IDRC-MR21

International Development Research Centre
MANUSCRIPT REPORTS

Science and technology for development: a selection of background papers for the main comparative report of the STPI project

PART A:

Science and technology policy and development

Contributors

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October 1980

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IDRC-MR21

SCIENCE AND TECHNOLOGY FOR DEVELOPMENT:

A SELECTION OF BACKGROUND PAPERS FOR THE

MAIN COMPARATIVE REPORT OF THE STPI PROJECT[1]

PART A:

SCIENCE AND TECHNOLOGY POLICY

AND DEVELOPMENT

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[1]This series of selections includes four volumes - Part A: Science and Technology Policy and Development (IDRC-MR21), Part B: Consulting and Design Engineering Capabilities in Developing Countries (IDRC-MR22), Part C: Technology Transfer in Developing Countries (IDRC-MR23), Part D: State Enterprises and Technological Development (IDRC-MR24).

A complete key to the full range of STPI publications is given at the end of this book.

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PREFACE

The STPI project was a large undertaking involving more than 150 researchers in the 10 participating countries. In addition, several consultants prepared background papers on topics identified by the teams. The main results of the project were presented to policymakers in a series of regional meetings held in Africa and the Middle East in 1977 and 1978.

The research, consultants' work, and dissemination meetings resulted in many reports. Some of these have already been published by IDRC, but several of the papers on specialized themes did not fit the general summary publications nor did they fit into the more detailed modules or monographs on the STPI project, also in the process of publication. It has therefore been decided to prepare these selections from STPI in order to ensure that the work receives a wider distribution. It should be remembered that the work leading to the articles was done and most of the articles prepared in the mid-1970s. Nevertheless, the work they report and topics they cover still have relevance for development in the 1980s.

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INTRODUCTION

This volume is one of a series published within the framework of the Science and Technology Policy Instruments (STPI) Project. The STPI Project, a large collaborative research effort that involved 10 teams from Latin America, the Middle East, Southern Europe, and Asia, was sponsored by the International Development Research Centre. Its principal aim was to examine the ways in which developing countries could ensure the effective contribution of science and technology (S&T) to development.

The central concern of the STPI Project was the process of S&T policy design and implementation. A detailed examination was conducted of the policymaking process, the ways in which policies were transformed into sources of influence through government action, and the impact that various policy instruments at the disposal of government had on the development of S&T capabilities (1). In addition, a number of complementary research topics were chosen for detailed analysis, and two volumes have been published on S&T planning in less developed countries and on S&T policies in China (2).

Other topics chosen for study to complement the central line of research of the STPI Project are the development of consulting and engineering design capabilities, the problems of technology transfer from industrialized to less developed countries, and the role of public or state enterprises in the process of S&T development. The participating teams worked on these topics according to their research interests, and there was not a uniform coverage of these topics complementary to the main line of research.

Volume A gathers a selection of reports prepared by the STPI teams on the above topics. The first chapter contains an overview of the field of S&T policy research for development, written by Geoffrey Oldham, IDRC's Associate Director for S&T policy, as an introduction to a series of meetings organized to disseminate the results of the STPI Project. The second chapter contains a compilation of statements on technological dependence/self-reliance, prepared by Onelia Cardettini on the basis of reports submitted to the Office of the Field Coordinator of the STPI Project. The third chapter contains an essay by Máximo Halty, a former IDRC Senior Research Fellow, commissioned

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(1) Sagasti, Francisco R., Science and Technology for Development: Main Comparative Report of the STPI Project, Ottawa, International Development Research Centre, IDRC-109e, 1978.

(2) Sagasti, Francisco R. and Aráoz, Alberto (Editors), Science and Technology for Development: Planning in the STPI Countries, Ottawa, International Development Research Centre, IDRC-133e, 1979 and Dean, Genevieve C., Science and Technology for Development: Technology Policy and Industrialization in the People's Republic of China, Ottawa, International Development Research Centre, IDRC-130e, 1979.

for the STPI dissemination meetings. This was one of the last essays written by Máximo Halty before his untimely death in December 1978.

Volume B contains two chapters written by Anil Malhotra, who coordinated the Indian contributions to the STPI Project, and undertook to prepare a synthesis report of the results of STPI research on the subject of consulting and engineering. Chapter 4 describes a conceptual framework developed by Malhotra, and Chapter 5 summarizes the findings of the STPI teams on the development of consulting and engineering design capabilities.

Volume C consists of four chapters on the issue of technology transfer, written in 1974-1975. In Chapter 6 Carlos Contreras surveys the main problems faced by the developing countries and suggests a policy framework to deal with them. In Chapter 7, Francisco C. Sercovich undertakes a preliminary assessment of the Argentinian system for the regulation of technology imports, and Anil Malhotra examines the evolution of Indian policies on foreign collaboration in Chapter 8. The Mexican Registry of Technology/Transfer Agreements is examined in detail by Alejandro Nadal in Chapter 9.

Volume D contains five essays on state enterprises and their role in technology policies. This was a complex and rather unexplored subject that engaged the preferential attention of the Brazilian team, and in which other country teams also became interested. Chapter 10 contains an essay written by Fabio Erber, describing the main issues involved in making public enterprises more active in promoting technological development. In Chapter 11 Sulamis Dain summarizes some of the key findings of the Brazilian team, and Dulce María Monteiro examines in Chapter 12 the research activities of PETROBRAS, the state's oil monopoly in Brazil. Ignacio Avalos and Rafael Rengifo summarize the findings of the Venezuelan team on this subject in Chapter 13, and in the last chapter Alejandro Nadal describes some features of the technological behaviour of the Mexican oil corporation, PEMEX.

Two criteria have been employed in selecting the essays to be included in these volumes from among the nearly 200 reports prepared in the STPI Project. The first is representativity, in the sense of providing a sampling of the various topics covered by the STPI Project in addition to the main research theme of policy design and implementation. The second is accessibility, in the sense of choosing reports that are not included in other STPI publications.

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CHAPTER 1

SCIENCE AND TECHNOLOGY POLICY RESEARCH FOR DEVELOPMENT

Geoffrey H. Oldham

The Origins and Growth of Science and Technology Policy Research

Science and technology policy research dates back to the immediate post Second World War period. At that time, the governments of the industrialized countries were concerned about how they could harness science for peaceful purposes, just as it had been used for military objectives during the war. The early policy studies were mainly concerned with science rather than technology and, within science, the focus was on 'research and development.' It was claimed, at that time, that science policy studies had the twin objectives of throwing light on both government policies for science and on science in policy. A differentiation was thus made between the welfare of the scientific establishment itself and the ways in which the outputs from this establishment contributed to national welfare.

As the interests of governments focused more on economic growth as a national objective, the science policy studies became increasingly preoccupied with technology. This switch in emphasis led to a semantic problem which persists to this day. Many of the research groups which were established in the 1950s and 60s had the words 'science policy' within their titles. This did not prevent them from studying technology policy issues, but it does occasionally lead to some confusion, particularly for those who view 'science policy' in the more restrictive sense of the words.

Although science and technology policy research is a post Second World War phenomenon, the interest of some of the social science disciplines in science and technology is much older. Questions of the role of technical change in economic growth have been debated by economists from the time of Adam Smith. Ricardo, Malthus, Marx, and Schumpeter all wrote extensively about technology, and the economics literature is still an important source of knowledge for science and technology policy-makers; to a lesser extent, the work of sociologists who have studied the sociology of science and the political scientists who have written on the politics of science is also important.

But despite the contributions of the disciplinary specialists, most of the specifically policy research has been carried out by interdisciplinary teams. By the mid 1970s, it could be claimed that a new field of policy research had emerged with its own journals, societies, and international meetings.

Policy research on science, technology, and development owes a good deal to the pioneering work of the secretariats of a number of international organizations. UNESCO, UNCTAD, UNIDO, and the ILO have all carried out substantial research on topics pertaining to their specialized responsibilities. But it was the Organization of American States in the mid 1960s which did the most to encourage national groups of developing country researchers to become involved in science and technology policy research. This led to a research capability in Latin America which has made important contributions not only to the body of knowledge but also to national decision-making capabilities on

matters relating to science, technology, and development.

Outside Latin America, the main developing country centres of science and technology policy research have been India and South Korea in Asia; Egypt and Kuwait in the Middle East; and Nigeria in Africa. Important work has also been done in the Caribbean, but elsewhere the build-up of local research capability in this area has been slow. It is hoped that the workshops will throw some light on the reasons for this situation and, if appropriate, might discuss what steps could be taken to rectify it.

A Review of Some of the Important Science and Technology Policy Issues

It would be difficult, and not very useful, to give a precise definition of what is included within the scope of science and technology policy research. It will suffice to give a very general definition and follow this with examples of important policy issues that have been the topics of research projects in recent years. This will also serve to identify some of those issues that require further study and research.

Science and technology policy research for development can be defined as any research that contributes to the body of knowledge on how science and technology contributes to development. Ultimately, this knowledge should lead to better decisions and policies. It is not only government policy-makers who can benefit from this knowledge, but anyone who makes decisions about how to use technology in their work, and indeed, in everyday life. These could include factory managers, farmers, and members of the general public. This general definition has little operational value, but it serves to demonstrate the very wide range of issues and approaches which must be considered. A better idea of the scope of science policy research can be gained by a consideration of some of the policy issues which have been studied in recent years.

At the national level one of the most fundamental technology policy issues is the choice of whether to import technology or to try to develop it locally. This decision will vary according to the level of development of the country and its existing scientific and technical resources, its development objectives, its attitude to foreign investment, the suitability of existing foreign technology, its ability to pay for that technology, its ability to find out what technology exists abroad, and a host of other factors. It will be a decision which varies from sector to sector in the economy, and will also depend on whether a short-term or a long-term perspective is taken. The 'make or buy' decision is, in fact, a central policy issue for all countries, industrialized or developing.

For many developing countries, in most sectors of the economy there is little real choice. They must depend heavily on foreign technology. The challenge to the policy-makers is how to improve their bargaining strength so that the technologies that are imported are most suited to the country's needs and are acquired on the most favourable terms. It was this latter issue which dominated the research agenda of most developing country research groups working on science and technology policy problems in the 1960s and early 1970s. The principal objective of the early work was to identify the costs of importing technology, especially from multinational enterprises.

Several instances of excessive financial costs were discovered, especially in the pharmaceutical industry, but equally important for the developing countries was the revelation of the extent to which the acquisition of foreign technology was accompanied by restrictive business practices on the part of the suppliers. This research led directly to a number of policy measures whereby governments sought to monitor and control the flow of foreign technology. There

are some doubts about how effective these measures have been in achieving their avowed objectives, but the link between policy research and policy formulation was extremely close. In many instances in Latin America, the researchers themselves assisted in policy formulation.

At the international level, the developing country's concern about technology transfer has been reflected in the efforts to negotiate, within UNCTAD, a code of conduct on technology transfer. This has led to a good deal of debate and the code is still a long way from being finally negotiated. Many of the more controversial issues would benefit from more research. The claims and counter claims are often based on too little information, but surprisingly, the amount of empirical research on technology transfer has decreased substantially in the developing countries in recent years. Those studies that have been carried out have demonstrated the complexity of the issues, and have shown that the market for technology has many imperfections. These need to be examined on an industry-by-industry basis, in order for appropriate policy measures to be designed.

Other research has started from the proposition that technology will have to be imported, but has tried to identify ways in which the previous turnkey package approach can be altered. It is argued that, if the developing country can learn how to put together the package of technology from its component elements, not only might it be possible to bargain more effectively for those elements purchased from abroad, but the learning effect will be considerable, and there will be more opportunity to substitute local technologies for some of the elements. Research on unpackaging technology was carried out very successfully in the Andean Pact countries, and the detailed studies in several industries had a major impact on the investment decisions in those industries.

While recognizing the need to import foreign technology, most developing countries are committed to a policy of building up their own problem-solving capabilities so that more techniques can be developed locally. But, as those countries which have tried to build local scientific and technological capabilities have discovered, it is one thing to invest in scientific and technological institutions and manpower, and quite another to ensure that the fruits of this investment are used in production. In part, the problem lies in knowing what policies will encourage local entrepreneurs to make greater use of the emergent national science and technology system.

There is little information to guide policy-makers responsible for building up a local science and technology system. In the past, most have modelled their institutions on those existing in the industrialized world. Science councils, universities, industrial research institutes, Academies of Science, scientific and technological information systems, have all been copied and transplanted often, without modification, in the developing world. Are they the most appropriate models? Have they performed their tasks well? What lessons can be drawn from the experience of those countries that have set up such institutions? Most observers would agree that the results have been disappointing, but very little policy research has been carried out to pin down the causes of the disappointment. The result is a good deal of conventional wisdom based on partial evidence. Some people argue that it is the fault of the scientists who use their newly established councils to act as pressure groups so that they can continue their own basic research, regardless of development priorities. Others point to the fact that the productive sectors of the economy exercise no demand on the science system, and hence the latter operates in isolation.

It was to examine the ways and means open to government policy-makers for encouraging closer links between supply and demand of technical knowledge that the Science and Technology Policy Instruments Project (STPI) was designed. This project has now shown how difficult it is to design a package of policy measures that will encourage entrepreneurs to make greater use of the local science and technology institutions and capabilities. This is a topic which will be explored in greater depth in subsequent papers and discussions at the workshop.

The rather simplistic picture of supply and demand of technical knowledge, so far portrayed in this chapter, needs to be modified by a better understanding of how technical change actually takes place in firms. Excellent empirical research on this topic has already taken place in Latin America, Korea, India, and Thailand, and the importance of minor adaptive research, the role of the engineering profession, and the extent of the similarities and differences between different industries is now well documented.

Much of the science and technology policy research carried out in developing countries has focused on the science and technology decisions related to modern industry. There has also been research on the diffusion of agricultural innovations, and some studies on the effectiveness of agricultural research. But many countries are embarking on a policy that puts much greater emphasis on rural development and the satisfaction of basic needs of the whole population. What are the implications of these policies for science and technology? How can local traditional technologies be upgraded and improved and new technologies designed? Can new ways be found to link the scientific and technological community with the problems of the rural and urban poor? These are questions for which there are no easy answers. Policy research is required.

Countries do not exist in a vacuum. They are connected to other countries through flows of capital, people, and trade in commodities, manufactured goods, technology, and knowledge. The nature of the flows is governed by many factors which collectively contribute to the constraints that national policy-makers face in devising their own science and technology policies. Some of the international relationships can act to release constraints, as happens when regional groupings of countries agree to share their scientific and technical resources. This occurred very effectively for awhile with the Andean Pact. Here there was a political commitment to rationalize industrial investment in the region, and this provided the opportunity for effective collaboration in a variety of scientific and technological activities.

The links between the developing and industrialized countries are the ones that have given rise to greatest discussion. The rules that govern the economic relationships between States were, for the most part, set by the industrialized countries. They have resulted in what all developing countries would call an 'unfair' distribution of the world's income in favour of those countries who made the rules. The efforts to change these relationships and hence gain a "New International Economic Order" (NIEO) have not, as yet, met with much success. But the relationships have considerable impact on science and technology policy issues.

The most obvious one is the trade in technology. This has already been mentioned, and the efforts to obtain improved access to world technology are a major issue for the negotiators at NIEO debates. The attitude of several of the developed countries to this issue appears to be hardening, owing to the perceived threat to their own economies' well-being, following increased competition

of manufactured goods from developing countries, produced with the technology originating in the industrialized countries. Both developed and developing countries have come to recognize that technologies provide the ultimate source of economic power. If the concern leads to policies that limit the export of new technologies, then the policy of technological self-reliance in the Third World will take on even more urgency than at present.

Another way in which technological developments in the North may affect the international economic relationships with the South is through the development of new technologies for substitutes and synthetics, which affect the demand for the primary commodities of the South. The development of high-fructose corn sweeteners already provides a threat to the cane sugar producers, and further research and development, which makes it economic to open up low grade mineral resources, weakens the position of many Third World countries.

The brain drain, international scientific collaboration, and aid are all issues that have a direct bearing on the science and technology policies of countries in the Third World. Appropriate policies, to exploit the opportunities afforded by international collaboration and to minimize the disadvantages, all require analysis and research of the issues before policy measures are devised and implemented. These studies all fall within the rubric of science and technology policy studies.

So far, only those lines of research that affect the major policy decisions have been discussed. There are other more microlevel decisions about technology which have been the topics of many research projects. Some are related to policy alternatives in specific sectors or industries, studies which seek to identify the full range of economic and social consequences of using one technology rather than another. Many of the studies on appropriate technologies fall into this category, as do recent studies on rural energy, and those studies that assess environmental impact. The methodologies for making these 'technology assessments' are still rudimentary, but the process of evaluation is a necessary one in order to make the most appropriate choice of technique.

This brief survey has identified some of the policy issues which have been studied during the past few years. The body of knowledge which has accrued is still partial and incomplete in most areas of policy-making. But the survey does reveal the wide range of issues which have been researched. It will be for the workshop to identify other issues and problems and to suggest priorities for future research.

Some Characteristics of Science and Technology Policy Research[1]

The previous section has summarized some of the policy issues which have been studied in the past few years. From this research experience, it is possible to make the following observations about science and technology policy research:

(1) The clients for most of the science and technology policy research carried out in developing countries have been government policy-makers. Some university researchers have seen their academic peers as the target audience

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(1) This section is based on discussions at a meeting convened by IDRC in September 1977 to discuss the future directions of science and technology policy research.

for their work, but most have been willing to work closely with policy-makers. This has meant that science and technology policy research, like most other policy research, has been 'action-oriented.' It has required interaction between policy-makers and researchers. There are implications for the time span of the research from this approach. There is usually a conflict between the immediate need for results on the part of policy-makers and the time required for a more rigorous and scholarly work. Furthermore, a balance has to be found between research to meet the immediate needs of policy-makers today, and research that anticipates the needs of policy-makers tomorrow. If exclusive attention is given to the former it may mean that many important policy decisions have to be taken before the relevant research is completed.

(2) Much of the research has tended to be diagnostic. It has sought to understand the way in which science and technology are related to the process of development, but only on relatively few occasions has it gone beyond diagnosis to devise solutions and outline policy options. The work on international technology transfer is a notable exception.

(3) The more recent science and technology policy studies have demonstrated: (a) Investments in the non R&D scientific and technological activities can be expected to yield quicker returns to production than investment in R&D. Hence science and technology policy-making must give attention to the full range of scientific and technological activities. (b) Policies originally devised for other economic and social objectives frequently have a greater impact in determining technological outcome than policies specifically formulated for this purpose.

(4) There has been an emphasis on industrial technology policy research, and a relative neglect of agriculture and social services (health, education, transport). Although agricultural economists have covered the field of agricultural innovation and extension, little work has been done from the perspective of science and technology policy, and even less on the ways of relating science and technology policies in the agricultural, industrial, and social services fields among themselves.

(5) There has been an emphasis on economics and engineering as the main disciplines involved in science and technology policy research, and many of the initial researchers in the field came from the physical sciences. There is a need to incorporate other disciplines such as law, administration, social psychology, anthropology, and history, particularly because science and technology policy is not a 'field' in the traditional disciplinary sense of the word, but more an 'area of concern' on which many disciplines should converge and be brought to bear.

(6) Science and technology policy research in the developing world has not paid sufficient attention to the differences among the various less developed countries, and there has been an implicit tendency to treat them as if they were a homogeneous group. The knowledge accumulated during the mid 1970s shows that this approach is highly inadequate for science and technology policy research, and that the heterogeneity of the developing world must be acknowledged and taken into account in the conduct of research.

(7) In many instances, the statements and opinions of 'wise old men' (particularly from the industrialized world) have been used as a surrogate for science and technology policy research.

(8) Although this chapter is concerned with science and technology policy research in the less developed world, there is a large body of knowledge

developed in the industrialized nations, which may be tapped to provide ideas and suggestions for science and technology policy research in developing countries. Great care must be exercised to avoid extrapolations of findings into different contexts, but there is no point in ignoring the contributions to knowledge, particularly those of individual disciplines, that may assist researchers in science and technology policy in the less developed countries in the generation of policy-relevant knowledge suited to their own countries.

(9) There are some topics on which a good deal of research has been carried out. However, science and technology change rapidly, and it is almost impossible to consider any particular problem area as 'closed' for research purposes. For example, even though much work has been done in the field of technology transfer, the changing situation and the modification in the behaviour of the suppliers of technology make it necessary to study their reactions to policy measures and their new forms of behaviour, both of which are rapidly transforming the existing knowledge of the situation into obsolete conventional wisdom. Furthermore, there is justification for replicating some types of studies in different regions and countries in order to take into account their specific contexts, and to ensure that a learning process emerges through involvement in research.

(10) One of the features of science and technology policy research carried out in the developing world has been that a large part of it was performed through research networks involved in comparative exercises. This has allowed a mutual learning process to take place, which has led to some generalizations and to the identification of 'transmittable' science and technology policy research findings. This is one characteristic that should be preserved whenever appropriate, but without neglecting completely individual studies that would shed light on the heterogeneity and uniqueness of some situations.

Types of Science and Technology Policy Research

Five types of science and technology policy research can be recognized. They are of complementary nature, and the experience of the last ten years shows that all of them are necessary.

(1) Empirical studies at the microlevel: These studies are to develop pieces of knowledge about particular situations on issues such as technical change, behaviour of particular institutions, and implementation of a given policy, in order to provide the factual basis for inductive generalizations.

(2) Review of past experience and attempts to link science and technology to development: There has been a large amount of experience acquired during the last few decades in the field of science, technology, and development, but few systematic efforts have been made to evaluate and review this experience from the science and technology point of view. Agricultural research and extension systems, national councils for science and technology, and industrial technology institutes are among the institutions and issues that should be examined and reviewed with the aim of deriving the lessons for science and technology policy formulation and implementation. Furthermore, different science and technology development strategies, planning systems, and implementation procedures should also be subjected to review and evaluation.

(3) Monitoring of on-going efforts to link science and technology to development: There is a need to build a monitoring and continuous evaluation component into the efforts that are currently under way to make science and technology more useful for development. To a certain extent the studies mentioned under (2) above would not be necessary if a social science monitoring and evaluation component had been built into the design of the institution from the

beginning. Areas of particular interest in this regard would be the attempts to link up the scientific community of a given country to the traditional rural sector, the efforts made to bridge the gap between industrialization research institutes and the productive sector, and the developments in institution building for science and technology.

(4) Studies of the international system: There is a need to examine carefully the nature and characteristics of international relations that condition the growth of science and technology capabilities in the developing countries - issues such as North-South relations and the role that technology plays in them; the impact of defence considerations in science and technology development at the world level; and the problems of economic integration and their impact on science and technology.

(5) Development of theoretical frameworks: At present, there is no coherent theoretical framework to place all the facts and elements of knowledge pertaining to science, technology, and development. This is a difficult task. There is now sufficient information available to be able to develop soon a theory of technical change in the less developed countries; theories on the relation between development strategies and technological strategies; theories to explain the behaviour of the scientific community; and historical studies to explain the evolution of science in the less developed world. The findings of the types of research mentioned under (1), (2), (3) and (4) above would provide the empirical basis for this.

CHAPTER 2

VIEWS ON TECHNOLOGICAL DEPENDENCE/SELF-RELIANCE

A compilation of statements by consultants
to the STPI project and commentators

Edited by

Onelia Cardettini

Introduction

The following chapter is a compilation of excerpts from four studies commissioned by the STPI project on technological dependence/self-reliance, and of comments made on these four studies by scholars and policy-makers of the underdeveloped and the developed countries (1).

The original four studies were provided with a questionnaire (see Appendix) which was intended to serve as a guideline. This framework was interpreted rather liberally by the four consultants, and was even, in one case, dismissed for being biased towards one of many possible approaches to the issue of dependence/self-reliance. Another aim of the four studies was to present a global view of the issue from the standpoint of Africa, Asia, the Arab World, and Latin America, using examples from each area's historical background. Instead of this, and partly for the aforementioned reason, the papers represent a wide spectrum of opinions which are fairly representative of the current debate in development studies. The four studies cover a range of approaches with Marxist theory on the one hand and neoclassical growth theories on the other, and the same appears among the commentators of the four studies.

The presentation of the extracts limits itself to highlighting an opinion or to making the quotations more readable. No attempt is made to present a critical review of the studies and comments, leaving it to the reader to make up his mind about the correctness and the consistency of each of the approaches offered by the four studies and the comments to them. An apology is given for any involuntary misquotations that may occur.

This chapter has been prepared on the basis of the following documents:

(1) Barrio, S. 1975. Technological Dependence? A study commissioned by the STPI Project, Lima, April.

