Technology Policy and Economic Development

A summary report on studies undertaken by the Board of the Cartagena Agreement for the Andean Pact Integration Process

Junta del Acuerdo de Cartagena
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(This work was carried out partially with the aid of a grant from the International Development Research Centre, Ottawa, Canada. The views expressed are those of the authors and do not necessarily represent the views of the Centre.)
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Preface

The Acuerdo de Cartagena (Cartagena Agreement) is the treaty signed initially by Bolivia, Colombia, Chile, Ecuador, and Peru and later by Venezuela that established the Andean Pact for economic integration and development of the signatory countries (member countries). The "Subregion" is the geographical area covered by those six countries.

The "Commission" and the "Junta" or "Board" are, respectively, the plenipotentiary decision-making and the technical institutions of the Agreement. In addition to its other tasks, the Junta is the only body that can formulate and elevate proposals to be decided by the Commission.

In the early 1970s the Board undertook, with a grant from the International Development Research Centre (IDRC), a series of studies on technology policy. The purpose of the studies was to add to the fund of basic knowledge on the impact of, as well as on the relation between, the technological development of a society and the process of its overall economic and social progress. The findings and conclusions of this research constituted fundamental inputs in the formulation of specific policies and in the implementation of corresponding activities within the integration process of the Andean Pact. Furthermore, the results generated by these studies have stimulated and induced additional research within the member countries on the subject of technology policy. Also, the use of the research findings and the generated policy instruments have brought the Andean Pact closer to other developing countries that face similar problems in their developmental process.

In this report the term "technology" refers to all elements of productive knowledge needed for the transformation of inputs into products, in the use of these, in the development and rendering of services, as well as in the generation of further productive knowledge. In this context technology yields a determining influence on the economic and social advancement of societies. Furthermore, it is recognized that productive knowledge and its development are subject to political and economic decisions and that the elements of knowledge, as defined above, are not neutral but serve specific purposes for countries, enterprises, and individuals as each pursues distinct objectives and undertakes corresponding activities. Also, knowledge and its command constitute elements of power that play a significant role within the overall relations in the world community.

Today many Third World countries confront serious problems of technological underdevelopment and possess limited capabilities for assimilating and using existing productive knowledge in accordance with their social and economic needs or for generating new knowledge to meet such needs. As a result their development strategies and efforts as well as their cooperation with the rest of the world are seriously hindered. It is with the objective of overcoming such limitations that the Andean Pact introduced in the first part of the 1970s a series of policies directed toward the technological development of their member countries and their integration process. The studies summarized in this report served as an input for the formulation and implementation of these policies. Up to the present, in the area of technological development, the Andean Pact as a whole has approved the following policies that constitute, in their legal context, international treaties:

1. a common treatment for foreign direct investments, trademarks, patents, licensing agreements and royalties (Decision 24 of the Commission of the Andean Pact);
2. the bases for a subregional technology policy (Decision 84);
3. regulations for the application of rules concerning industrial property (Decision 85).
These three decisions together with a position paper prepared by the Board on technology policy have been published as monograph IDRC-060e by the IDRC. Other decisions approved in the Andean Pact on technology policies are:

1. Andean projects on technological development on the hydrometallurgy of copper (Decisions 86 and 87);
2. Andean projects on technological development in the use of tropical forest resources (Decision 89).

These latter decisions have initiated multimillion dollar activities in the corresponding sectors that will be completed during the coming 2 years. Further studies, financed by the IDRC and presently being undertaken by the Board, cover the following policy subjects:

1. An information system for the Andean Pact to cover the areas of technological development, foreign direct investments, and industrial property;
2. An Andean project of technological development for the production of protein- and calorie-enriched and balanced food substances for low-income pregnant and lactating mothers and for children;
3. A technology policy project to cover the explicit technological requirements, amounting to about U.S. $400 million, for the recently approved Andean Pact sectoral program of industrial development in the field of petrochemicals.

The report that follows presents summary results of some of the studies undertaken by the Board in connection with technology policies already approved by the Commission. The researchers included political and industrial economists, engineers with backgrounds in distinct fields, and some sociologists. The professional differences are present in the content and style of the chapters that follow. Although similarity in fundamental concepts as well as certain common elements and standards of analysis were established, part of the research objective was to maintain an interdisciplinary approach and not to force uniformity in the form of analysis. The reason behind this approach is that technology policy requires the participation of specialists of distinct disciplines, each one, perhaps, having different perceptions and interests as to what the content of technology policy covers. Also the application of technology policy in a society affects the activities in various disciplines and groups. The research undertaken was designed to reflect this multiplicity of disciplines and appreciations.

The first four chapters of this publication cover the most important conclusions drawn from experiences in national and sectoral technology policy in Italy, Yugoslavia, Japan, and Czechoslovakia. The first chapter deals with the problem of defining areas of technology, science, and economic policy. The second chapter concentrates on the problem of technology policy in the case of such industrial sectors as the pharmaceutical, copper, petrochemical, and metalworking industries. The following two chapters refer to the role of official institutions, in the above-mentioned countries, as they undertake activities in the technology policy area. They also assess briefly some policy instruments in this area. The various countries under study were visited and the corresponding reports were written by Sergio Barrio, Juan Tamplier, and Sergio Alandia.

The fifth chapter presents the main findings and conclusions reached by a group of researchers who studied the process of commercialization of foreign technology in the Andean Pact countries. The research covered the operations of several hundred enterprises that invested in, had licensing contracts with, held patents in, and sold equipment or technology embodying intermediate products to, the Andean Pact countries.

The sixth chapter examines some theoretical conclusions reached from diverse empirical studies on the importation of distinct elements of productive knowledge that are combined and sold in a package form.

