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Policies for Industrial Technology

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INTRODUCTION

In the world of microelectronics and genetic engineering, it is unnecessary to belabor the importance of science and technology for the economy. Innovation is critical not only for those who wish to accelerate or sustain the rate of economic growth, but also for those who are appalled by narrow preoccupation with the quantity of goods and wish to change the direction of economic advancement or improvement in the quality of life. It is crucial to consider the long-term conservation of resources and improvement of the environment in the formulation of the economic planning of a nation. The prevention of most forms of pollution and the economic recycling of waste products alike, requires advanced technology.

In the most general sense, economists have always recognized the central importance of technological innovation for economic progress. Adam Smith's *Wealth of Nations* plunges immediately into a discussion on improvements in machinery and division of labor which promotes specialized inventions. Karl Marx's model of the capitalist economy ascribes to a central role to technical innovation in capital goods, whereby 'the bourgeoisie cannot exist without constantly revolutionizing the means of production'. Alfred Marshall had no hesitation in describing 'knowledge as the chief engine of progress in the economy'.

The velocity and cost with which innovations are developed in response to opportunities and constraints depend on the state of development of science and technology. Research and Developments (R & D) on the horizon already suggest that conditions exist for a second industrial revolution.

New lines of advancement are many. These include:

1. new energy resources (nuclear and renewable) and new technologies for a much improved energy management,
2. new manmade materials,
3. new ways to exploit the oceans (for example aquaculture,

mineral resources from the sea) and the space (for example telecommunication and observation satellites, orbiting stations for production of energy),

4. development in electronics and information technologies, which have dramatically change production techniques and services through extensive automation and the diffusion of the microprocessor and computer techniques,
5. new means of communication, which will change the transport sector by substituting the flow of information,
6. development in biotechnology, streaming from the progress in microbiology, biochemistry, and genetic engineering, will profoundly change related sectors such as agriculture, health, chemical and food industries. This will give rise to a new stream of innovations and inventions.

It is clear that most firms in industrial countries and some firms in developing countries have already discovered these opportunities and are actively exploring them.

INDUSTRIAL TECHNOLOGY IN DEVELOPING ECONOMIES

Most issues on technology development tend to address the problem of technology acquisition and it is only recently that the focus has changed to the development of technological capability. In general the new perspectives are concerned with the technology in a dynamic setting, with attention on how technological capability develops over time. Previously, the major concern was the static question of cost and terms of technology transfer. The rapid industrial development achieved by new industrialized economies (NIEs) like Korea, Taiwan has generated much interest in the field of technological changes in developing economies. Increasing technological capability has been perceived as an important national objective. The concept of indigenous technological capability has important theoretical and practical implications.

Absorption of technology requires extensive indigenous technological effort, especially in product development and the found to facilitate the development of local mastery over imported technology. This process, in which local staff participates in varying degrees may continue for sometimes after completion of the original transfer.

In developing countries, technological innovations are viewed as important learning process of gaining mastery over imported technology.

It is also recognized that the viability of an economy and its capacity to respond to changing market environment will partly depend on the presence of strong innovative skills in the economy. For a country with a strong export strategy, such capacity plays a much more pervasive role in determining the success or failure of an economic performance than many other factors.

During the past two hundred years, technological innovations have been dominated by a handful of countries. The developed countries are responsible for 97 percent of world's research and development expenditure. Six nations employ nearly 70 percent of the world's research and development manpower and spend nearly 85 percent of R & D funds. Six percent of an estimated 3 1/2 million patents issued in 1972 were granted by developing countries, and less than 1/6 of those issued by developing countries were owned by developing country nationals.

In recent years there has been some increase in the technological capacity of developing countries. As is to be expected, the increase has been unevenly spread among developing countries. This is indicated by rising expenditure on research and development and by some evidence of incipient exports of technology by some countries. While these developments are potentially significant, particularly in relation to policy, they are of relative insignificance in the general picture. The developed countries retain a massive preponderance in technological innovation which is a fundamental fact which must underlie any discussion of technology development. It is this preponderance that is sometimes described as technological dependence.

