SCIENCE POLICY IN THAILAND*

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1. Science, Technology and Economy: A New Dimension of National Development

1.1 The close relationship between science, technology and economy has been evident since the dawn of modern economic history.¹ The closer the relationship is fostered, the greater are the potentials for economic growth of the nation. The economic leadership of England after the Industrial Revolution was attributed to an unprecedented wave of technological innovations in that country. When such a wave swept through the entire Western world, the economic power of England was challenged. Later when Japan joined the technological race, the economic supremacy contest has become world-wide. In the world today, technological capability is a decisive factor in practically all aspects of international relations. International advantages and disadvantages are no longer determined by natural endowments, but rather by technological capabilities and their potential growths. Technology therefore reigns supreme.

1.2 Scientific discoveries at the early stage of the history of science were not necessarily related to economic activities. They were products of human intellectual efforts to satisfy curiosities on natural environment surrounding men. Only when those discoveries have been accumulated as a body of scientific network which deepens and widens the understanding of men regarding nature, that they become ready to serve as means to promote economic and social improvements. While men keep on searching for scientific knowledge, they increasingly make use of the available knowledge for economic applications, thus transforming science into technology. The "modern economic epoch" clearly has been brought about by the emergency of science-based technology, and its continuation is based on the close link between science, technology and production. The tremendous impact of this phenomenon has given rise to the hope for further economic and social progress, increasingly turning desire into reality. The success in economic development in turn demands further technological innovations and a continuation in scientific research. More scientific discoveries have become candidates for technological innovations, while a greater number of innovations have entered a list of candidates for economic and industrial applications. Modern economic growth is, therefore, basically founded on the relationship between science, technology and economy.²

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1.3 Despite the significant role of technology in economic development, most of the growth models are explained in terms of capital accumulation, leaving technology as a residue. The general negligence of science and technology in growth theories is perhaps due to the difficulty to quantify their direct contribution to economic performances. Although the impacts of science and technology appear to be very strong, their presence is like shadows: seen, felt, but somehow uncontrollable. Under these circumstances, capital, not technology, has been generally accepted as the central growth variable. In fact, capital and technology are closely related. Technological progress is a major determinant of capital investment, and it also guarantees the latter's rate of return. Meanwhile, capital investment essentially serves as a vehicle for transforming technological innovations to economic and industrial applications. A steady economic growth, therefore, requires a parallel and co-ordinated contribution of these two variables. While technological progress needs capital investment, the latter's rate of return depends on the former. For this reason, the industrially advanced countries always see to it that a substantial portion of their national investment is earmarked for technological development.

1.4 When Thailand decided to launch her economic and industrial development programs in the early 1960's, an emphasis was placed exclusively on capital formation. During the first decade of intensified development efforts, heavy investments, mostly financed by generous foreign grants, were made on infra-structures to sustain further development of the economy. Industrial investment was also promoted by generous grantings of tax concessions with an aim to establish industries serving domestic requirements. By the 1970's, Thailand's import bills have already grown so large following heavy imports of capital goods, intermediate products and energy. These growing import bills have been paid for by foreign exchange earnings from agricultural exports supplemented by the inflows of foreign capital funds. As the export growth rates do not keep pace with the import growth rates, the country's trade deficits, as well as the foreign debts, have become larger, thus adversely affecting both internal and external equilibrium.³ During recent years, realizing that her international economic performances cannot sustain the national currency's exchange value, Thailand is forced to undergo a series of devaluations in order to restore the equilibrium.⁴ The devaluation policy has been supported by monetary and fiscal policies of spending restraints, and a shift of economic policy from import substitution towards export drives. Attention is also focussed on an improvement of the price system as a means to strengthen productivity, efficiency and international competitiveness. It appears that in their attempt to find a solution to the country's economic problems, Thailand's policy-makers and economic planners have brought into consideration practically every conceivable policy measure. However, they tend to overlook a very important factor — the nation's technological capability and self-reliance.