Chapter VII is a summary of the studies of engineering and consulting services in the Andean countries undertaken by Carlos Prudencio with the cooperation of Juan Tamplier. Chapter VIII deals with the experiences gained in the international search for technology in the steel industry in Mexico, Japan, India, Italy, Spain, Germany, and Sweden; this study was carried out by Sergio Merino and Rene Barbis.

Chapter IX presents the first part of the position paper prepared by the Board on the necessary policies for technological development in the Andean Pact. It links the issue of
technological dependence to the overall problem of economic development. As stated above the full text of this position paper together with the texts of the corresponding policy decisions of the Andean Pact are included in a separate publication by the International Development Research Centre.

In addition to the studies presented here, the Board carried out research in the following areas:

(a) The treatment of copper ore and pollution, by Luis Soto-Krebs, with the cooperation of Canadian experts and experts from the Subregion;
(b) Tropical forest resources, by Marcelo Tejada, with the cooperation of Canadian experts Marcel Goulet, Leo Sayn-Wittgenstein, and Udo Nielsen;
(c) The requirements of an information system to cover the areas of technology policy and foreign direct investments, by R. Soifer with the cooperation of P. L. Diaz, D. Medina, S. del Pozo, M. A. Moreno, and G. Caferatta;
(d) An appraisal of research institutions in the Subregion, by Jorge Sábatô;
(e) The methodology for creating and developing a multisectoral and multidisciplinary technology institute in the Subregion, by Luis Soto-Krebs;
(f) The methodology for formulating and executing multinational projects in the field of technological cooperation and development, by Luis Soto-Krebs;
(g) Collaboration, with the support offered in some research areas by the Organization of American States, by F. Sagasti who also undertook studies in Peru;
(h) A study by Dora Medina on the evaluation of explicit technology policy in Peru;
(i) A study carried out under N. Clark by the Science Policy Research Unit at Sussex University and another by Gaston Oxman of the Organization of American States, both dealing with sources of information on the prices of intermediate products;
(j) A study by Galo Cascante on the Indian electronics industry; and
(k) The legal advice on policy instruments formulation, by M. Guerrero.

All these studies contributed equally to the fulfillment of the research objectives and to policy formulation. Most of their conclusions have been included in the technology policy instruments adopted by the Andean Pact.

The present summary was prepared on the basis of the reports of the staff of the Board who carried out the studies concerned, and was compiled by Sergio Barrio. The overall supervision of the research work was undertaken by C. V. Vaitsos.

In addition to the generous financial assistance from the IDRC, funds for part of the research were obtained from the Organization of American States and the Canadian International Development Agency. Without the support of these three institutions, the studies presented here could not have been carried out. Obviously the research results and the policy conclusions reached may not be shared by the above-mentioned institutions. The responsibility of the contents belongs to the researchers, while the position of the Board of the Cartagena Agreement is presented in the proposals made in these areas to the Commission of the Andean Pact.

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Lima, Peru, October 1975
Chapter I

Science, Technology, and Economic Policy

The insights obtained in the countries visited, together with previous experience in the Subregion, have led to a proposal for the development of a conceptual framework that will shed light on the field of technology policy, its objectives, and institutional standards. The purpose of this inquiry is to differentiate between the usual concepts of science and technology policy and their relationships with other aspects of economic policy.

This distinction may be established according to normative as well as analytical criteria. Analytical verification of what, in some countries, constitutes effective technology policy, implicit or explicit, is one of the bases on which the criteria for a conscientiously developed technology policy may be defined.

Science and technology policy cannot categorically be differentiated with any clarity, since they overlap to a considerable extent. In spite of this difficulty, an attempt will be made to establish a difference on the basis of criteria related both to the objectives and to the time limits, means, and institutions in the two areas of policy.

Criteria for Differentiating Policies: Objectives, Deadlines, and Degrees of Uncertainty

Science policy may be said to have the object of encouraging the acquisition of scientific and technological understanding, which may be used as an input for its further development and is possibly, though not necessarily, of use for the development of knowledge directly applicable to economic and social goals. Its objectives are thus related to the training and organization of human and institutional resources for scientific activities, the primary justification of which rests on the declared interest of scientists and research workers who consider such activities essential for scientific advances. These scientific activities initiate long-term progressive developments in knowledge and, in the final analysis, fit within the context of social, cultural, and economic needs in general. Nevertheless, their main goal is the development of science and its resources.

The goals established by institutions involved in science policymaking within this context insofar as basic research is concerned are defined (by these institutions) only according to areas of interest, leaving the question of the exact definition of research subjects, stages, and methods to the research worker. These objectives are therefore relatively less open to programming at the policymaking level. This also means that they generally have a longer time scale and consequently that their results are evaluated over a longer period.

The objectives of technology policy, on the other hand, may be defined as stimulating the generation of the scientific and technological knowledge to be applied in the solution of well-defined problems in certain areas of production (industry, agriculture, the extractive industries, services) and in social welfare (health, housing, education, environment, employment, individual and mass consumption). There is no "natural" harmony among these interdependent objectives; indeed, they may even be contradictory (e.g., direct
employment and industrial efficiency), since they may be affected by problems of global economic policy, problems of meeting completion deadlines, priorities, etc. These objectives of technology policy can be and have been more accurately defined and in most instances it is possible to forecast their probabilities of success, program their time schedule, and define criteria to evaluate their results. Their time scale is thus determined by the objectives themselves, and may be only short-term. The fact that the objectives of technology policy are, under some circumstances, dependent on advances in basic research into certain phenomena should not be excluded, and for that reason some uncertainty remains.

The "programmability" of technology policy objectives stems from the fact that these objectives are defined by the requirements of economic and social development. Furthermore, they are highly dependent on the use of scientific and technological knowledge acquired previously, or the development of which may be equally well measured with relative accuracy in terms of material, human (including skills) and institutional resources (training and information), and the stages into which it is to fall.

