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ROLE OF NATIONAL PLANNING IN SCIENCE AND TECHNOLOGY:

MEANS FOR CHANGING THE TECHNOLOGICAL DOMINANCE OF INDUSTRIALIZED COUNTRIES.

Comments on experiences in selected countries*

by

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Summary

It is noted that currently developing countries are by necessity drawn into much closer international contacts than the earlier industrialists. The reasons are threefold: first, the technologies are becoming increasingly complex and large-scale; second, bigger sectors of the developing country's economy require modern technological inputs; third, advanced technology is also required for exports which are necessary to pay for the high technology imports. Consequently, in order to achieve rapid modernisation, developing countries have, at least for the time being, to become substantial net importers of foreign technology.

Economic, social and industrial development in the existing industrialized countries is considerably science-based. Developing countries should not, therefore, neglect laying the foundation for scientific research and should continue to be aware of the urgently needed extensive surveys of conditions and resources which must have a scientific base and which require scientific inputs. However, it is indicated in the experience of recently industrialized developing countries that the S and T efforts will have to be concentrated in the technology sphere. The possibility of utilizing science and technology lies in the ability to create innovations and to introduce transfer of technology. In this way expenditure on R and D and the development of R and D infrastructure can be a substitute for other essential functions.

Technological change is a major contributing factor to economic development, besides increased use of capital and manpower. In the industrialized countries the technology factor may contribute as much as two thirds of productivity increases. There is no reason to believe that increased productivity would be considerably less in developing countries at various levels of economic development. To realize this potential it is necessary to have a realistic understanding of where technological change occurs and under what conditions it can be influenced.

It is stressed that technology makes a contribution at four levels: national; sectoral, organizational; and productive. Additionally the element of technological change originates in the formal R and D institutes. In accepting the above levels of technological change the following specific recommendations were made for a technology policy of national economic development:

- Setting standards and priorities for making technological choices in various sectors;

- Suggestions for and control of the balance between research and other activities which influence technological change in the various sectors.

The two sets of policies must, in order to be effective, be closely integrated with economic planning.

Brief descriptions are given of the following countries in which attempts have been made to plan science and technology at the national level: Ethiopia, China, Viet Nam and the Republic of Korea.

In conclusion, the crux of the matter does not primarily lie in providing more funds, more personnel and new laboratories for the technology and science sector. The more pressing problems for efficient use of technology resources lie outside the sector itself. They concern matters such as the organization of the country's economic sector, the relations between and inside enterprises, changing price structures and incentive systems which will promote rather than hinder the introduction of new and efficient technologies. It is also of the utmost importance to identify how S and T institutions should be organized, linked and influenced through the decision making process in order to contribute most efficiently.

INTRODUCTION

Almost all technological change today originates in industrialized countries; this is not surprising as they control almost all research and development resources in terms of finance, a little less in terms of manpower. It seems axiomatic that in pursuing the goal of industrialization the late-comers are by necessity drawn into much closer international contacts than the early industrialists. The reasons for this are three-fold. First, the technologies are becoming increasingly complex and large scale. Second, bigger sectors of the developing country's economy require modern technological inputs. Third, advanced technology is also required in the manufacture of exports that are necessary to pay for the high technology imports. In order to achieve rapid modernisation, it appears, developing countries have no choice but to become at least for the time being substantial net importers of foreign technology.

There is no doubt that R&D is an essential resource for economic development and many developing countries have attempted to address the problem of planning the sector. So far, only limited countries have been successful in this endeavour. This paper will attempt to address some of the problems which make this kind of planning so difficult. Before doing so I would like to highlight the focus of this paper.

The level of global resources spent on research and development is rapidly rising and now stands at around US$ 300 billion (US$ 200 billion in 1980). The scientific and technical manpower engaged in research and development has reached almost 4 million people. However, it is common knowledge that only 6% of the financial resources and around 10% of manpower are found in the developing countries. There can be no doubt that it is highly desirable to change this extreme imbalance of R&D resources.