1.5 A careful study of the Thai economy and its development reveals that the root of the problem is found in the country's low level of technological capability and self-reliance. The national weakness in science and technology has become an acute problem as the Thai economy is increasingly dependent externally. Technologically unprepared, Thailand has entered the world-wide economic competition. She is simply producing goods of the nineteenth century in exchange for goods of the twenty-first century. The price differentials between her imports and exports are large, and there is a strong tendency for the international price gap to become wider. Technology does not only form a major part in the cost structure of modern products and services, it also, through quality and design, decides on their demands. Rapid technological progress in the West and Japan has left Thailand much behind the world, even in the area of her traditional industries such as agriculture and other primary sectors. Her weakness in technological

self-reliance has created a negative effect on her manufacturing sector, import-substitution and export-orientation alike. Without a domestic technological capability, an import-substitution strategy for industrialization imposes a heavy burden on the trade and payment balances, as local industries have to pay high costs of imported technologies, both hardware and software, just to get goods manufactured in Thailand. Similarly, an attempt to export foreign technology industrial goods will not alleviate the economic problem. As long as Thailand still cannot rely on her own technology, there will be no permanent solution to the problems of economic growth and stability. The question of science and technology, therefore, is very crucial.

1.6 Science and technology have been unfortunately neglected by the Thai policy-makers and economic planners. Before the energy crisis, the negligence was evidently due to lacks of strong pressures on trade balance and international payments, and perhaps also to the busy engagement in building of the physical infra-structures. But since then the negligence of science and technology in the Thai planning scenario is attributed to a misunderstanding of their role in the economy. In the first place, the term "technology" is often considered alien to the basic economic culture of Thailand. There is some apprehension that its presence, if not controlled, could produce an adverse effect on Thailand's economic life. Technology, therefore, must be carefully selected, not on the ground of international competitiveness, but in the sense of its "appropriateness" to the existing socio-economic conditions. Such an apprehension has prevented a serious attention given to technological applications. Secondly, technology is viewed as expensive and luxurious consumer products only to be enjoyed by rich nations. Thailand is considered too poor to afford it. The concept of investment in technology has never been clearly understood in Thailand. Taking it as a national financial burden, technological investment is preferred to be left to the private industrial sector, and not as a national concern. Lastly, it is always assumed that technology transfer automatically accompanies imported capital. Since the Government already promotes foreign investment, it automatically promotes technology transfer. The investment promotion scheme, therefore, only emphasizes the objectives of job creation and product exportation. There is no need to include technological capability and self-reliance in its objectives. An evidence of the negligence of science and technology is found in the national economic plans. From the First to the Fourth Plans, there was hardly a reference to science and technology. The Fifth Plan (1982-1986) devotes a few pages to a discussion of the supporting role of science and technology in industrialization. Until very recently, public policy statements on the economy rarely mentioned science and technology.⁵

1.7 The negligence of science and technology on the part of policy-making and economic planning bodies has created a concern in the country's scientific and technological community. Scientists, technologists, techno-economists, and businessmen with technological backgrounds have long been convinced that a national science policy is needed to strengthen the Thai economy. As their voices have been increasingly heard, the Government decides to respond to them by establishing the Ministry of Science, Technology and Energy (MOSTE) as the governmental body responsible for the promotion and development of science and technology. Since its inception, MOSTE has been advocating the inclusion of science and technology in government policy. Recently, it has taken one step forward, by insisting that science and technology must be accepted as a main tool for the national economic and social development. MOSTE argues that science and technology transcend all economic and social sectors; they are direct answer to the questions of productivity, efficiency, and international competitiveness; and their development is the base for national economic self-reliance. With the improvement in technological capability,

Thailand will enter the twenty-first century as a technologically developed nation. MOSTE's efforts are, however, not confined to the promotion of science and technology, they are also oriented towards the strengthening of the research and development activities (R&D) in strategic areas, such as bio-technology, metal and material technology, electronics, and industrial engineering, together with the expansion of technological services in the areas of testing and standards, engineering consultancy, technological data and information, and the transfer of R&D products to industrial production. In pursuing this policy, MOSTE has Thailand Institute of Scientific and Technological Research (TISTR) as its arm. Under the new policy, TISTR is expected to play the role of the national research and development centre, as well as the national center for the transfer of international technology. A new dimension for national development is, therefore, taking shape.⁶