No clear distinction may thus be drawn, on the basis of the type of knowledge involved, between the areas covered by technology and science policy. Both are concerned with the generation of scientific and technological knowledge. The basic difference lies in the fact that the knowledge concerned is organized, promoted, financed, etc. by technology policy-making institutions with the explicit purpose of using it to serve specific social and economic needs. In other words, it is totally defined by objectives external to the scientific world as such. Once again, this does not exclude basic research, but it only concerns basic research geared to specific purposes of technology policy. As soon as it seeks immediate social and economic benefits, technology policy is oriented to find "satisfactory" solutions within a definite social context and an established time limit.

The variables determining the formulation and fulfillment of technology policy objectives are not mainly or even partially dependent on the imponderables or risks inherent in any kind of scientific or technological development from the mere fact of generating research. In other words, such development entails a search for new forms or relationships between different or previously unknown physical, chemical, mechanical, or biological principles or new empirical data. "Economic" or "commercial" and "social" variables are added to this "scientific and technological uncertainty." Since the objectives of technology policy are production and social welfare and it is not developed in the abstract, it is subject to decisions of a scope much wider than merely solving technical problems.

In programming technology policy objectives, it is impossible, for instance, to allocate unlimited resources in order to attain a specific objective, seeing that such planning further depends on the availability of the said resources and on the suitability of using them for that objective and not for alternative objectives of equally immediate relevance. For this reason planning is subject to an order of priorities defined at the political and economic level. It is further subject to efficiency criteria and social priorities as to the use of any resources to be allocated or proposed for such objectives and social priorities. In other words, it depends on policy on employment, the growth and redistribution of incomes, consumer orientation, etc. None of these variables and "risks" or "uncertainties" are technological or scientific in character but they are much more important in the programming of technology policy objectives than are uncertainty or calculated risks.

Among the factors influencing the attainment of the objectives as well as the process of development of the science policy is the level and quality of university activity and that of scientific research centres. In the case of technology policy development, on the other hand, the factors of most weight are of an institutional nature and involve the availability of particular resources. Institutional considerations include not only the type of institution (the presence of technological research centres) but the whole institutional network (dynamic links between production units and the scientific and technological infrastructure). This includes the approach of the persons responsible for directing research (i.e., their attitude toward the efficient generation of technology for specific social and economic purposes) and for clearly defining economic and social goals and applied technical goals, which will depend on science and technology for their accomplishment.
Origin of Traditional "Science Policy" Concepts

All methodological and conceptual developments concerned with the institutional problem of science and technology policy are determined by prevailing conditions in the countries of origin, that is, the most industrially advanced countries. They thus apply to countries with a sufficiently developed scientific and technological infrastructure, this concept including the introduction of science and technology into the automatic or near automatic mechanisms of the social organization of production. For this same reason, institutions of "science policy" were initially considered to be those affecting the "supply" of engineers and qualified scientists, subsidies, and financing of research and scientific research projects in certain areas of particular interest.

At a later stage, two important factors affected the development of concepts as to "science policy." The first was related to the allocation of an increasing proportion of available resources to scientific and technical research for military purposes. In the industrialized countries this proportion often fluctuates between 40 and 60% of total national expenditures on research and development. Since its objectives were of a military nature, these resources gave rise to scientific and technological activities evaluated according to criteria of a noneconomic nature, in contrast to those prevailing for the evaluation of expenditure or investments for civil purposes. Technology developed for military objectives, moreover, although its adaptation for civil purposes was possible in many instances, was and continues to be extremely expensive (and inefficient from the social point of view). Its suitability for civil purposes is also highly questionable. The cost of adapting military technology for civil purposes (when possible) is equally high. Often it is considered as high as the original costs of military innovation.

The second factor is related to the fact that a highly significant proportion of internationally commercialized technology was concentrated in a relatively small number of transnational enterprises. To these companies, scientific and technological know-how constitute a key instrument enabling them to establish world monopoly or oligopoly positions whilst they optimize their profits. Their position is strengthened by specific government policies regarding innovations (e.g., state protectionism and the present patents system), the presence of other types of policy (concentration of state financial support of research and development (R & D) in certain firms¹), or the lack of policies opposed to concentration (e.g., of effective antitrust legislation in some countries). The position of these companies is further enhanced by the use of their know-how (e.g., cross-licensing, which tends to encourage the formation of market cartels), the relation between publicity for brands and the use of particular techniques, etc. It should be stressed that most of the technology handled by the transnational enterprises merely involves regrouping already existing knowledge, translated and combined for commercial purposes ("cutting & taping"). This type of effort requires scientific and technological activities quite different from those required to discover scientific principles or those carried out by the well-known research centres.

This whole process brought in its wake an extension of the term "science policy" to include problems related to the "role of the State," the amount of funds devoted to R & D, the minimum scale or "critical mass" of R & D, technical cooperation, antitrust policy, policies on patent rights, even the commercial or other policies of the transnational enterprises etc.

For this reason, no conscious distinction was ever maintained between the concepts of "science policy" and "technology policy," as proposed in this study. Both types of policy were developed simultaneously, although the former was (and is) more explicit in nature. Technology policy has been developed implicitly, and has only recently been recognized as

¹About 50% of all patents resulting from research financed by the U.S. government for several years after the war belong to 20 large companies (see D. S. Watson and M. A. Holman, Concentration of patents from government financed research in industry, The Review of Economics and Statistics, 49(3), Aug. 1967, 375–381.
a distinct issue although no centralized ad hoc institutions have as yet been set up. The latter point is still under debate: although the need for covering the areas defined as peculiar to technology policy in a consistent manner has been recognized, there is no consensus as to the need for centralizing its management, encouragement, and financing in one sole institution.