Economic, social and industrial development in the already industrialized countries is to a considerable extent science-based. Developing countries should not neglect laying the foundation for scientific research and one has to be deeply aware of the fact that the urgently needed extensive surveys of conditions and resources must have a scientific base and also require scientific inputs. However, there is every indication from the experience of developing countries which have recently industrialized that the S&T efforts will have to be concentrated in the technology sphere.

Furthermore, the possibility to utilize science and technology lies in the ability to create innovations which are often of an organizational nature and in the ability to introduce and transfer technology. Thus, the spending on R&D and the development of R&D infrastructure can hence be a substitute for other essential functions.

There appears to exist two major reasons why industrialized countries are able to maintain much higher real incomes. First, it has its basis in favourable conditions for various types of innovations and the high level of R&D spending is one of the elements. Second, industrialized countries are on the whole able to rapidly introduce new technologies within their countries and diffusion to developing countries takes considerable time.

In order to maintain their high real incomes the industrialized countries are forced to maintain innovativeness at a high level and the introduction of new technology at a high rate. The subsequent restructuring of the economy takes place at several levels.

Technological change is a major contributing factor to economic development, besides increased use of capital and manpower. In the industrialized countries the technology factor may contribute as much as two thirds of productivity increases. There is no reason to believe that the potential of technology to increase productivity would be considerably less in developing countries at various levels of economic development. In several more developed of the developing countries and in the industrialized countries there already exists a well-developed structure for technology generation and decision making on technology issues. However, in order to realize this potential, it is necessary to have a realistic understanding of where technological change occurs and under what conditions it can be influenced.

In this context it is important to stress that technology makes a contribution at the following levels

1. National - changes in the sectoral composition from low productivity to high productivity sector

2. Sector	- changes in the operation of existing production enterprises and service organizations
3. /Organization/Company	- changes in the production of various commodities and services
4. Product	- changes in products and components.

A remaining element of technology change originates in the formal R&D institutes. In addition their activities contribute or rather influence technological change at various levels. Accepting such a model of technological change naturally leads to specific recommendations on how to organize the science and technology activities.

First, the sectoral composition of the national economy is mainly influenced by investment decisions on new plants, expansion of existing ones, agricultural mechanization on regional development programs etc. All such investments have a heavy technology component where the choice of which is likely to have a considerable bearing on the overall productivity of the investment projects - most of which includes technology transfer from abroad.

Second, there is likely to exist considerable scope for technological change at the level of enterprises and organizations requiring inputs from the formal R&D system. Such changes will in most cases depend on the availability of domestic engineering and management manpower, and a willingness to undertake administrative reforms.

Third, research results for sectoral development are more likely to be utilized if the research activity can be directly influenced by user needs. This would then underline the need to establish a close integration between researchers and users which speaks against centralized research institutes. Such institutes, however, will be required for long term exploratory research. Thus a technology policy for national economic development must have two major components:

A. Setting standards and priorities for making technological choices in various sectors. This requires a long term development of analytical capability to handle economic and technical factors in integrated analysis.

B. Suggestions for and control of the balance between research and other activities which influence technological change in the various sectors. This must include policy for organizational forms, phased development of institutes and training programs.

Both sets of policies must, in order to be effective, be closely integrated with economic planning.

In the following brief descriptions are given for countries which have attempted to plan science and technology at the national level.

TECHNOLOGY CHOICE AND DIFFUSION IN ETHIOPIA

In 1983 Ethiopia carried a major attempt to formulate a national economic plan which also included science and technology plan and various economic sector plans. The industrial plan indicated that Ethiopia over 10 years would import 269 plants with a total value of 7.5 billion Birr. These new plants will, according to the plan, contribute approximately 75% of the increase of the gross value of industrial production.