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(1) The participants in this task were Sergio Barrio, Jong-bin-Kim, Godfrey Lardner, and Rosemarie Said and Antoine Zahlan, who wrote background papers which were complemented by an introductory statement prepared by Onelia Cardettini. The commentators were J.N. Behrman, Guillermo O'Donnel, Ignacy Sachs, Francisco Sercovich, M.K. Tolba, and Oscar Varsavsky.

(2) Behrman, J.N. 1975. Dependence/Self-reliance. A comment on the studies commissioned by the STPI Project, University of North Carolina, May.

(3) Kim, Jongbin, under the supervision of Taiwan Shin. 1975. Technological Diffusion, A Response to the Questions Regarding Technological Dependence/Self-reliance. A study commissioned by the STPI Project, Lima/Seoul, April.

(4) Lardner, G.E.A. 1975. Technological Dependence and Developing Africa. A study commissioned by the STPI Project, Lima/Addis Abeba, April.

(5) O'Donnell, Guillermo. 1975. Comments on the Works on Technological Dependence/Self-reliance Commissioned by the STPI Project, Buenos Aires, April.

(6) Sachs, Ignacy. 1975. Comments on the Works on Technological Dependence/ Self-reliance Commissioned by the STPI Project, Paris, June.

(7) Said, Rosemarie J. and Zahlan, A.B. 1975. Technology Dependence in the Arab World. A study commissioned by the STPI Project, Lima/Beirut, April.

(8) Sercovich, Francisco. 1975. Technological Dependence/Self-reliance: Some General Remarks. A comment on the studies commissioned by the STPI Project, Buenos Aires, October.

(9) Tolba, M.K. 1975. Comments on the Works on Technological Dependence/Self-reliance Commissioned by the STPI Project, Nairobi, July.

(10) Varsavsky, Oscar. 1975. Comments on the Works on Technological Dependence/ Self-reliance Commissioned by the STPI Project, Buenos Aires, July.

What is Technological Dependence?

In order to answer this question, many authors felt compelled to clarify first the meaning of technology.

Technology

Lardner (4) gives what he himself calls "a static definition" that, in his opinion, is appropriate for discussing technological dependence: "Technology, for the purpose of this paper, may be defined as a tool or stock of tools, developed by man principally to satisfy his physical and intellectual needs by the conversion of raw material into semi-finished and finished products. This tool is singular by virtue of its immense complexity, its extraordinary vitality, and the fact that each unit of technology is a structurally related system of human resources, raw materials, energy and machines."

Said and Zahlan (7) also give a definition restricted to the subject matter: "In this study, it is assumed that science and technology are integral parts of a culture. The level of scientific activity is intimately related to the social and economic order which, in turn, is a function of the political organization of a nation....There is a marked difference between technology - the know-how, the human activity - and the products of technology - the hardware. In this essay we shall be discussing the know-how: whether a nation has the

know-how to design and produce a product and not whether it has purchased the product."

These two conceptions of technology - the first asserting that technology can be decomposed into several elements (know-how and hardware) and the second that technology, through science, becomes an instrument of progress or of backwardness depending on the social, economic, and political organization - are used by Kim and Barrio, respectively.

Kim (3) sees technology as a body of knowledge that can be classified into pure science, engineering or applied science, and engineering technology: "Pure science is simply systematized and organized knowledge per se, while engineering (applied) science is concerned with ways and means of producing or destroying existing or potential physical things not necessarily with the purpose of "making money;" thus, a non-physical thing such as human behaviour is excluded from the scope of engineering science. Engineering technology is also concerned with physical things and how to produce or destroy, but the primary purpose is "making money" in contrast to the other two fields. However, these three are not exclusively separate."

For Barrio (1) the problem is first and foremost to analyze technology under the prevailing economic system, i.e. to look at the purpose of technology under the present phase of capitalism. He asserts that: "The chief motive force for the development of technology in a capitalist society is the drive to reduce production costs, which in the last analysis is the saving of wages. It is because it aims at saving wages that it ends up saving labour, as it decreases the use of direct living labour force. In capitalism therefore technological development implies a reduction of socially necessary labour for the production of use values." Barrio then offers a general abstract definition of technology: "In essence, technology is determined by the social development of man, by its endless struggle against nature, by its strife to dominate nature's laws so to subordinate them to the satisfaction of human needs through the development of techniques of production."

Despite their divergent approaches to defining technology the authors concede implicitly that their definition is not exhaustive. For instance, Lardner concurs with the opinion that technological change is induced by the necessity to satisfy human needs (4, p.2). Said and Zahlan also agree that costs of production are an important factor in technological development (7, p.1). But, for Kim, it is only engineering technology that constitutes the driving element of technological change. Development through market demand and the search for profit is not regarded as one with much possible economic growth (3, p.2).

The most comprehensive definition of technology is provided by Sercovich (8): "Like any other commodity, technology can be looked at from two distinct standpoints (2): (i) as a use value, it is a compound of practical knowledge instrumental to production, management, marketing, and distribution. In this sense, it can be categorized in terms of the various elements of technical knowledge related to the pre-investment, erection and operation stages of a productive

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(2) For further details on this see: Sercovich, F. 1974. Dependencia tecnológica en la industria Argentina. Desarrollo económico, No. 53, April-June.

unit; (ii) as an exchange value, that is, a privately appropriate asset conveying market power and, therefore, potential capacity to earn monopoly rents for those who control and exploit it. From this viewpoint, technology takes a wide variety of shapes, related either to processes or to products or to forms of organization and management; either under a physical format or under a purely legal appearance, such as blueprints, drawings, instructions, specifications, designs, formulae, methods, systems, techniques, patents, trademarks or brand-names. In the first sense, and within certain limits, technology can be considered as largely universal, i.e. its usefulness transcends particular forms of social organization. Instead, in the second sense, it is peculiar to the capitalist economy (peculiar but not exclusive), and acquires its most conspicuous form of development cua commodity in the oligopolistic stage of market organization. Free knowledge has as much exchange value as atmospheric air or sea water: nobody would pay a bit for it. Proprietary knowledge, on the other hand, irrespective of how useful it may be for various people at different places, has a price at the market-place. Because of the imperfections of the market for this particular kind of assets, that price may be as divorced from embodied labour inputs they comprise as in the case of art works or antiques. However, even though within very wide margins, the market still exerts a regulatory role on the mechanism of price formation for technological assets." (3)

Technological Dependence

When defining technological dependence, authors generally search for a more complete or self-contained definition: For Kim, Said and Zahlan, and Lardner technological dependence basically equates reliance on non-national sources of technology.

Kim regards access to information as the basic, or even unique, component of technology that affects technological dependence: "Technological dependence literally means dependence upon a foreign source to attain necessary information to manufacture a commodity; technological dependence is essentially a phenomenon of information transfer from one country to another."

Lardner sees information (knowledge, competence) as one of two components of technological dependence, the other being resources: "Dependence may be defined as a relation arising from a deeply felt need of an individual or a group which - whilst it cannot be satisfied through the application of competence and resources at the disposal of that individual or group - can be so satisfied by knowledge and resources at the disposal of another which in turn have felt needs which can be satisfied only by knowledge and resources at the disposal of the first individual or group."

For Said and Zahlan, it is not the mere ownership of information and resources that counts, but the combination of holding these possessions together while using them in such a way as to be aware of other countries' technological developments: "A nation is technologically dependent if it does not possess the essential instruments and human skills to be aware of technological developments in the world: it is incapable of analyzing the political, military, economic, social, industrial and cultural implications of scientific and technological

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(3) This mechanism is analyzed in: Sercovich, F. 1975. Tecnología y control extranjeros en la industria Argentina. Siglo XXI, Buenos Aires-Mexico.

discovery; if it is incapable of a planned adaptation to technological challenges; and if it is incapable of manufacturing its strategic hardware. Naturally, this dependence varies continuously from totally independent to totally dependent."

These definitions are close to the understanding of O'Donnell (5) who adopts for the analysis of technological dependence the framework elaborated in Latin America for the general concept of dependence (4) and who defines technological dependence according to the relative importance attributed to sources of domination (5): "In the first place the problem of technological dependence is an aspect or a dimension of the general problem of dependence which manifests itself also in cultural, military and economic aspects among others. Notwithstanding it is possible, of course, to distinguish in an analytical and empirical fashion the first dimension so as to make it a valid and undoubtedly important object of research....The fact that this distinction is possible does not imply on the other hand that the analysis may omit reference to the other dimensions, nor that in the final analysis the whole of these dimensions may not be seen as part of the global characteristics of given societies and the ways they insert in the international context....Technological dependence like all other dimensions of dependence implies an asymmetrical relation of power. In this case we are concerned with the power to control the information or the know-how necessary to detect a need, to analyze, evaluate, generate, concretize the production of goods or services, which aim at satisfying the necessities of a society at a given moment in time, and the necessities of its historical development."

Varsavsky (10) also agrees that the problem of dependence is a matter of relative power or strength. He believes however that: "It is annoying that several authors and the very same questions recur in the definition of "in essence" concepts that are of common use; what "is" dependence or technology or freedom cannot bring anything useful as it can be seen by the answers. It could be sufficient to say in each case the meaning given to the term for the specific objective of the work. I think in particular that in terms such as those treated here it is convenient to use "dependence" as the synonym of "incapacity to decide correctly because of external pressures," whether military, economic or cultural. This would oblige to say what people mean by "correctly" instead of limiting oneself to declarations against something or someone."

A slightly different point of view is put forward by Behrman (2). He is of the opinion that individual and collective behaviour are not dissimilar. As a result, concepts that may characterize individual behaviour also apply in his mind to collective behaviour even to the extent of international relations, and to the collective responsibility of nations towards the planet earth. He holds that: "In one sense, the dichotomy between dependence and self-reliance is a false one. In one sense, all of us are totally dependent on everyone else,

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(4) Reference is made by O'Donnell to the work of Cardoso, H. and Faletto, Enzo, 1969. Dependencia y desarrollo en América Latina. Siglo XXI, Mexico. See also: Cardettini Onelia. 1976. Technological Dependence/Self-reliance: A Survey and Critical Appraisal. Office of the Field Coordinator, STPI Project, Lima, January.

(5) See: O'Donnell, G. and Linck, Delfina. 1973. Dependencia y autonomía. Amorrortu, Buenos Aires.

and there is no doubt that the maximum of social and economic progress as well as political modernization will require an increasing dependence among all nations and people of the world. There being only one world means that there is one dependence around the world. At the same time, all of us require an assumption of individual responsibility, which is translated, at the national level, to a national responsibility to be self-reliant."

Finally, a third approach to the concept of technological dependence is provided by Barrio. Barrio insists that, whilst he does not deny that there is such a thing as dependence, "the concept rather obscures and hides the essential problems of backwardness in the so-called "underdeveloped" or "developing" nations ...because it... hides a contradictory phenomenon and only looks at the surface appearance of the conflict between backward and advanced capitalist countries." He gives as an example of this contradictory phenomenon the relations established between England and India over the past centuries: "India and England have been mutually dependent for a number of years. England has through history been the dominant country, and her domination has ultimately rested upon the force of weapons, whether administered directly by "the Queen" or "King" or by the local subservient elites. But, what is the essential feature of this mutual dependence and the essential basis for domination? Both countries are mutually dependent because the development of productive forces has reached a world level, that is, the market is a world market, and technology is developed for a world market. In this context no country can be technologically self-reliant, except for ancillary operations, in the secondary, not dominant branches of the economy. From this point of view, England is much more dependent than India, since, being a more developed capitalist country, it cannot cut itself off the world market without an imminent economic catastrophe. India may resist a lot longer such isolation, in spite of the acute shortages and poverty that reigns in that nation. India, instead, is more dependent than England from the point of view of the non-development of its productive forces that results from domination. England is the dominant nation."

Origins of Technological Dependence

Lardner feels that: "The scope and degree of technological dependence may be limited by the extent to which the socio-economic system remains largely static and traditional. The greater the penetration of the forces carrying ideas of change and the greater the response of decision-makers to change and the greater the response of decision-makers to change stimuli, the greater the scope and degree of technological dependence."

This generalization of the origins of technological dependence means not only that colonial occupation was the determinant in spreading technological dependence, but also, inversely, that total autarky would be the only state of an economy where technological dependence would not arise.

For Said and Zahlan also, the confrontation starting in the 16th century, between the Ottoman Empire and the Western European powers, marked the beginning of the Arab World dependence (7, p.4, 10). In a very exhaustive account of the Western European powers' penetration in the Middle East, they show how domination was imposed first through the monopolization of trade and, later, through military intervention:

"The Capitulations, or trade agreements, between the Porte and different European countries were first concluded in the sixteenth century. Their original aims were to promote better trade relationships between Constantinople and Europe,

but they finally became the determining factor in the economy of the Empire. The capitulations provided for a fixed import tax on foreign goods; an exemption from all taxes imposed on the internal trade of national products; the protection of the life and property of foreign traders; the authorization of each country to have one trading agency in the region; and the authorization that foreigners be tried in a court by their own country's representative rather than be held responsible to the Ottoman authorities.

"By the late seventeenth century, largely because of the inability of the Porte to stem the process, the terms of the French and English capitulations called for the very low import tax of 3%, and an 8% export tax on Ottoman goods, while the internal duty on goods carried by land was 8%....Furthermore, the British and French companies with headquarters in Constantinople and branches (or "factories", with "factors" or agents in charge) throughout the Empire, particularly in the rich Arab region, began to yield local power that went far beyond the definition of commercial representation. The economic results were disastrous to the Arab World. Unable to protest against the foreign merchants who flooded the market with their own national products and drastically competitive prices, the local traders found little or no outlet for their goods. The industries that once had produced famous and sought-after merchandise, all but ground to a halt.

"Until the sixteenth century, for example, the Arabs used to produce such varied goods as damask and damascene (from Damascus), muslin (from Mosul), gauze, alcohol, arsenic, etc., much of which was exported to Europe. After the sixteenth century, only textiles and raw silk continued to be exported to Europe. By the second half of the eighteenth century, however, France had introduced heavy import duties on cotton yarn, and machine spinning in England had become developed; both events dealt heavy blows to the export of Arab yarn and Levantine textiles for which raw cotton was finally substituted. At the same time, the products of the English and French textile industries flooded the Ottoman market, dramatically affecting employment and local industry....The reasons for this decline become clearer when a glance at the figures of the imports into the Ottoman Empire of English cotton fabrics reveals their tenfold increase between 1828 and 1831....The economic impact of this devastation of national technology was evident everywhere. The artisans and craftsmen gradually lost their skills, many of which were soon to become defunct. It was the textile industry of brocades and silk that suffered the most, progressively reducing its output until it became almost too negligible to be worthwhile. The Arabs, and the Ottomans with them, began to rely on foreign products of all kinds; local industries were almost bankrupt.

"The turning point in this dramatic decline came when Napoleon invaded Egypt in 1798. The event, although brief in actual time of occupation, had numerous repercussions in the Arab World. We are here concerned with two of them. The first was that the isolation of the Empire was at an end....The most outstanding result of this first contact was the desire to start the process of modernization along the same lines as the West. The history of the Arabs and the Ottoman Empire throughout the nineteenth century is chequered with leaders and decision makers who were strongly motivated by this force. Muhammad Ali of Egypt, Emir Abdul Qadir of Algeria, and Midhat Pasha of Constantinople and Baghdad are perhaps the most outstanding examples. The second ramification of Napoleon's expedition, one that, to a certain extent, neutralized the first, was that it ushered the era of Western colonialism into the region. It was the French occupation, for example, that first awakened British interest in Egypt....Almost immediately

after Napoleon landed in Egypt, however, Nelson followed. Britain by now had seen the strategic and economic importance of Egypt, and for the next century and a half, it became directly involved in Egyptian affairs. France, Russia, and later Germany, followed suit in extending their respective spheres of influence in the Ottoman Empire, and the "Eastern Question" was born. On the one hand, therefore, the events of 1798 brought with them the stimulus for modernization; on the other hand, those same events provoked the extension of direct colonialism in the region that was to interfere radically with the process of modernization.

"By 1882, Muhammad Ali's effort at economic independence had been thoroughly destroyed....When Britain occupied Egypt, it was a relatively easy process in view of the dependence of the country on Europe. Britain's main preoccupation with Egypt was based on imperial considerations because of its strategic location in relation to India. British policy, briefly, was to stabilize the authority of the traditional ruling classes by improving the police, legal systems, and other forms of administration; also to increase the national agricultural output adequately enough to pay back the debt to the European bondholders....Advanced education, industrial and technological independence, therefore, were not objectives of British rule in Egypt. Egypt was on route to India; it produced cotton and other useful raw materials; and, it was a market for British goods. The maintenance of the internal status quo was consequently imperative to British policy. Technological dependence resulted....(The Arabs') technological and military weaknesses led to increasingly unfavourable terms of trade which in turn led to the invasion of the Ottoman market by the products of European industry, thus destroying the entire local industrial base."

Despite all the evidence presented above, Said and Zahlan think, nevertheless, that the roots of technological dependence are to be found in cultural factors: "The fundamental causes of the passivity of Arab society in the face of the challenges and provocations over the centuries can be found in the confluence of, (i) The enormous human and economic exploitation of the farmer, that has reduced him to a level of abject poverty. This gave the entire field of agriculture a lowly place in Arab culture. (ii) Arab civilization has long been dominated by Bedouin cultural traits. It thus holds agricultural and industrial occupations in low esteem."

This view is challenged by Tolba (9). He rightly wonders "why this civilization did hold agricultural and industrial occupations in low esteem. As such the above statement does not actually give an explanation or a meaning of the Bedouin cultural traits which would explain that statement."

Kim's approach is the one that helps the least to understand why technological dependence arises. His explanation of technological dependence is a total abstraction of the concrete historical conditions of development, since he assumes that the origins of technological dependence are rooted in a so-called universal "law" of stages of economic growth. According to this conception, all countries would go through basically three stages of economic growth or development: A dormant stage (in the conventional terminology, underdeveloped); an emulating stage (developing); and a mature stage (developed).

This is not the place to repeat the arguments that refute such a non-historical conception of history. Let us only recall that all the evidence provided in support of Rostovian growth theories is based on elementary simplifications. Only pseudo-psychological arguments can be put forward by this "theory" to explain why people would act apathetically during the dormant stage of

development, but turn dynamic in later stages of development.

Military occupation by colonial powers, and trade wars, are, to Barrio, examples of the general and worldwide process of capitalist development, which at a later expansion stage turns into imperialism (1, p.7-27). After outlining the main characteristics of capitalist development since the Second World War (import substitution industrialization, barriers to capital formation in agriculture, monopolistic control over know-how, the development of local markets in underdeveloped countries as markets for foreign capital), he wonders: "Can one agree, therefore, in a situation like the one described, that the "major or dominant" factor of "underdevelopment" is technological dependence? I hold that such conception only obscures the real essential problem of backwardness, and the relation of such an essential problem with the issue of technology. The essence of the problem of backwardness lies in the agrarian question, i.e., the semifeudal fetters to production and accumulation in the countryside, and in the national independence question, i.e., the colonial and semicolonial fetters to production and accumulation of the whole economy, closely bound with the preservation of the semifeudal barriers to the development of productive forces in the rural areas. These two basic and interlinked phenomena determine backwardness in its concrete form of today, and determine technological backwardness."

Sercovich also believes that dependence can be understood only by examining the international economic order as it stands today: "It should be useful to ask why are we exchanging views on this issue at this particular time. To my mind, this debate should be seen in the light of the world economy's present crisis and the bargains that are currently taking place (through means ranging from confrontation to piecemeal negotiations) towards the establishment of a new international economic order. Current difficulties in conciliating rapid capital accumulation with present patterns of development (and the social structures they involve) and the observed rupture in the process of increasing unification of the economic space within the Western world, are events placed at the very core of this changing world balance....The concept of "technological dependence" refers to one of the central aspects of the contemporary form of integration of backward countries into the world market. Although its origins should be traced back to the colonial period, it has acquired a specific meaning and importance mainly after World War II, paralleling the intense absorption of science by industry in advanced industrial countries. As a social and economic phenomenon, it has little to do with the productive functions or use value of technology. In this sense, the notion is related to a specific, non-material quality of technology: i.e., that of being a privately owned asset which conveys market power. Certainly, there is a use-value aspect of technological dependence. It is involved in the very little defferentiation of technical skills in backward countries. But this is not the dominant one. The mechanisms of technological - and with it, commercial and financial - dependence are, in the last resort, means for the international redistribution of the economic surplus. And this redistribution depends upon the monopoly power conveyed by technological assets, that is, the exchange-value aspect of technology."

Manifestations of Technological Dependence

For Lardner, technological dependence manifests itself in what may be called an "enclave effect," i.e. an effect that perverts urban-rural relations, research, education, and the planning system to make them a caricature of what they are in the developed countries (4, p.13-21). The "enclave" effect obviously has a distorting, negative incidence on technological management and planning.

Said and Zahlan also agree that technological dependence is a spread-out phenomenon: "Technology dependence is manifested in a wide variety of ways. The

most striking, visible and documentable expression of this dependence is the fact that virtually all the hardware in the Arab World is imported and little is actually designed and manufactured in the region." However, despite this and other statements which emphasize the trade and economic relations of the Arab world with the sources of technological advance, and the vital importance of development in the rural areas, the authors still believe in their conclusion that social and economic conditions are, in the final analysis, less of a determinant than cultural factors: "Since 1945 the Arab States have progressively liberated themselves from colonial rule. Following independence, a process of liberation from feudal exploitation past ensued. Major dam and irrigation projects, for example, became the subject of considerable investments; also, programs of land redistribution, and agrarian reform. This is only a part, however, of the efforts that need to be deployed. The required capital investment in Arab agriculture is immense because of centuries of neglect of the land itself and of rural living facilities. The radical improvement of the ideological, social,and economic position of the farmer is a sine qua non in a policy of technological independence: it is only through the re-establishment of an imaginative and positive relationship between man and his environment that the necessary intellectual capabilities of Arab youth could be released to pursue science. The vehicle for supporting and accelerating such a transformation is the educational system. It is through the medium of education that the social and cultural acceptance of rational, pragmatic and empirical thinking and action in daily life can be promoted. Naturally, an economic order that penalizes the toiling farmer and worker, at the same time rewarding corrupt dealings, monopolies and trade, contributes little to the creation of the appropriate cultural environment for scientific and technological independence. Technological dependence is thus only a symptom of pervasive and fundamental cultural atrophy whose reactivation and development to normality is a basic prerequisite for flourishing technology."

A complementary view to that of Said and Zahlan is the one expressed by Behrman. This author believes that dependence (and independence) are a matter of choice. "Historically, dependence was considered important in order to gain the returns of specialization. But specialization determined by market criteria is quite different from specialization determined by company-dictated criteria. Independence is sought to retain social and economic diversity as well as political and economic freedom. To let the degree of cultural diversity or freedom be determined by an outside corporate entity is increasingly unacceptable to host governments." According to Behrman's view, dependence, being subject to conscious choice, would not arise inevitably out of a set pattern of economic relations. In other words, the economic relations that typify dependence would only be the result of choosing to be dependent; such economic relations would not be the cause of being dependent. Being a matter of choice, dependence would ultimately stem from cultural characteristics. Thus, Behrman, Kim, and Said and Zahlan concur to the same conclusion though their respective arguments began with different premises.

A divergent point of view is offered by authors who give preeminence to the material manifestations of dependence. The manifestations that are generally attributed to dependence are caused, for Barrio, by the degeneration of monopoly capitalism. The expressions of dependence are to be found in the economic structure of the underdeveloped countries rather than in cultural characteristics or in superstructural phenomena (enclave effect), or even in mathematical constructions (balance of technological diffusion). Turning to the economic evolution of the underdeveloped countries since the Second World War, he argues that the situation created by the developed capitalist countries after the Bretton Woods monetary agreement led to an economic process based on laws of plunder:

"Such (import substitution) industries were in the most cases highly

inefficient, functioning with extremely aberrant cost considerations, comfortably booming under the umbrella of the "nationalistic" policies of protectionism within the Nation State. Inefficiency could thus be comfortably in harmony with profitability and "nationalism." The laws governing such an economic process were not economic, but of plunder. The main victim of such "economic development" was the agricultural economy, which was in the last analysis the unwilling bearer of that ever heavier parasitic "industry." Agriculture paid the bill in the final analysis since the expensive industrial products resulting from inefficient industry could only be consumed by transferring, through direct and indirect channels, the rural income to urban and finally foreign areas. The chief consequence of this process (and of key importance for technology) has been the nondevelopment of an internal market due to the "decapitalization" of the countryside, in other words, the widening of the barriers that prevent capital formation in agriculture. But the barriers to capital formation did not limit their action to agriculture. It was the whole economy which through the "import substitution industrialization" was drained of capital resources, and for the same reason of any fixed capital formation. This may sound contradictory since the process of "import substitution industrialization" was itself leading to the opening of a number of industries, therefore to fixed capital formation. It is out argument however that such "fixed capital formation" was in fact an entirely artificial process, a superstructural phenomenon rather than a structural process. No economic laws governed directly that process, but the arbitrary decisions of government bureaucrats subservient to international finance capital. Far from becoming a means to develop agriculture and the internal market, these industries became a means to expand profits of foreign finance capital through the appropriation of ground rent (agricultural and mining), thus draining all possible resources for local "primitive" accumulation. One of the most open manifestations of this process has been the high profits to investment ratio of foreign capital (in Latin America a ratio higher than 3 as an average), and the progressive worsening of the balance of payments and external indebtedness situation of all backward regions."