Institutions for Technology and Science Policy and Their Interrelations

The type of institutions that, at the executive or decision-making level, affect the fulfillment of the objectives of any science policy are, generally speaking, those peculiar to the scientific community, which are in turn affected by others belonging to the state administrative apparatus, including the educational policymaking bodies. In other words, science policy involves institutions such as the board of directors of universities and scientific institutes, academies of sciences, national research councils, scientific associations, and educational programming departments (at the ministry and planning level). The institutions that fulfill or implement the objectives of science policy at the operational level are generally the universities or scientific research centres, and occasionally industry. The latter case generally involves only the big companies that are in a position to carry out basic research, or specialized medium-size firms.

Concerning the development of technology policy objectives, the institutions responsible for their formulation and fulfillment (implicit and explicit) are generally (and it is normal and positive that this be so) the departments and offices for sectoral planning of the ministries specifically designated to formulate sectoral policy and carry out the functions concerned. These are the ministries of health, housing, industry, etc., planning institutes or ministries, technological institutes, financial and state holdings and, in some countries, the ministries of technology. The latter generally have the most doubtful results. At the operational level, technology policy is generally implemented within the production units themselves (companies, technological institutes, or departments created ad hoc in the aforementioned policymaking institutions).

It was noticed in the countries visited that the overlapping of technology and science policy is expressed at the institutional level in two types of relationships. Either the responsibility for the joint implementation of science and technology policy has been officially delegated to institutions like national research councils, or it has been decided (as an alternative not necessarily excluding the former) to delegate functions concerning science policy to agencies responsible for economic policy, such as planning (e.g., by means of participating in interministerial agencies). For this reason, institutions like research councils have established technology “departments” or “committees,” and the national planning institutes have for their part established specific groups for “science and technology development planning” or institutions especially for science and education policy (see Chap. III).

This type of institutional solution tends to create serious problems with respect to the definition of spheres of activity, rivalry as to resources, prestige, power, etc. A clear-cut institutional distinction between technology and science policy has proved much more effective. This distinction does not mean that technology policy institutions should be created on an ad hoc basis; on the contrary, this area of policy should be incorporated into an existing institutional framework, or one to be developed, of economic and social planning and implementation. The institutions responsible for formulating and implementing technology policy must, in turn, encourage the establishment of links between the requirements of technology development on one hand and social and economic objectives and the scientific and technical resources available in independent academic and scientific institutions on the other. This would be so, and there are examples of it, if basic research were stimulated and its use encouraged by means of funds directed to specific research areas: funds created by industry and by national institutions responsible for the formulation of technology policy. Another channel frequently used, and which has yielded good results, is to engage university personnel to carry out specific tasks within applied research projects.
The connection between technology policy and economic policy is much more complex and difficult to establish, particularly in view of the fact that technology policy has been considered merely as an implicit instrument of economic policy and has only recently been organized in a few countries in the form of explicit policy with clearly defined objectives.

This is also happening in the developing countries, the dependent nature of whose industrial development meant that when technology policy statements were first made, these were regarded as incidental to policy on licences and the selection of technology suitable for importing.

In fact, any technology policy must comply with the requirements of economic policy if it is to solve technological production problems, and is indeed immediately determined by it. Besides policy on the purchase, imitation, and adaptation of imported technology, this involves stimulating and programing technology development (in accordance with strategic criteria defined at political levels) to mobilize scientific resources and native technicians.

However, an analysis of implicit technology policy in the Subregion and the countries visited indicated that this policy was not and should not be limited to technological and industrial objectives per se; it should be extended to the organization of scientific and technical resources to be used for social objectives (health, housing, education, employment, environment, etc.) subordinating production interests to these objectives and making use of industrial resources. The fact that the fulfillment of the immediate objectives of economic policy is not necessarily in harmony with social welfare objectives means that similar contradictions probably exist within the institutions responsible for technology policy. The most important argument may be adduced that the aforementioned social objectives cannot be solved separately at the individual company level but require a consistent national policy at the level of social and economic programing; such a policy in turn necessitates the organization of scientific and technological activities.

Thus, although technology policy is and must be subordinate to social and economic policy, it is not passive but must be capable of extending the prospects of both economic and social policy. It must equally be capable of coordinating its objectives and even formulating social and economic objectives.

In short, it is felt that technology policy must be an integral part of economic and social policy, contributing in this way to formulating and attaining its objectives. This should not give rise to new independent institutions, which would merely emphasize the existing schism between scientific and technological activities and the creation and fulfillment of social and economic needs.

Some conclusions may be drawn from a comparison of experiences obtained in the countries visited concerning the effect of economic policy on technological development. For instance, the Italian heavy industry and Yugoslav industry have both been aided in their development by a "subsidy"; in Italy by the nationalization of heavy industry, and in Yugoslavia by a policy on raw materials stipulating low prices. The nationalization of the shipyards and the steel, basic chemicals, and communications industries in Italy operated like a subsidy. It permitted capital, which had previously been tied to the little or no profit of these activities, to be mobilized for new sectors with a higher growth rate and profitability, whilst keeping the nationalized sectors alive with controlled prices. A policy of subsidies was also implemented in Yugoslavia by imposing a lower amortization rate for these activities, to be mobilized for new sectors with a higher growth rate and profitability, whilst keeping the nationalized sectors alive with controlled prices. A policy of subsidies was also implemented in Yugoslavia by imposing a lower amortization rate for the basic industries. That meant a policy of relatively low domestic market prices (considering the system of price control operating in the planned Yugoslav economy). However, the effect of this policy was different. It created serious difficulties for the technological advancement of the Yugoslav basic industries while the renewal of fixed capital was restrained and the export of raw materials limited. At the same time, the effects of future, unavoidable, technological changes on employment were only postponed. In Italy, the State basic industries operated within a much wider European market with strong competitive pressures and carried out extensive subsidized investments. Both factors
influenced the development of their own technology, but at the cost of strong inflationary pressures.