1.8 The present design for Thailand's science policy concentrates on the strengthening of technological capability and self-reliance through the research and development activities, the expenditures of which form an integral part of the national investment. These R&D activities are directed towards the development of the national capability to handle technological problems concerning production. It is conceived that a successful industrialization program cannot depend largely on imported technology, either hardware or software. A certain degree of technological self-reliance is definitely needed, and it must be vigorously raised in support of further industrialization. With an increase in technological capability and self-reliance, Thailand is expected to cut down the cost of imported technologies, presently amounting to billions of dollars per annum. It will also raise productivity and improve efficiency in the economy, finally eliminating poverty. The standard and quality of Thai products are also expected to improve, thus strengthening their competitiveness in both home and foreign markets. Apparently, the road to an economic success begins at R&D. Although the national science policy as described is a new dimension for national development, it does not start from scratch. For many past decades, Thailand has invested heavily in human capital, and has in possession a sizable stock of scientific and technical manpower, not including those brain-drains living in developed countries. The time now is to utilize that previous human stock fully and effectively for the national economic and social development, and also for modernization.⁷

2. Technological Capability and Self-reliance:

A Basic Objective of Economic Policy

2.1 As for the economy functions, that is to produce, to distribute and to exchange, with the view to satisfy the overall needs of the society, a combination of productive factors, together with a system must be taken into consideration. A sound economic policy should be designed in such a way that the necessary productive factors are available sufficiently in quantity and quality, and the system in which all these factors are put to work is an effective one. Technology is one of the most important factors, the absence of which renders the working of an economy inefficiency. Technology takes the form of either hardware or software. Hardware technology consists of machinery, equipments, and component parts, which are required for the production of goods and services. Software technology, on the other hand, consists of what is termed "technical know-how" which includes production process. In a broader context, software technology also covers the services of technologists and engineers which are an integral part of technical know-how.⁸ In a much broader context still, there exists technology of a third kind, the social technology, which is needed for an efficient organization of

production, distribution and exchange. Social technology comprises the vast knowledge of social sciences, including economics, law, business administration, sociology and psychology. Even languages may also form part of social technology.⁹ Each economy requires a minimum stock of technology, in addition to the capital stock of both physical and human. To acquire a technological stock, there is a need for investment in technology, just the same way as investment in physical and human capital.¹⁰ An economy's technological capability is measured by the size and the quality of such a stock. Meanwhile, if an economy could function with its own stock of technology, it is said to be technologically self-reliant. The success in international competition is determined largely by the degree of technological self-reliance.

2.2 Economic underdevelopment is fundamentally conditioned by low levels of technological capability and self-reliance. A limited capability makes it impossible for a country to fully utilize its own resources, no matter how rich they are. Under-utilization of resources means an economic underdevelopment. On the other hand, if a country lacks self-reliance in technology, an attempt to develop its economy will be a costly undertaking because of the fact that technology is normally the most expensive of all costs. For many products, technology costs much more than all other costs combined. For this reason, every industrially developed country is willing to devote a substantial portion of its expenditures on research and development in order to maintain or increase its technological self-reliance. For an industrially developed country, so much of its financial resources have been utilized in order to acquire a technological capability and consequently an economic development. Fortunately, developing countries of today are not necessarily required to carry financial burden of the same extent. It is possible for them to transfer technology from developed countries, provided that they have an ability to transfer it.¹¹ However, since a transfer of technology is not just simply the purchase of a research product, a developing country must see to it that she possesses the necessary preparations for the task.

2.3 Technological capability of a nation in essence is an aggregate knowledge on how to produce goods and services, and also an ability to use such knowledge for actual production. This national capability is not measured by the existence of plants, machinery, equipments and other hardwares in the country, because without knowledge of how those things work, even if knowing how to operate them, the technological capability is non-existent. In other words, technological capability means the mastery of technology which could lead to the design, development, and adaptation of both hardware and software technologies, including the actual production of products based on those technologies. The mastery of technology is, therefore, much more significant to economic and industrial development than the utilization of local manpower and raw materials. In fact, utilization of the resources also requires a technological capability in processing. Similarly, manpower training also calls for technology. It is sometimes overlooked that before natural resources are brought to industrial production, they have to be explored, analysed, developed and processed. Each step needs technology, without which they remain economically useless.¹² For this reason, technological capability and self-reliance become a basic objective of economic policy. They do not compete with any other objective, namely, economic growth, employment, price stability, a satisfactory balance of payments and social justice, and they cannot be traded-off with any of them. It should be realized that technological capability sustains growth, employment, price stability, and a satisfactory balance of payments, and it is basic to practically everything an economic policy strives for.¹³