Many of the disadvantages of present technology transfer practices can be overcome through proper planning and the build-up of the required domestic capabilities. However, this will require considerable time and a further constraint is in the expected scarcity of trained manpower in most sectors. This would indicate that the plan for industrialization and production increases may experience a number of serious difficulties.

Table 1: Origin of the gross value of industrial production at 1982/83 prices

	1982/83 million Birr	1992/93 million Birr	Percent Distribution
From existing factories	1 708	2 208	8.4
Projects under implementation	30	567	9.1
New projects	-	4 894	82.5
Sub total	1 738	7 669	100
Small scale industries	126	188	
Handicrafts	148	500	
Total	2 013	8 357	

Thus from a technology perspective one could see two possible modifications of the country's industrialization plan. First it would be beneficial to improvethe transfer terms, conditions and procedures now prevalent. Secondly it would be desirable to identify alternative industrialization strategies.

In the past, production and services technology imported into Ethiopia has came in mostly as complete packages on terms and conditions mainly set by the technology suppliers, as in any sector, acquired technical skills essential for the proper utilization and maintenance of the technologies. Consequently the benefits which would be expected fail to accrue to the users. Among the disadvantages and defects in current industrial practices that aggravates the resulting technological dependence may be enumerated as the following:

- Little importance was attached to regular preventive, maintenance and repair programming. It was lacking in quality or not carried out at all. cadre of engineers and technicians who have the requisite skills and experience is still insufficient.

- Drawings, instruction manuals and catalogues of machinery and equipment are seldom available. Where they exist they are often in several languages according to makers.

- Repair workshops are grossly inadequate where they exist.

- Facilities are lacking for the fabrication of even minor spareparts requiring unsophisticated technological capability, although there may exist an appreciable demand for such particularly for example in the textile and transport sectors.

- Equipment and machinery imported for the same or closely similar use may not only originate from a wide variety of sources but has been acquired haphazardly with standardization requirements seldom being prescribed. The variety of spareparts that must be held in stock is therefore excessive.

- Much of the machinery in use in production and service activities is more than 15 years old, the period beyond which the maker is not customarily obliged to deliver spareparts.

On the whole it appears desirable to reduce the technology imports envisaged and/or give higher priority to the small scale industry sector. Given the size of the country, the still undeveloped transportation network and the potential for agricultural and rural development it appears that the small scale sectors has been neglected.

No doubt the industrial plan should and must contain a major element of technology imports. The experiences of certain developing countries clearly indicates that considerable possibilities exist for selecting the industrial technology which constitute the complete package in a manufacturing plant. The development of such a capability requires the establishment of a considerable analytical capability in terms of economic and technical knowledge. However, the return on investment for the acquisition of such capacities is likely to be high.

The arguments above for rethinking the relative importance of technology imports and the desirability to invest in an analytical capability to unpackage technology before importing has a general relevance for many other production and service sectors. Not-withstanding the specific emphasis of the industrial strategy the science and technology plan for the industrial sector will include a number of basic elements which are required for the country's long term development. However, institutional structure, manpower requirements and phases of development is dependent on what kinds of industrial strategy is adapted.

The comments above, indicate a possible or even a likely gap between the potential of industrial technology imports and their full exploitation in the economic and social environment in Ethiopia. Similar gaps may develop in other sectors where an R&D capability is being developed. R&D resources will be wasted if the results from research station and laboratories are not utilized. Thus it is essential to establish efficient links between research output suppliers and its potential users and the situation in agriculture may serve as an illuminating example of the problem.

Concerning improved agricultural technologies there is the contradiction that, on the one hand, the Institute of Agricultural Research claims that it has in its possession a number of improved agricultural practices and inputs in the form of research results. The extension set up complains,on the other hand, that the research results are not yet in a usuable form.

Secondly there is strong criticism that many if not most of those research results introduced were found not to be any better than those the farmers are currently using. This has been especially true when recommendations were based only on the yield per hectare of new crop varities at a research station. Unless the seed has been tested locally, however, local soils and climates may be sufficiently different so that the improved variety is no better than strains already in common use.

