary to launch into the production and marketing of entirely new products. It is of course true that in the global diffusion of radical innovations, TNCs may have an extremely important role. They are in a position to transfer specialised equipment and skills to new locations if they so wish and to stimulate and organise the necessary learning process. They are also in a position to make technology exchange agreements with rivals and to organise joint ventures in any part of the world. It is for this reason that many governments in Europe as well as in the Third World and the ex-socialist countries have been anxious to offer incentives to attract a flow of inward investment and associated technology transfer from firms based in Japan and the United States.

However, such efforts will meet with only limited success unless accompanied by a variety of institutional changes designed to strengthen autonomous technological capability within the importing countries. This is especially true of those generic technologies which have been at the centre of the worldwide diffusion process over the past two decade Here it is essential to emphasise the interdependencies between innovations and between technical innovations and organisational innovations. A theory of technical change which ignores these interdependencies is no more helpful than a theory of economics which ignores the interdependencies of prices and quantities in the world economy.

Perez (1983) has pointed out that the social and institutional framework which is hospitable to one set of technologies will not be so suitable for a radically new technology. Whereas incremental innovations can be easily accommodated, this may not be the case

with radical innovations which by definition involve an element of creative destruction. When we are talking about large clusters of radical innovations combined with rapid processes of incremental innovation, then the problems of structural and social adjustment can be very great. This is quite obvious when we consider such aspects as the change in management techniques and skill-mix which are called for, but it also applies to many other types of institutional change in standards, patents, new services, new infrastructure, government policies and public organisations.

It is in this context that the concept of national systems of innovation assumes such great importance and in the light of this approach, it is not surprising that the recognition of the scope and depth of the computer revolution, which was accelerated by the microprocessor in the 1970s, has been followed by a growing recognition of the importance of organisational and managerial change ('multi-skilling', 'lean production systems', 'downsizing', 'just-in-time' stock control, worker participation in technical change, quality circles, continuous learning, etc., etc.).

The diffusion of a new techno-economic paradigm is a trial-and-effort process involving great institutional variety. There are evolutionary advantages in this variety and considerable dangers in being locked in too early to a standardised technology. A technological monoculture may be more dangerous than an ecological monoculture. Even when a technology matures and shows clear-cut advantages and scale economies it is important to retain flexibility and to nourish alternative sources of radically new technology and work organisation.

National and international policies thus confront the need for a sophisticated dual approach to a complex set of problems. Policies for diffusion of standard generic technologies are certainly important and these may sometimes entail the encouragement of

inward investment and technology transfer by MNCS. But also important are policies to encourage local originality and diversity.

II. TRADE IN TECHNOLOGY

The recent theoretical and empirical literature on international trade has emphasised the contribution of technology and skills to countries' relative competitiveness. The neo-technology theory, in particular, highlights the role of technology gap in determining a country's international trade pattern. Among the empirical studies, it has been found that, technology is an important factor in explaining international trade and most of those studies have observed that US industries associated with a relatively high research effort also tend to export a relatively high proportion of their output. It has been found that net exports of Canadian industries to be significantly related to the industry's R&D intensity. In case of 40 industries from OECD countries, it has been found that, export performance is directly linked with their share of patents. In case of developing countries the literature points out that the developing countries enterprises are unlikely to achieve competitive advantage on the basis of their own technological activities in high technology industries because of their inability to compete through product innovations, shorter product life cycles, firm specific nature of knowledge and hence significant economies of national integration and geographical diversification. The industrial country enterprises many of which are multinational in terms of coverage of their operations and integrated vertically to handle all the tasks related to production and marketing of high technology products, reap these economies. Therefore, at the policy level, it is very important that the export competitiveness of low and medium technology industries is acquired on the basis of the indigenous R&D strength while in case of high technology industries options for reverse engineering and imports of technology should be explored.

Developing economies can grow faster than mature ones in part because they can acquire advanced production systems but we need to clarify how FDI contributes to technology development. We need to be clear about what technologies are traded, by whom, to whom, and in what form before we can be categorical about the effect of technology on growth.

According to one survey by the National Institute for Science and Technology Policy in Tokyo, 93 per cent of Japanese technology export agreements are "hardware". The technology that is being exported is, indeed, "embedded" in the equipment. For the most part, it is not "process" technology, but 'product" technology. The same survey reports that Japanese firms import higher value added technologies and export lower value-added ones. One of the cardinal lessons of the Japanese experience, the survey points out, is that technology transfer can be achieved without higher levels of inward FDI. According to Bank of Japan Data, while Japanese technology exports have expanded more than 14 fold in the past two decades (presumably largely embedded in manufacturing equipment), technology imports have also grown nearly 450 per cent in the same period. The point here is that Japanese technology exports largely follow Japanese outward FDI, but Japanese technology imports are independent of inward FDI, and that while both are important, they are different in kind. The lesson for developing economies from Japanese experience may be that relying entirely on FDI may be a sub-optimal way to deepen the national technology base.