The ensemble of external factors that affected technological development is in fact very complex. It may also be stressed, to illustrate its complexity, that although basic industry can stimulate technological development (as, in fact, it did in Italy, Japan, and Czechoslovakia), this is not always the case. The selection, whether conscious (planned and centralized) or unconscious (through the laws governing the market), of industrial activities may or may not act favourably on technological development. The argument that certain industries (chemicals, metalworking, electronics, heavy industry) would, of their own nature, have “multiplier effects” of technological development must be qualified. A heavy industry developing exclusively on the basis of imported technological inputs may have a lesser “multiplier effect” than that of scientifically organized agriculture. The “multiplier” values of heavy or large-scale industry has notably stimulated technology development at the international level, whereas the large-scale organization of production and particularly that of means of production, made necessary and possible a scientific inquiry into the entire production process and its application to nonhuman sources of energy. At the present moment, there is no reason why this process should be mechanically repeated in every country, particularly in the developing countries.

There is thus no mystic connection between scientific and technological industrial development and the development of certain industrial sectors, conferring priority upon basic industry. It is important to stress that no such biunivocal connection exists, and that the technological argument is incorrectly used to justify industrial policies, with a high rate of investment in basic industry, that generally relegate the problems of employment, consumption, and general welfare to third place. International experience and the particular characteristics of the developing countries indicate that these need to find their own strategy based either on existing natural, industrial, and human resources or on those that can be developed or advantageously obtained. This strategy necessitates their developing the infrastructure for generating technology in their own way (not economically self-sufficient), at the same time directing it to the immediate solution of the most pressing social problems.

The Yugoslav experience is instructive in two senses: technologically, the food industry in Yugoslavia has little reason to envy the most advanced of its counterparts in the world and hence needed no “multiplier effect” from basic industry or means of production. Equally, concerted technological and scientific efforts succeeded in raising the standard of the Yugoslav copper and by-products industry, which now occupies one of the leading positions in the world, in spite of the fact that it did not have the financial resources to enable an accelerated rate of capital renewal.

A production process that is nowadays considered technologically trivial and of little complexity may be transformed into its opposite, “science-intensive” production, within a short space of time. This is chiefly determined by a simple political decision.

Science and technology are developed on an international scale, while available and accumulated knowledge and resources can potentially be used in any field. The main obstacle to their application is really artificial (in the sense that it does not arise from any economic “need” or “inevitability”). It is related to private appropriation of scientific and technological knowledge (e.g., the present patents system) and the use of privileges of ownership to block competition and avoid the free diffusion of its use; this obstacle must be overcome by any industrial and technology policy if it is to succeed. There are, of course, obstacles that are not artificial in the above sense and that are connected with backward conditions in industry and the economy in general. An example is the split between research and production in the developing countries or in the developing regions of wealthy countries. However, neither this split nor the passive nature of the policy followed to date in the developing countries with respect to the international search for technology is self-explanatory nor may it be explained by merely personal factors. The only possible and permissible explanation is to be found within their original historical context.
Technology and Development Strategies

With respect to what one might call technology "strategy" and its relation to a strategy for economic development, all the countries visited went through a stage of imitation, one of adaptation, and finally one of selective innovation. These stages were strictly necessary, since all of these countries started from a lower level of industrial and technological development than that of the other countries from which they imported technology. There were two alternatives: to import technology or to follow in the footsteps of other countries to obtain previously existing specific technological results. The former was much more advantageous, particularly at first. However, in no case did it prove favourable merely to import "black boxes," which allowed no scope for any kind of apprenticeship. Moreover, particular conditions of local demand (market capacity, the characteristics of raw materials, degree of skill and availability of labour, import costs, access to foreign technology, etc.) allowed them to progress, by means of explicit or implicit modification of technological strategy, to a strategy of "adaptation" or even "innovation." The possibilities of "selective innovation" depended in large measure on the success of the strategy of importing technology and the policy implemented to augment imported technical and scientific resources imported by the use of local inputs (that is to say, disaggregation policy and selective technology imports).

All the countries visited carried out some form of policy equivalent to that of the "selective replacement of imports" at the level of technological inputs. All the countries (and large companies) tried to replace technological inputs, most of them starting with one important input: engineering and consulting services. However, they precluded any possibility of self-sufficiency.

The Italian attempt at "self-sufficiency" was only brief and it developed within the context of the imminence of a world war. In the case of Yugoslavia, it is particularly clear that she has, since the beginning of her industrial and technology policy, been seeking integration in the international field, in conflict with the limitations imposed in the world market. In Japan the strategy on industrial and technological development also required a policy intensively geared to the encouragement of exports.

This does not mean that success has been invariable and that monopoly barriers have always been overcome. On the contrary, traditional cartels and the new postwar cartels are still the major hindrance to the technological development of these countries. However, insofar as their technology policy has been successful, this success has been particularly due to policies designed to break monopoly control.

It may be said, in this respect, that an "imitative strategy with selective replacement of imported technological inputs" is perhaps the only type possible when the degree of dependence is considerable, whereas "selective innovation" and "adaptation" require a greater degree both of integration and of conflict in monopoly relationships. This policy may, by increasing bargaining power, enable native companies or planned industrial units to obtain certain more favourable conditions for exporting their products, importing technology, and developing their own scientific and technological infrastructure. It is worth noting that, in all circumstances and no matter what the strategy, an effort must be made to generate technology in key economic areas and in the social field.
Chapter II
Sectoral Technology Policy

The Pharmaceutical Industry in Italy

The study carried out by the Board in Italy includes an analysis of selected companies as to the subjects and efforts undertaken in the fields of science and technology. The report further includes an evaluation of the consequences of abolishing patents for products and processes on the industrial and technological development of the Italian pharmaceutical industry.