Until about three years ago both research and extension were under the Ministry of Agriculture, each organized separately as an independent activity. Now the Institute of Agricultural Research has been removed from the Ministry of Agriculture because it was feared that the research needs of the new Ministries of State Farms and Coffee and Tea Development will not be met if the Institute remains under the Ministry of Agriculture.On the other hand the only Ministry which is directly involved with the farmers is the Ministry of Agriculture.

Taking into account these and other related factors, the Agricultural Task Force has proposed that research and extension not only be brought under the Ministry of Agriculture but also be organized under a Research and

Extension Authority. This Authority would control, direct and administer both research and extension. Following from this research and extension co-ordinating departments or sections would be set up for major crops and livestock - such as, for example, crop research and extension in all major agricultural research stations. Such an arrangement would help strengthen the extension arm of research. Research stations would be encouraged to produce basic seeds so that these can be taken up by producers cooperatives and the seed enterprise for further multiplication.

The above discussion indicates mainly one dimension; the institutional linkages and sharing of responsibility in diffusing new knowledge. Equally important is the adequacy of the qualifications of the extension workers. In many sectors when new or improved knowledge is needed the requirements of the users and conditions for successful introduction are poorly known. Thus more general surveys may initially be more important or at least as important as the creation of formal research laboratories and stations. Naturally, the S&T Policy and strategies must be formulated accordingly.

CENTRAL PLANNING OF SCIENCE AND TECHNOLOGY IN CHINA

China is by far the biggest developing country and has since the establishment of the People's Republic in 1949 paid great attention to the planning of science and technology. Today China claims to have the same research manpower as Japan and be spending approximately 1% of her gross national product on research and development. The stated ambition in the past has been to increase both resource factors.

The real problem for China's policy makers in the science technology field does not lie only in providing more money and manpower for the sector. The crunch of the matter lies also in setting the right priorities and providing a more efficient structure for China's scientific and technological resources. When new policies were formulated after the death of Mao, the new leadership decided to favour basic sciences and emphasise a centralised control of R&D through its academies and ministries and through government agencies. The goal was to catch up with the industrialized West and the results from science and technology would naturally contribute to the modernization of the economy.

It appears that two major groups influenced the plan. First, the scientists, who recreated the role of the academies and emphasized long-term and basic research. Second, the political leadership and high-level bureaucracy who promoted the idea of science and technology as an instrument for economic development without looking into the needs of changing the economic and political structure. Other important groups do not seem to have had much influence:

1. The educators - otherwise they would have pointed out that it would be impossible to train so many so quickly.

2. The engineers and the industrial people - otherwise they would have emphasized the role of engineering research and all the immediately pressing problems.

3. The social scientists and policy analysts - otherwise they would have pointed to the need for the careful policy analysis which so many of the top people are now thirsting for.

In readjusting her economic development plan in favour of agriculture and light industry, China has already been forced to change her priorities in science and technology. The emphasis since early 1980 is very heavily in favour of engineering sciences. As a consequence, the 1978-1985 plan is gradually being replaced by new plan for the 1980s, yet to be announced.

The structural problems of reorganizing science and technology have two major dimensions. First, the decision has already been taken to decentralize the control over R&D resources. In implementing the change towards engineering sciences it would be necessary to persuade the academy leaders, the institute directors, and other power holders that the country's economic development is best served if they give up part of their control and agree to meet the needs of industrial companies.

The lack of qualified manpower is the other major dimension of the restructuring problem. China has more than 600 institutes of higher learning of which 88 have been designated priority universities in the allocation of funds, teachers, and other resources. However, only 30 of these are considered to provide teaching of an acceptable quality, and it will be years before China has a high quality university system.