2.4 Unfortunately, technological consideration has never been taken seriously in the economic policy of Thailand. The lack of conceptual clearness is perhaps the most accurate explanation for this phenomenon. In fact, the significance of science and technology to modernization and development was for a long time conceived by thinking men in Thailand.¹⁴ However, as the sense of history appears to be rather weak among policy-makers and economic planners of the present generation, their ears do not record the whisperings of men in the past. Moreover, scientists and technologists tend to have a limited representation in the country's policy-making and economic planning, while only a few of those decision-makers have been truly exposed to the magic of science and technology. Most Thai economists tend to look at the economic problems in a financial perspective, and as such almost all attention is paid to the working of the price system. Only recently when it appears that economic problems cannot be coped with by traditional financial and monetary measures, attention is gradually drawn to a new approach – the techno-economic approach – which combines economic reasoning with technological reality. The recent awareness in the role of science and technology in the national economy, though still at the beginning, is an encouraging sign of the new trend. It gives hope and encouragement to the re-shaping of the country's economic policy: the hope that knowledge will overcome ignorance; and the encouragement that the scientific and technological assets of the nation will be given a chance, for the first time, to make a valuable contribution to the economy.

2.5 With the existing stock of personnel, knowledge and experience in science and technology, the task of strengthening technological capability and self-reliance can begin systematically. MOSTE, of course, is expected to play a leading role in this challenging task at the national level. Its role consists of sharpening the concept, drawing up the design, the implementing the various projects formulated under this scheme. In the policy context, it is crucial to program national investment in science and technology which covers the education and training of scientific and technical manpower, the support given to R&D activities, the provision of technological services, and the transfer of R&D products to actual industrial production. Most of the funds for the national investment in technology is expected to come from the national budget. However, to alleviate the national financial burden, the investment program should be supplemented by international co-operation and assistance. At the macro level, a target will have to be set for the amount of funds available during the plan period. These funds will be allocated for education and training, research and development, technological services, and also the cost of transferring technologies for further development and adaptation. At the micro level, there will be a program for the efficient allocation of the national investment fund to various science and technology projects selected on criteria of national priorities. In this respect, special attention should be given to the strengthening of TISTR as the national center for R&D activities and technological services. TISTR's R&D network, however, will be extended to cover research activities at institutions of higher learning and also at governmental agencies dealing with science and technology. It is also through TISTR that R&D products and technological services will be passed on to industry for actual production and distribution. At present, TISTR has been reorganized to serve as an effective implementing agency for the national science policy. It, however, needs more support both technically and financially in order to accomplish its important task.

3. Research, Development and Transfer of Technology: A Structural Design for Industrialization

3.1 Economic development theorists and practitioners have come a long way, through

heated debates at times, to a conclusion that industrialization is needed to generate growth, achieve development and sustain progress. The reason is that so many of the goods and services required by the society come from industries, both directly and indirectly. In other words, outputs of industries become inputs of the other economic and social sectors, while the rest goes to final demand and export. The industrial inputs of, say, the agricultural sector include farm machinery, fertilizers and processing equipments. The communication sector also requires wires and cables, and electronic products from industry. Even the public health sector needs medical equipments and pharmaceutical products, while the defence sector depends on industry for weapons, ammunitions and other military supplies. Industry, therefore, is the base for an economy. The question is not whether a country should industrialize, but rather how to do it effectively and efficiently. The industrialization concept is essentially a techno-economic concept, and its design is a techno-economic design which blends technological capability with economic rationale.

3.2 Conceptually, an industry is a physical transformation of "raw materials" to finished products" at specific stages. The transformation is carried out with science-based technology, and its purpose is to create value-added. The economic principle is that to maximize the desired value-added, the most efficient technology should be adopted. Economic and technology, therefore, join hand in hand in the industrial transformation process. On the one hand, industry is an application of science and technology to solve economic problem. On the other hand, it is an economic application to solve scientific and technological problems. An industrial concept possesses an inter-disciplinary character, a balanced techno-economic consideration, and a dual role of the two disciplines in action. Very often in the Thai experience, an industrial policy lacks the techno-economic balance which in turn has led to a failure in the industrial development, both at the macro and the micro levels. The most obvious instance of imbalance in Thailand's industrial policy is the on-going industrial re-structuring program under which, R&D as the main determinant of technological capability, is almost completely absent.