The ability to make independent technological choices, to adapt and improve upon chosen techniques and products and eventually to generate new technology endogenously are essential aspects of the process of development. The process may be described as accumulation of technology capacity and is as important to economic development as the accumulation of capital. The accumulation of technological capacity is the outcome of a complex series of forces. One significant element is 'learning by doing'. Another is an educational, infrastructural and institutional setting which permits and encourages the learning process. These aspects are crucial, although in the past, policy has tended to overemphasize the institutional side, which is most obviously amenable to government policy, and underestimate the 'learning by doing' side. Weak links between an elaborate institutional structure and industrial, and learning by doing activities have tended to

'marginalize' the activities of the scientific institutions.

Accumulation of technology capacity is not a simple, easily described activity. It cannot be measured in a straight forward way at either macro or micro levels. At a macro level, residual methods of measuring technical change, suggest the substantial significance of increases in productivity which are not explained by increases in inputs. The relationship between technological transfer and creation of technological capability is rather complex and little is known about the process of accumulation of technological capability.

Empirical study in this area is very limited although the World Bank is now carrying out some in-depth studies in several newly industrialized countries. However, literature dealing with technological development in developing countries has generally acknowledged that creating indigenous technological capability is of vital importance to developing countries as part of the development process. This will improve the developing countries' bargaining power in relation to the technology, increase their ability to make independent technological choices, enable them to improve on chosen techniques and products and eventually generate new technological capabilities. Direct investment has been virtually excluded and the acquisition of advanced technology has been achieved through a policy which has relied heavily on licensing agreement together with a large R & D. According to Ozawa (1974), Japan's remarkable success story seems to have been a result of the government's strategy for introducing foreign technologies in ways that have emphasized their local linkages.

One of the objectives of promoting diffusion of imported technology in the firms is to increase the indigenous technological capacity at the enterprise level. The idea is to provide the enterprises with the necessary capacity to understand better the application and to introduce modifications to make it more suitable for their specific operating conditions. Through the effective diffusion of the technology by enterprises, pressure can be put on technology suppliers to force them to improve continuously their technology and quality of the services they provide. Further, the absorption of imported technology will not be imported subsequently in an identical form when additional technology is acquired for further expansion. Technology transfer will become more of a dynamic process as the capability gained in absorbing one technology enables greater involvement in subsequent transfers of related technology. Therefore, the firms can reduce its payments for technology, widen its sources, make better choices and to source for

local suppliers for certain technological components.

ROLE OF INDUSTRIAL TECHNOLOGY POLICY

There is a need also to formulate explicit short, medium and long-term technology policies based on both current and future technological needs to meet current and future market requirements. It should, however, be flexible and responsive to meet any unforeseen changes in technology, the economic climate and market needs. It must be emphasized that technology planning attempts to tackle in a comprehensive fashion the building up of technology infrastructure in human resources and institutions, the optimal use of technological capabilities and the increase in efficiency of the technological activities. This requires that priorities be specified in accordance with the development of style and national needs and the program defined and carried out to attain them. Malaysia is fortunate that it has formulated a short and medium-term Industrial Master Plan (IMP), covering the various relevant sectors of the economy. Much effort has been made in formulating this detailed industrial strategy covering the period from 1986-1995. The formulation of the IMP had really facilitated the preparation of the Technology Action Plan. Technology policy presupposes the existence of well-defined industrial strategies. Studies in the field of technology policy and research found that countries do not have well-defined industrialization strategies have only vague technology policies. They generally encourage the development of infrastructure but are incapable of guiding the development of technology capability in the industries.

For others however, the policy instruments and institutional mechanisms to foster industrial technology development remain inadequate. The generation of a minimum level of indigenous technology necessary to absorb technology from foreign sources and adapt them to gain comparative advantage in the market is also given little attention. Market forces alone may not be sufficient to generate technological development and industrial growth. This has been recognized in countries such as Japan and South Korea, where the governments have worked to shape and promote technological development. For technology policies, as with other plans in Malaysia, the premise being that while market mechanisms are indispensable, rational planning is fundamentally important in achieving development objectives.