How does this process of economic exploitation relate to technological development?

"Technological advance is both theoretically and practically inseparable from capital accumulation, fixed capital formation; in agriculture as well as in industry. As monopolies impose private appropriation of technical knowledge, this technical knowledge is transformed into a means of monopolistic profits, and into a means of realizing such profits through exploitation of dominated backward nations. Surplus labour and agricultural rent is transformed into profits of foreign capital which, particularly after World War II, is fictitious capital. This prevents capital accumulation in backward regions. Capital accumulation taking place in backward colonial or semicolonial regions is a means to glean surplus labour and agricultural rent, massively expropriating the native capital resources of those countries. Technology is in this context only a tool for that expropriation of capital resources. Whether locally supplied or imported, technology cannot become a tool for development unless the economic basis for domination are broken: the stranglehold of monopolies over industries, banks, land, trade, through the abolition of semi-feudal productive relation in the rural areas."

Measurement and Assessment of Technological Dependence

Each of the contributors offers a different approach for measuring and

assessing technological dependence. They are a concrete illustration of the difficulty of such an exercise.

The first is Kim's mathematical approach. Having defined dependence as a quantifiable entity ("a balance of technological diffusion"), Kim builds several mathematical formulae indicators using three basic variables: the number of specialists sent abroad for training, the imports of written information, and the number of specialists hosted at home: "The quantification of these three forms of technological diffusion is possible by providing statistical data on the number of personnel sent abroad for training and the years of their residence, the number of foreign patents utilized, and the number of foreign specialists invited and the years of their residence."

Kim holds that: "The purpose of the measurement and evaluation of technological dependence is to assess its impacts upon the material welfare of a society, expressed possibly by the level of GNP and the pattern of its distribution. In this sense, the task cannot be done very currently. Even on a micro level, it is not possible to impute precisely, say, an increase in profit of a firm to technical change due to the so-called ceteris paribus clause, though there do exist econometric works on the subject. When an estimation of the aggregate production function itself is not very feasible, how can one identify impacts of foreign technology from those of domestic on the GNP?....However, it is meaningful and useful to think of various indicators to measure the "importance" of technical dependency....Technological dependence or assistance can take various forms, such as invitation or dispatch of technological personnel and borrowing or lending of patents. Though not very precise, it is possible to measure the magnitude of technological dependence or assistance in terms of money by adding up the salaries of the technological personnel and the royalties of the patents. For free service, an appropriate "shadow price" can be assigned."

Yet Kim agrees that, "Contribution to GNP is not a very good criteria for evaluating the impacts of technology on the performance of a firm or an industry. The national income accounting practice is such that wages and salaries of engineering personnel are automatically included in value added, and thereby become a component of GNP. Hence, it may happen that a firm or an industry contributes significantly to GNP paying a large sum of money to engineering personnel whose work is of dubious character. Indicators to measure "balance of technological diffusion" are hardly anything more than mere devices for condensing quantitative data concerning technological diffusion. One should not get the illusion that these indicators, or any statistical indicators, reveal any causal relation of a phenomenon. In fact, the whole business of descriptive statistics concerns how to put diverse and complicated data into a precise and simple form retaining details of the original data as much as possible."

The second approach, exemplified by Lardner's, assesses technological dependence by reference to the nature of its manifestation. The assessment is based here on a normative approach which bears, therefore, implicit ethical criteria. As Lardner puts it: "The particular forms and areas of dependence are, as we have suggested, a reflection, in the first instance, of the recognition and definition of needs which determine the approach to the acquisition and use of technologies." In other words, Lardner suggests that dependence, in general, and technological dependence, in particular, could have been avoided if the needs that technology is to serve had been previously identified and defined in a better way. According to this view, a country would be spared dependence if it had only chosen the appropriate development goals. This approach closely parallels the discussion on appropriate technology which reached a

deadlock because the definition of what is appropriate bases itself on fundamentally subjective judgements. This is so because, though it is feasible to list the characteristics of an appropriate technique (6), it is impossible to visualize them working except in an ideal, i.e. unreal world.

Said and Zahlan see technological progress as part of cultural progress. To them, therefore, "maximal achievements in science and technology depend in the first instance on the cultural environment in which they function. A culture that gives a lowly status to science will achieve little in the way of technology independence irrespective of its population. If, for example, one compares the scientific output of the entire 135 million Arabs today, one finds them equivalent to about 1 million Americans, Germans or Soviets in output. When science is a major cultural factor the maximal attainment is determined by population and GNP. Thus a small nation will always be more technologically dependent than a larger nation even when both are equal on a per capita basis. Even major nations, such as the USSR and USA, transact science and technology."

Said and Zahlan's statement is close to O'Donnell's point of view, who asserts that: "it is precisely the internal incapacity to generate viable alternatives in a reasonable time and at the reasonable cost that constitutes one of the main factors that sustain the greater capacity of the technological dominant partner to impose sanctions on the dominated one."

In the context of this approach, the problem of assessment of technological dependence would be to find out what makes a society technologically creative or technologically repellent. Should we qualify it, as Kim does, on the basis of the well-known conservative and thoroughly criticized theory of stages of growth? If this were done, dependence would be a psychological matter that in second instance develops political, social, economic, and why not, technological feedbacks. To accept this interpretation would inevitably lead once more to very subjective criteria of judgement, as those pointed out in the context of Kim's Rostovian approach.

What makes Said and Zahlan's argument slightly more complex than the worn-out theory of stages of growth is that it sees dependence arising out of a confrontation between isolated cultures, a statement that Lardner also supports with examples drawn from Africa. Said and Zahlan say that: "The Eskimos, for example, were technologically independent; when the "white men" introduced metal weapons, they became technologically dependent. The transformation resulted from the fact that the Eskimos found desirable the use of products which they could not produce. The Ottoman Empire was technologically independent until the eighteenth century. But soon thereafter the Egyptian military campaign of Napoleon exhibited the scientific and technological backwardness of the Ottoman Empire relative to Europe. Since these two regions of the globe had been, and continued to be, in constant conflict, the technology gap became of vital military and political significance."

Despite the correctness of the examples given by Said and Zahlan, other opposite historical examples could be found to disprove the argument. For instance, the Roman Empire was destroyed by successive invasions of barbarians whose scientific and technological achievements were in many aspects much lower

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(6) See for example: Schumacher, E.F. 1973. Small is Beautiful. Harper & Row, New York.

than the Romans'. Similarly, Genghis Khan's hordes, armed with comparatively primitive weapons, wiped out the sophisticated Chinese cultural era that had invented gun powder. These examples of military victory by an unsophisticated society have so deeply impressed Mao Tse-tung that he wrote, as recently as 1958: "Since history exists, in the revolutionary wars, those that have weapons of inferior quality always win over those who possess weapons of superior quality. In China, in the periods of the civil war, of the resistance war against Japan, and of the liberation war, we did not control the whole country and we did not possess modern arsenals (7)."

Neither Said and Zahlan's arguments, nor Mao Tse-tung's, are, to my mind, satisfactory explanations. Looking at the closer example of the war waged by Vietnam, we see that despite all the genuine imagination displayed by the Vietnamese during their long war against France first and the United States, and despite the cultural achievements of the Vietnamese nation, there are no reasons to say that they won the war because their culture is superior to that of North America or to that of France. Likewise, it is not quite correct to say that the Vietnamese won the war because they had weapons of inferior quality. In fact, Vietnam had to resort to very sophisticated weapons to defeat foreign occupation, particularly in the last years of the war against the USA.

The fact that cultural factors are an inadequate explanation is partly recognized by Said and Zahlan who turn back to economic indicators for quantification. They hold that: "Technology dependence may be quantified according to the following criteria, determining: (i) percentage of projects designed in country by field, percentage of manufacturing/construction performed by national institutions by field, percentage of new projects conceived in national institutions by field; (ii) dependence on foreign patents and leases; and (iii) sources of technological developments of national industry."

It is worth noting that, when coming to measure technological dependence, both the approach of Kim and that of Said and Zahlan converge towards the same method which, founded on the concept of technological gap, compares selected data on locally conceived technology with foreign imported technology.

Sercovich presents a well-thought view of technological dependence as the result of foreign imports of technology in backward countries that are subject to the domination of imperialism:

"If we look at the nature of foreign technological assets negotiated by semi-industrialized countries, particularly in Latin America, we shall find that most of them consist of bits and pieces of proprietary technology and related rights (packaged with each other) that are required to feed an imitative pattern of industrial development based above all on concentrated morphologies with interdependent patterns of behaviour leading to non-price competition. So, whilst backward capitalist countries tend to reproduce the forms of industrial organization behaviour developed in advanced industrial countries, they remain unable to generate and even less to control the sources of technology inputs needed to sustain such imitative ways of industrial development. Though entrepreneurs in developing countries intensively deal in innovation, their innovative capabilities remain underdeveloped. This basic asymmetry describes, in my view, how technological dependence works.

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(7) Mao Tse-tung et la construction du socialisme, Seuil, Paris, 1975, p. 137.

"There are historical and economic organizational aspects behind this. Usually, developing country markets are preempted by foreign corporations early in their development process. Because of their previous business development through trade links, these corporations often have some established advantages in the developing country market. They may have been supplying such market through exports and hence developed a demand for products embodying the technology which they control. In this case, good will and company reputation may have been gained already. Property rights may have been registered and so be protected by the national legislation in the developing countries. And marketing facilities through local agents and distribution networks may have been set up. By these means, foreign corporations usually enjoy well established advantages when locally-owned firms start their manufacturing development. These advantages are mainly technological. They are exploited in developing countries' markets either through wholly owned subsidiaries, joint ventures, pure licenses or other contractual forms with one thing in common: all of them involve a certain degree of control exerted by the technology suppliers. The advantages enjoyed by them give rise to substantial entry-preventing barriers and the subsequent quasi-rents in such a way that: foreign technology inputs supplied to locally operating firms through license agreements and other contractual means play a critical role in creating and sustaining their market positions; to the extent that industrial concentration develops in the recipient market and that the licensed inputs consist mostly of frequent minor innovations being currently generated at home by the technology suppliers, firms at the recipient end are encouraged to engage in a pattern of non-price rivalry similar to that typical at the supplying end; and, in so far as such a pattern of rivalry becomes generalized in the recipient market, particularly thanks to the development of differentiated oligopoly market structures, it affects all firms, irrespective of ownership links with their suppliers.

"Control of recipients' decision-making helps, on the one hand, to remove competition (from third suppliers and recipients, and from the recipient firm itself), thus increasing potential rents and, on the other, to guarantee the appropriation of these rents. Those who control the generation and the mechanisms for appropriation of technological advantages have also the capacity to control their exploitation, wherever it takes place, either directly or through associates or licensees, with or without ownership links. Foreign technology suppliers' control on decision-making concerning investment, production, management, and marketing in the context of concentrated and non-price patterns of rivalry make technological dependence a self-reinforcing phenomenon. Patterns of income distribution and culture favouring the permanent recreation of imitative consumers' and producers' preference habits, coupled with the foreign of the innovative process close the vicious circle of technological dependence.

"The high rate of obsolescence of non-price advantages makes for technology commercialization agreements to inaugurate long-standing relationships between recipients and suppliers; this also follows from the type of technical efforts made by recipient enterprises, which are geared to the efficient exploitation of foreign technology inputs, rather than to their substitution. From a private standpoint, it does not really matter too much how "useful" is the technology being imported, considered as a basis for the development of local skills and domestic creative capacity in so far as its exploitation results in a profitable operation. At the same time, it is difficult to find cases of State enterprises which could challenge this usual approach at the private level and supply a ready-made alternative. Risk-minimization by State enterprises is a proxy for

profit-minimization by private enterprises as concerning technological behaviour.

"During the period covered by the last fifteeen or twenty years, increased capacity for domestic production has been traded-off against decreasing relative capacity for domestically deciding what and how is to be produced, and where and how what is being produced is to be marketed. Foreign technology suppliers provide together with their proprietary know-how, a protective umbrella against risk and uncertainties, as well as education, under the form of a certain type of skill formation. Though local entrepreneurs and personnel go through a learning process which enhances their technical skills, in so far as this is not translated into a legal appropriation of what they learn and create, and a change in business behaviour patterns, those gains are bound to be recurrently lost in the long-run. So the process is characterized by a permanent dis-appropriation of externalities."

Finally, the approach adopted by Barrio gives preeminence to the role of capital accumulation in the process of capitalist development. According to him the degree to which capital accumulation is prevented would be in a way the "measure" of dependence. Barrio holds that: "This domination (over semi-colonial and colonial countries) is not a "technological domination" but an imperialist domination. Technology as such is neutral. Its private monopolistic appropriation - a juridical, legal, relation - is under imperialism a mechanism for the drainage of wealth from the dominated nations, but not technology as such. Freed from the fetters of private property, technology as well as capital itself, and only in those conditions, can become the chief element for the liberation of backward countries....Concerning technical features, the phenomenon of colonial and semi-colonial domination creates basically the following features: (i) the advanced technology is mostly applied in export sectors, so to cheapen the production of food and raw materials destined to the metropolis; (ii) the application of technology in certain industrial activities (preventing its open use) creates protected monopolistic markets and blockades exports; (iii) no technological advance of any significance takes place in most agricultural land; and (iv) technology as such is negated by transforming it into a tool for a parasitic market structure of a highly inefficient nature."

Alternatives to Technological Dependence and the Concept of Self-Reliance

In the studies and comments under review, no categorical answer can be found to the question of whether (technological) self-reliance is an alternative to (technological) dependence. The authors have tried to outline what should be done to increase the underdeveloped countries' scientific and technological capabilities, explicating sometimes that this process represents a move towards self-reliance of independence.

The challenge of studies on technological dependence is synthesized by O'Donnell, who is thoroughly acquainted with theoretical framework in which the concept of dependence was elaborated in Latin America. "The two levels of analysis of dependence (the first focussing on a variety of components of the problem of dependence, and the second considering the general characteristics of a society) must be kept as a general framework in connection with which technological dependence is defined, but this general framework cannot be itself the object of research. If this general framework is omitted, or if it is only briefly referred to the general conditions (which presumes a very erroneous view of this framework), the specific problem of technological

dependence will be excessively isolated and, in the end, it will be immediately negated....On the other hand a too rigid total view of a global society also eliminates the problem of technological dependence as a problem that can be a subject of analysis on its own. Furthermore, this vision imposes an obviously impossible task for the size of research papers, the task of sketching a general theory of human society and its dynamic laws." According to O'Donnell the task should be restricted first, "to "situate" the specific theme in a discussion which is at the same time synthetic, illuminating and well documented as far as the frame of reference is concerned, and, on the other hand, to discuss with talent and creativity this specific theme....(Some of the studies reviewed) eliminate from the beginning this problematic. (Others) make it subject to such extensive preconditions in knowledge and social change that it is not clear why, or at least how, technological dependence and self-reliance are worthwhile being considered without having reached these previous achievements."

The authors implicitly recognize the difficulties outlined by O'Donnell with respect to defining technological self-reliance in relation to technological dependence and with respect to determining the specific elements of a strategy of technological self-reliance. The two aspects of this question are presented here successively in order to reproduce with the least distortions the views of the authors.

(1) For Said and Zahlan the route towards self-reliance involves the creation and establishment of capabilities for the management of scientific and technological knowledge (the "software" part of technology), more than the actual knowledge of producing technology in its hardware form.

"It is true that a certain level of technology is needed to own and operate a car or a railway system. When we refer to technology independence in the railway field, for example, we mean that a society has the entire capability to design and manufacture a railway system. Whether the final railway system is completely "homemade" or not, we consider to be of secondary importance. Any intelligent society will procure its products after carefully examining production costs; this is related to the economy of scale. Thus a nation that may have the ability to design and produce a particular hardware may decide to do so. Thus the concept of technological self-reliance does not require total autonomy in production, acquisition, innovation or design. On the other hand, self-reliance would imply a complete capability to analyze, design and produce a particular product if this is considered a strategic requirement of a nation....It is possible to acquire a technological know-how in a particular field at a particular time without acquiring much basic science or going into much basic research. Although it is always necessary and desirable to atomize the process of change, a community will never be technologically independent in a particular field until and unless it acquires the basic research capabilities associated with that technology. The individual scientific and technological activities are independent of each other, yet they form a coherent continuum when viewed over a period of five or more years....Technological self-reliance rests on individual performance, institutional infrastructure and a political leadership that is keenly aware of the technological implications of social and economic policies. These three pillars of technological self-reliance are loosely interdependent. The state of technological independence is a consequence of a large variety of actions and attitudes, each of which is necessary but not sufficient to enable a community to achieve this status. Without a political leadership that is keenly aware of the strategic decisions required to acquire technological self-reliance, it is virtually impossible for

a developing nation to acquire this capability today. The more complex science and technology becomes, the more difficult it is for countries to bridge the gap. The efforts that must be deployed by Third World countries are enormous for two reasons: (i) An accumulated wealth of knowledge exists that is diffused throughout society in the form of skills, attitudes, and values. (ii) The increasing complexity of science and technology makes the demand for complex and expensive institutional structures greater."

In order to achieve technological independence, Said and Zahlan recommend a three-pronged action. First, action should be directed towards the establishment of an integrated relationship between individual scientists and technologists and society at large. Secondly, action should be taken in the field of institutional planning. Thirdly, improvement in policy-making should take place at the political level.

Said and Zahlan detect many requirements for achieving these three goals. In the relationship between the science and technology system and society, they recommend the following: "(i) Economic support for the activity: the scientist or technologist has to be able to earn his living directly or indirectly from his activity. Thus he could have been either a teacher, and "advisor", or the owner of a factory that delivered some product his society wished to purchase; he could also have been rewarded for a treatise he issued or for medical treatments he performed. (ii) A certain level of education must have been provided to enable the individual to be knowledgeable. (iii) A certain degree of tolerance of ideas and information must have prevailed. Many scientists were persecuted for their ideas, but nevertheless it was society that made it possible for them to have persecutable ideas. (iv) A certain degree of mobility across national borders is necessary to permit scientific communication. (v) A certain degree of political stability must prevail to permit an individual to free himself from worry and insecurity in order to acquire a minimum amount of knowledge."

In addition, financial requirements are also to be considered: "In the post-industrial era the dependence of the scientist and technologist on society has been aggravated because of an enormous increase in the scale and cost of science and technology. Thus one must add, at least, the following additional factors: (i) The requirements of institutional facilities: space, equipment, libraries. (ii) Science and technology call for large teams of researchers. Thus some authority has to provide the funds in order that the effort exists. Such support naturally depends on the social need for the products of the activity. (iii) A society will not provide funds for technology unless it delivers useful and profitable products. (iv) A substantial portion of technological research is for military use. This effort therefore depends on the defense needs as perceived by the political leadership of the country."

In the field of institutional planning, the requirements perceived by Said and Zahlan call not so much on material resources (financial and human) as on the introduction of new societal values.

"Technology independence can be considered to exist when: (i) A society has the capability to become aware of a technological need. Unless a society is aware of a need it will not devote the necessary resources to acquire the technology. (ii) A society has the informational base to be aware of world technological progress. (iii) A society has the base in all areas of technology that are of obvious importance to the community. For example, for all States a technology capability in: defense matters, agriculture,

health, construction (housing, etc.), transport industry, roads, and food products. In this regard the Arab States should focus on oil and petrochemicals technology, and shipping. (iv) A society has the scientific base to support its technology. (v) A society has the industrial base to utilize the technology. (vi) A society has the political and technical institutions to be able to identify its technology options, and to implement the most appropriate ones. (vii) A society impacts on its youth values that promote innovation, discovery, love for nature, quality in job, performance, perseverance, patience, and a sense of ɔcial responsibility.

"Awareness of technological need is absolutely necessary, but certainly not a sufficient condition for technological independence. Awareness is a complex state: there is a whole range of awareness spanning from a mere visual registration to an understanding of the technology and its implications. Awareness, because of its complexity, involves more than one person: the larger the number of individuals aware and familiar with technology, the greater the opportunity for taking effective action. For example, the English realized the strategic importance of technology; they promulgated laws to prohibit the export of machinery and the emigration of skilled workers from as early as 1750. In 1825 it was illegal for a British skilled artisan to work abroad. Also throughout the 19th century there was a great deal of literature in all the major European states on their relative advance, or backwardness, in areas of science and technology and/or the implications of national wealth and security. In the Ottoman Empire, such awareness was nonexistent. Arab leaders in the present century have been concerned strictly with the pursuit of political independence, not realizing that there is an intimate interrelationship between the political, economic and technological spheres of a nation. The Arab-Israel war of June 1967 has had a salutary effect on Arab thought in that it has emphasized and illustrated this interdependence."

Thirdly, at the political level, Said and Zahlan suggest a scheme that would improve decision-making in their opinion. The main emphasis is placed upon decisions at the project level. The authors claim that in relation to project management, decision-makers take responsibilities at basically two levels. At the first level, decision-makers must apply criteria for accepting or refusing the project, taking into account ideally the aims of the national plan and the insertion of the new project with others. At the second level, decision-makers must determine the economic and technical feasibility of the project, its relevance, the agencies and institutions responsible for execution, follow-up, and monitoring. Said and Zahlan argue that:

"A project is central to technological change because it is the instrument through which a Third World country delays or accelerates the flow of technology. The distribution of decision making authority among Levels 1 and 2 varies from country to country. In rapidly developing countries Level 1 would consist of the president of a republic and the revolutionary command, while Level 2 would consist of ministers; thus Level 2 has considerable authority and responsibility. In slowly developing countries, all powers and responsibilities reside in the person of a president or a king. It is not so much who decides but how and why a decision is made. The signing of 100 large-scale contracts to build or buy dams, roads, factories, houses, ships or trucks is not in itself an act of technology promotion. It is the extent to which the decision-makers have a clear concept of a national plan, examine the implications of each project as to its integration with a master plan, evaluate the ways and means that the project is going to impact on

employment and know-how that one can gauge if it is purposeful strategy aimed at technology independence. In a developing country it is frequently the scientist, engineer or project manager that attempts to be the agent of technological change. But these persons occupy positions that are constrained by the strategic decisions taken by the political leadership; technocrats can in fact accomplish little without being provided with the appropriate means. Although project management occupies a crucial position, it is subordinate, and many projects fail as a consequence of failures at the leadership rather than at the project level."

Apart from the material and ethical requisites outlined above, Said and Zahlan also believe that it is necessary to alter the pattern of acquiring the foreign products of technology, mainly through a change of attitude of the people that belong to the science and technology system.

"Technology transfer takes place through numerous channels. Newspapers, movies, textbooks, foreign travel, household and capital equipment all provide channels for the transfer of science and technology. But we have already seen how this acquisition through trade (as in the nineteenth century Ottoman Empire) is a poor vehicle for technology transfer: it can ultimately destroy the national technology base. Since 1800, European industry, European armies, and European military equipment and know-how have been penetrating the entire world. Beirut in Lebanon and Berlin in Germany had their first water works system installed by British companies at the same time around 1856. But the amazing thing is that, despite these intense and prolonged contacts, in the case of the Arab World, the people have failed to acquire science and technology. The modern history of the Middle East, however, has clearly shown that despite the presence of oil companies in the area for decades the rate of transfer of science and technology in the petroleum field has been minimal. It appears that the basic hindrance to the acquisition of the aforementioned capabilities in the Arab World is the prevailing confusion between science, which is an activity, and technology which is the hardware product of this activity. Governments and individuals are interested in acquiring tanks, airplanes, refineries, ships, cars, trucks and houses. But they want them in the form of a turnkey job: they want to "contract" or "buy" the refinery, the car or the ship. There is no desire to invent the device required, design it, or even produce it. Such an attitude is obviously inimical to science and technology and, unless systematically and effectively overcome, there may never be any science or technology, and the Arab World will persist in its backwardness. There are, however, situations and conditions under which a "turnkey" contract is the only solution. Even then there are ways and means to maximize the impact of imported hardware."