III STRUCTURAL ADJUSTMENT PROGRAMME AND DEVELOPMENT OF TECHNOLOGY

Recently, like in India, many other developing countries have undertaken the opening up of their economies for trade and investment as part of the IMF/World Bank sponsored structural adjustment programme (SAP). These reforms are to make these

economies much open than before. The recently concluded multilateral trade negotiations place further obligations on developing countries with respect to the liberalization of trade, and on their policy regime with respect to intellectual property rights, FDI, and trade in services. Developing countries have committed to expand tariff bindings - commitments that tariffs will not exceed particularly bound levels to cover 61 per cent of imports compared to 13 per cent earlier. This means that developing countries enterprises can no longer enjoy protected domestic markets and would have to be internationally competitive even to retain their own spheres.

The other implication of the structural adjustment programme is on the local allocations for technological development. It is often seen that as R&D allocations do not affect the economy in short run, they are seen as soft targets for squeeze on government expenditure. In India the R&D allocations as per cent of GNP has gone down from 1.62 per cent in 1992 to 0.8 per cent in 1997. Similarly, in Sri Lanka, it has gone down from 0.23 per cent to 0.15 per cent in the same period. The issue which deserves much more attention is that, as part of SAP the R&D allocations decline and it automatically gives rise to a tendency among domestic enterprises to import technology. In view of several commercial attractions of imported technology and its trustworthiness, local generation of technology which is inherently risky will not be taken up in the absence of any protection to it from foreign technologies. It is not that R&D expenditure has declined in India or Sri Lanka alone. It has happened in China, in several countries in Latin America, Africa and the Caribbean. In Asia, R&D expenditure has gone up basically because of Japan, South Korea and Singapore.

The neglect of domestic R&D activities in developing countries will have serious repercussions on their local capabilities and will affect not only their ability to absorb and adopt the fruits of

technological developments elsewhere in the world, but even their ability to make the right technological choices and obtain favourable terms of technology transfer contracts. It would therefore, their ability to manufacture better goods and thus could undermine their international competitiveness.

Table 1: Foreign direct investment to East Asia ($ billion)

	1990	1991	1992	1993	1994	1995	1996	1997
China	3.5	4.4	11.2	27.5	33.8	35.8	40.2	43.0
Indonesia	1.1	1.5	1.8	2.0	2.1	4.3	8.0	5.7
Japan	1.8	1.3	2.8	0.1	0.9	0.0	0.2	3.4
South Korea	0.8	1.2	0.7	0.6	0.8	1.8	2.3	2.3
Malaysia	2.3	4.0	52	5.0	4.3	4.1	7.7	7.6
Philippines	0.5	0.5	0.2	1.2	1.6	1.5	1.5	1.3
Singapore	5.6	4.9	2.2	4.7	8.4	8.2	9.4	9.0
Thailand	2.4	2.0	2.1	1.8	1.4	2.1	2.3	3.0
Taiwan	1.3	1.3	0.9	0.9	1.4	1.6	1.9	2.1
Hong Kong	0.3	0.2	0.3	0.3	0.3	0.4	0.4	0.4
Vietnam	0.2	0.3	0.5	1.0	1.5	2.4	2.5	3.0
India	0.1	0.1	0.3	0.6	1.0	2.1	2.2	2.7
Total	20.0	21.6	28.1	45.7	57.4	64.0	78.6	83.5

IV SUPPORT R&D IN PRIVATE SECTOR: DO NOT PRIVATISE

Growing internationalisation of markets over the past years has emphasized the role of technology as a key element of international competitiveness. Hence, technologies are not available any more on an off-the-shelf basis at relatively low prices as in the 1970s, as technology suppliers are apprehensive of creating their own competitors. This explain the relative slow-

down of technology transfers to developing countries in recent years .

In order to retain and further sharpen the technological edge of their corporate enterprises, governments of industrialized countries have been supporting the technological activities of national enterprises through a wide variety of government-industry complexes. The governments of Japan, the US and major EU member states such as Germany, France, the UK and the Netherlands have already taken steps to strengthen the technological competitiveness of national enterprises through increasing subsidization of research in a manner that could be termed as a 'technology race'. The focus of the extensive subsidies provided by the governments to their enterprises is on the core technologies, viz. microelectronics and information technology, biotechnology and new materials . Table 3 shows that the governments in France, Germany, the UK and the US, for instance, accounted for 48.8, 37, 34.2 and 47 per cent of total gross R&D expenditure in their respective countries. Complementing the national programmes of collaborative research, the EU established a number of Community-wide technology development programmes in the 1980s known as framework programmes. The European Framework Programmes have brought together European industries, universities and research centres in joint initiatives in the form of transnational projects since 1984. The EU contributes one half of the cost of the projects, the other half being borne by the participating firms. The first framework programme (1984-7) had a total budget of ECU 3.7 billion; the second (1987-91), a budget of ECU 5.4 billion; and the third Framework Programme (1990-4) tying up with the second programme had a budget of ECU 7.7 billion . The major focus of these programmes is on strengthening the EU's competitiveness in new and emerging technologies such as microelectronics and information technology,