Within this framework, there is an important role for the private sector, which Malaysia has not yet fully developed. A technology plan which is indicative, showing the broad technological development objectives and strategies of the nation, would be a mean of guiding the private sector in the national effort towards industrial technology development. The Government should therefore be prepared to adopt a strategic long-term approach to technology policy. This will be based on an assessment of current and future technological, economic and social needs and problems, and an awareness of technological trends and associated commercial opportunities. It will tackle in a comprehensive fashion the building up of the technology infrastructure in human resources and policy instruments. It will represent a positive consensus between government, industry and society. It would provide a focus for policy makers of technology development and facilitate cooperation among them towards achieving the desired technological objectives, for example, agencies involved in education, manpower development and retraining will be able to formulate and examine their program in the light of the skilled profile specified in the Technology Action Plan.

Skill formation, is a central feature in technology planning. Companies must have trained personnel, take into account the need for trained personnel arising from the importation, adaptation and evolution of new techniques. In deciding on the priorities of training, for example, as between chemical and electrical engineers, note will have to be taken of the manpower requirement of planning technological changes which is obvious enough and hardly needs stressing. Less obvious, however, is the question of technological innovation which is also related to decisions on training that facilitates teaching and research. Decisions have to be taken on whether to give priority to – using the same example – innovation in electronics or in chemical engineering and the policy regarding manpower training in these fields also will reflect these innovational priorities. The importance of incentives has been emphasized in the context of indirect ways of carrying out technological planning. Given the central importance of these issues, it is useful to treat it as a component of the technological planning. The incentives could include taxation measures, grant, subsidies and information exchange. There are several reasons why economists believe that a free enterprise market system in the absence of government intervention is likely to support insufficient efforts and not allocate these efforts in an efficient pattern.

Markets fail to work as adequate mechanisms for allocating resources to scientific efforts because decisions made by firms and individuals are based upon their private profits and gains and these frequently differ from social gains. A company or an individual may not be able to appropriate an adequate share of the total gains to society from a discovery though the total gains to the society significantly exceeds the cost of making the discovery.

Risks and uncertainties provide grounds for government intervention for scientific and technological development. Individuals and companies can be too short-sighted on actions to be adopted by developing new technologies even when they can expect substantial long-term gains from adapting or developing new technologies. Therefore there is a need for government to intervene to counteract one's myopia of this kind. Cultural background and attitudes to change may play a role in other cases. There is a case for government assisting with the development and dissemination of scientific knowledge, in particular, with relevance to small firms. Capital markets are claimed to be imperfect sometimes since most scientific and technological changes require investment. These activities can be adversely affected. At least two types of problems can be identified. Small firms may have restricted access to funds and this can retard their capital performance. The capital required for research and development projects is so large and there is lack of investment before returns are obtained and the uncertainty of returns is great that funds cannot be easily raised in the free market. Imperfect capital markets may form a basis for government's intervention in technological efforts. Markets may fail to steer industries and associated research into development in areas of industrial fields of greater national gains or advantages because decisions about resources are made upon a basis that is too individualistic and isolated. While it may not be profitable for an individual firm to branch out into new fields, the position may be different if many firms can be convinced to enter the field almost simultaneously. It may then obtain external economies which may be achieved because specialists spring up to deal with different parts of the activities of the different industries. The implication of this is that the government may need to coordinate and encourage the development of selected industrial fields and back its industrial strategy by giving support to science and industrial research and development appropriate to the selected fields of industries.

TECHNOLOGY POLICY IN INDUSTRIALIZED COUNTRIES

Table 1 shows various public policy instruments that can be employed to influence firms' innovative activities. They are classified according to whether they operate on the supply side, the demand side or on influencing the environment in which firms operate. Not all countries utilize these instruments equally.

TABLE 1. Innovation policy instruments

Supply Side
R & D subsidies• Grants for innovation• Technology tranfer• Skilled manpower• Infrastructural• R & D

Demand Side
Volume of public purchasing• Creating quality demand• Innovation-oriented purchasing• Underwriting the cost of new equipment

Environmental
Government regulations• Planning procedures• Patent policy• Taxation policy• Macro-economic policy• Stimulating the social acceptance of new technology

In Japan, the Netherlands, Sweden and Canada, the main emphasis was on providing the technical and financial inputs to the innovation process, and in the UK there was considerable emphasis on taxation measures. A more fundamental difference between nations, however, lay in the role that government play in influencing directly the rate and direction of technological change. In some countries, for example in Japan and France, public policies involv the choice of specific technologies and high technology product groups, with selective support from government in the chosen areas. There was relatively high level of coordination at the national level and public policies were designed to influence both the rate and direction of industrial innovation. Essentially, public innovation policies were aimed at the structural transformation of the industrial base towards higher value-added, more technology-intensive sectors and product groups. In other words, these policies had a strong reindustrialization content.