A further complication is the fact that most of the central research laboratories are narrowly specialized within certain fields and are often not flexible enough to mobilize new resources or to handle new problems. Many large companies in the west - in particular the multinationals - have realized that it is more efficient to have R&D combined with product development and manufacture in separate divisions rather than using central research laboratories for all their needs. This should be compared with the situation in China, where the equivalent of the central research facilities of big western company are completely outside the control of the company. This is likely greatly to hinder incremental as well as major innovations in both products and processes. The quality of staffing also needs improvement. These organizational problems must be solved if China is going to become an innovative society and two major changes are contemplated: the introduction of contract research and the creation of joint companies. The creation of industrial companies will most likely mean the transfer to them, in part, of the industrial research laboratories presently under Ministry leadership.

VIET NAM

There can be no doubt that the potential role that science and technology can play for Vietnam's economic and social development has been clearly recognized among its politicians and planners. Such an attitude appears to have been prevalent throughout the armed struggle. This manifested itself via a continued emphasis during this difficult period on establishing new research institutes and expanding higher education. This emphasis remained strong during a period which witnessed the cultural revolution in China - a major economic and political partner until recently - institutions of higher learning almost completely closed down for 7-8 years.

The unification of the North and South in 1975 made it relevant and necessary to reconsider the imposed self-reliance in technological development. For a time, Viet Nam saw great possibilities in the expected war reparations from the USA, together with World Bank loans, bilateral assistance programs with a number of countries, as well as the prospects of joint ventures with multinational companies to prospect and exploit the country's natural resources.

The prospects for rapid modernization have now vanished due to the political events but also due to unrealistic expectations. So, plans for modernization and utilization must be more long-term in nature and must, more than previously, consider bottleneck problems such as transportation and agriculture's lagging productivity.

A National Science Center was established during the period which came to a rather abrupt end in mid 1960s. When peace came to the country in 1975 the reconstruction included tasks both in the North and the South. The foreign technology utilized in the South posed problems of being incorporated into the economic system of the North due to a different technological level and different administration and industrial standards.

The present five-year plan 1981-1985 envisages that the budget for science and technology will expand greatly if Viet Nam's economy can support it. The new science and technology plan will have a number of new characteristics which are mentioned below. While applied research is still being stressed, the natural and social sciences are considered to be equally important. The basis for this is found in the belief that modern research is becoming more and more interdisciplinary in character.

The planners in Viet Nam are obviously aware of the need to utilize science and technology for the country's development. The availability of trained manpower is generally good but the modernization suffers from two major bottlenecks. First, Viet Nam lacks financial resources which make it almost impossible to utilize modern technology except in a few high priority sectors. Second, knowledge concerning the country's resources is inadequate and there is an urgent need to gain knowledge about atmospheric conditions, forestry resources, hydropower and water/aquatic resources, and availability and quality of minerals, etc in order to formulate proper plans.

Viet Nam is a planned socialist country which today has close economic relations with the countries within the Council of Mutual Economic Assistance (CMEA or COMECON). Thus it is natural to find an organizational structure for science and technology which is similar to that in the USSR and many of the other planned socialist countries. This is true for the State Commission for Science and Technology, the specialized bureaus for science and technology within the various ministries and the important links between industrial ministries and national laboratories which are directly under ministerial leadership. Viet Nam, however, still lacks an Academy of Sciences which in most other planned economies plays such an important role in basic sciences.

The country's leaders often refer, in general policy documents, to the three revolutions - in ideology and culture, in production, and in science and technology. The latter can be seen as a tribute to the idea of a scientific and technical revolution which is a standard concept in socialist countries when discussing the future.

Throughout this, as well as in many references to a new policy for science and technology to be discussed in the following, one sees a strong influence from the Soviet model for science and technology and senses that strong relationships have been established in many fields and not only in the science and technology sector.