When planning procedures at policy-making level are the bottleneck, Said and Zahlan suggest the following scheme: "Subcontracting the maximum amount of the project to national firms; opening up subcontracts to competitive international bidding; coordinating all subcontractors in civil engineering and the training of personnel required to operate and maintain the plant; deducing implications of the project to the entire industrial and economic program of the State initiating studies to optimize on the project; ascertaining that all contractors and subcontractors are kept on schedule, properly coordinated, and that unexpected problems are resolved promptly."

Finally, the achievement of technological independence requires, according to Said and Zahlan, a time-paced strategy that involves action over the short-, medium- and long-term planning horizon:

"The acquisition of technological independence in the Arab World is a difficult, expensive and arduous process which will involve the totality of the nation's strength and resources. It is most unlikely that any nation could achieve self-reliance unless it is willing to devote 10% or more of its GNP for this effort. The acquisition of this capability must be pursued simultaneously on several levels and with clearly defined short-, medium- and long-term objectives. The rewards are, of course, immense, the least being economic prosperity and social well-being. The fundamental starting point is the total commitment of the political leadership to the securing of technological self-reliance. Given this dedication, the State has to invest heavily in actions that will have effects over the: short range, intermediate range (first 10 years), and long range (first 20 years).

"Over the short range, the State should acquire a capability in planning and management of technology transfer, and should develop the research and development capabilities at its universities. The cost of acquiring a planning capability may be of the order of $10 million/year. As for the development capability at the universities, this should be no less than 1% of the GNP. Virtually all Arab States today have one university or more. These universities are impoverished and lack most of the basic facilities to conduct scientific and technical research. Yet without the library and technical facilities, these countries will continue to be divorced from the wealth of existing know-how that could be tapped to solve national problems. It is through these two major tools that a State would be enabled to analyze its problems and select adequate and relevant solutions. Thus these tools have to be integrated into the existing instruments of planning and policy formation. Furthermore, through a more effective higher education system it will be possible to train a new generation of young engineers, scientists and planners equipped with the proper vision and skills to cope with the developmental problems.

"Over the intermediate time range, a massive effort has to be deployed in the agricultural and construction sectors to introduce intermediate technologies through on-the-job training and non-formal means of education. Almost 70% of the Arab labor force is employed in these two sectors and is predominantly illiterate. It is today possible through systematic, inexpensive and simple techniques to increase productivity and yield. Here the designed changes are of a technical, political, social managerial and financial nature. The yield will also be progressively forthcoming. The success of such a program would rest heavily on the ability of the political leadership to motivate and mobilize the educated minority to serve the bulk of society. The industrialization plan should also be geared to producing the devices and instruments essential to such a large scale program. At the moment the industrial sector's goals are geared to middle class needs or to assemblies of expensive machineries (such as tractors and trucks); it pays little attention to the production of the large numbers of simple tools for daily use by the majority of the population. A few Arab States have the manpower and financial resources to attend to the development of high and low technology; none of these, however, have established a coherent plan of action to optimize on their potential.

"Over the long range, the State has to transform its entire social order. It should give value to farming and industrial work, as well as develop a completely new educational system. The entire educational system in the Arab world needs changing: the textbooks, teachers, curriculum, the school building, the values imparted and the academic standards. At least 20 years of strenuous, imaginative and steady work will be required to achieve such a transformation.

"The short and intermediate range actions will generate the financial resources to invest in the educational system. However, the three main lines of action have to be in parallel and not sequential. All three of a high priority: it must be remembered that there is no one action or one product that in itself will solve the problem. Naturally the short range program of the first five years will grow and expand along with the expansion of the economy. The resources of the Arab World in mineral wealth, transport, agriculture, tourism and manpower are such that with the growth of population from 125 million in 1970 to somewhere in the range of 280-320 million in the year 2000, it should be relatively easy to increase the GNP from $32 billion in 1970, $75 billion in 1974 to between $1 and $1.5 trillion in the year 2000. To perform such an amazing feat is precisely what is needed to attain technological self-reliance."

(2) Lardner's position reflects a deep preoccupation with the challenge of dependence for Africa. His recommendations, quoted below, have been open to criticism (10) for lacking realism and carrying contradictions, particularly with regard to private enterprise.

"It is not difficult to see that developing Africa faces several challenges in regard to the development of technology. The first is whether policy should assume that Africa must create the socio-economic structure within which the technologies presently available (as well as those expected to be available) in technologically advanced countries can be accommodated, domesticated and further developed and that African socio-economic and techno-structures must therefore be as close an approximation as possible to those of the source countries, or whether Africa should attempt to establish some alternative viable socio-economic system within which such technologies can be effectively established and developed.

"The first approach is likely to produce caricatures of advanced societies. The alternative requires a considerable understanding of the dynamics of technological growth as well as the working out and adoption of such an alternative working hypothesis (model) of society. Laissez-faire will not do both because the initial conditions in which technologies developed in advanced countries are not the same as are to be found in developing Africa, and because the historical path of such development is closed.

"A second challenge arises from the fact that the technologies developed in advanced countries are now so manifestly inflicting damage on society that the basic philosophies on which they rest are not only in question but under attack. Out of this have emerged conflicting theses and propositions, social control of science and technology (including questions of what forms and degree of control, who is to exercise this control, and by what means), corporate social responsibility (or management social trusteeship), and even alterations in the nature, direction of growth and objectives of technologies to fit alternative arrangements of the presently advanced societies. With the exception of the last, all are attempts, in one form or another, to compensate for the distortion impact of advanced technology on industrial societies.

"A concrete and identifiable challenge is the creation of a multinational base for industrial and technological development together with the instruments for exploiting the resources and market opportunities that become available. The alternative is to let foreign transnational corporations continue to create their own multinational production capabilities and markets within and without the potential group by pre-empting comparative advantages in potential partner states. This point requires some elaboration.

"For most of the countries of developing Africa there is hardly any serious alternative to common market type arrangements. At times governments seem to regard these arrangements as a substitute for the essential internal socio-economic engineering which ought to inform economic policy and planning. Most of the time governments regard multinational economic cooperation as an extra, something to which to turn attention once the problems of domestic growth and diversification have been settled. This has been particularly true of countries which consider themselves capable of generating economic growth and diversification on the basis of their own resources and capabilities. It is only very slowly that multinational cooperation in the production of strategic industries has begun to be recognized as a necessary condition for the solution of domestic problems of economic growth and diversification. The region is therefore littered with embryonic forms of free trade areas and economic communities."

From these general considerations, Lardner goes on explicating his recommendations. First, he warns that mere controls on imports of technology will not do. Rather than adopting a defensive strategy, countries should choose an offensive one, take the initiative through direct State intervention in production and direct State support to domestic and Third World private enterprise.

"It is, in our view, an error to assume that if patents, trade marks, franchise clauses, provisions in technology licenses relating to management and consultancy services, to excessive emphasis on quality control and to technology-related purchases, to access by the licensor to improvements divided by the licensee, in short if other known or suspected restrictive arrangements were removed, this would automatically guarantee the emergence of concentrated local effort to adaptation, invention and innovation. Nor would the mere installation of more sophisticated and more diversified R&D facilities by itself represent a significant contribution to inventive activity. Indeed, in the light of the socio-economic structures of countries in developing Africa, to establish such facilities would in all likelihood only create a new species of enclave. Technological adaptation, invention and innovation cannot be carried out in a vacuum.

"What then is required is the development of local capital goods industries, interlocked in such a way that one subsector provides the market for or constitutes the supplier to another. One advantage of this deliberate interlocking is that passive sectors (e.g. producing basic metals, chemicals and petro-chemicals) maintain a built-in relationship with active growth sectors such as mechanical and electrical engineering, the manufacture of mining and transport equipment, of agricultural implements, tools and machinery, of machine tools, and so on. Another advantage is that the gains from specialization are compounded as production moves through successive stages. Ultimately production must be linked to final demand: the expansion of consumer durables whether private (as in Japan) or public.

"The public segment, as is now recognized, arises from the vast lacunae in physical infrastructure required to effect the socio-economic integration of national economies, and thus to expand employment opportunities for ex-rural workers. This is the centerpiece of the case for African multination State-owned enterprises. These enterprises would not be primarily profit-oriented in the sense that profits are sought for payment to shareholders. They would be growth and technology oriented, and responsible for creating - in some cases virtually out of nothing - key industrial sectors on a multinational basis. They would, through the establishment of affiliates or subsidiaries, or through subcontracting, not only contribute to the realization of complementary agreements among partner-states but through group facilities for R&D and for management

and technology consultancy would facilitate technological invention and innovation. They would not only be able to negotiate technology package more competently but, also to assist governments and national State enterprises in such negotiations and in the design and implementation of policies for technology. They would, by preempting key sectors, protect the national or multinational economy from domination by multinational foreign enterprises. They would also provide resources for teaching and learning which could be utilized by universities and other third-level educational institutions for producing the high and middle level manpower now in such short supply. This is in no way a full list of the ways in which African State-owned multinational enterprises could contribute to the development of technology in developing Africa.

"For the technological multiplier to work within the national economy, however, governments will have to undertake a great deal of responsibility. Planning perspectives and methods will have to be considerably altered. New national institutions relating to industrial standards and quality control will have to be established, or their orientation altered. The same would apply to so-called "development banks." Modern foundries will be necessary, sometimes developed out of existing centres for mechanical and electrical maintenance. Above all specially designed "inducement mechanisms and focussing devices" will have to be installed and put to work."

Lardner then concludes that, in his opinion, "technological independence, in any complete sense, is an unreal object of policy because needs, factor availabilities and technologies change all the time, and dependence in particular areas and at particular stages in the evolution of technologies also changes. What should be aimed at is technological interdependence reflected in substantial contributions over time to the pool of international scientific and technological knowledge and skills."

(3) Kim's view of technological self-reliance involves sociocultural factors to a lesser extent than his view of technological dependence. Technological self-reliance has much more to do with trade than with the national characteristics, that he asserts are "natural" factors of dependence. Kim sees technological self-reliance as the "capacity to break even" the so-called "balance of technological diffusion." Self-reliance thus is reduced to the ability of a country to export as much technology as it imports. He categorically states that: "Technological self-reliance refers to potentiality, while technological dependence is phenomenal. That is, if a country has sufficient manpower and financial resources to develop independently engineering technology comparable to any technology of foreign origin in a reasonably short period of time, the country is technologically self-reliant. However, the country may depend upon a foreign source in some line of commodity and develop its own in some other line simply in consideration of "comparative advantage." In this sense, most of the so-called developed countries are technologically self-reliant....The relation of technological self-reliance and complete technological autonomy has an analogy to that of trade and autarky. Though almost all of the so-called developed countries can manufacture almost any commodity, they specialize in some lines and engage in international trade. There are lots of theoretical reasons and empirical facts to prove that autarky is an extremely inefficient way of economic activity. Similarly, complete technological autonomy, if it is defined as "doing everything by itself," is an inefficient way of carrying out research, simply because there are significantly increasing returns to scale in research. (It should be mentioned that international specialization is not necessarily due to increasing returns to scale

in production). However, we have been noticing a tendency toward technological autonomy as well as that of trade restriction."

Kim perceives that the economic theories on which he bases his arguments fail to explain why there are restrictions on trade if common sense dictates complying with an international comparative advantage. He resolves this dilemma by first supposing a distinction between autonomy and autarky and then deducing that technological self-reliance and technological interdependence are complementary.

"Technological self-reliance is not compatible but rather complementary with technological interdependence in view of our previous discussion....If technological autonomy is interpreted to be technological autarky, there is no point for a country in a developing stage or any country in trying to be technologically autonomous unless the countries refuse to exchange technological information with each other as shown in signs of a return to the protectionism in international trade recently....Any country would like to be technologically self-reliant, if it is not yet. However, as mentioned earlier, modern engineering technology is crucially dependent upon a pure and engineering (applied) scientific background so it is not possible to be technologically self-reliant without having a broad and sound scientific background, but this takes a long time and requires tremendous efforts if a country has not already attained an advanced level of science. Therefore, technological self-reliance is not an operational objective to be achieved within a specified, short period of time.

"The age of backyard discovery of invention has passed away. Well financed, systematic, and organized research efforts are essential to advance modern technology; so, technological research competes with other investment opportunities for resources. In this sense technology is like any other commodity. If the benefit-cost ratio is higher in technological research than in the production of other commodities, the resources will be allocated into the former; otherwise into the latter. Moreover, a pure and engineering (=applied) scientific background is absolutely necessary for technological research as the production of a commodity on a commercial scale requires the development of basic industries. So, unless an educational system is well established, and the research effort is soundly institutionalized, the benefit-cost ratio is probably much lower in technological research than in the production of other commodities. As most countries in a developing stage of the present day lack this "infrastructure" for technological research, they would be better off to concentrate in the production of physical goods based on the "borrowed" foreign technology. It would not pay back sufficiently for a country in a developing stage to try to be technologically self-reliant in a short period.

"The edifice of modern technology is built upon foundations of pure and engineering (=applied) sciences. And scientific information propagates rapidly beyond national borders and is freely available from academic journals or visiting scholars. Scientists constantly entice or even challenge technicians to commercialize their findings. However, only qualified and motivated technicians can take up the tasks, the accumulation of which eventually establishes technological self-reliance.

"Though it is not possible or feasible for a technologically dependent (potentially and actually) country in a developing stage to be in the forefront for a long time to come, it certainly can lessen the degree of technological dependence or be partially self-reliant by making a marginal contribution to the reservoir of technological knowledge. Two opportunities are open to a technologically dependent country in a developing stage, if it has modest

technological manpower and financial resources: (i) It can modify foreign technology so as to suit its own economic structure and social environment; (ii) it may pick up research subjects neglected by technologically advanced countries for one or another reason, but suitable for a modest research team to tackle, just as one may pick up gold particles in a deserted gold mine."

In this conclusion, Kim believes that more education, in the widest sense, and even the free circulation of ideas are not prerequisites for technological development. Since economic growth demands a greater input of scientific and technical skills, education and other "social" expenditures should be optimized in this sense. "The road to raising per capita income and shaping a pattern of equitable income distribution may diverge from the road to freedom of speech and political liberty. The latter is a "luxury" for most countries in a developing stage. They can hardly afford to have "university" education. Any courses which are not directly related to learning existing technology or creating new technology should be cut from the curriculum of higher education."

(4) For Sercovich, technological advance in underdeveloped countries can only be achieved through deep structural changes. Sercovich sees the breakaway from dependence as a deep societal movement that involves changing the determinants of technological policies (the implicit factors of technological policies) before acting on the proper science and technology system.

"It appears quite clear that we are dealing with a problem which is very deeply rooted in the whole way of development of these underdeveloped countries. It concerns where decision making power is located and in whose benefit it works. But it goes much further. It comprises such things as the nature of the entrepreneurial class, the whole process of skill formation and the basic structure and behavioural pattern of the economic system. These determine the degree of freedom available concerning technological policies.

"What does a strategy of technological self-reliance mean in this context? It may mean a lot if we take it as involving changes in the basic determinants of technological dependence. Otherwise, it may mean very little. Basic changes may imply, inter alia, such as: referring the process by which technology inputs (either from abroad or locally-generated) are incorporated into production to social needs rather than to profit-maximization or risk-minimization; breaking away from the path of imitative industrial development; acting on the legal superstructure which legitimates technology suppliers' monopoly power and making it work as an instrument of national and regional policies; creating conditions for a complete appropriation of the externalities stemming from the process of technological change.

"Compared with an ideal situation in which technology would freely circulate around the world on a cost-free basis, with the enthusiastic support of those who control it, all what we are saying would certainly imply a rather expensive procedure. Even though self-reliance strategy, in the sense we have defined it, should not imply delinking from the international system, it certainly involves relinking to it in a new way. And if we are faced with alternatives to choose either for the social costs involved in keeping present linkages (poverty and marginalization, amongst other things) or for the economic costs involved in relinking in the context of national and regional self-reliance strategies (which may imply confrontation), I think it would be better to opt for the second alternative."

(5) Barrio, similarly to Sercovich, demands fundamental social changes.

He outlines two basic requisites for preparing the conditions to make better use of the scientific and technological skills and resources:

"Two are the essential, the truly essential, conditions for the liberation from backwardness: the conquest of national independence and the solution of the agricultural question to the benefit of the majority. Those two conditions are therefore the essential tools for the liberation of technology from its fetters, for the liberation of productive forces. The national independence is an essential condition because while foreign monopolies continue plundering the economy and pumping out every ounce of potential capital accumulation, anarchy, poverty, and technological backwardness shall prevail in the whole economy. National independence implies emergency measures: no further payments of the foreign debts, expropriation without compensation of foreign monopolies, whether in trade, industry or finance, and the immediate abolition of all patent rights, of all the semifeudal proprietary rights over scientific and technical knowledge. Those measures are not a sort of "revenge" nor a sort of xenofobia, but absolutely necessary measures. They are the basic structural conditions necessary for the abolition of national oppression and exploitation. Without them backward countries will be permanently drained of the essential capital resources, and will continue to suffer from technological backwardness. The second condition is the solution of the agricultural question, that is, the abolition of the "latifundia" and of the "minifundia"; this is the essential historical source of backwardness, and without its abolition there can be no talk of technological advance. While the best land remains in the hands of the few privileged landowners, or in the hands of a bureaucracy no possible development of agriculture can take place. Ground rent will remain mostly a parasitic rent absorbed by imperialism; therefore: no possible investments in agriculture, no possible technological advance."

Apart from these two previous conditions, Barrio believes that four basic complementary measures must be undertaken to overcome technical backwardness.

"The first and most important question is the relation between agriculture and industry. Technological backwardness cannot be overcome in the rural areas without an industrial development oriented to the needs of agriculture, and in turn this industrial development cannot take place - in particular in conditions of foreign hostility - without transferring some of the agricultural surplus to a planned industry....Second, it is obvious in our whole argument that the leading element in the development of technology is industry (economically oriented), and within industry the machine-making industry. It is clear that the mere possession of these industries does not imply economic and technological independence, since without a policy which breaks the reign of monopoly there is no possible independence. On the other hand, the lack of certain capital goods does not imply dependence. The young Russian State in the 1920's and 30's, as now, imported technology from abroad, even entire plants, and that by itself did not mean "dependence," nor did it cause backwardness. With those conscious qualifications, it can be said that industrial development is essential for technological development. The third question arises from the second conclusion: most industry in the backward countries is - as was discussed - an artificial and parasitic industry, due in particular to its protected inefficiency under the world domination of monopolies (inflation, imposed devaluations, etc.). This situation is changing during the present phase of the international crisis, as industries close one after the other throughout the world, including industries in the backward regions. The self-destructive drive of fictitious capital is destroying the

fictitious industries it created. But protectionism is a superstructural phenomena. In given conditions, i.e. early industrialization period of British mercantile capitalism, it played a progressive role. Under the domination of imperialism, in the colonial or semi-colonial countries, it plays a progressive role, but if freed from such domination, a backward country will need to protect its own market for a given transitional period. This "protectionism" - chiefly through the monopoly of foreign trade - is qualitatively different from imperialism-imposed "protectionism," and can only be considered a transitional, unfortunate, necessity. Fourth, there is little that can be done in the technical sense, if the backward countries lack the technical and managerial cadres for running production, particularly if we remain within the pessimistic hypothesis that the international situation will remain as it is now."

Barrio then suggests that, for the future, only the most advanced technology can be of use, once the two basic requisites of national independence and agrarian change have been achieved. This proposition has aroused many comments, both against and in favour of it.

"Only the most advanced technology can help to definitively overcome backwardness. This means that backward countries shall depend on the transfer of technological developments of advanced countries as long as productivity levels remain vastly different, even if this dependence does not mean necessarily colonial or semi-colonial domination. If the international situation remains unchanged (an unlikely possibility when considering the present crisis) and monopolies continue appropriating legally and physically scientific and technical knowledge, the backward country may be forced to pay ransom for such know-how for a given period. If the three essential questions first mentioned were solved (agrarian question, national independence question, and State question) this form of "dependence" would be of a qualitatively different nature, since it may hinder development but could not cause backwardness, even if implying, for instance, the renegotiation of the foreign debt and not its total rejection, or the acceptance of foreign loans....Modern advanced technology makes possible now, in backward as well as in advanced countries, to diminish - thanks to efficiency - the number of hours of direct labour, both in industry and in agriculture, distributing the necessary labour among the able. Only in this condition - an essential one for technological advance - could the social resources for education at all levels be considerably increased, having in turn a direct and immediate positive effect in the levels of productivity of industry, agriculture and services. Education at all levels can increase productivity, since productive efficiency does not depend precisely on the direct labour force in production or of its organization, but on the development of "human fixed capital" transformed or "embodied" in productive technologies at all levels and sectors."

Barrio's definite position in the debate on advanced, capital-intensive technologies versus labour-intensive technologies has provoked the most polemical reactions to the studies. While Varsavsky applauds to the "denunciation in simple words of the suicidal policy of using labour-intensive technologies," Sachs (6) replies that Barrio's arguments "put him for all practical purposes (whatever his intentions) in the camp of those who argue for wholesale transfers of highly capital-intensive techniques as the only solution to development." Tolba takes a more moderate stand when he says to agree that "the accent on the problem of employment would be put not on labour-intensive technologies but on the reduction of the direct working hours through the distribution of all necessary labour among the available labour force, and increasing indirect, social, scientific, educational labour." Tolba sees, however, two main obstructions:

"Where would the developing countries obtain the most advanced technologies? How can the developing countries reach the possibility of having the option of getting the accent in employment on these elements before they actually combat backwardness. Backwardness, by its nature, does lead to an immense amount of unemployment which is caused by the great amount of ignorance in such backward countries and I think, and I believe so many others think, that, unless we start training or making use of the existing non-used labour by applying labour intensive techniques or technologies, there is no easy way to increase the rates of growth or to achieve the process of development in the developing countries. It seems to me overambitious to expect that the developing countries can jump immediately into the most sophisticated techniques to build up the processes of development. First, because of the fragile economies of these countries which cannot cope with the financial implications of such sophisticated technologies, and, second, because of the high level of training required to apply these techniques where the developing countries are still short."

It is unfortunate that some authors consulted in the exercise have neglected to debate the question of capital and labour-intensive technologies because it is a central part of a discussion on self-reliance. If a country is to make a more productive use of its scientific and technological skills and resources, the question arises whether it is an absolute necessity to adopt more labour-intensive techniques and, if so, what are the costs of using such techniques.

Some Concluding Remarks

The reports under review belong to basically two categories or schools of thinking. They further divide into three separate lines of thinking.

The first group includes researchers who deny that dependence is a "problem." The exponents of this point of view, of which J.N. Behrman and J. Kim are two examples, do not always deny the existence of dependence as a phenomenon that characterizes relations among the developed and the underdeveloped countries. They coincide, however, in opposing to the concept of dependence that of interdependence, arguing that international relations carry both a degree of dependence and a measure of interdependence and that, among the two sorts of linkages, it is the latter which is the most remarkable and the one on which action should focus.

The second group, which includes most of the authors consulted by the STPI project, recognizes dependence as a source of serious distortions. Differences among this school arise from giving a precise content to the concept; defining its scope; and attributing to it an explanatory power. Two points of view confront each other when explaining the ultimate reason for dependence, and consequently when giving prescriptions for an anti-dependence alternative. The difference is basically one of methodology of research. Some researchers view cultural factors as determinants of dependence (Said and Zahlan, Lardner). They perceive dependence as a condition felt by anyone (an individual or a group or a society) who cannot satisfy its needs independently. Their proposals for action (as illustrated best by Said and Zahlan) are directed foremost to improving planning and management procedures, and above all to making institutional and political reforms that embody new ethical criteria. Others explain dependence as the result of unequal ties established among countries by the rise of the capitalist economy. The spread of capitalism to all the regions of the world has meant that some states use their economic, technological,

military, and other material forms of strength to dominate less developed States and nations. They therefore maintain that the true meaning of dependence - and the really effective actions against it - can only make sense if dependence is understood in the context of capitalist domination. The solutions they put forward entail deep changes of the whole economic and social set-up, particularly through acting upon factors that are outside the science and technology system.

In all these discussions, self-reliance remains an unprecise alternative. For some people self-reliance should become "living within ones' own means" (Behrman), a suggestion that calls the underdeveloped countries to restrain their demands upon their richest partners of the world economic order and to limit voluntarily their economic goals. This form of self-reliance could well be compatible with the maintenance of the present economic order.

A greater use of domestic skills and resources of the science and technology system is the major policy recommendation of the researchers who implicitly equate independence with self-reliance. They also suggest at times that new alliances or blocks among the weakest nations (collective self-reliance) should be formed as a way of backing up national self-reliance. It is maintained that this solidarity could establish a new, non-dominating form of interdependence.