In other countries in contrast, for example in West Germany and the United Kingdom but most notable in the USA, policies were aimed largely at developing an environment conducive to firm based innovative activities through creating the appropriate fiscal and regulatory

frameworks. In this case, technology choice, at least in theory, was vested in the hands of management, with the rate and direction of technological change being determined by 'market forces'. Today public policy in the UK remain, again in theory at least, the `hands-off' kind.

Besides R & D incentives, some countries have also set forth incentives pertaining to the acquisition of offshore technology, its adaptation and modification, design and engineering capabilities. These countries have also devised specific means to appropriate public sector R & D funds, often have specific programs for human resource development and programs to link universities and existing R & D facilities with the private sector, and sometimes have intervened in the formal banking sector to promote industrial technological development. Many have also intervened in the area of public procurement and tender, and have developed a wide range of fiscal instruments to promote industrial innovation in the private sector.

A highly relevant example for Malaysia is South Korea. In each industrial development period, the Koreans first decided what industries they wished to emphasize. They then scrutinized both, what types of priority products should be developed within such industries and what types of production technologies that were both essential and optimal for their manufacturer. They then analyzed which of these products and production technologies they should predominantly import through joint-ventures with the multinationals. They then set up specific 'technological performance incentives', as they are called, promulgated through a series of technology laws, supporting both R & D in certain fields, and industrial innovation. Such performance incentives are aimed at inducing forms to enhance technical performance. These instruments are particularly critical in developing countries, since technology imports from multinationals usually dominate the industrial infrastructure, and indigenous firms at an early stage of development are particularly risk-averse in modifying technology and usually engage in no research activities beyond quality control and maintenance. In most countries, there are two classes of performance incentives; tax incentives for R & D and credit lines for financing pilot plants and capital goods prototypes. More recently, Korea has became aware of the necessity to make its industrial structure more technology intensive. With the growing technology sophistication of Korean industries, Korean entrepreneurs have now realized that besides continued and somewhat difficult importation of transferred technologies, they must also develop rapidly their technical capabilities to maintain international competitiveness.

As a result, governmental industrial policies have focussed on the development of R & D capabilities through a variety of means. The government, for example, has been encouraging the private sector to collaborate through R & D cooperatives in emerging fields of strategic technologies such as biogenetic, and in 1989 there were 26 such R & D cooperatives in Korea. Korea has also encouraged private sector R & D investments through several incentive schemes, freed foreign technology imports, attempted to increase linkages between the non-profit research institutes and the private sector and created several innovative funding mechanisms for R & D.

It would appear then that policies and policy approaches appropriate within the particular social, political and industrial framework existing in one country may be inappropriate in other different countries. This can be illustrated by considering some principal features of the situations existing in USA and Japan during the 1960s and 1970s, which are summarized in Table 2. It seems clear that the sociopolitical framework and the postwar policy approach adopted in the USA, a world technological leader in 1945, between them were well adapted to the creation of new technology-based industrial sectors and to sustain technological leadership. In Japan, a technologically backward nation in 1945, postwar policies were conducive to rapid technological 'catching-up' along established trajectories and to efficient international market exploitation.

An important implication here is that care must be taken by countries attempting to adopt policies and instruments that have proved their effectiveness elsewhere. They must be suitably adapted to match the unique set of conditions prevailing in the adopter country. It also means that it is difficult to make judgments on a more than national basis concerning which policies and instruments are better than others.

IMPLICATIONS FOR MALAYSIA

The introduction of technology serves two economic purposes of which are, it improves efficiency in the production of existing products and services and it leads to the introduction of new products and services that fulfill new needs. Clearly, industrial innovation is one of the driving forces, if not the prime mover of economic progress. As innovations diffuse through the economy, they help to enhance product quality, reduce costs and improve productivity. In short, they contribute to improve the competitiveness and enhanced living standards in a given

TABLE 2. Different attitudes and policies to innovation and technical change

America during 1960s and 1970s

- Emphasis on 'market-pulled' innovation; based on large, innovation-demanding home market.
- Great personal mobility of researches and managers (conducive to rapid technology diffusion).
- Relatively strong university/industry links in crucial areas.
- Legislation and education directed towards entrepreneurship.
- High availability of venture capital.
- Many industry and university spinoff entrepreneurs. Many new technology-based firms formed.
- Rapid growth of new industry sectors based on radical technologies.
- Support for strategic sectors/technologies in connection with position as a super-power (defense, aerospace).