The Italian pharmaceutical industry has been developed on the basis of the abolition of patents formerly governing this sector. This measure was responsible for great advances in the industry, which today occupies an extremely strong position in the world market. The success of the Italian pharmaceutical industry abroad is, however, in contrast to its internal inefficiency (prices of pharmaceutical products tend to be high owing to expenses for advertising and overall marketing) and the overwhelming predominance of foreign capital.

All over the world, the majority of the scientific and technological activities undertaken in the pharmaceutical industry at the industrial level are of an imitative nature. Especially since the mid 1960s, the decrease in the number of basic active principles placed on the market annually has been accompanied by a substantial increase in research of an imitative nature. In Italy, the fact that no patents are applied meant that the predominance of imitative research set in at a much earlier date.

Nowadays, however, it is much more difficult to draw a clear distinction between innovative and imitative research, particularly because, since 1965, the systematic mass screening of molecules, which enabled the identification of a large number of active substances, has become increasingly unproductive. Such mass screening put the American companies at an enormous advantage compared to their European rivals, because the former, being so much larger, were able to conduct a much greater number of research programs, testing thousands of molecules in search of active principles.

At present, mass screening is no longer carried out, having been replaced by selective screening aimed at introducing minor modifications of molecules already, for the most part, known or in use, and at identifying substances that can be used in combination with active principles. The difference between an innovational and an imitative strategy is that the former tries to find effective improvements in the therapeutic qualities of certain molecules or the synthesis of new ones, seeks a wider application and attempts to reduce secondary effects; the later, imitative strategy, on the other hand, has the prime objective of evading patent restrictions by introducing modifications in the product or in the process used to manufacture it. Naturally, this does not preclude the possibility that such modifications may lead to "innovative imitation" (any more than that "innovative imitation" may lead to imitation pure and simple, evading patents without introducing any effective improvement). According to opinions given in Italy and Yugoslavia, the purpose of the vast majority of industrial research in the pharmaceutical sector is that of evading patents.

\footnote{\textit{It is said, for instance, that screening of soil to find bacteria for the production of antibiotics has been carried out on the vast majority of soil types in the world.}}
In the companies interviewed in Italy, it was possible to obtain information on the critical mass or minimum scale necessary for commencing scientific and technical research, whether imitative or innovational. A description follows of the characteristics (qualitative and quantitative) of the critical mass in each research phase, according to the information given.

Information and Documentation

Information and documentation are indispensable adjuncts to scientific research in this sector. Information is needed on human illnesses and the advances made in medical research, and it is necessary to be up-to-date as to technical and scientific advances in the pharmaceutical field all over the world. Company A solves its information problem by carrying out its own specialized library research in its field of interest; it has an automatic retrieval system, which it took 1 year to install.

Their supply of basic bibliographical information consists of abstracts covering 350 international scientific publications, obtained from a specialist English company, Ringdove Service, Derwent Publications, through which they get 40,000 references per annum at a minimum cost of $12,000. This system was improved by introducing more complex programming for retrieval requiring greater precision in the formulation of requests for information, thus increasing the percentage of "useful information" from 20 to 80%. The minimum staff needed for this information service consists of one university graduate, who may be a medical doctor, pharmaceutical chemist, pharmacologist, or biologist, with only 2 days' on-the-job training, and who can attain maximum efficiency (manual identification of 50 references per minute) within 1 month.

Definition, Analysis, and Chemical Synthesis

A chemist capable of defining molecules with therapeutic potential on the basis of an understanding of their structure and spatial and photochromatical characteristics is the key person in a research laboratory. Company B, which gave the most information on the research phases described below, considers that an experienced chemist can define 150–200 molecules per year. The techniques used include photochromatical, spectrographical, and chromatographical analysis, and definition of the synthesizing process. This stage requires at least two or three graduate chemists, three or four technicians experienced in the use of chemical laboratory instruments, and four semiskilled assistants for each chemist employed in the preceding phase of molecular definition. These two or three chemists in the analytical and synthesizing phase in turn contribute to the definition of new molecules, which means that altogether a minimum of 300 molecules may be prepared and correctly defined per annum for the following pharmacological phase. According to company B, the equipment required for the chemical laboratory is very inexpensive with the exception of the fractional stills. The initial investment for their laboratory is said to have been less than U.S. $10,000.

Pharmacology

The function of this laboratory is to define the pharmacodynamic characteristics of the compounds defined in the preceding stage. This means determining the mode of action of the molecule on different types of animals, that is, their analgesic, physiological, anti-infective, neuroactive, cardiocirculatory, etc., properties. Similarly, it includes the localization of the pharmacodynamic action of the molecule, its mode of absorption.

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3To preserve the confidentiality of the information given, the companies interviewed will be identified here only as company A, B, etc.

4There are between 7000 and 8000 scientific publications in the pharmaceutical field in the world, from among which 500,000 references per year may be selected. The optimum amount of useful information, however, does not exceed the figure of 350 publications of major importance, given above.
transformations undergone in the organism, and the manner in which it is eliminated by the
organism. The next stage is the toxicological test, which determines the lethal dosage,
acute and chronic toxicity, collateral effects and teratogenic effects (on embryos).

For each chemist employed in the initial phase of molecular definition and synthesis
(taking the testing of 300 molecules per year as a minimum), seven pharmacy graduates are
needed, which means a minimum of 21 employed in all.

This pharmacological laboratory similarly requires a technical pharmaceutical
laboratory that provides the final conditioning of the products that, having successfully
undergone all the pharmacological tests, are then ready for clinical testing. This technical
pharmaceutical laboratory identifies the neutral excipients permitting optimum absorption,
decides the forms of presentation, and ensures rigorous control of quality and homogeneity
of the raw materials and their stability under various environmental conditions.