CHAPTER 3

TECHNOLOGICAL STRATEGIES FOR DEVELOPING COUNTRIES

Máximo Halty Carrere[1]

Introduction

The whole Technological Strategies field in LDCs is facing adverse reactions, ranging from indifference, to incredulity, to benign neglect: Indifference from those who consider that all developmental problems should be tackled through economic policy and instruments; incredulity from those who admit that some action is required in the technology (T) field, but who rest with good conscience after promoting a National Research Council and establishing a National Research Institute; and benign neglect from those who, having adventured themselves into the loosely defined "science and technology policy" field, do not visualize that anything more is required than to try to formulate policies and plans. After all - so they reason - they have enough problems convincing everyone that they should have both. Thus, why bother with another dimension, and another extenuating task?

This chapter attempts to indicate why it is necessary for LDCs to design a T strategy; what is meant by a T strategy; what has been done in the research field on T strategies; and what should be done in the future. The first part attempts to reach the "unbelievers;" the second, to define a conceptual framework and the scope of the field; the third, to visualize the "state of the art;" and the fourth, to define what is researchable in the field and to formulate a research program.

Why is it Necessary to Have a Technological Strategy?

The Absence of Explicit Technological Development Strategies

A paradoxical situation arises among many decision-makers in LDCs and also among many policy-analysts in international organizations dealing with development problems: Technology is omnipresent in almost every developmental issue, but technological strategies are missing. Technology is taken as a "constant," as an exogenous input to be bought outside whenever needed, or to be taken "off the shelves" and provided by foreign consultants and experts; but not as a "variable" to be nurtured and managed as part of the development strategy, as an endogenous factor of the process of development to be promoted, developed and used. Technological development is not considered as a subobjective of the development drive. In summary, technology is implicit everywhere, but technological strategies are nowhere to be found.

This benign neglect brings a clear-cut bias into development policy analysis. Those development issues that have strong implicit technological

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(1) This work was carried out with the aid of a grant from the International Development Research Centre, Ottawa, Canada. The views expressed are those of the author and do not necessarily represent the views of the Centre.

connotations are either evoked as economic problems and are dealt with exclusively by economic policy measures and instruments; or, even when technological issues are explicitly mentioned, instead of developing a technological strategy to deal with them, they are only handled implicitly through economic traditional policies. Furthermore, even in the few cases when technology is used as a development tool and not only taken as a constraint, and even when technological policies are attempted, the whole effort tends to be concentrated on the "microplanning" of research activities (inventory of the S&T system; sectoral research requirements, etc.), instead of defining the major orientations, identifying the long-term options of the S&T effort, and the priorities attached at the "macrostrategic" level. In one word, even when technological policies might be "in" (like in the Latin American context), technological strategies are definitely "out."

As an example, the evolution of the Latin American thinking provoked a gradual shift in the policy emphasis given to the components of the technological development process: (1) the S&T infrastructure; (2) the international transfer of technology; and (3) the application of local technology. But no previous definition of an overall strategic orientation for technological development was present. Some partial implicit strategies could be derived from the previous approaches, but no global explicit technological development strategy was generally formulated; "ex-post" implicit strategies could be assumed, but no "ex-ante" explicit strategies were delineated. The partial strategies that can be detected - "laissez-passer," dependent strategy for the first stage; defensive strategy for the second stage; defensive-offensive for the third stage - are implicitly deducted more than explicitly stated. They can be inferred a posteriori, but they are not action-oriented positions established "a priori." They are, to a large extent, reactions to the excesses of the previous stage; for instance, the second phase is more an instinctive reaction to a previously unknown fact - the imperfections of the technological international market - than an elaborated strategy as such; and the third phase is in turn originated by the search for a way out of the second, of a "negative" "passive" controllist attitude, without dynamic projections.

In essence the Latin American experience seems to show first, the failure of implicit internal "push-supply" interventionist approaches, combined with open, "laissez-passer" external technology policies; the failure of using the classical recipe of establishing a National Research Council and a National Technological Institute; the failure to do anything else about technology progress, as well as the failure of strict controllist approaches of exclusively defensive strategies, with no positive orientation of the internal supply; and of expecting that the setting-up of a National Register for T imports will solve by itself technological dependence. Some have argued that these failures could be attributed to the Latin American attitude of promulgating a law and establishing an institute, and resting with the nice feeling of having solved the problem. But we are convinced that there is more to it than a "folkloric cliché." We feel that something essentially wrong is behind the classical recipe given by international organizations and "donor" countries; that the strategy itself is wrong; or worse; that there is no strategy.

This critical appraisal of the experience, derived in the technological policy field, tends to conclude that the formulation of strategies is a most neglected area. But what are the consequences of the absence of any explicit technological strategy in the actual context of underdevelopment?

Technological Dependence as a Structural Element of Underdevelopment

In the absence of any technological strategy - bringing implicitly a liberal technological model of laissez-faire, laissez-passer - technological dependence is being reinforced when advancing along the industrialization path, and is thus being built-in as a long-term structural problem. Let us analyze first some of its causes and contextual factors, then its effects, and finally its constraints.

When LDCs advance along the path of industrialization, from the initial stages of import substitution of consumer goods to the last stages of import substitution of capital goods, and from the initial phases of export of low technological intensive goods to the final phases of exportation of high technological intensive products (Figure 1), some obvious consequences appear in the technological realm: (a) Technological requirements increase dramatically all the way along the path of industrialization, and in a geometrical manner towards the last "outward-oriented" phases. Specially critical is the shift from import-substitution to export-oriented approaches, where increased demand pressures for technological sophistication are put forward by foreign markets, when compared with "easier" home markets. (b) The corresponding increased technological demand orients itself heavily towards foreign sources, owing to a complex set of reasons: the weakness of the local scientific and technological infrastructure; the linkage problems with the productive system; its bypass from the flow of imported technologies; the marginalization of the local technical base from the process of technico-economic decision-making of the country (mainly from investment projects evaluation); the specific characteristics of the process of technical decision-making that tends to privilege foreign in relation to indigenous technologies: lesser risks, shorter time periods involved, and above all, because a different, more convenient type of product is bought (local research institutes are offering only a "commodity" at the level of R, while foreign sources are selling a "commodity" at the level of R+D+E+P+M: a complete "product" involving research, development, design engineering production and marketing); the important role played by foreign investment and transnational corporations; the characteristics of bilateral aid, with tied-up credits; and the characteristics of international financing favouring the participation of foreign consultants and experts, as the main source for technical decision-making.

As these are some of the causes and contextual factors of technological dependence and are tied-up to the prevailing implicit "liberal" technological model derived from an absence of any explicit technological strategy, what are, in the present economic order, the effects, problems, and constraints,faced by LDC policymakers?

The effects of technological dependence appear, in political terms, as the loss of autonomy in decision-making; and in overall economic terms, in the lack of a basis for a self-reliant development, in that it affects unfavourably the chronic balance of payments deficits of LDCs and the deterioration of their terms of trade. The first effect is somehow obvious because the cost of technology and technology-related services augments dramatically when technological requirements increase and when research intensive sectors and products are involved. Secondly, the effects of technological dependence are also detected in the deterioration of the terms of trade. Even when LDCs reach the level of exporting capital goods (technology embodied products), they are still facing a deterioration of their terms of trade, which is

qualitatively different from the "classical" previous situation of exporters of raw materials and importers of manufactured goods. The main difference lies in the technological factor. Such deterioration is now due to the fact that they are exporting low technology goods (low priced) and importing high technology intensive goods (high priced). The difference in the technology intensity mix between imports and exports is the main reason behind this qualitative new phenomenon. In short, LDCs still face in their last stages of industrialization a deterioration of their terms of trade, which is not due now to lack of appropriate "industrialization" levels, but to lack of adequate "technologization" levels.

The problems and constraints of technological dependence, being compounded during the first phases of industrialization, reach at the end of the path a critical stage: recourse to foreign technology is no longer a viable substitute for the building up of a national "industry of technology." When entering into the intermediate and high level technological sectors and products, which constitute the "classical domain" of industrialized countries' predominance in world markets, the required technology, in many instances, is not available in the market. If it is available, many restrictive conditions are usually attached to it because of the potential threat to DC "acquired" shares of the capital goods markets, and these are mainly in terms of export limitations to avoid any possible danger of interference in the current subdivision of world markets. At this stage, even for buying in the technology market, it is required to have its own technology in exchange (interlicensing is common practice in high technological intensive sectors). Internal technical capability is absolutely essential at this stage. It was already significantly important in the previous phases of industrialization - mainly to buy better -, but in the last phase it is a prerequisite. To buy foreign technology is no longer a substitute for developing the internal technological capability. Industrialization without technologization is no longer viable. The advocates of an "all out" industrialization effort based on foreign technology face now the harsh reality: They cannot advance further in the process. As the successful Japanese experience shows (and as South Korea is attempting to do), it is impossible to succeed at this stage without having previously defined a clear-cut technological development policy, a well-formulated strategy, and having invested heavily in science and technology. To have no technological policy and strategy is no longer a viable alternative at this stage. Technology and not capital accumulation constitutes the critical and limiting factor of development.

In summary, the previous analysis of the problems faced by LDC policymakers, derived from an open model in the current economic order, clearly shows that developing countries are not only facing a situation of technological gaps of enormous magnitude, but that they are facing, in the present economic order, a structural condition of technological dependence. In essence, the industrialization process of LDCs is being accompanied by increased technological dependence, which is itself reflected in a progressive deterioration of the terms of trade. Unless this tendency is changed, the status quo broken, the "laissez-passer" policies in the technological realm abandoned, and some urgent national and international action is taken, the technological gaps will expand themselves into unprecendented levels. But on all this problematique what can be done at the "internal" policymaking level? What sort of action must be taken by LDC policymakers at the technological strategy level? In the first place, what is a T strategy?

What is Meant by a Technological Strategy?

The Need to Establish a Process of Technological Development (TD)

Let us now first examine why technology is an all important instrument for developmental purposes, and should be made explicit in any strategy. It is probably stating the obvious to say that the importance of technological progress for economic growth has been largely recognized in economic theory and practice. Industrialized countries, East and West, have attached great importance to technological advancement to reach growth and trade targets, and have organized specific programs of technological enhancement to reach their political, economic, and social goals. On the other hand, developing countries are confronted with dramatic increases in their relative technological gap with developed countries. These are reflected by the fact that on the average, according to UNCTAD statistics, their rate of importation of technology augments at a rate of two and a half times their rate of industrial growth. In one word, LDC industrialization tends to be accompanied by a growing technological dependence from foreign sources, as previously shown.

This long-term structural problem can be illustrated by how LDCs are facing, in the technological field, the classical "vicious circles" of underdevelopment: In the initial stages of industrialization, there is small demand for technical change; this brings no pressures to build up the technical infrastructure, and the corresponding lack of local technological supply; this in turn means that growing technological demand derived from a further advance in industrialization is met by foreign sources; this in turn reinforces the weakness and increasing marginalization of the local technological infrastructures; consequently, owing to the lack of appropriate local supply, a larger importation of technologies takes place, etc. The whole "problematique" of a strategy for technological development is how to break the endemic "vicious circles" of technical underdevelopment, and convert them into a "virtuous spiral" of technological accumulation that will back up the development process.

The Nature of TD: A Conceptual Framework

By making an analogy with economic development, technical development can be conceived as a process of production, distribution, consumption, and commercialization of an intangible commodity: "technology." It constitutes per se an extremely useful conceptual framework to define the content of a technical development policy. Technical development can be considered as a continuous process which includes the stages of generation (research), diffusion (technology transfer), and application (technical innovation) of knowledge. Technical development only takes place when the three stages are harmoniously developed and linked (see Figure 2).

Figure 2 stresses the need for complete interaction between all components of the process and for harmonious development of all of them. From the viewpoint of its impact on development, the creation of new knowledge is worthless unless it is incorporated into the production system as technical innovation. On the other hand, exclusive concern for the demand and promotion of technical change, to the exclusion of developing the indigenous capacity to generate knowledge, will lead to total dependence on foreign technology, and lack of efficiency in its utilization. The essential characteristic of development is not so much the generation and accumulation of wealth per se, as the internal capacity to generate, distribute, and invest wealth. Similarly, in technological development, emphasis on application of knowledge

without promoting the indigenous capacity to create knowledge will bring higher levels of "technical change," even higher levels of "technical progress," but not of "technical development." For technical development to occur, all the components of the process must be developed in full harmony.

Creation of knowledge constitutes a "supply" that should be followed by its application; on the other hand, the capacity to apply knowledge has a powerful "demand" effect that activates both internal creation of knowledge and importation of technology. Technical development will be determined by the interaction of technology supply, as the output of the scientific and technological system, and technological demand, as put forward by the productive system. Therefore, a policy for technical development should make use of a series of instruments that tend to balance and orient both supply of and demand for technical innovation.

A Policy for TD: An Analytical Model

A technical development policy has two components: (i) the promotion of the domestic capacity for production, dissemination, and application of technologies; and (ii) the orientation and selective control of technology transfer. In other words, a technical development policy requires an adequate combination of: development of a scientific and technical capability for domestic production and dissemination of technologies (supply of domestic technology); development of a capability for technical innovation, i.e. promoting a series of technicoeconomic and social measures to increase the propensity to use and apply new technologies (rate and orientation of the demand for technology); and an organized process of importation of technologies, through proper evaluation, selection, adaptation, and improvement of imported technologies and their adequate mix with indigenous technologies to reach the appropriate balance (regulation of external supply).

Traditional conceptual approaches to "science policy," originally developed in industrialized societies, were almost equating it to "research policy." A much wider scope is required, because of the critical importance for developing countries of the process of diffusion of technologies, of promoting the demand for technical change, of assisting the process of innovation, and of improving and regulating the flow of importation of technologies. This broad conceptual framework could be retained as the analytical model to be used for guiding our enquiry.

It should, however, be kept in mind that this model is built up only on the "internal technical objectives" of improving the process of technological development "per se." But this process is governed by societal values and must be directed towards overall development objectives of economic, social, and cultural nature: "external overall objectives." The technical development goal (internal objective) should be accomplished under a broader framework of overall political and socioeconomic goals (external objectives). The objective of TD is only a subobjective of global development; it is only another dimension of it, although most critical. Any "project of civilization," any sociopolitical goal, requires a corresponding T capability. Consequently, we should be centrally concerned about how to build up that basic capacity, regardless of political orientation or lifestyle. A "closed" model, centred on the internal objectives of TD, is therefore essential to compare, on an international basis, many experiences framed by different socioeconomic approaches. Our model is, on purpose, a "neutral" model in sociopolitical and economic terms, in order to be able to guide an international comparative analysis that crosses all these dimensions. As it must be applied to different socioeconomic contexts, it

should be able to describe the process of TD in all these environments, and be of generalized utilization.

It is necessary from the start to acknowledge its advantages and limitations. It describes a process and its components, and permits the classification of the corresponding strategies. But it cannot pretend to allow the discussion of fundamental political and policy questions: TD why?; TD for what purposes?; TD for whom? It is only designed to answer the "how" and "where" questions: "how and where" to build up a TD capability (internal objective), to be subsequently applied for specific overall societal goals (external objectives). It is essentially a model of analysis of TD strategies.

The Concept of a TD Strategy

The military have been using the concepts of strategies and tactics for centuries. It is time to apply them to technological development purposes. Everyone has the intuitive concept that strategic choices are long-term decisions taken in order to reach certain objectives, while tactical ones are of short-term nature. But on top of the different time periods involved, there is also a more substantive differentiation: The strategic choices of priority areas tend to be guided by "external" societal objectives; whereas the selection of technical projects and problems is of a tactical nature, and is done predominantly with "internal" technical criteria. Moreover, we might define: policy, as the doctrine and principles for guiding action; and strategy, as the overall orientation, priorities, and sequence of actions designed to attain policy objectives. The concept of strategy implies a well-articulated approach in pursuit of a particular objective, defined as policy. It involves defining the general principles of operation and the broad choices between major alternatives.

When applied to the S&T field, a strategy for TD consists, in the overall orientation, of the major options and basic priorities required to implement a TD policy. T strategies should make explicit the major options taken, in order to evaluate their adequacy to the previously defined policy. The trade-off between the conflicting objectives of the overall development policy, to define the concentration of national efforts among several goals, is basically a strategic decision. It must be done at the overall development and TD levels, and both are interlinked. A technological development strategy must be evaluated by political, economic, social, and technological criteria, in accordance with societal development priorities; it must be inscribed in the overall development strategy of the country.

For that reason, in most cases, TD strategic decisions are not taken generally by the institutions in charge of the S&T system, but by central development planning bodies. The "upper" central institutional structures are generally in charge of strategic decisions (for instance, concentration of efforts in priority areas); the "intermediate" structures are in charge of tactical decisions (for instance, distribution of funds among projects and institutions); while the lower ones are in charge of execution (i.e., research itself). Accordingly, the global development agencies are generally in charge of defining T strategies; while the Ministries of Science and National Research Councils are in charge of tactical decisions.

In summary, policies answer the why and what for; strategies answer the how, where and what; and tactics answer the when and which. Policies provide objectives and overall guidance; strategies define the major options and priorities; and tactics implement them.

After these conceptual and terminological precisions, let us define in concrete terms the model of analysis to be used for assessing TD strategies: The basic components of a T strategy are essentially given by the elements of a TD policy: internal supply; external supply; demand and orientation of TC. But a fourth component, of most critical strategic importance, is the balance between foreign and internal flows. The mix of both inputs characterizes essentially the strategy: There is an evolution from dependent, to imitative to defensive to offensive strategies, whenever the relative importance of the indigenous inputs in relation to foreign ones increases progressively.

Accordingly, the four major components of a strategy for self-reliant technological development are: (i) to promote the utilization of local technological supply by reinforcing the technological infrastructure and by improving the linkage between the technical and production systems; (ii) to regulate the flow of T imports in order to make: better evaluation of alternative T; adequate selection of appropriate technologies; proper absorption of FT; and improve the bargaining capability for the purchase of FT; (iii) to balance both inputs, through "opening of the package", in a manner that will gradually incorporate more indigenous technologies into the technological mix; and (iv) to promote the demand for technological change, and to orient adequately its rate (how much), concentration (where), and direction (what kind), through proper mechanisms of T diffusion.

As visualized in Figure 3, the TD strategy is characterized by three inputs: linkage with indigenous sources, regulation of foreign sources, and the balance of both; and by three characteristics of the "output": rate of TC (how much), sectoral concentration (where), and orientation of TC (what kind), which constitute essentially the "results" of the strategy being applied. These parameters are essential to analyze the characteristics of any TD strategy. The most important components of any TD strategy are not those traditionally emphasized by classical "science policies." The most critical and most neglected ones are the interfaces: between the local scientific and production systems (IT linkage component: vertical transfer of technologies); between the foreign sources and the local production system (FT regulation component: international transfer of technologies); between the enterprises of the production system (diffusion component; horizontal transfer of technologies). Essentially, each strategy is defined by three regulatory elements: regulation of IT (linkage), regulation of FT (balance with IT), and regulation of T demand (orientation and diffusion of TC). In these interfaces and regulatory elements lie the major difficulties and problems faced by LDCs.

The previous conceptual framework was evolved through many years of experience in Latin America. As in any model, it is based on some explicit assumptions (T as a commodity; TD as a process) and implicit ones (the concept of technological self-reliance). It certainly oversimplifies reality. But when applied to concrete situations, it has shown to be fully operational, to the extent that it allows a description and analysis of different experiences around the world. The following section shows how it was used to conduct an extensive research project in the technological strategies field.

What Has Been Done in the Research Field on Technological Strategies?

Although we are not pretending that our research enquiry is representative of "what is going on" in connection with technological strategies, it constitutes, however, a very comprehensive comparative review of alternative technological strategies on a worldwide basis. Because of its very ambitious aims and its extensive coverage, it constitutes a major piece of research in a very important field.

Characteristics of the Research Project Undertaken

Because of the critical importance of offering to policymakers in developing countries a systematic review and comparative analysis of the technological strategies being followed by countries with different levels of development (North-South dimension) and with different economic and social systems (East-West dimension), the International Development Research Centre (IDRC) sponsored an extensive research project in this field during 1974-1977. As no systematic comparative analysis had ever been made of such a critical issue, and there had been no attempt t give a global worldwide perspective, it was felt timely to provide LDC policymakers with a full "spectrum" of alternative T strategies.

The objectives of such research were consequently twofold: (i) to undertake an international comparative study of the experiences, in promoting technological progress, of countries at various levels of development and with different social and economic systems (the assessment of these experiences being concentrated at the strategies level), altogether with a detection of the major policy objectives and some initial identification of the main mechanisms utilized; and (ii) to present the alternative approaches to policymakers in developing countries, in a manner that facilitates an assessment of their relevance to each country's conditions.

The study was oriented mostly as a fact-finding project, with the objective of conducting a technical analysis of the different experiences. Consequently, no rigid approach of testing and proving specific hypotheses was followed. However, the following lines of thinking were explored: (i) on the "East-West" comparison, an analysis of relative differences and similarities of the experiences was conducted, to explore to what extent there is some convergence of approach; to what extent the "rules of the game" of industrial growth and technological accumulation impose some basic analogies, irrespective of the political-social-economic context; or in other terms, which are in this field the "constant" and the "variable" aspects, when the sociopolitical environment changes; and (ii) on the "North-South" comparison, an assessment of the relative relevance or irrelevance of the strategies being applied by developed countries, to explore to what extent there could be some similarity in the management of the technological development process, irrespective of the levels of development; or on the contrary, to what extent there must be basic differences of approach.

The analysis of the collected information was therefore organized along two basic dimensions: (i) a comparative analysis of the experiences developed by countries with socialist and capitalist political systems (the centrally planned or market economic structures), in terms of differences and similarities between their technological strategic approaches (East-West analysis); and (ii) an assessment of the most relevant aspects of those experiences for the developing countries, in terms of identifying the strategic elements that could be of more direct relevance for their own situation and could be more easily adapted to their own conditions. (North-South analysis)

The project was undertaken with a very specific audience in mind: the policymakers and decision-makers dealing with technological policy matters in developing countries. It was intended to present to them various alternative T approaches, while making explicit the environmental factors associated with each strategy, especially the interaction of historical, cultural, socio-political, and economic dimensions with technological policies and strategies.

This knowledge of the contextual factors should allow them to verify to what extent they are, or are not, applicable to their own conditions.

The methodological approach heavily stressed "interviewing," compared with the more classical methods of analysis of primary and secondary sources of published information. Strategies are seldom formalized and much less publicized. Nothing replaces the experience, views, and assessment of a policymaker on the very strategy he is applying, and which is behind decisions taken; especially so, when the output of the enquiry is directed towards other policymakers. On the whole, however, a very large amount of information was assembled through various channels and means: published and unpublished material collected during the field work; specific contributions of consultants who were studying deeply the experiences of some of the countries involved (N. Jequier for Japan, J. Sigurdson for China; F. Chesnais for Yugoslavia, etc.); and extensive interviewing of "policymakers," "policyusers," and "policywatchers" during the field work undertaken in the countries being studied.

The selection of countries was made on the basis of analyzing and comparing different alternative models of technological development in countries with different socioeconomic systems and at different levels of development. For instance, France was included as an illustration of a "dirigiste" approach; Italy as a "liberal" approach in science and technology with little governmental intervention; USSR as a centralized bureaucratic model; Poland and Czechoslovakia, to analyze the application of the Soviet model to smaller economies with different levels of industrialization; Yugoslavia as a decentralized approach open to international markets; China because it offers a unique "walking with two legs" approach in science and technology; Japan as an example of technological development model based on control and regulation of foreign technology and investments; India because of following an interventionist approach with a "self-reliance" objective; and South Korea as a developing country following an "outward-looking" strategy under an interventionist approach. From another perspective, the coverage included a sample of the First World (capitalist developed countries): France, Japan, and Italy; the Second World (socialist developed countries): USSR, Poland, Czechoslovakia; and the Third World (from both political orientations): Yugoslavia, China, India, and South Korea - in essence a balanced sample, in terms of the political and development dimensions.

Sociopolitical Dimension

Development Dimension		East Second World	West First World
	North	USSR Czechoslovakia Poland	France Japan Italy
	South	Yugoslavia China	South Korea India

The analytical model was centred on the previously discussed conceptualization of a technological development strategy. Accordingly, we concentrated the comparative analysis on the four strategic critical components of

a technological development policy: (i) linkage between the research and the productive systems (or following the terminology used in socialist countries: the research-development-production cycle); (ii) control and regulation of the flow of imported technology; (iii) the proper balance of imported and domestic technology; and (iv) orientation of the demand for technical innovation and the diffusion of TC. The comparative analysis was thus mostly concentrated on the linkages and the interfaces: the linkage between industry and the scientific systems; the interface between demand and local supply, between foreign and indigenous technologies, etc.