biotechnology, and advanced materials, in view of the widespread linkages these core technologies have with other sectors of the economy. Almost all the subsidies go to the private enterprises that undertake R&D projects or participate in the joint projects undertaken with other EU enterprises for eventual commercialization of the technologies developed. This phenomenon contributes to increasing privatization of new knowledge in these core technologies. In the US and Japan much of the knowledge in these core technologies is already in the private domain. A further concentration of scientific knowledge in these areas in the private sector has serious implications for the access of developing countries as well as for research priorities. A high degree of privatization of research in the area of biotechnology in the US, for instance, has stunted dissemination of even basic scientific information on advances which used to be available to scientists through professional channels such as conference presentations and publications in learned journals. Furthermore, with privatization, the research priorities are dictated more by commercial prospects than long-term considerations of sustainability.

Table 2: Share of core technologies in strategic technology alliances and technology transfer agreements, 1980-9

Region	Share of core technologies in strategic technology alliances, %	Share of core technologies in technolgy transfer agreements %
Triad	73.5	61.4
Developed economies	73.0	60.9
Triad-NICs	53.6	52.4
Triad-LDCs	23.4	38.5

Source: Freeman and Hagedoorn (1992)

Table 3: Pattern of R&D financing in select industrialized countries, 1992

	Government's share of total R&D expenditure, %	Direct government's share of R&D performed by business enterprises, %
France	48.8*	19.8*
Germany	37.0	10.7
United Kingdom	34.2*	14.6
United States	47.0	28.3

***belongs to 1991; **belongs to 1990**

Source: compiled from OECD (1993): Table 1 for the respective countries.

V FDI AND TECHNOLOGY SPILLOVERS

Since launching of structural adjustment programme and thereby opening of economies for foreign investment an argument which is being extended to support this is the likely spillover effect of the technology which foreign investor brings in. It is being explained that an important indirect consequence of FDI and technology licensing contracts on host economies could be in the form of spillovers of knowledge to locally owned firms. These may include exposure to new production or management technologies employed by foreign firms and spillovers of knowledge through employee mobility. Another source of spillover, being expected, is through the increased competition from foreign entry which forces local firms to become more efficient users of technologies.

These views from IMF/World Bank economists have attracted a serious debate on this kind of expected spillover effects.

The World Bank's World Development Report 1991 (p.94) accepted that there is no concluding evidence for this hypothesis. However, this debate has attracted lot of attention in recent years. Some of them really deserve our attention. Hadded and Harrison (1993) in Journal of Development Economics (# 42, p.51-74), examined the impact of FDI on the productivity of firms in Morocco's manufacturing sector using a firm-level panel data set for 1985-89. They found that, foreign firms do not exhibit higher levels of labour productivity on a greater outward orientation for most sectors, although they do continue to pay higher real wages than domestically owned firms. Foreign firms achieved on an average a higher level of total factor productivity than local firms but the growth rate of their productivity was not much higher. Similarly Aitken and Harrison (1993) in their Policy Research Working Paper (# 1248) from World Bank showed that in Venezuela spillovers from FDI to other local enterprises are negligible and do not justify the incentives granted by host governments to foreign investors. A. Kokho (1994) in Journal of Development Economics (#43:p.279-93), examining Mexican data, found no evidence of spillovers in industries where foreign affiliates had a much higher productivity and much higher market share than the local firms. This study also shows that spillovers are dependent upon local capability in industry. If local firms are too weak they will not be able to absorb spillovers and might vanish in the pace of competition from foreign firms. Cantwell (1989) in his book," Technological Innovation and Multinational Enterprises ", from Blackwell showed that entry of US firms in European markets between 1955 to 1975 forced out local firms from those markets where these firms did not have traditional technological strength. Recently, extensive research has come forward on carriers of foreign investment, that is, the multinational corporations. One of the them which has attracted most attention of researchers is

the extent to which these firms have been internationalising their technological activities. The study by Pari Patel and Keith Pavitt (1991) in Journal of International Business Studies (#22 $_{(1)}$) is very important. They have used US patent data, which registers patenting activity by subsidiary and country of origin, to assess the extent to which the world's 700 largest firms have been undertaking R&D in different parts of the world, picking and chosing the best locations by the availability of local talent. The enclosed table summarises their conclusion. The diagonal gives an indication of how far firms are patenting in their home base. Most of the US firms (91.9 per cent) prefer to hold patents in their own country. Same is the case with all other countries.