3.3 A design for industrialization should aim to develop a permanent and self-reliant base for the industrial system, which may be termed "the industrial root". As industrial development is a long-term process, it needs an exceptionally strong base to withstand disturbances derived from technological change, market fluctuations, financial and monetary unstabilities, and political turmoils. The base or the "root" of an industry is its technological capability and self-reliance. A national industry cannot be developed and sustained without national technological capability and self-reliance. TISTR is at present undertaking a techno-economic research project with the view to measure the degree of technological self-reliance in Thai industries. Pending the outcome of the study, a preliminary finding has given a hint that the technological self-reliance appears to be very low in many industrial groups. This means that those industries are just foreign industrial establishments in Thailand operating independently of the national technological capability. The success of an industrialization program depends on the extent to which technological self-reliance is attained. It is, therefore, an illusion to mistake the existence of industrial establishments in the country for industrialization. As long as the country's industrial system still depends on imported technology, without a serious effort to master it, there is no industrialization. As the cost of imported technology is always high, the domestic industrial value-added will be negligible, no matter whether the manufactured products are sold in the home market or exported. The Thai public has always been misinformed about the country's industrial growth as reflected in the national income statistics. The statistics on manufacturing value-added shows the figures which include

the costs of imported technology. Once these costs which are believed to be substantial are deducted, it will be seen that the remaining nett value-added derived from the manufacturing sector is indeed very small. The problem of imported technology and the external cost involved are vaguely recognized by economic planners and investment promoters. Accepting that the imports of capital goods, intermediate products, raw materials and energy account for more than 85% of the total import bill, they have adopted a policy to encourage the utilization of local raw materials as a solution. An enlightenment on the concept of technology will provide them with the light to see more clearly that the technology contents of those imports are substantial, and their values are also enormous. The problem cannot be solved merely by providing incentives for the investors to produce them in Thailand. The problem should be tackled from a technology standpoint which is at the root of the problem itself – the strengthening of the national technological capability and self-reliance. A design for industrialization is expected to start from here.

3.4 The grasping of technology and its mastery are delicate and complex. The process is an intellectual rather than physical undertaking. The learning process is perhaps the best analogy for an illustration purpose. A student cannot be said to obtain knowledge only when he pays the school fees, purchases textbooks and even attends classes. He then has not learnt yet. To obtain the knowledge, the student must read textbooks, do exercises, and participate in class until he feels that he has mastered the subject. Similarly, in the case of technology, the R&D activities are imperative for a successful transfer and mastery of technology. With a strong R&D base, the country will not only transfer ready-made technology from outside, but it will also adapt, develop, and even pioneer new technology of its own. On the other hand, without an R&D base, there will be no possibility for the country to build the national technological capability and to attain technological self-reliance. The R&D process is, however, lengthy and costly, particularly at the initial stage of knowledge accumulation. But once the momentum has been gained, the development will become quickened. The cost burden for R&D is high, but inevitable for the future, in the same way as the cost of education for the children's future. Since there is no alternative to R&D for a country seeking industrialization, the question centres on how to design the best R&D program under limited resources.¹⁶

3.5 There is, however, no need to start every R&D project from basic findings. The technological knowledge at this stage can be purchased, or even obtained free of charge under technology co-operation agreements with friendly nations. In most cases, it is advisable to pick up the activity at the development stage, thus by-passing the initial research. In fact, this approach is less costly and consumes less time to reach the objective. The focus then will be on "development" with the aims to achieve better quality, lower production cost, or more suitable for the local conditions. It is an ideal to achieve three aims, but even the achievement of only one is considered satisfactory. TISTR has recently adopted the "development approach" for its R&D policy in order to accelerate its research output with a minimum time and financial cost. Besides, TISTR is concentrating on R&D projects with a combination of quick results and strong economic impacts. To qualify as a R&D project, TISTR will see to it that the research and development stages are complete, covering also the engineering stage. After that, TISTR's research products are passed on to industries under a technological co-operation agreement. In return for the technological royalty, TISTR for five years will provide the industries concerned with technical and technological assistance, including plant installation, selection of machinery and equipment, and quality control. In the future, it may be

possible for TISTR to contribute an investment fund to the enterprise's equity, as a psycho-business support to the investment project.