Over the past couple of years there has been a heated debate over what kind of science and technology strategy Vietnam should pursue. Three major strategies have been advocated:

1. Comprehensive strategy
2. Selective strategy
3. Adaptive strategy

The proponents of the first strategy claim that given the country's demography, the availability of natural resources and the demands from the population, all branches of science and technology should be developed. The advocates of the second claim that VietNam's science and technology should specifically be geared to take advantage of the fact that VietNam is a resource-rich and tropical country. The proponents of the third strategy claim that VietNam, being a late-comer in modernization, should selectively pick up the most suitable sectors for technological development.

This debate is likely to continue for some time, although there is an awareness that VietNam needs a definite strategy for scientific and technological development. Without such a strategy it is difficult or even impossible to formulate a long-term plan which means that for the time being there will only be short-term plans. There is little evidence from the resolution on science and technology adopted in 1981, or later on, that a consensus has been reached on the country's science and technology strategy.

LONG-TERM INDUSTRIAL RESTRUCTURING IN THE REPUBLIC OF KOREA

A few years back the Government of the Republic of Korea announced that the country, in order to reduce the technological gap with the advanced countries, should increase the ratio of research and development expenditures to GNP from 0.9% in 1979 to 2% in 1986. It was simultaneously stated that joint ventures and technical licensing agreements would be encouraged to facilitate transfer of sophisticated technologies from advanced countries. Financial support was promised for developing those technologies where the private sector was still lagging in capabilities.

Underlying this policy shift is the realization that the Republic of Korea is today gradually losing its competitiveness in low-priced goods. Pursuing technological development is the only possibility when rapid wage increases and intense competition from the less developed countries are eroding the basis for the country's exports in labour-intensive products.

Today the major companies in the country have become eager to make major investments in research and development. This is also a major shift in attitudes as companies in the past considered such expenditure as unnecessary. However, the core of R+D in the country does not yet represent technological innovations but should rather be seen as basis for further catch-up with companies in the industrialized countries through creative adaptation. Most imports of sophisticated technologies still come from Japan.

It is expected that the government's policy for R&D will emphasize such fields as computers, semiconductors, genetic engineering and fine chemicals. Naturally, it will be necessary to strike a balance between development of new sophisticated technologies and improvement of existing technologies. There is little doubt that this will require major investments in basic science in order to support the country's future science-based technological development.

The shift in R&D policy and the new elements are the latest stage in a progression of policies which have successively been pursued over the past decades. The science and technology strategy to support industrialization can be divided into three stages. During the first stage, in the 1960s the strategy was to strengthen technical education, build a technological infrastructure and promote the importation of technology. Two major institutions were established, the Ministry of Science and Technology and the Korea Institute of Science and Technology (KIST) which has more recently become the Korea Advanced Institute of Science and Technology.

In the following stage, in the 1970s, the Government's policies were aimed at strengthening technical and engineering education for the heavy and chemical industries. Considerable attention was given to the improvement of adapting institutional mechanisms for adapting imported technology and promoting R&D activities to meet the more immediate industrial needs. During this stage the Government established and funded specialized research institutes in the fields of machinery, shipbuilding, marine science and electronics. Special laws such as Technology Promotion Law and the Engineering Services Promotion Law were enacted to provide the necessary administrative support.

The Republic of Korea is currently in the third stage of developing science and technology and on the industrial side the Government policy is aiming at the transformation of the industrial structure on the basis of a changing comparative advantage. This will involve the expansion of technology-intensive industries such as electronics and telecommunications as well as developing the necessary scientific and technical manpower. Thus the Government will continue to encourage the training of scientists and engineers through graduate school education and overseas training programs and also the recruitment of Korean scientists abroad.

The gradual approach is evident when looking at the stages of the country's development of science and technology and is summarized in Table 2.