The Potential Interest of the Research on Technological Strategies

Many factors tend in fact to underline the potential interest of this research line:

First, the interest derived from cross-cultural international comparisons. Cross-national research is required for a true probing generalization of policy measures and an accurate assessment of their scope and qualifications. Any kind of overall, general guideline for an LDC strategy for TD could not be attempted without having a sufficient wide sample of different national experiences and a range of strategies. Comparison is essential to all science. Cross-national research is of great value, even to someone not interested in the particular country being surveyed. The political scientist interested in development problems, and the LDC policymaker himself, could become a better analyst or operator if the corresponding phenomena were fitted into a perspective that included information from other political, economic, and technological systems.

Secondly, political and social scientists have underlined both the interest and limitations of policy comparative exercises. As expressed by C. Freeman (2): "The importance of evaluation of policies in the context of international comparisons is undeniable but very complex. Problems of values, of cultural bias, of individual bias, and of the nature of the political process are inextricably involved in policy research. The most that can be hoped for is that research will enable better informed judgements and decisions to be made, not that these will become "scientific." Thus, although we must not expect too much of policy research in the sense of providing unequivocal answers, we should expect to reduce our ignorance and to increase the probability of being able to make good "decisions"." From these words, which we fully endorse, it is clear that the conclusions of our international comparative research project cannot be expected to tell LDC policymakers what to do, but to help them in deciding what to do.

Thirdly, comments related specifically to the implications of comparative exercises in science policy tend to show also their importance and difficulties: "Science policy owing to its nature and implications, stops neither at political nor geographical frontiers: by comparing data, confronting structures and orientations, and putting national experiences into perspective, it is possible to establish a system of reference and discover the common denominator of different policies." (3) Our project was aiming

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(2) Introduction to the OECD study. 1975. Policies for the stimulation of Innovation. Analytical Report.

(3) Piganiol, R. Introduction to the "USSR Science Policy Study". OECD, Paris.

precisely at these elements to compare experiences and confront orientations (on T strategies formulation and implementation), putting national experiences into perspective (by stressing the conditioning factors of the strategy, the problems faced, and the solutions attempted), and define a common denominator (by identifying the elements of T strategies East and West).

It is further recognized that: "it is difficult to perceive the essence of science policy through tests or even results. It should involve participation in its elaboration first, or at least unhampered methods of enquiry. We need an overall approach to see simultaneously the effects of all the facets of the problem." (4) We have attempted in our project to overcome the previous difficulties by designing a conceptual model and a framework of analysis that provides an "overall approach" to our field of concern; and in designing a methodology that, by privileging direct interviews with "policymakers," "policywatchers," and "policyusers," tends to avoid some of the problems mentioned and spotlights the potential interest and impact of its findings. Out of our research experience, we cannot emphasize enough the fundamental importance of the "interviewing" approach for our purposes. Strategies are largely implicit. They cannot be found in books, or in documents of the UNESCO type. Only by interviewing those responsible for shaping them (policymakers), assessing them (policywatchers), and implementing them (policyusers), can they be fully identified and understood.

Fourthly, the present period of "detente and peaceful coexistence" brings certain decreases of international political and ideological tensions, which provide a more favourable context for an attempt to make a neutral, comparative assessment of national technological experiences, East and West. Such an ambitious goal was never attempted to our knowledge. Ideological dogmatism and political tensions tend to preclude the knowledge and analysis of experiences of the "other" system. The implicit assumption of that premeditated ignorance is that different political and economic systems must have different technological approaches. An overall unprejudiced analytical comparison - that will test to what extent this is true, or to what extent similar technological approaches and strategies can be carried out in different sociopolitical systems - seems very timely.

Finally, we should stress the importance of comparing T strategies as such. As discussed in the first part, a most important element to spotlight the interest and importance of our research effort for LDC policymakers is derived from our previous experience in the field of S&T policy and planning in LDCs. It is our assessment that the most neglected and overlooked area in the whole field of T policy and planning is the initial clarification of the "major options:" i.e., a T strategy. Too much emphasis has been placed on "microplanning" of the technological activities (inventory of the S&T system, the definition of T "needs", etc.), without determining first the overall direction to be given to the S&T effort. Many studies - "on the shelves;" extensive research not leading to policy implementation; and diagnostic studies in search for a strategy - are silent but eloquent witnesses of our assertion.

An Overview of Technological Development Strategies

A Typology of TD Strategies: To present our results it may be of

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(4) Piganiol, R. Introduction to the "USSR Science Policy Study". OECD, Paris.

value to make reference to the typology that we used in our research, to analyze country experiences, and to conduct international comparisons. A typology, like any descriptive model, may be useful or useless, but it is not intrinsically true or false. One criterion for its utility is the readiness with which it can be operationalized. For our own operational objectives, we required a typology whose dimensions cut across the East-West and North-South axes, in order to compare experiences from both.

We selected two major dimensions to characterize the different political systems and their socioeconomic policies, TD policies and strategies being an integral part of them: (i) The political system dimension is characterized by its decision-making process. The position in the whole spectrum of the different political systems could be better defined and assessed, for our purposes, by the kind and degree of centralization in the decision-making process. The degree of government intervention along the centralization-decentralization path constitutes a very representative factor to classify the different countries' political systems, and the kind of T strategies followed. (ii) The social and economic policies are characterized by the degree of opening to the external world. The orientation towards foreign interchange constitutes a decisive characteristic for the analysis of TD policies and strategies.

In essence, we are supposing that, in any political system, policies in the economic and social fields can be sufficiently well defined by these two dimensions to facilitate their analysis. Technological policies cannot be an exception as they are immersed in the corresponding political, economic, social, and cultural policies. The first dimension characterizes the internal functioning of the political system, and the second one its external exchanges; the first one constitutes basically a political dimension, and the second one basically an economic-social policies dimension. Between the two, we are able to define the position of the different countries in our field of concern - TD policies and strategies - as we are covering the internal and external relationships of the system being analyzed, and the whole political-economic-social context.

It is, however, necessary to make more explicit the "direct relationship" between the dimensions of our typology and our specific field of analysis: TD itself. In order for the typology to constitute a suitable tool in guiding the comparative analysis of TD strategies, it is essential that the two chosen dimensions are by themselves characteristic factors in our field of concern. It is our contention that both dimensions influence directly the components of the process of TD and characterize the strategy of TD: (i) The orientation of and demand for TC is being affected by both factors, the pressure for TC tending to diminish while moving towards the centralized-bureaucratic, and towards the "closed economy" type of models (as it will be confirmed when analyzing and comparing the Soviet Yugoslav and Western models). (ii) The orientation towards external exchange affects mostly the supply components: the foreign and local sources and their relative balance. In short, overall TD strategies are directly conditioned by the two variables of the typology, and are thus characterized by it: the demand side mostly by the decentralization; and the supply side by the opening dimensions - although, again, both components are affected by the two factors. On the basis of the previous considerations, a tentative typology of the countries experiences has been drawn (see Figure 4), by using both major dimensions - the degree of centralization and decentralization of the decision-making process; and the degree of opening of the society to external world.

A Review of the Various T Models: We identified several different T models, as a result of our fieldwork. Their location in the typology reveals a few interesting findings. It shows first three main different types of T models, along the central diagonal of the diagram:

(1) A centralized and semi-closed (5) model followed in the "traditional" period by USSR, Poland, Czechoslovakia, trying to evolve later, during the 1965 reforms, towards more decentralized and open models. But owing to ideological barriers, an orthodox return to centralization is currently underway.

(2) An interventionist and protectionist model followed by Japan and South Korea; Japan evolving in its last phase towards a more open model, and South Korea just introducing some "liberalization" measures. India joined the "group" a few years ago, coming in reverse direction from an open-interventionist situation.

(3) A decentralized, open model followed by Italy and Yugoslavia (after the 1953 and 1965 reforms). Both models tend lately to evolve towards more interventionist approaches; but, while Italy maintains a fully open model, Yugoslavia - fighting ideological barriers - seems to attempt to introduce some initial protectionist measures.

(4) France and especially China are situated somehow out of the central diagonal: France with an interventionist-open model; and China with oscillating positions between a basically decentralized and semi-closed model in Maoist periods, that evolve in Liuist periods - fighting ideological barriers towards the central case.

The central diagonal corresponds to the more "classical" approaches; decentralized ones tend to be open; centralized models tend to be more closed; and government interventionist approaches tend to be protectionist. The "classical" approaches along the diagonal are in a continuous state of "flux:" the most extreme models of the diagonal would tend, if liberated from ideological constraints, to move towards the "central case." In its defect, they move to the adjacent case: the liberal models towards greater interventionism; the centralized towards more open positions. China is moving periodically in and out of the central diagonal, in accordance with the pendulum reactions derived from the "struggle of the two lines".

If we include the detailed sequence of the different T strategies followed at some point in time, the only "vacuum" in our typology corresponds to the "centralized-open" model which is not covered in our sample. It does not seem a very common situation, but it would be interesting to introduce it in any further research in order to complete the whole spectrum of possibilities. (Would some Middle Eastern Countries fit into this category?)

The most important conclusion of our overall review, which is clearly revealed by the typology, is that TD models are not bound by the system of ownership of the means of production. TD strategies are not biunivocally linked to a socialist or a capitalist orientation; or in other words, there is no direct correlation between both: different TD strategies can exist among similar sociopolitical systems and similar TD strategies can be found between

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(5) We could detect in our field work no fully closed, autarkic model in the T field. But in relative terms they are closer than other models, at least in the full central control of T imports.

different sociopolitical systems (to the extent that they are characterized by the property of the means of production).

Let us elaborate further this central proposition. First, there are differences in T strategies among countries with the same basic capitalist or socialist orientation. We initially supposed, and we were later able to confirm through the analysis and comparison of national TD strategies, the existence of three different models of TD strategies in the present multipolarity of the socialist world, which are dramatically located in three well-apart corners of our typology: (i) the Soviet model, followed by the USSR, Poland and Czechoslovakia, a centralized, semi-closed type of approach that corresponds basically to the same kind of technological "bureaucratic centralism" (with minor variations between each of them); (ii) Yugoslavia following, after abandoning the Soviet approach, an open-decentralized-participationist model, that corresponds basically to a fully fledged "technological liberalism;" and (iii) China following, also after abandoning the Soviet model, pendulum oscillations between decentralized, semi-closed (Maoist line), and more centralized and open positions (Liuist line), in accordance with the "struggle of the two lines." China's ambivalent approach basically corresponds to what might be called a technological "democratic centralism" model.

In a similar manner, we can also detect among capitalist countries, some clear differences in TD approaches, between Japan (highly protectionist and interventionist TD strategy), France (interventionist and open strategy), and Italy (open-decentralized, "liberal" technological strategy).

From another end, we can identify total or partial similarities in T strategies between socialist and capitalist countries, such as between Italy and Yugoslavia, having both technological liberal policies (decentralized, open models); Japan and USSR, having both technological "protectionist" policies (with different degrees of control: in the second case, it is fully centralized, while in the first it is only selective protectionism); and France and Poland, having both technological interventionist policies (based on heavy sectoral concentration).

We have, therefore, "internal" differences in TD strategies between socialist countries, as well as within capitalist countries; and similarities of TD strategies between capitalist and socialist countries. This latter finding of the existence of some similarities of TD strategies should not be surprising if we consider, first, the coincidence in the finalities of the S&T effort. Both capitalist and socialist doctrines are based on similar materialistic, positivist philosophical avenues, and have the same mechanistic approaches and deterministic confidence in science and progress (whatever it means and wherever it leads). They have the common objective of the maximization of economic output through the application of S&T, and consequently a common goal of achieving technological progress, almost as an end in itself (except for the Maoist approach in China and for some recent questioning, mainly in Western countries). Secondly, it should not be surprising if we realize the growing importance of technocracy in modern industrialized economies, East and West. Nowadays, management of the means of production is more important than ownership: shareholders in the West, or workers in Eastern Europe, who theoretically detect the ownership of the means of production, are being gradually or abruptly displaced by managerial-technocratic-bureaucratic rule, which is actually in control of them.

The obvious and important consequence of our basic finding, that TD strategies are not "predetermined" by capitalist or socialist political orientation, is essential for the justification of the potential value of this

research line. LDC policymakers can both select, from East and West, those strategies and/or their elements that correspond more closely to their own internal policies and objectives. No rigid a priori approach of considering only the capitalist or the socialist experiences should be followed because of its direct coincidence with the internal political orientation of the country involved. It gives to our research line full justification and stresses the importance of its potential impact.

LDC policymakers, backed by our basic conclusion of the lack of "ideologization of T strategies," have three extreme models to choose from, which are located at three well-apart "corners" of our typology: the Soviet, the Chinese, and the Western "liberal" models; and one "intermediate" "central" model at the "core" of our typology: the protectionist-interventionist Japanese model (see Figure 6). To this central "case" all three extreme models would tend to converge if liberated from their own corresponding ideological barriers. This "frustrated" convergence merits from LDC policymakers some "double thoughts." We will return to this capital "frustration" and the lessons involved from other LDCs in the following summary of the research project's findings.

An Overview of the Major Findings: What follows is not a summary of the conclusions and findings of a worldwide search for a period of four years involving ten countries, but it is rather an attempt to pick up some of the most relevant points and significative elements identified during our search. It is neither complete nor structured. It only provides the "flavour" of the kind of analysis undertaken, a few corresponding examples, and an illustration of what sort of conclusions can be derived from this type of international comparative research program.

The East-West Comparative Analysis: Similarities and Differences

The constant factors are an indication, for LDC policymakers, of the basic prerequisites in the technological field needed for any industrialization and modernization drive. The following elements seem to constitute, in the T realm, the "rules of the game":

(1) Technological development is taken as a national goal - explicitly formulated or implicitly deducted - connected to political and economic objectives (mostly for growth aims in the East and trade purposes in the West).

(2) The establishment and reinforcement of the S&T infrastructure is a common priority: all models have incorporated some diversification of the S&T activities along a nonoriented, horizontal base.

(3) All models have also incorporated some selectivity, manifested through the concentration of T efforts, in certain critical sectors or problem areas. A sectoral profile of "vertical" technological concentration in certain priority areas tends also to emerge as a common characteristic.

(4) In dynamic terms, all models tend to converge along these "horizontal-vertical" dimensions; they search for the proper balance between diversification (horizontal) and selectivity (vertical). Although centralized approaches tended originally to emphasize concentration and selectivity (Soviet and "Liuist" model in China), and decentralized models (Italy, Yugoslavia, and Maoist models) are more apt for diversified approaches, both tend to converge, under a historical perspective, towards a more balanced vertical horizontal T strategy (towards the intermediate one, followed by Japan, South Korea and to some extent, France). They tend as well to reach an appropriate balance and equilibrium along the "push-supply" and "pull-demand" dimensions of TD strategies

(see Figure 7).

(5) Also, under a dynamic perspective, all models, left to their own rationale, would tend to reach an appropriate balance along the interventionist and protectionist dimensions of our typology, to correct the deficiencies caused by "extreme" positions along them (as discussed in the previous section).

(6) When considering the critical components of technological strategies, it must be first recognized that all T models allow for partial or total opening to the external world. An external component of technological imports is common to all of them and there are no technological autarkic models. The difference is the relative degree of opening; this in turn seriously affects the mix between foreign and indigenous technologies, influencing directly the "inputs" of the strategy.

(7) In all models, emphasis is given to improve the linkages between the scientific and production systems, between "supply" and "demand" of new technical knowledge. Even similar instruments were tried to improve the "vertical transfer of knowledge:" location of RD activities within the production system; contractual research; use of the engineering design function for linkages purposes; technical extension services; etc.

(8) The importance attached to the diffusion of existing technologies has been traditionally placed outside the "classical" S&T policy domain, still largely dominated by the "research syndrome." But the priority goal of increasing productivity through the diffusion of existing technologies among the productive structure (horizontal transfer), not for being implicit as part of a T policy, is less recognized in its full importance for growth purposes.

(9) Finally, with respect to the "output" side of T strategies - the "how much," "where," and "what kind" problematique - there are a few elements of partial similarity and/or convergence between some models (for instance, the convergence along the "where" and "what kind" dimension between the classical Western and Soviet models, this convergence of qualitative I being at the root of the same lifestyle). But it is here that we witness more elements of dissimilitude, although this is largely due to the fact that within Eastern and Western experiences quite different technological models have been adopted. There is thus no clear cleavage between technological models on an East-West axis, or to put it in another way, the differences among them cannot be traced back to the "East-West problematique."

The variable elements between the various Western and Eastern models are of such varied nature that it is not possible to cover them here. To illustrate the kind of elements identified, the following are a few examples:

First, in relation to the centralization-decentralization issue: (i) Decentralized approaches have higher potential than centralized models for quantitative innovation, for increasing the rate of technical change all along the economic structure ("how much"), as proved by the comparative analysis of the Soviet and Western models, and by the internal experiences of Yugoslavia and China. This is due to generalized pressure and demand for technological change, and to a more favourable climate for innovation all along the economic base. (ii) Centralized approaches are effective, however, in reaching high rates of technical change in a concentrated manner (into very specific priority areas) under high political pressure ("where"). (iii) While centralized approaches are more apt for undertaking selective "vertical" approaches, decentralized approaches, because of their nature, tend to favour diversified "horizontal" structures. (iv) Centralized models have a greater potential capability for the orientation of technical change or qualitative innovation

("what kind"). Decentralized models, because of a high dispersion of centres for decision-making, face greater inherent difficulties in making technological choices consistent with overall political-social-economic goals. In principle, although largely neglected in most cases, centralized models could be more apt for social assessment of technology and adequate choices of appropriate technologies. But the paradox is that those who seem better prepared for such a task are ignoring it because of a set of complex ideological political-economic pressures (for example, the Soviet model); while some decentralized models have tried to overcome their inherent disadvantage by attempting some action, largely unsuccessful, into the whole problematique of social assessment of technologies, and the correlated issue of appropriate technologies.

Secondly, in a parallel manner, the influence of the other characteristic dimension of technological models - the opening to external world - can also be shown at the "how-much," "where," and "what kind" levels. While closer models face greater difficulties in promoting the rate of technological change along the whole economic base, due to lack of generalized demand pressures, they are however better prepared for the orientation of TC and qualitative I, by avoiding the danger of indiscriminate technological imports. Moreover, open models tend to face more difficulties than closer models in the concentration of technological efforts in priority sectors and areas.

In summary, both the degree of centralization and the degree of opening influence directly the output of technological strategies: "how much, where, and what kind." The existence of differences under an East-West perspective can only be traced back to the existence of a different choice in the technological model per se.

The North-South Comparative Analysis: The Most Relevant Aspects

It is more difficult to summarize the relevant aspects that could be derived from each experience for LDC policymakers. We are, therefore, only extracting from each national approach those relevant elements that have been instrumental in shaping our guidelines for a general technological strategy for LDC (see next section):

From France: (i) the importance attached to the concept of formulating a technological strategy: namely, the importance of defining the major options and major orientations prior to any detailed planning of the effort to undertake; and the importance of a concerted strategic action by all social agents involved in the process of TD, over the exclusive reliance on technocratic-methodological approaches; and (ii) the correlation between industrialization vis-a-vis technical infrastructure levels and strategies: to the various stages of the process of industrialization (different industrialization levels and approaches) correspond different critical technological capabilities and different mixes of technical skills and services of the infrastructure (different technological strategies). This interrelation between industrial and technological strategies was also detected in other national experiences (namely, Italy and Japan), although with different specific approaches.

From Italy: the overall lessons derived from a non-research-based successful industrialization and export drive, based on the following elements: (i) the convenience of utilizing the lessons of the product cycle theory in establishing a gradual "up stream," specialization process, from "mature" to intermediate, to highly T intensive products and fields (also confirmed by the South Korean and Polish experiences); (ii) the importance of imitative technical

change, through the spreading of existing technologies (horizontal transfer), especially critical at the dependent-imitative-technological levels; and (iii) for initial imitative strategies, R&D is not the critical component: the internal technical capability is based on technological sources other than R&D as such, mainly management, design, engineering, and marketing skills. The overall interest for LDC policymakers of the Italian experience is derived from the lessons of a strategy oriented to substitute for a relative lack of a sound research capability.

From the Japanese experience we draw: (i) the appropriate balance between promotion and control dimensions in any T strategy: the organization of a controlled competitive system by protectionist mechanisms and incitative competitive measures; (ii) the concept of "infant T" parallel to the classical one of infant industry: the convenience of some initial degrees of T protectionism to develop locally generated technologies, altogether with a gradual process of liberalization, in order to increase their competitiveness; (iii) the gradual passage from imitative to defensive to offensive stages in the "technologization" path: from initial stages of copying foreign technologies, to their adaptation and further improvement, and in final stages to generate brand new technologies (also incorporated in the Eastern European proclaimed approaches); and (iv) the approach of technological development "in reverse": the process of TD on the basis of imported technologies, instead of following the "linear" R&D based, internal supply-push approach of DC. This process of TD "in reverse" requires the regulation of the importation of technologies in order to stimulate and orient their internal production.

From the Polish experience: (i) the open demonstration for LDC policymakers that the previous Japanese strategy of TD "in reverse" can also be attempted from lower levels of technical infrastructure; and (ii) the idea of progressive "entry," for gradual specialization in sectors of higher technological levels, based on the concept of critical mass and of technological complexity (derived from a matrix of intersectorial technical requirements).

The USSR experience is especially relevant to LDC because it constitutes an example of initial T underdevelopment in the process of full technologization, with poor performance in innovation along the whole industrial base due to lack of demand for TC, a separate S&T system, and severe linkage problems. Its most relevant aspects include: (i) the explicit recognition attached to technological development as such, to the extent of conditioning in some cases industrial priorities to it; (ii) the importance of building up rapidly a scientific and technological infrastructure; (iii) the limitations of an exclusive push-supply approach, and the need to combine it with promotion of T demand (as also proven by the French experience); (iv) the importance of undertaking selective efforts of concentration (vertical profile), especially at the first levels of technologization; and (v) the relevance of a sequential approach by starting with a semiclosed approach (although mainly valid for the largest economic spaces), and its gradual opening through the importation of technology, while developing in parallel, and using for its regulation, the internal technological base.

From Czechoslovakia: (i) the danger of applying a model of extreme industrial and technological diversification (a too large horizontal structure) to smaller economies; and the corresponding need to balance the vertical (selectivity) and horizontal (diversification) components in any strategy; and (ii) the convenience of moving away from the classical sectorial approach and concentrating the effort in technological problem areas.

From Yugoslavia, being itself also a developing country: (i) some initial

measures of interventionism and protectionism are indispensable for TD, owing to the negative environmental conditions faced by LDCs: interventionism to build up the S&T base, and protectionism to utilize it; (ii) the convenience of undertaking afterwards some liberalization measures to increase T demand and facilitate linkages; and (iii) this sequential path from interventionism and protectionism towards liberalization should be a gradual move; its timing and scope are essential to avoid the corresponding dangers of a too precipitated move, too early and too fast. (The Yugoslavian experience illustrates vividly the inadequacy of "extreme" T strategies - the Soviet and Western ones. In showing their opposite limitations and the dangers involved in abrupt and wide oscillations between them, it confirms the advantages of a smoother, gradualist approach for TD in LDC); and (iv) the importance of organizational innovations and of a participationist climate to favour mobilization for technical change, which brings higher technological demand and higher supply because of less linkage difficulties. (This is also proven by the Chinese experience.)

From China, self-proclaimed as belonging to the Third World, several lessons can be detected at various levels: (i) the importance of following a balanced "walking with two legs" development strategy of accumulation and distribution, but with emphasis on the distributive aspects; and the need for taking advantage of a dual economy by designing balanced urban-rural, modern-traditional, industrial-agricultural development strategies; (ii) the confirmation of our TD model, balancing production, distribution, and consumption of technologies - again with emphasis on the distribution aspects (the horizontal and vertical transfer of technologies); and of a dual T model of close interaction between FT and IT (abandoning the linear accumulative models inherited from DC), and of an adequate balance of supply and demand components; (iii) the convenience of a "walking with two legs" technological strategy combining and balancing the control of FT and the stimulation of IT (similar to the Japanese experience); and the concentration in priority sectors (vertical) and the diversification along the whole production system (horizontal); (iv) covering and linking the modern and traditional sectors through the establishing of a continuum of appropriate technologies (from small scale labour-intensive to large scale capital-intensive technologies); and (v) the previous technological pluralism is achieved through the organization of a massive technology diffusion network and a systemic approach where rural local industry plays the most crucial role.

General Guidelines for Strategy of Technical Development

Based on the findings of the East-West analysis (supported by its main contention that technological strategies are not predetermined by the political option of the ownership of the means of production) and of the North-South analysis (identifying the most relevant strategic aspects of the various technological experiences), we were able to identify the following major guidelines that could be characterized as a balanced and evolutive strategy for "technologization."