Table 4 : Geographical Location of Patenting

Home Country of Firms	Country of Origin of Patenting							
	US	Japan	France	West Germany	Netherland	Belgium	Sweden	Large U K
US	91.9	0.7	0.5	2.3	0.2	0.3	0.0	1.8
Japan	0.7	99.1	0.0	0.1	0.0	0.0	0.0	0.1
France	3.4	0.2	90.9	2.5	0.2	0.3	0.0	0.5
W. Germany	8.3	0.2	1.2	87.1	0.1	0.8	0.3	0.4
Netherland	25.0	0.4	6.0	13.3	43.4	0.6	0.6	7.7
Belgium	27.0	0.0	1.2	16.7	11.7	39.4	0.0	1.9
Sweden	5.1	0.3	1.2	13.5	2.8	0.3	71.2	1.7
UK	21.5	0.1	2.4	3.8	0.9	0.4	0.3	65.9

Source: Patel and Paritt (1991)

Thus it is clear that multinationals prefer to use their home base for strategic, patent - creating R&D activities. Hu (1992) in California Management Review ($34_{(2)}$) points out that it is not just R&D but corporate headquarters, finance and strategic planning have all remained predominantly home based. As Hu puts it, "a modern multinational company is necessarily a national company which may have less important international activities".

Thus in light of these evidences how one can presume that by depending on the enterprises from developed countries, Third world countries, can meet their technological requirements?

VI. FARMERS AS INNOVATORS

"Every farm is an experiment station and every farmer the director thereof" [Warner and Livermore (1911, p. 385)]

At times we tend to forget that our farmers have contributed in evolving our agricultural system. Their knowledge base has greatly contributed in enhancing the agricultural productivity. On-farm innovations by farmers has taken place as a continuous process throughout the period of settled agriculture. However, after Independence, at the time of formulating our technology policies in agriculture, we over looked this strength of our system and blindly allowed the super-implantation of an alien agri(culture). Until and unless we encorporate this dimension of our tradition in our overall policy frame-work we would continue to have low agricutural productivity and continued fear of getting our knowledge patented by the outsiders.

The history of recognising this important contribution of the farming communities does not extend very far back in time. But in recent years, a vast body of literature has been generated of this issue, particularly in response to the global initiatives at

preserving and conserving of bio-diversity and the role of the indigenous people in these conservation activities. The nature of farmer-innovation is succinctly presented by Biggs and Clay (Biggs and Clay, 1981) as under: "Farmers select by identifying and using plants of economic importance, continually retaining and reusing seed, and propagating material with preferred characteristics, such characteristics related to a whole series of attributes which the farmer comes to associate with performance in terms of yield robustness, and sustainability for time bounded production". This nature of purposive selection that the farmer has been engaged in, has been recognised by the authors as one source of innovation which is implemented by informal experimentation.

The above mentioned description of the farmer-innovation process wherein the farmers are seen to be adopting a clearly defined criteria to identify the improved varieties they have been able to develop, has a certain resemblance with that followed by the modern plant breeders. The latter relay on the three-fold criteria of distinctiveness, uniformity and stability (DUS), of the plant varieties they develop in order to lay claim on the breeders' rights. But even when the farmer-innovation process has been seen to have an objective basis in so far as the criteria for identifying the improvements are well laid out, no recognition is accorded to this system of innovation akin to that available to the modern system of plant breeding. The recognition that the modern plant breeders receive is facilitated by the extensive codification of their knowledge, while the lack of such codification lies at the heart of the relative neglect of the contribution that the farmers have made in the development of agricultural technology over generations.

The issue of extending intellectual property protection (IPP) to agriculture has assumed significance, particularly in developing countries, in the context of the extensive changes which could

take place in the peasant-dominated agricultural systems in these countries. The importance of the changes, as we have argued, lies in the fact that countries are expected to adopt a framework of IPP having a strong bias in favour of the modern plant breeders. This form of IPP has been proposed in recognition of the contribution that the breeders are seen to be making in the development of agricultural technology. The reward system through the grant of IPRs thus proposed, discriminates against the traditional farmers in developing countries. Not only would the latter encounter problems in continuing with their traditional practice of retaining a part of their harvest as seeds, the breeders can also exercise their rights over the harvested material. By giving such sweeping rights to the breeders, the proposed system of IPP almost completely excludes the farmers from the agricultural system.

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Annex. I

THE THINKING PROCESS