An important element of the country's recent science and technology policy has been the high level of political guidance. This has been institutionalized as a National Technology Promotion Conference held every third month over which the President presides. The meeting which takes one day brings together everyone that matters in science and technology planning in the country - altogether around 250 people. The participants include cabinet members, industrial leaders and members of the research community. No formal decisions are taken at these meetings although many of the basic issues in science and technology policy are discussed. This could for example include discussions on tariffs, technology development funds or tax exemptions for certain projects. Thus there is a broad sharing of information and insights which are relevant to the formal decisions which are taken outside the conference. Equally or more important is the involvement of the president which indicates the importance of the science and technology questions and in a way provides the leadership over this field.

The idea was launched in 1982 and the Ministry of Science and Technology is the coordinator for the meetings. The approach has a striking similarity with the National Export Promotion Conference which was organized along similar lines and presided over by the late President Park during the

1970s. These export meetings were seen as very important for supporting the export orientation of the Korean economy during the 1970s.

Table 2: Changes in the Republic of Korea's industry and S+T policy

Period	Industrialization	Science and Technology
1960s	1. Develop import-substitute industries	1. Strengthen S&T education
	2. Expand export-oriented light industries	2. Build scientific and technological infrastructure
	3. Support producer goods industries	3. Promote foreign technology import
1970s	1. Expand heavy and chemical industries	1. Expand technical training
	2. Shift emphasis from capital import to technology import	2. Improve institutional mechanism for adapting imported technology
	3. Strengthen export-oriented industry competitiveness	3. Promote research applicable to industrial needs
1980s	1. Transform industrial structure on the basis of comparative advantage	1. Develop and recruit high-level scientists and engineers of
	2. Expand technology-intensive industry	2. Promote productivity of R&D
	3. Encourage manpower development and improve productivity of industries.	3. Localize key strategic technology

Source: Ministry of Science and Technology; ("Companies March to the new beat of R&D", Business Korea, May 1984, pp 37-39)

CONCLUDING REMARKS

The planning of science and technology is in most countries associated with basic research and major development programs. These are important elements but rarely constitute major portions of what goes on in science and technology even in advanced industrialized countries. Among the major elements are the following three. First, technology transfer which is not only international transfer but equally or possibly more important domestic transfer between companies and regions. Second, the building of infrastructure which includes national research institutes and company laboratories. Third, the training of manpower in required number and with relevant capabilities to be provided at the right time.

The use of foreign technology must be analysed in relation to the transport system, the machine-building sector, and the availability of raw materials for large-scale plants. In adopting foreign technology it is also necessary to handle the relationship between the introduction of advanced foreign technology on the one hand and on the other to preserve enthusiasm among the scientific workers at home to develop domestic technology. The need for policy analysis is equally important for the sciences and it is necessary to come to an understanding of the role of big science and what contributions local science can play in the country's modernisation.

The crux of the matter does not primarily lie in providing more funds, more personnel and new laboratories for the technology and science sector. The more pressing problems for efficient use of technology resources lie outside the sector itself. They concern matters such as the organization of the country's economic sector, the relations between and inside enterprises, changing price structures and incentive systems which will promote rather than hinder the introduction of new and efficient technologies.

Science and technology activities must be institutionally organized in such a way that they make a maximum contribution to the country's economic and service sectors. This would indicate that it is of utmost importance to identify how S&T institutions should be organized, linked and influenced through the decision making process in order to contribute most efficiently.

This consideration indicates the need to clearly distinguish between technology policy formulation and technology planning. Technology policy is a basic function of government aimed at creating a network in which decisions concerning technological choice can be made and complemented.

Technology planning on the other hand is defined as the development of a formally constructed internally consistent set of goals, objectives and instruments.

It has been advocated that all developing countries should seek to formulate technology policies within which basic choices can be made. The preparation of comprehensive technology plans along the lines mentioned above may be beyond the scope and unnecessary for countries with limited regulatory and supervising capabilities. Naturally there is little chance of successfully implementing a technology plan in a country when a national planning system is not yet in operation.