Clinical Analysis

Once positive results have been obtained with certain molecules (the world average is
for one active molecule in every 3000 to yield positive results in the empirical
pharmacological test5), these then undergo clinical testing to determine their
pharmacodynamic properties in man, the indications and contraindications of the product,
and the most suitable dosages. This laboratory requires one doctor and one specialized
pharmacist for each chemist employed on synthesis. In other words, a total of three or four
graduate specialists is needed, of whom two or three should be doctors.

The total volume of the minimum resources needed by a research institution was
estimated both by company B and company C as approximately U.S. $1 million per
annum. A more detailed analysis of investments and costs for a pharmaceutical research
centre (based on Italian market prices) conducted by Professor Leonardi on the basis of his
experience in managing the Mario Negri Institute in Milan, indicates the following figures.

As an initial investment, to be spread over 2 years, approximately $1.7 million are
considered necessary. Of this sum, an estimated $170,000 are needed to buy a site 4000 m²
in area and another $700,000 for construction expenses. The initial investment in scientific
instruments, accessories, glassware, stock, etc., was estimated at $600,000, and the cost of
office and laboratory furnishings at $260,000. The annual costs are estimated at around
$860,000. The greater part of this sum, $450,000, represents expenses in the form of
salaries, fees, and overhead.

Company B indicated that the trial period needed for accumulating experience in a
pharmaceutical research centre before satisfactory results are obtained would be no less
than 2 years, but no more than 4. In other words, good results may be expected, according
to company B, within 2–4 years.

The pharmaceutical sector does not present any very complex problems at the
industrial level. The processes required to obtain an organic chemical substance in the
laboratory, whether natural or synthetic, are not very different from those taking place in
industry. The design of an industrial plant may thus be based on research aimed at
discovering a new active substance and experiments on its conditioning. Because of this
and in view of the scale of operations, which is in physical terms of pharmaceutical
production relatively small, the industrial engineering problems presented by
pharmaceutical production are relatively easy to solve.

Again according to company B, industrial production is the prime incentive for
research. There is no scientific research without production, nor production without at least

5This figure could give the impression that the minimum scale described in this summary would
yield positive results only once every 10 years, seeing that in the first phases of the research process
two to three chemists can define only 300 molecules per year. However, this applies only to new
active components, and not to scientific and technical activities of an imitative nature. On the other
hand, the Subregion has abundant top-level, underemployed scientists at its disposal (medical doctors,
chemists, pharmacologists, etc.). Their present scientific level and its development in the Subregion
may lead, via the development of an understanding of the physiology of disease and pathogens or of
genetics, to developments in pharmacology surpassing the excessively empirical basis typical of
pharmacological research all over the world.
rudimentary research. Production demands absolutely rigorous control of quality and homogeneity; quantity control may serve as the basis for a research centre to build up its resources and experience. Company B suggests, perhaps reflecting its own experience, that research is best centred around an organization producing raw materials (in the absence of which no research is possible), with the object of reducing the unit value of the raw materials and other components. According to company B, once this stage has been reached and a laboratory for quality control including pharmacological tests has been established, the conditions for starting basic research into new active principles would be fulfilled.

International Surveys, Traveling

The pharmaceutical companies visited expressed the opinion that research in this sector requires much less traveling than in others. It is generally felt that to carry out the development or imitation of products, no extensive traveling is necessary on the part of the research workers. The information available from the abundant specialized scientific publications, publicity brochures, and medical samples is considered sufficient for an experienced chemist to define the processes of synthesis or extraction involved.

The above statement, however, is in contrast to the well-known fact that the Italian pharmaceutical industry practiced large-scale industrial espionage, especially in the early stages of its development. It was not possible, for fairly obvious reasons, to obtain more precise information on the manner in which the international technology surveying involved takes place.

Internal Company Decisions on the Generation of Technology

The crux of the decisions made by company A in respect of scientific and technical activities lies in the links between the departments of marketing, production management, and research programming. The marketing department needs information on the products to be introduced. In turn, production management, besides needing the same information for the purpose of programming production, gives information on the feasibility and technical difficulty of manufacturing certain goods. The research programming department, on the other hand, requires data on the sales potential of these new products, on the technical feasibility of their manufacture, and on the possibilities of the product for modification or adaptation to the requirements of the market to increase sales.

This type of dynamic relationship between research programming, marketing, and production management is nevertheless a relatively new development in company A. Until 2 years ago, the marketing department used to carry out studies directed exclusively toward increasing sales, profits being in any case guaranteed by government policy on prices (which were fixed in accordance with the expenses of small companies and frequently unrealistic). Nowadays, profit criteria are being progressively included in programming, a development that was not, in its most advanced form, introduced into company A until the beginning of 1972. At present, the marketing department is in a position to form an opinion as to potential products and the most suitable specific forms of presentation, stating that it is possible to arrive at a given sales volume at a given price, at a given production cost and within a given time, involving given changes in the production installations; all of which predictions entail calculated risks. Marketing can also give drastic negatives if, for instance, the problem of industrial production is impossible to resolve economically. In other instances, it may suggest modifying the presentation and final formula of the product to increase its acceptance.

Marketing goes even further: it defines the strategic orientation of the economy. After studying market trends and their potential (including a study of the behaviour of the rival companies), marketing recommends the introduction of a product with certain required characteristics and, after comparing the costs of research with those of purchasing a licence, recommends the "development" of the product or the purchase of the licence, as the case might be.