Japan during 1960s and 1970s

- A politico/economic infrastructure involving interweaving of state, banks and industry.
- A number of large, diverse, R & D - performing corporations actively seeking to absorb and adapt foreign technology.
- Coordinated policy towards the acquisition and diffusion of foreign technology.
- Strong emphasis on efficient mass production and total quality control.
- Innovation-demanding home market.
- Strongly coordinated export policy
- Aggressive industrial policy involving long-term public and private sector strategies.

economy. For an individual firm, the successful early adoption of innovations puts it ahead of its competitors and in a position to earn better profits and develop or increase exports.

For a small export dependent economy such as Malaysia's, there are equally clear benefits of being near the leading edge of technology adoption. The payoff lies in improved productivity that sustains high income and the ability to compete internationally ally even with short production runs. Unfortunately, Malaysia's capability to apply and exploit new technology does not match those of other NIEs. Part of the explanation lies with the relative lack of a comprehensive policy on promoting industrial technology. Market size, foreign ownership and the greater role of the plantation sector in the Malaysian economy are also significant reasons.

While original research in bio-engineering or fifth generation

microtechnology will command the spotlight in the next decade, the important economic success stories should be those that involve the use of Malaysian skills to develop new creative adaptations and extensions of new technologies. Some new industries will be created, but the biggest impact will be from the use of new technologies to revitalize existing industries, whether it be manufacturing or services.

Excessive lags in Malaysia's rate of technology adoption will mean that productivity gains are not captured quickly by existing industries, with adverse consequences for their international competitiveness. As Malaysia moves towards an industrialized economy in the next decade, it need to develop sound and comprehensive industrial technology policies which should address the five key areas of which are:

1. Promoting technological innovation in industries;
2. Building technological competence in key and strategic technologies such as biotechnology, advanced materials, automated manufacturing, micro-electronics, information technology, laser and optics, communication and artificial intelligence;
3. Strengthening education and training at all levels relating to science and technology;
4. Improving organization and management of industrial technology in both Government and Public Sectors;
5. Undertaking activities and programs to promote science and technology culture.

Under the five broad strategies, Malaysia need to undertake strong policy shift emphasizing development of industrial technology in the next decade, which among others, would include the following key issues:

1. Promoting industrial innovation in industries through fiscal and financial support, public procurement and other policy instruments.
2. Invest in R & D infrastructures relating to new technologies particularly information technology, microelectronics, advanced materials, robotics and artificial intelligence, laser technology and optics, biotechnology and automation.
3. Achieve 1.5 percent gross expenditure of research and development as a percentage of Gross Domestic Product.
4. Increase contribution of private sector in total R & D expenditure to 40 percent.
5. Strengthen infrastructure in training and education to ensure supply of skilled and trained personnel in the emerging areas

of technology. This could be achieved through upgrading of industrial training, enterprise based training, and postgraduate education.

6. Promote strategic alliance between industries and Government research institutes to undertake research on selected areas of interest to the country.
7. Formulate new policy framework to encourage development of technology intensive industries including establishment of innovation centers, common facilities for R & D and 'high-tech' industrial estates.

CONCLUSION

Malaysia is beginning to recognize the importance of a sound domestic technological base for development. In recent times, it has been given greater attention as exemplified by the establishment of Malaysian Institute of Micro-electronics System (MIMOS) and various technology centers within Standard Institute and Industrial Research of Malaysia (SIRIM), the expansion of public R & D expenditure and the recent announcement with regard to the technical assistance fund. The effort by the Ministry of Science, Technology and the Environment to formulate the Industrial Technology Action Plan is very timely. These augur well for the industrial technology development in the next decade. It is hoped that such an effort would pave the way for the development of an industrialized economy in the next decade.

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