From a political science perspective it is of interest to characterize the countries mentioned earlier and a few others with regard to their approach in organizing and control of the R&D sector and indicate the relative success or failure.

China before 1976, still influenced by the cultural revolution, used an organization which although decentralized in theory meant centralism in reality. In the years after the death of Mao Tsetung much of the decentralism disappeared together with the political control. Instead the scientists for a few years gained the superiority. Today the economic reforms and the decentralization of economic decision-making has reduced the organizational approach to coordination. At the same time the control is shifting away from the scientists to the market (companies) and the bureaucracy. The new situation in China in fact appears to have considerable similarities with the situation in Japan which, however, has a weaker organizational approach which should rather be termed pluralism.

VietNam has in the past seen an extreme centralism and a strong political control over science and technology resources - approaches which both can be traced to heavy influence from the Soviet Union. The Province of Taiwan and the Republic of Korea today share similarities in the balance between pluralism and coordination while they differ in their control over science and technology. The former has stronger market control while the latter has a strong political control element. Finally India has a strong element of centralism and strong control by the scientists. The characteristics are summarized in Table 3.

Table 3: Approaches to science and technology policy

	Organization	Control	Decision-making	Require-ments
China				
- before 1976	centralism	political	"rationalism"	
- after 1976	centralism	bureaucracy/ scientific		
- today	coordination	bureaucracy/ market		
Vietnam	centralism	political	"rationalism"	
Japan	pluralism/ coordination	bureaucracy/ market		
Korea	coordination/ centralism	political/ bureaucracy		
Province of Taiwan	pluralism/ coordination	bureaucracy/ market		
India	centralism/ coordination	scientific/ bureaucracy		

Naturally, the approaches chosen for organization and control will be shaped by the cultural and historical traditions and are also likely to change with the economic development of the country. However, it appears that a certain approach followed has, often been chosen without fully considering the necessary requirements. The apparent rationalism in several of the attempts in following centralism and political leadership will require a dominant decision-maker, clear objectives, good information and means of optimizing the use of resources. Quite often only the first requirement is met and only for a limited period of time. More often the situation is characterized by conflicting interests, uncertain goals and lack of information.

However, it is possible that time is the most serious constraint for the building up of research institutions in several of the sectors. Research institutes require not only finance, equipment and manpower. They also require time to grow into organizations which can identify problems and search for optional solutions. The infrastructure like communications, information base etc., have to be established. Research managers do not graduate out of universities but only reach maturity through training on-the-spot and on the job. All these factors clearly indicate that it is essential to establish an R&D network. But an equally important interpretation of the same facts is the research institutions do not grow only by being provided with resources. Thus a slower growth after an early establishment may in many cases mean a more efficient use of resources compared with a rapid build-up.

Many countries, in particular planned socialist economies, have had the ambition to encompass all elements of science and technology in comprehensive national plans. So far there is little to show for these efforts and major reason is that the control of science and technology inputs must be subordinated to the objectives of various sectorial goals, e.g. in agriculture, transportation, defence etc. Thus, the question must be asked what is left to be included in a national plan for science and technology. There is no easy ansewr as will be seen from the various national approaches which have briefly been mentioned on the earlier pages.

In the opinion of the author there are a few general lessons which emerge. First, the national leadership over science and technology is essential and must be subordinated to various interests such as those of the economic sectors. The leadership to be exercised must be political in nature and have not only the objective of coordinating various resources and interests but also set the visionary long term but realistic goals. Second, the realism must be based on an assessment of both the domestic and international situation which requires substantial and good information. Third, the national plan should also establish a temporal framework for the gradual build-up of the infrastructure and the capability in science and technology. There are only limited possibilities to leapfrog and there is little reason to provide scientific and technological inputs which are not demanded because the sector is far ahead of the industrial or agricultural development of the country. Finally, there are a number of issues affecting the orientation, level and quality of the R&D sector. These include tax exemption rules, patent law etc which naturally fall into the realm of national planning.