Although our main concerns are the measures to be undertaken by policy-makers at the national level, they must take into consideration the environmental problems linked to the international level. The constraints that affect the usual T liberal models, being implicitly or explicitly adopted in LDCs (interventionist-open, and/or decentralized-open), are mainly those derived from: (i) the international division of labour and the rules of the game of

world trade (with a very imperfect technological "sellers" market); (ii) the role of foreign investment (and the critical strategic behaviour of transnational firms); (iii) international financing practices (and the critical role of foreign engineering-consulting firms to privilege FT); (iv) the essential dualistic characteristic of LDC economies (and the crucial role of the modern industrial sector, as the only one which submits effective demand for TC); (v) the pattern of industrialization (and the primacy of initial import-substitution strategies favouring imports of FT); and (vi) the characteristics of the process of public and private DM (and the tendency to favour FT in relation to IT). Out of these contextual constraints, a structural unbalance in the mix of IT/FT with self-reinforcing effects prevails, and structural T dependence follows; all the more, because on top of the previous political-economical environmental factors (international and national), other "internal" constraints of the S&T system are present, such as: the weakness of the S&T base; the marginalization or bypass of the scientific and T system from the process of DM, both on investment projects and plant operation (the "linkage problem"); and the resulting lack of "competitiveness" of indigenous technological solutions.

LDC policymakers should assess the policy variables, the strategic parameters, that can improve T behaviour, within the current constraints; or to put it another way, the kind of explicit strategic action that can counterbalance the negative effects of the external constraints. It must first be realized that all constraints - the first set of six "political-economic" ones, and the second set of three technological ones - tend to establish, in LDCs, T dependence by reinforcing the structural unbalance of FT/IT. Consequently, our objective of starting a self-sustained process of increasing indigenous T accumulation and consumption runs, in fact, against all odds. Therefore, how should it be tackled? Which general strategy guidelines can be applied?

First, we should realize that the main strategic parameters chosen (T demand, linkage of IT, regulation of FT, rate of TC) affect directly the causes of T dependence: the orientation of T demand, the structural unbalance of FT/IT, the imperfections of international trade, and the marginality of the S&T system. By acting "through them" we can influence the levels of T dependence. But the problem is what kind of a general strategy is applied: how these parameters are combined and used. A few general indications can be given on how to deal with the external constraints.

The fourth and fifth constraints of the set of six economic contextual elements, which are directly linked to the current overall development strategies, must be dealt with by changing the same overall and industrial development strategies that have a negative impact. The essential dualistic characteristics of LDC economies must be dealt with by employing dualistic development strategies, and by stimulating both the modern and traditional sectors, by linking them in a manner so that the latter will be "pulled" - economically, socially, and technologically - by the former. In the process, modern urban industries should be linked to rural traditional plants, and an industrial network should be built up to increase gradually the technological capability levels and dynamism of the whole productive structure (as illustrated by the Japanese and Chinese experiences). In so doing, industrialization will be correlated to "technologization;" whereas now, industrialization occurs at the expense of "technologization," by the very expeditive way of increasing the "foreign technological debt" and augmenting T dependence.

The first three constraints must be counterbalanced by the adoption of T models, with higher initial levels of protectionism and interventionism.

The control and regulation of FT represents the most important element of strategy in order to deal with the imperfections of international trade, and the international financing and investment practices. Against the imperfections and excesses of the international arena, the obvious national reaction on psychological and economic grounds is protectionism and control. Although it is a double-edged tool, it must be carefully used in a dynamic manner by leading towards gradual liberalization, whenever interventionism has stimulated the local technological base.

Thirdly, the remaining constraints should be dealt with directly through the specific characteristics of an appropriate technological development strategy, namely: (i) the marginalization of the S&T system should be dealt with mainly through the increase of the linkage capability; (ii) the weakness of the S&T infrastructure should be alleviated mainly by the stimulation and support of indigenous T sources (promotion of T supply); and (iii) the lack of competitiveness of IT should be counterbalanced by the promotion of the demand for IT, and by the regulation of FT in a manner that the balance of IT/FT will be gradually improved (an "infant T" approach).

The different experiences, which have been analyzed, show to LDC policymakers the advantages of formulating dual-balanced models and evolutive TD strategies: Balanced, to establish the appropriate degrees of complementarity between many of the required dimensions of a T model (accumulation and consumption; interventionism and decentralization; protectionism and openness; selectivity and diversification; supply and demand); and Evolutive, because the adequate relative emphasis or priority attached by anyone to these dimensions should change in time, when advancing along the path of "technologization." This path is characterized by a tendency to improve the mix of IT/FT - to correct the initial structural dependence on FT - in order to reach higher levels of national T accumulation and distribution. In our research, we detected some interrelationships between the levels of industrialization reached and the kind of T strategies followed, characterized mainly by one of its input parameters (the ratio K between the inputs IT/FT), and one of its output parameters (T intensity and the rate of TC) (see Figure 8). It means that T strategies must change along the path of TD, to be adapted to the level already reached and to the following one to be attained. The main problem is how to conceive and when to establish these balanced and evolutive TD models and strategies.

We formulated the following evolutionary strategy by combining the following components:

(1) The promotion of a balanced T model of accumulation, distribution, and consumption. At the first levels of T development, the distributive aspects should prevail to distribute and apply whatever T exists. At later stages, the accumulative ones should receive higher priority (and consequently, the "mix" of S&T activities gets gradually more research-intensive).

(2) The adoption of the appropriate levels of interventionism and protectionism: interventionism to establish the T infrastructure and protectionism to utilize it. At the first stages of development larger levels are required, to be relinquished gradually whenever the effects of structural T dependence are progressively disappearing, and more dynamic and offensive approaches are pursued.

(3) The regulation of the flow of importation of T to stimulate larger internal production and utilization of IT. The essence of this component - promoting "TD in reverse," starting from the reality of current T dependence - is the appropriate combination of protectionism (regulation of FT) with interventionism (promotion of IT). Control and stimulation are the two basic

ingredients of this "walking with two legs" dual T approach.

(4) The increasing participation of IT in a self-sustaining process of T accumulation and consumption should be obtained through a gradual passage from dependent to imitative, to defensive, to offensive strategies (with increasing rates of K=IT/FT) in order to reach more T dynamic phases (with increasing rates of TC, and technological dynamism).

(5) The establishment of a balanced vertical-horizontal profile with corresponding appropriate levels of selectivity and diversification (see Figure 7). The proper balance is achieved by keeping a harmonious relationship between both; the horizontal base is gradually broadened while, in parallel, new sectors of concentration are added. Both dimensions are gradually expanded: either simultaneously and in parallel, like in the Japanese experience; or doing it subsequently one after the other following the Chinese "walking with two legs approach."

(6) The evolutionary strategic path described in (4) should be sustained by the buildup of the most critical T capability for each stage, and the corresponding T skills directly related to it (see Figure 9). The technical infrastructure (diversified horizontal component) should be, therefore, established and reinforced by following a sequential and progressive path of promoting the critical technical capability and skills.

(7) The areas of concentration (selective vertical component) should be selected in such a manner that the sectors of specialization will be gradually more T complex, and the products will be progressively more T intensive (from traditional to intermediate to high T intensive type of products) (see Figure 10).

In a few words, the whole suggested approach is based on the concept that development is a long-term adventure; that there are no "miracles" around - many "so-called miracles" have been started centuries ago, through the cultural and sociological fabric of the society involved; that shortcuts do not exist; and that the shortest route is the pragmatic path of starting from current realities and trying to influence them positively, while taking always into account the existing constraints. For the amateurs of drama, we are offering nothing. For those interested in evolutionary progress, we are suggesting a viable path.

FIGURES

Figure 1.

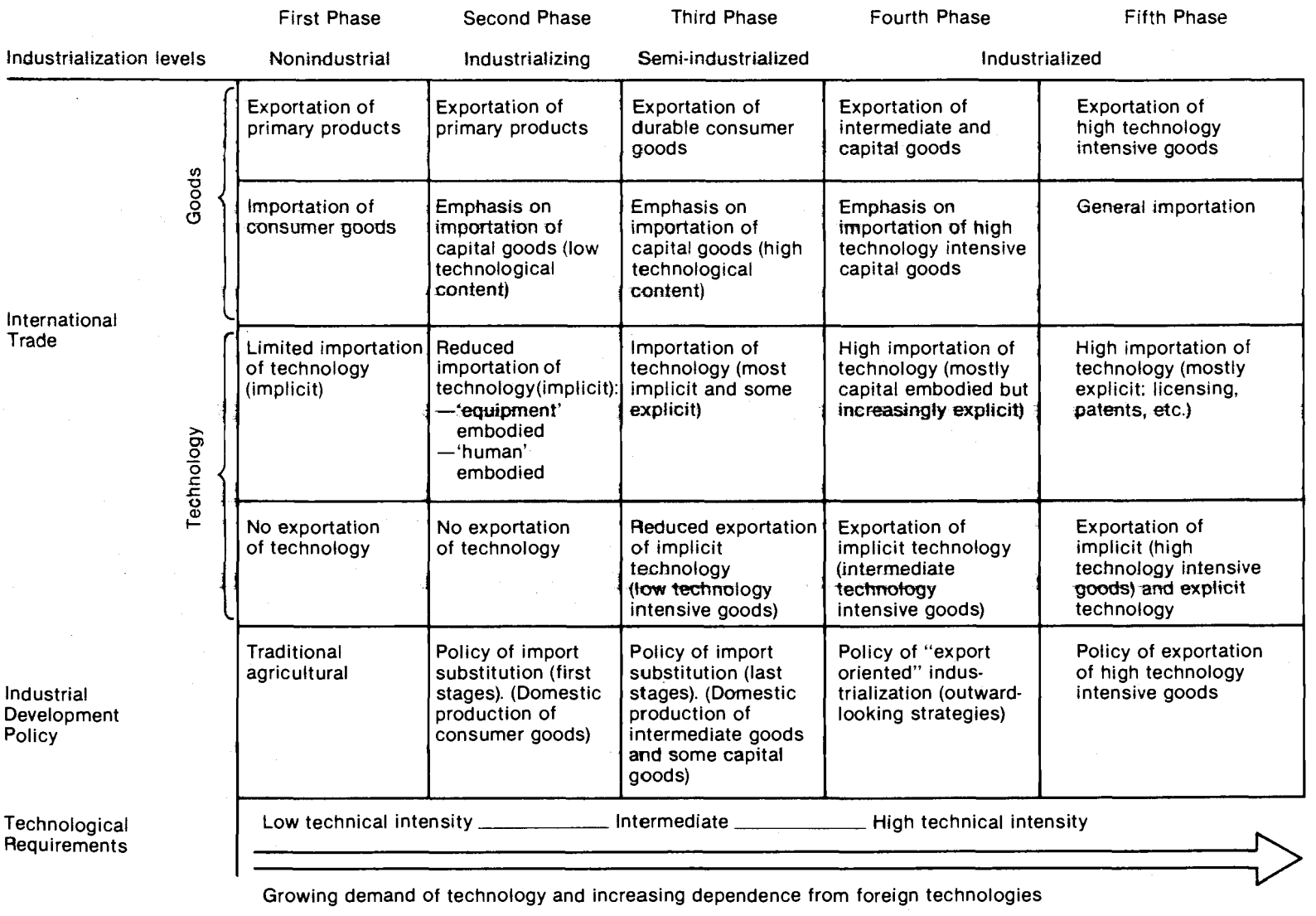

First Phase
Second Phase
Third Phase
Fourth Phase
Fifth Phase
Industrialization levels
Nonindustrial
Industrializing
Semi-industrialized
Industrialized
International Trade
Goods
Technology
Exportation of primary products
Exportation of primary products
Exportation of durable consumer goods
Exportation of intermediate and capital goods
Exportation of high technology intensive goods
Importation of consumer goods
Emphasis on importation of capital goods (low technological content)
Emphasis on importation of capital goods (high technological content)
Emphasis on importation of high technology intensive capital goods
General importation
Limited importation of technology (implicit)
Reduced importation of technology(implicit): —'equipment' embodied —'human' embodied
Importation of technology (most implicit and some explicit)
High importation of technology (mostly capital embodied but increasingly explicit)
High importation of technology (mostly explicit: licensing, patents, etc.)
No exportation of technology
No exportation of technology
Reduced exportation of implicit technology (low technology intensive goods)
Exportation of implicit technology (intermediate technology intensive goods)
Exportation of implicit (high technology intensive goods) and explicit technology
Industrial Development Policy
Traditional agricultural
Policy of import substitution (first stages). (Domestic production of consumer goods)
Policy of import substitution (last stages). (Domestic production of intermediate goods and some capital goods)
Policy of "export oriented" industrialization (outward-looking strategies)
Policy of exportation of high technology intensive goods
Technological Requirements
Low technical intensity
Intermediate
High technical intensity
Growing demand of technology and increasing dependence from foreign technologies

Figure 2.

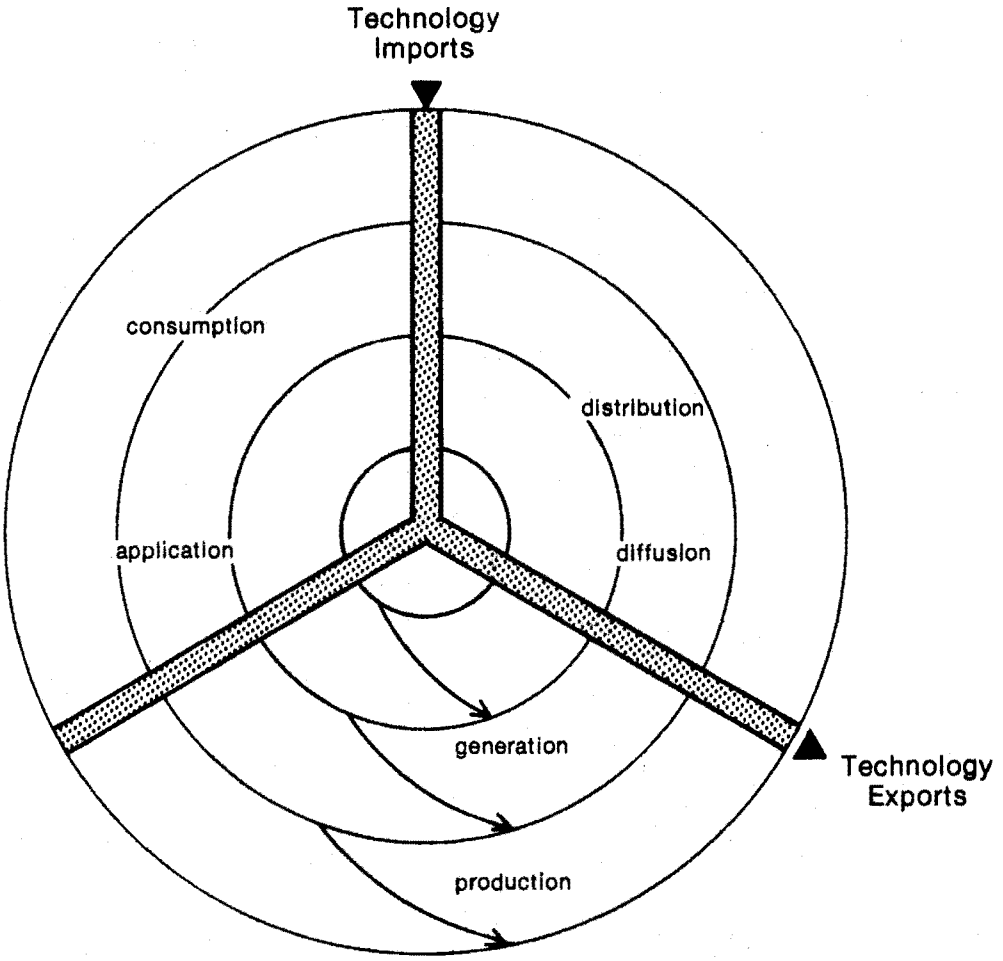

Technology
Imports
consumption
distribution
application
diffusion
generation
Technology
Exports
production

Figure 3.

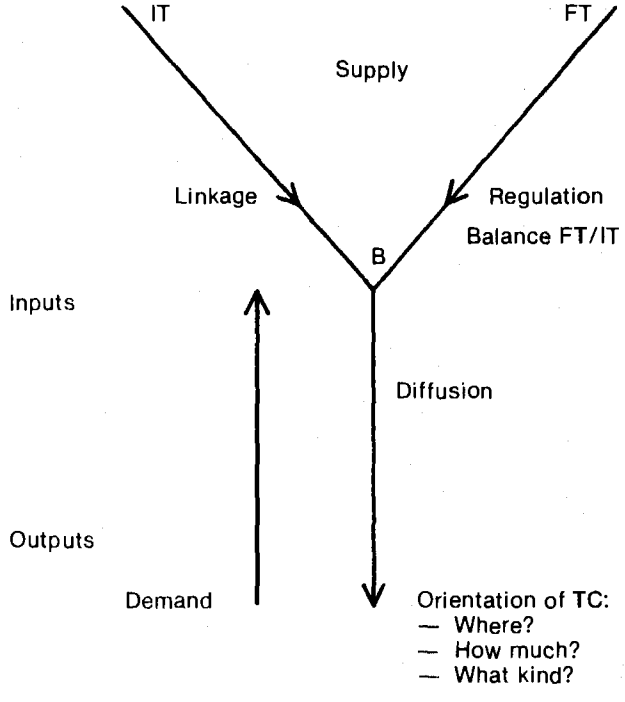

IT
FT
Supply
Linkage
Regulation
Balance FT/IT
B
Inputs
Diffusion
Outputs
Demand
Orientation of TC:
— Where?
— How much?
— What kind?

Figure 4. A Typology of Technological Models.

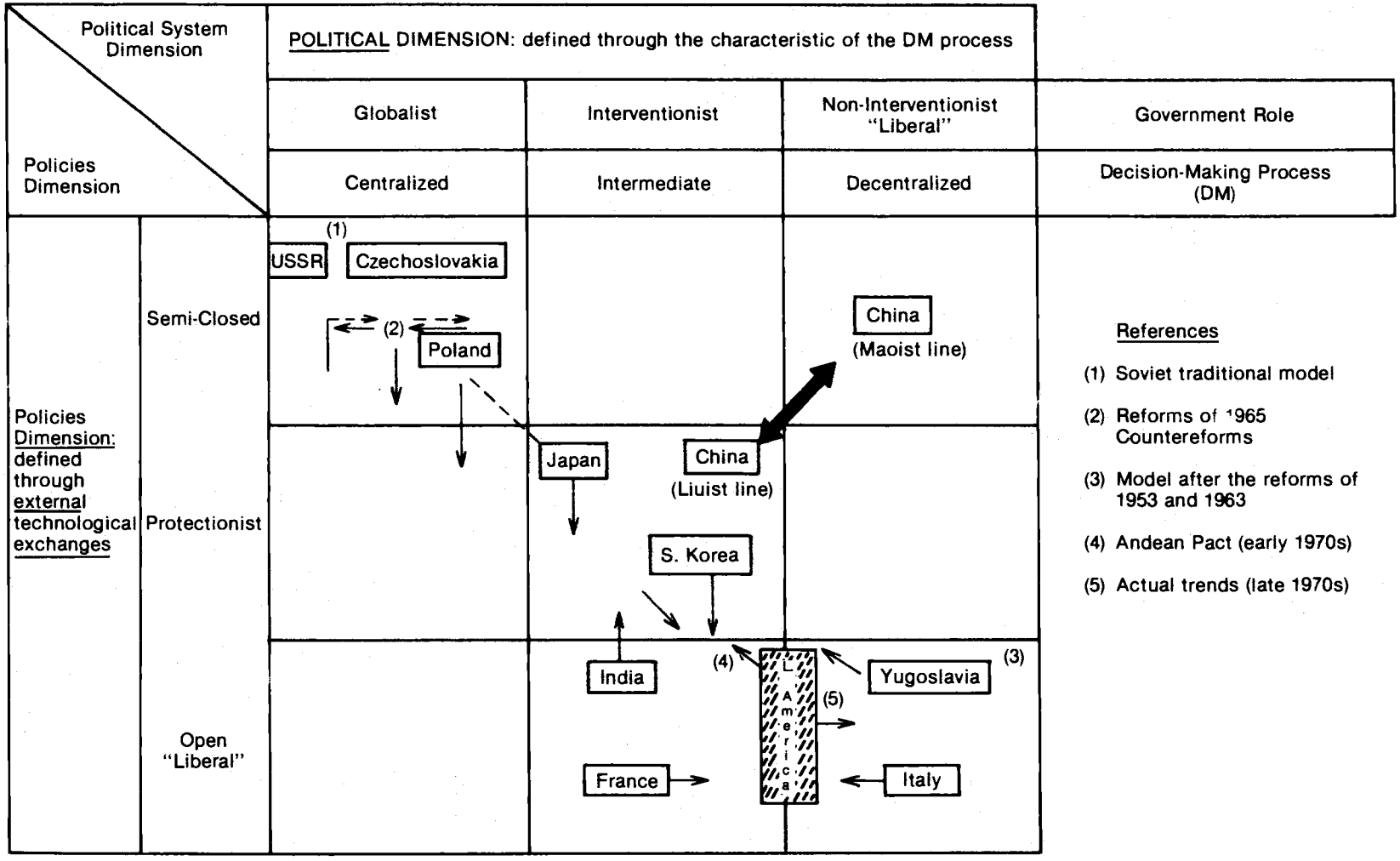


Figure 5. Dynamic Trends of TD Models: "Dynamization" of the Typology.

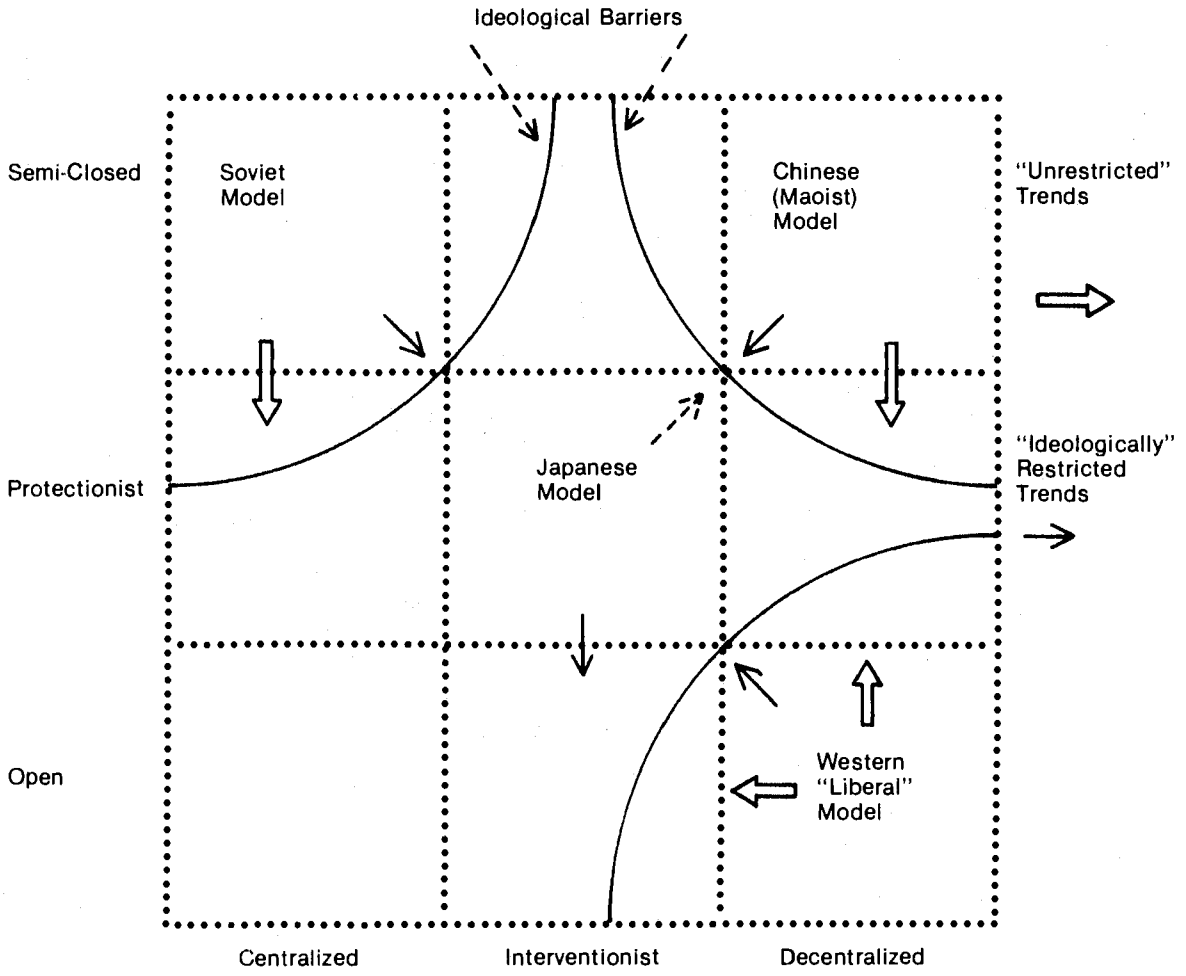


Figure 6.