3.6 Complementary to the R&D activities in the process of strengthening the national technological capability and self-reliance are those activities grouped under "technological services". In fact, the transfer of technology, both from outside and to industry, is also part of these essential services. The other important services include testing and standards, technological information, engineering consultancy, and the so-called "contract research". In Thailand, TISTR alone provides all these services. TISTR's testing service covers a wide range of materials and products, and among its clients is the Industrial Standards Institute. As the demand for testings is rapidly increasing from both the public and private sectors, TISTR needs the strengthening of its testing equipments and technical personnel. On the information service, TISTR's Thai Documentation Centre with a world-wide network has been operating for two decades. The Centre services both TISTR's own R&D activities and the rest of the science and technology community in the country. In fact, its clients are to be found all over the world. Like the testing and standards service, TISTR's information centre is seeking further support for its improvement to become a real nerve centre for the nation's technological information system. The engineering consultancy service of TISTR is still on the initial stage of development. The present objective of the service is to build up the national capability in the area of engineering consultancy, particularly for large and medium-size development projects contained in the national economic and social development plan. The service under consideration covers engineering feasibility studies, engineering designs, and the supervision of the constructions of engineering projects, the technology costs of which have been enormous, adding to the country's external debts burden. The contract research service of TISTR aims to assisting private industrialists, government departments, and public enterprises in finding the solutions to their operation problems concerning science and technology. Many of the research contrasts are "diagnostic" in nature, the undertaking of which gives TISTR an image of a "technological clinic". All of these services form part of a design for industrialization.¹⁷

FOOTNOTES

1. Literatures on English economic history in the eighteenth and nineteenth centuries provide supportive evidences of the decisive role of science and technology in the "Industrial Revolution". The followings are quotations from some of the authoritative works:

T.S. Ashton, "The Industrial Revolution 1760-1830", Oxford University Press, 1948.

"The stream of English scientific thought, issuing from the teaching of Francis Bacon, and enlarged by the genius of Boyle and Newton, was one of the main tributaries of the industrial revolution". (p. 15).

"About 1760 a wave of gadgets swept over England. It was not only gadgets, however, but innovations of various kinds — in agriculture, transport, manufacture, trade, and finance — that surged up with a suddenness for whic it is difficult to find a parallel at any other time or place." (p. 58).

"In the industries so far considered the growth of production was associated with new forms of power, new machinery, or new knowledge derived from science". (p. 79).

Max Weber, "General Economic History", Collier Books, 1961, (translated by Frank H. Knight).

"Finally, a through the union with science, the production of goods was emancipated from all the bonds of inherited tradition, and came under the dominance of the freely roving intelligence. It is true that most of the inventions of the 18th century were not made in a scientific manner; when the coking process was discovered no one suspected what its chemical significance might be. The connection of industry with modern science, especially the systematic work of the laboratories, beginning with Justus von Liebig, enabled industry to become what it is today and so brought capitalism to its full development." (p. 227).

"The tendency toward's rationalizing technology and economic relations with a view to reducing prices in relation to costs, generated in the 17th century a feverish pursuit of invention. All the inventors of the period are dominated by the object of cheapening production; the notion of perpetual motion as a source of energy is only one of many objectives of this quite universal movement." (p. 231).

"Furthermore, only the occident possesses science in the present-day sense of the word. Theology, philosophy, reflection on the ultimate problems of life, were known to the Chinese and the Hindu, perhaps even of a depth unreached by the European; but a rational science in connection with a rational technology remained unknown to those civilizations". (p. 232-33).

Abbott Payson Usher, "A History of Mechanical Inventions". Beacon Press, 1929.

"Broadly conceived, technology is an important part of the central core in the evolutionary process. It is an essential aspect of the accumulation of knowledge and development of skills." (p. 2).

Witt Bowden, Michael Karpovich, Abbott Payson Usher, "An Economic History of Europe since 1750", American Book Company, 1937.

"The improvement of industrial techniques was stimulated less by the actual increase of trade by the opening up of new commercial opportunities The full utilization of these opportunities required improvements in modes of manufacturing and transportation. The expansion of trade further stimulated industry by the introduction of new commodities and the development of new manufactures." (p. 105).

"The incentives for the improvement of industrial techniques were primarily economic, but the intellectual background and the instrumentalities of change are to be found in the evolution of the scientific spirit." (p. 106).

"The distinctive feature of the era of technological history which began in the eighteenth century is the increase in the scope of mechanization. The outstanding feature, then, which distinguishes the period since the industrial revolution from the ages preceding it, is the extent of the use of machines as substitutes for manual labour." (p. 108).

2. According to Kuznets, an economic epoch means "a relatively long period in economic history of a number of human societies, possessing distinctive characteristics that impart to a given epoch a unity and differentiates it from the others that preceded or followed it". The modern economic epoch is characterized by "continuous technological progress and a series of new scientific discoveries" which are the "necessary conditions" for economic growth. See **Simon Kuznets**, "**Six Lectures on Economic Growth**", The Free Press of Glencoe, 1959. (pp. 29-35).
3. The problem of trade imbalance was noticed even before the oil crisis, mainly in the light of the country's unfavorable trade balance with Japan. The pressure became stronger after the rise of the oil prices. In 1983, Thailand's trade deficits grew to a peak of over Bht 80 billion, or about one-half of her export value. The foreign debts, meanwhile, have grown to Bht 220 billion, or about 25% of the GNP. The Government concentrates on export promotion, particularly through investment promotion and marketing improvement, as the main corrective measure of the trade problem. However, as the Thai manufacturing sector depends heavily on imported technologies, both hardware and software, its net export gains are not expected to be substantial. The trade situation become worse with the declines in the prices of agricultural exports.
4. In November 1984, Thailand decided to switch from a fixed exchange rate system to a floating exchange rate system, with an instant devaluation of about 17%, the largest in her monetary history. Since then, the exchange value of the baht has further declined. Although officially, the monetary event is a crucial measure to cope with the growing trade imbalance, it is critically viewed as an inevitable result of the failure in the economic management.
5. Strange, but it is true that Thai economists have never taken the question of technological capability and self-reliance seriously. Perhaps this peculiar attitude is due to their relative weaknesses in economic history and also in technological background. To them, the role of science and technology in the economy is only peripheral.
6. At present, MOSTE is still not classified "an economic ministry" in contrast with Commerce, Communication, Agriculture, Industry, Foreign Affairs and Interior ministries. It is grouped with Education, University Affairs, and Public Health.
7. Most Thai scientists, many of them first-rated, are engaged in teachings, and to some extent in basic research at universities. It is MOSTE's policy to recruit them for R&D activities while still academically fresh. The success of this policy needs strong support both administratively and financially.
8. Technology is generally considered from a software aspect, that is, technical know-how. Its hardware side needs a stronger emphasis, particularly in the light of the import trade. Machinery and equipments imported are priced in accordance with their technological values, rather than with the costs of material and labor inputs.
9. "Social technology" is a new-brand concept designed to stress the role of social sciences in the strengthening of technological capability.
10. "Investment in technology" is also another new concept, as contrast to fixed investment and investment in human capital. The purpose is to emphasize that economic development is not feasible without a national stock of "Technological capital". Investment in technology is reflected in the expenditures on R&D.

11. A full discussion on the opportunities for technology transfer is found in **ESCAP, "Technology for Development"**, a study by ESCAP secretariat for the 40th Session of the Commission, held in Tokyo in April 1984 (p. 72). One paragraph reads: "They (developing countries) do not have to reinvent the wheel. Many useful technologies are available for purchase which make it possible to compress the time needed for development".
12. In Thailand, "natural resources" are generally conceived without reference to the need for technology to develop and prepare them for manufacturing process. For that reason, there frequently are policy advocates for an increasing use of "local raw materials" in industries, without reference to the country's existing technological capability to process them.
13. In the past, the objectives of economic policy normally included only growth, stability, full employment, equilibrium in the balance of payments, equality in income distribution, regional balance development, economic diversification and economic freedom. See **SCAFE, "Programming Techniques for Economic Development"**, 1960 (p. 6), and also **Kenneth E. Boulding, "Principles of Economic Policy"**, Prentice-Hall, 1958, (pp. 19-20).
14. The first Thai who conceived science and technology as a means for national modernization was King Mongkut (1804-1868). He is recognized "Father of Thai Science" for his intellectual leadership in modern science in his country. Another Thai scientist whose contribution to science and technology is well remembered was Dr. Tua Lapanukrom (1898-1941), the first Director-General of Science Department. From his numerous writings on the subject, it shows that Thailand never lacks men with foresights.
15. MOSTE's new role in the promotion of science and technology took shape when Minister Damrong Lathapipat assumed office as Minister of Science, Technology and Energy in 1983. A political scientist, Minister Damrong closely follows the policy advocated by Dr. Tua Lapanukrom before the Second World War.
16. See **ESCAP, "Technology for Development"**, *ibid.* "One most important cornerstone of the technological infra-structure is the R and D unit." (p. 38).
17. See **TISTR, "Operation Program 1985-1989"** (in Thai).