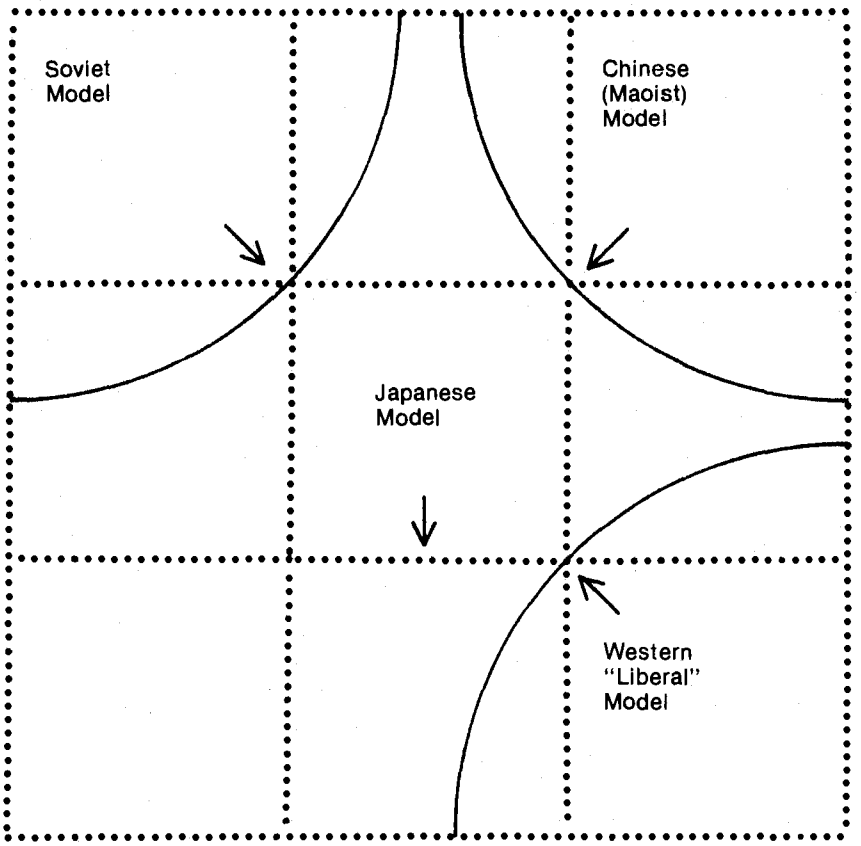
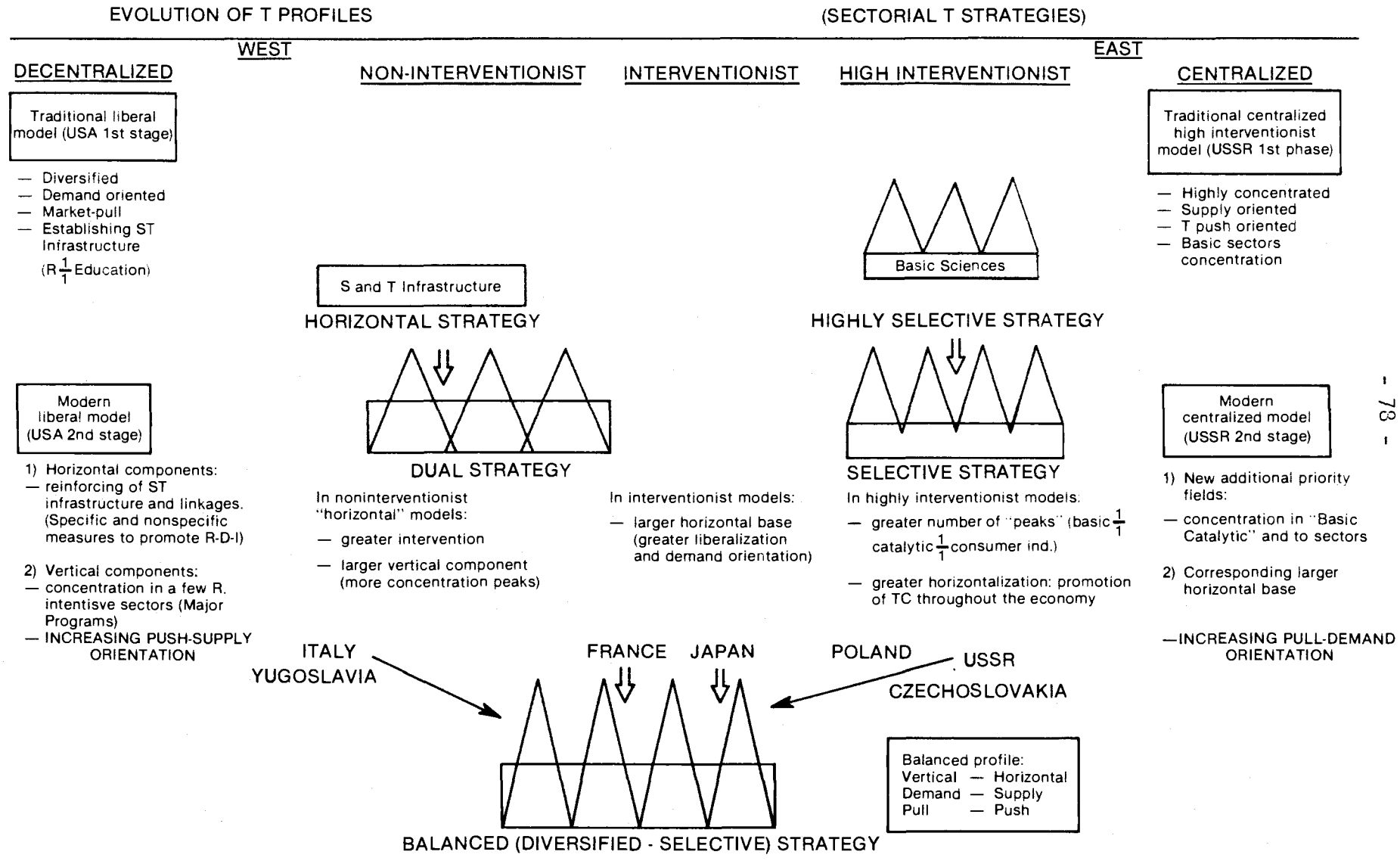

Soviet
Model
Chinese
(Maoist)
Model
Japanese
Model
Western
"Liberal"
Model

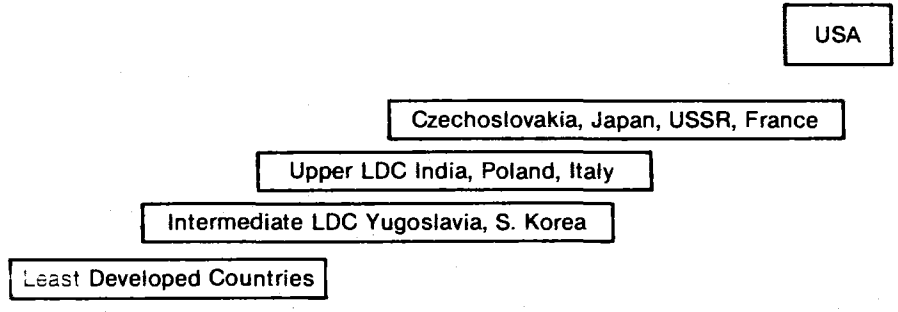
Figure 7.



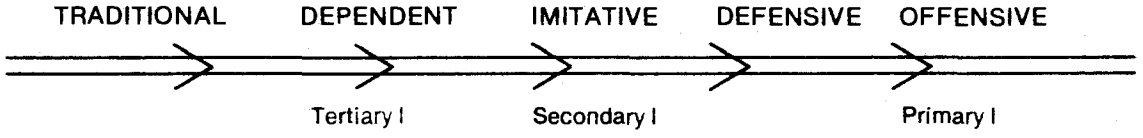
Note: A "Technological Sector" corresponds to either an area problem, a technical discipline, or an industrial branch.

Figure 8. Characterization of T D Strategies: A Typology.

Industrial Development	T D
Post-Industrial	(Post-T) ?
Industrialized (Consumer Societies)	Technologized
Semi-Industrialized	Semi-Technologized
Industrializing	Technologizing
Non-Industrialized (Subsistence Societies)	Non-Technologized



— TD STRATEGIES:
higher K = $\frac{IT}{FT}$ along the path:



— Emphasis:

— Rate of I:
higher % $\frac{IT + FT}{GNP}$

T Intensity

— Orientation of I along the path:

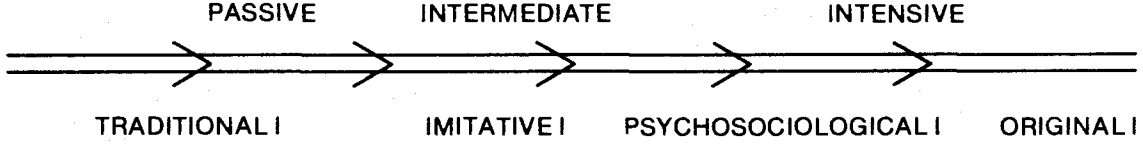
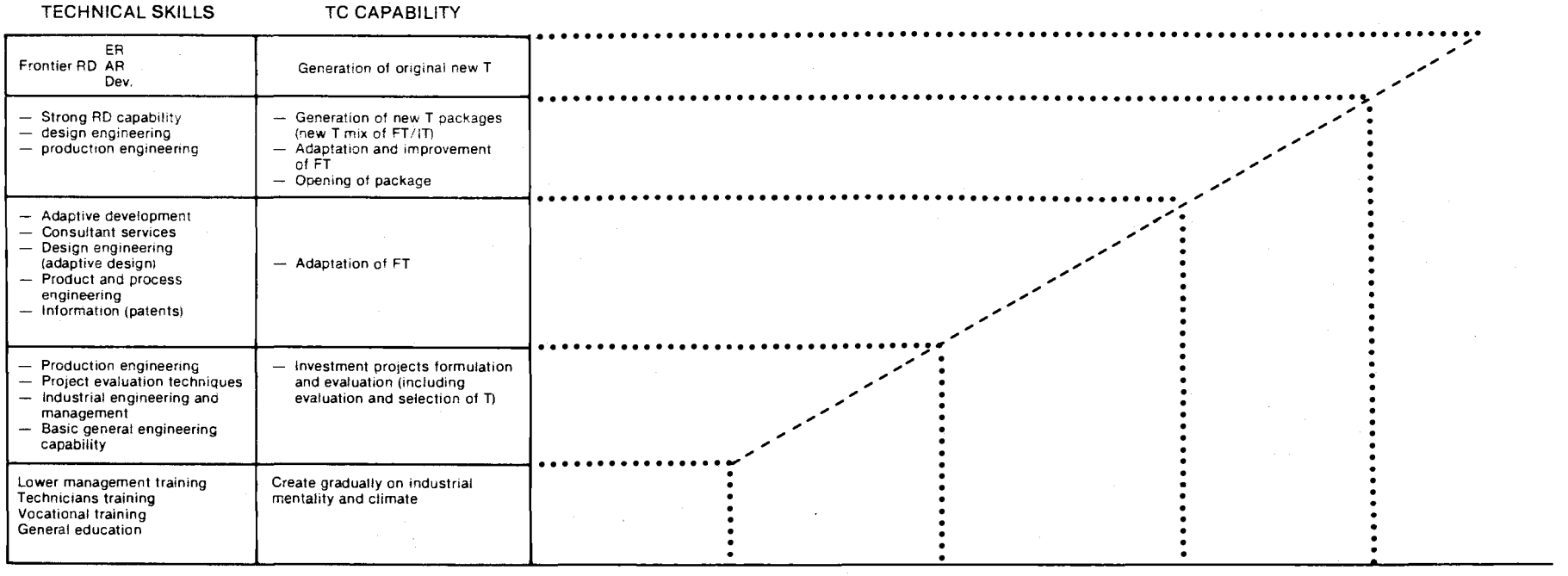
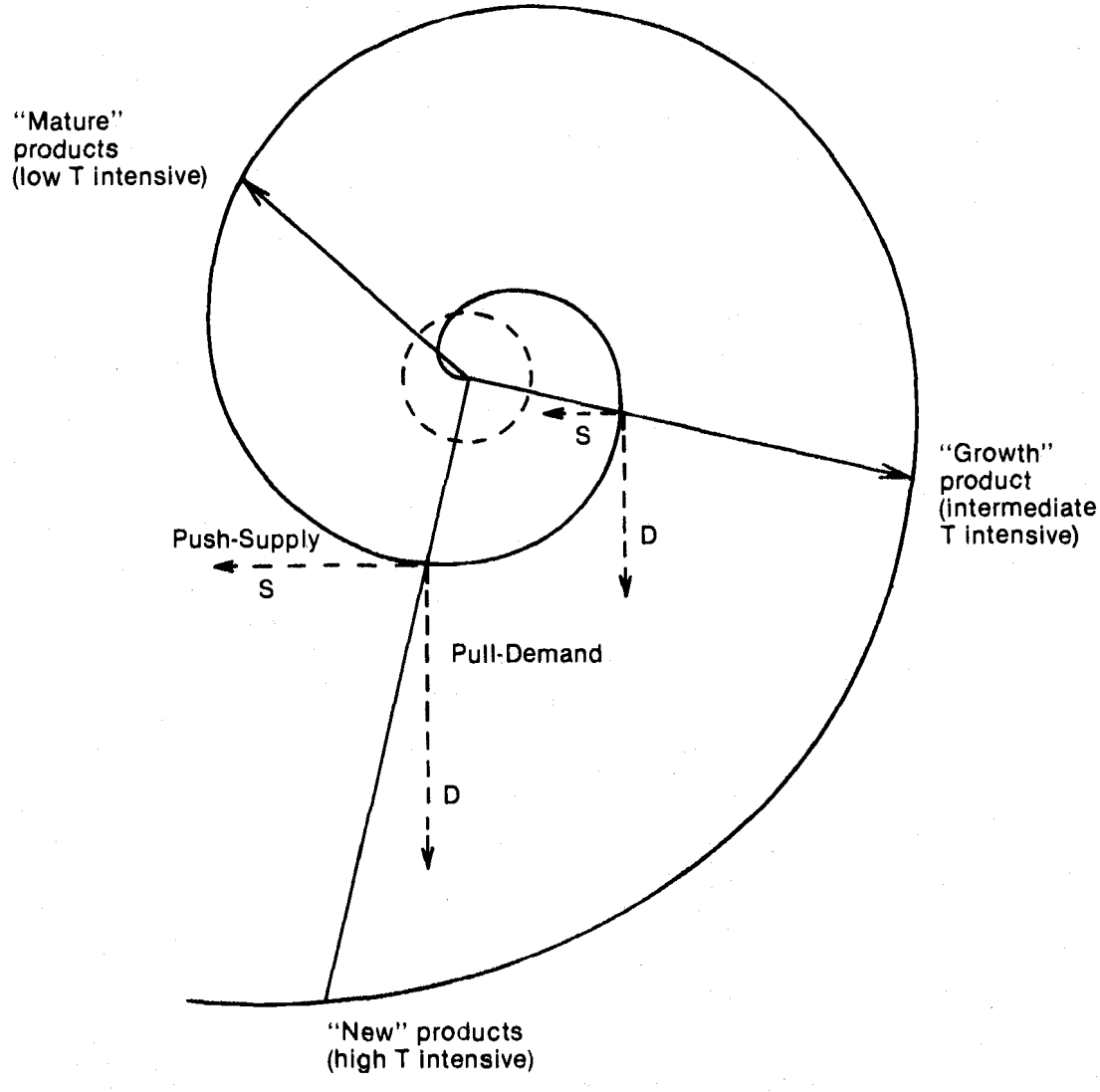


Figure 9. Relationship between TD Strategies and Technical Resources — National T Capability.

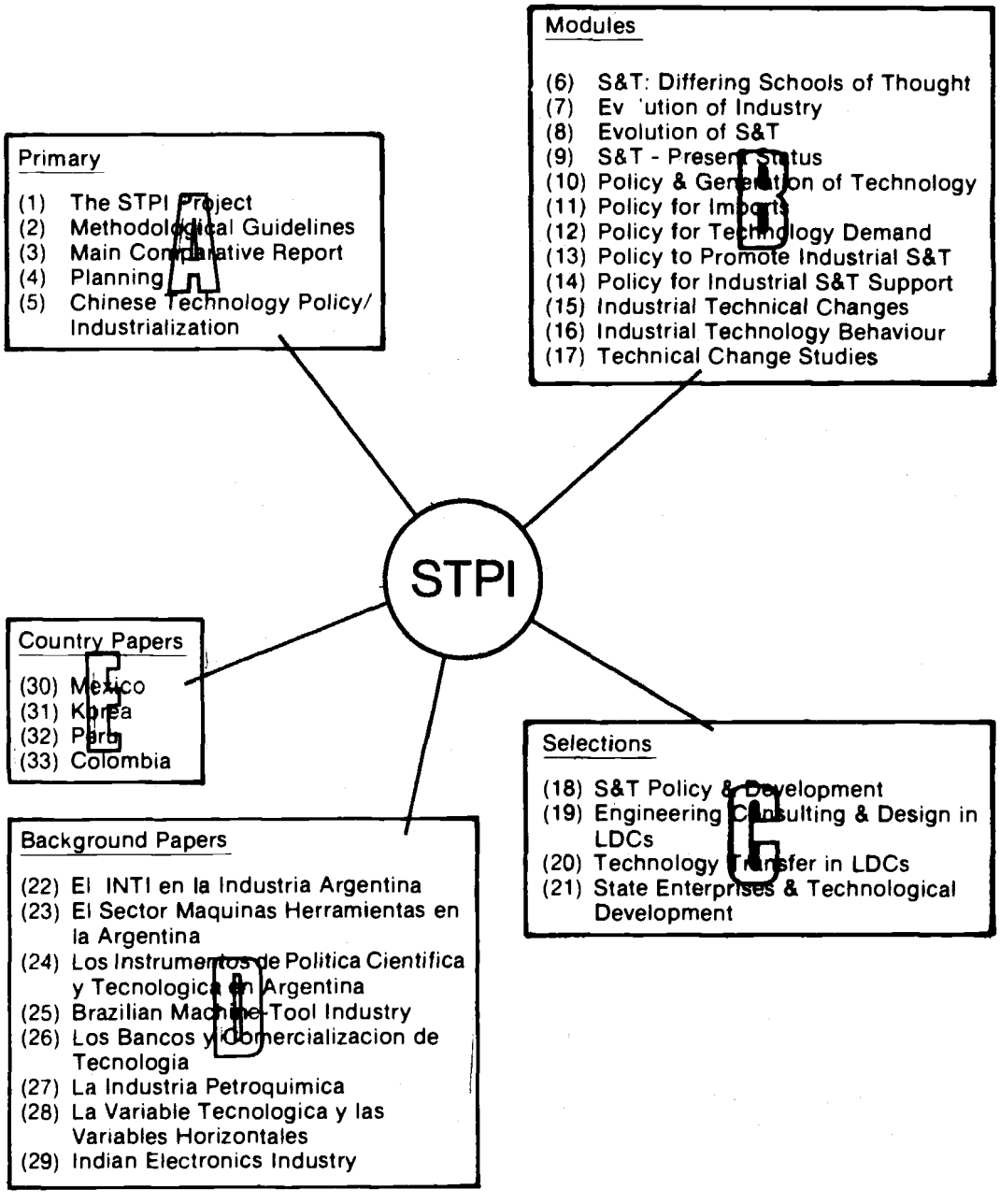


	Traditional	Dependent	Imitative	Defensive	Offensive
Emphasis:	Local T.	Tertiary T (diffusion of existing T)		Secondary I	Original I
Cycle Phase:	Local Products	Mature-growth	Growth	Growth-now	New products
Major Characteristics:	— No contacts with FT	— Satellite or subordinate role to T stronger countries	— Following the leader country with a short T gap; importing propietary T (patents, licences)	— Following the leader country as close as possible	First in the world in introduction of new products and processes
	— Technology based on traditional skills	— Following them with a long T gap: Importing know-how and T-assistance	— Process improvements (increasing productivity)	— "Catch up and overtake" objective	— "Maintain the leads" objective: keep the T gap
	— No product changes (no demand for it)	— Copying (little product changes)	— FT adaptation	— FT adaptation and improvement	— "Frontier" research
				— New T packages and product differentiation	

Figure 10.


"Mature"
products
(low T intensive)
S
"Growth"
product
(intermediate
T intensive)
Push-Supply
S
D
Pull-Demand
D
"New" products
(high T intensive)

Key to STPI Publications



A GUIDE TO THE SCIENCE AND TECHNOLOGY POLICY INSTRUMENTS (STPI) PUBLICATIONS

A. Primary Publications

(1) The Science and Technology Policy Instruments (STPI) Project (IDRC-050e) (out of print)

(2) Science and Technology Policy Implementation in I. 's-Developed Countries: Methodological Guidelines for the STPI Project (IDRC-067e) (out of print)

(3) Science and Technology for Development: Main Comparative Report of the STPI Project (IDRC-109e). (Also available in French (IDRC-109f) and Spanish (IDRC-109s).)

(4) Science and Technology for Development: Planning in STPI Countries (IDRC-133e)

(5) Science and Technology for Development: Technology Policy and Industrialization in the People's Republic of China (IDRC-130e)

B. Modules

These constitute the third part of (3) above and provide supporting material for the findings described and the assertions made in (3).

(6) STPI Module 1: A Review of Schools of Thought on Science, Technology. Development, and Technical Change (IDRC-TS18e)

(7) STPI Module 2: The Evolution of Industry in STPI Countries (IDRC-TS19e)

(8) STPI Module 3: The Evolution of Science and Technology in STPI Countries (IDRC-TS20e)

(9) STPI Module 4: The Present Situation of Science and Technology in the STPI Countries (IDRC-TS22e)

(10) STPI Module 5: Policy Instruments to Build up an Infrastructure for the Generation of Technology (IDRC-TS26e)

(11) STPI Module 6: Policy Instruments for the Regulation of Technology Imports (IDRC-TS33e)

(12) STPI Module 7: Policy Instruments to Define the Pattern of Demand for Technology (IDRC-TS27e)

(13) STPI Module 8: Policy Instruments to Promote the Performance of S and T Activities in Industrial Enterprises (IDRC-TS28e)

(14) STPI Module 9: Policy Instruments for the Support of Industrial Science and Technology Activities (IDRC-TS29e)

(15) STPI Module 10: Technical Changes in Industrial Branches (IDRC-TS31e)

(16) STPI Module 11: Technology Behaviour of Industrial Enterprises (IDRC-TS32e)

(17) STPI Module 12: Case Studies on Technical Change (IDRC-TS34e)

C. Selections

These are a selection of the numerous reports prepared for the STPI Project chosen as a representative sample of the various topics covered by the STPI Project in the course of the main research effort on policy design and implementation.

Science and Technology for Development: A Selection of Background Papers for the Main Comparative Report.

(18) Part A: Science and Technology Policy and Development (IDRC-MR21)

(19) Part B: Consulting and Design Engineering Capabilities in Developing Countries (IDRC-MR22)

(20) Part C: Technology Transfer in Developing Countries (IDRC-MR23)

(21) Part D: State Enterprises and Technological Development (IDRC-MR24)

D. Background Papers

(22) El INTI y el Desarrollo Tecnologico en la Industria Argentina (In press)

(23) El Sector Maquinas Herramientas en la Argentina (In press)

(24) Los Instrumentos de Politica Cientifica y Tecnologica en Argentina (In press)

(25) The Brazilian Machine-Tool Industry: Patterns of Technological Transfer and the Role of the Government (In press)

(26) Rol de los Bancos en la Comercializacion de Tecnologia (In press)

(27) Comportamiento Tecnologico de las Empresas Mixtas en la Industria Petroquimica (In press)

(28) Interrelacion Entre la Variable Tecnologica y las Variables Horizontales: Comercio Exterior, Financiamiento e Inversion (In press)

(29) A Planned Approach for the Growth of the Electronics Industry — A Case Study for India (In press)

E. Country Reports

(30) Instruments of Science and Technology Policy in Mexico (In press)

(31) Technology and Industrial Development in Korea (In press)

(32) Los Instrumentos de Politica Cientifica y Tecnologica en el Peru: Sintesis Final (In press)

(33) STPI Country Report for Colombia (In press)