The final decisions, however, are not made either by marketing, production
management, or the programing and research department alone. Company A has a management team composed of the managing director of the company, a chemist, medical doctor, biologist, pharmacologist, and a member of the research planning department. This committee holds monthly meetings, at which the priority to be given to subsequent programs, the rate of increase in the number of programs, and the strategic orientation of the research to be carried out by the company are decided. Company A deliberately defines this committee somewhat vaguely thus making its decisions seem like discussions, and avoiding too heavy a reliance on any one department (such as marketing) and resistance on the part of the others.

**Research Coordination and Programing**

In company A, the coordination and programing of research is the responsibility of a special department with only two employees, who are themselves research workers. These handle all research projects, which are handed in to them on standard printed forms by the company research workers or by the marketing department (the latter are generally projects concerned with new combinations of active substances or with new forms of presentation), and may include projects requested from outside the company, which thus acts in a consultant capacity. This department assesses whether a project can be carried out within the budget for research and development, appoints the team to carry out the project, and then approves it. Only for costly projects is the explicit approval of the management of the company required.

In this context, "coordination" means ensuring that the research projects are free from interruptions at all stages of their development; this involves regular reports from the project director to the coordination and programing department. Similarly, coordination involves ensuring the implementation of a complex of projects meeting the conditions required for the strategic specialization of the company. There is a certain minimum number of selected molecules and their derivatives that must be submitted to a series of tests designed to define their pharmacodynamic properties. This minimum guarantees that a sufficient number of new or modified active principles is introduced to increase or maintain company sales.

**Nonpatentability of Pharmaceutical Products and Processes in Italy**

Since 1939, Italy has not recognized the patentability of pharmaceutical products and processes. The ostensible motives for this decision were framed as being of an ethical nature, rather than a matter of economic, let alone technology, policy. The ethical arguments given centred around the consideration that, pharmaceutical products being destined to relieve urgent social necessities (health), their use should not be restricted by any limitations imposed by cartels or monopolies. Nevertheless, behind this ethical justification lay the requirements of the policy of self-sufficiency initiated at that time. It was absolutely necessary for Italian government policy, in the face of the blockade imposed by other powers during this period, when World War II was imminent, to make itself independent of the monopolies operated by hostile foreign powers, in return strengthening its alliance with German monopolies and supporting the home industry. It was for similar reasons that the United States government, as a war measure, confiscated all "enemy property," including pharmaceutical patents held by Italians or Germans, which were freely utilized by U.S. industry.6

During the initial stages in the application of the policy of nonpatentability, an industry was established that became vertically integrated with relative rapidity. Capital from home and foreign sources (predominantly Swiss and German: Merck, Ciba, Sandoz, and Bayer) developed an industry not merely producing pharmaceutical products but actually manufacturing the raw materials and active principles required, on the basis of the free, legal use of information. The fact that Switzerland was neutral and Germany an ally explains why capital from these two countries predominated at this stage.

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During the post-war period, in spite of foreign pressure, the policy of the nonpatentability of pharmaceutical products and processes was maintained, this time for different reasons, in accordance with the needs of the expanding system of medical insurance and those of industrial policy. Meanwhile, this policy did not block the movement of foreign capital. The Italian market continued to attract foreign companies that were not only seeking means to protect their own market, but even wished to take advantage of the Italian policy of nonpatentability to profit by those held by other, rival companies, thus avoiding the payment of licenses. During this same period, as before, foreign investments took the form of establishing new manufacturing industries and, in the already more frequent event of the purchase of Italian companies, the usual result was to extend the production activities of the subsidiaries.

The scientific and technical activities carried out both by foreign and native companies were thus, within this context, given an imitative character. Few companies carried out basic research. Nonpatentability gave many international companies an opportunity to imitate products manufactured by competitors. Such imitation did not in general involve any great scientific or technical effort since these companies already had sufficient expertise to be able to reproduce products with relative facility.

The Italian companies, generally the smaller ones (which boomed in the 1950s), depended on the development of an entire network of international industrial imitation, which is said still to operate. It was impossible to obtain information about this particular form of "international survey."

However, activities devoted to the imitation of products were and are not necessarily either complex or expensive. A description of any product can be obtained relatively easily. The important point was and is to maintain an efficient minimum team of biologists, microbiologists, chemists, and specialists in the synthesis of chemical products, capable of "reconstructing" technology, i.e., of discovering the process used for a product on the basis of analysis so that it may be reproduced.

Mere imitation led to technical failure in many companies but, in spite of the material difficulties, Italian industry managed, within a relatively short period of time, to produce nearly all the raw materials or active principles in the international pharmacopoeia. Research into the production process also allowed products to be modified by manipulating the active principle to improve their therapeutic potential.

To carry out the imitative-type strategy that follows from the policy of nonpatentability, the imitative pharmaceutical companies had to establish their own laboratories to carry out testing or clinical and pharmaceutical "screening," in addition to any experiments on synthetic or fermentation processes required. Once installed in a fair number of companies, these laboratories could then be modified at a cost inferior to that of installing a new laboratory so as to accommodate innovations or "innovational imitation." At the same time, scientists and laboratory technicians acquired a fund of experience, which today forms part of Italy's permanent human resources.

Nevertheless, as an isolated instrument of policy, the nonpatentability of pharmaceutical products and processes is not sufficient in Italy, nor has it ever been, to achieve all the beneficial effects possible. The unfortunate consequences of not having suitable legislation governing foreign investments and particularly the takeover of existing Italian companies by foreign firms were thus obvious, as were those of not having an industrial program regulating the formation of companies and the uses of brand names and advertising.

The absence of any policy of the first type allowed the foreign companies to attempt to balance the lack of control of the market due to nonpatentability in this sector by replacing Italian managers and by taking over Italian firms. Indeed, in 1966, 88% of all sales on the home market were made by companies with predominantly foreign capital. Apart from the question of control of the home market, taking over Italian companies also facilitated a reduction in the factors affecting the equilibrium of the international cartel-dominated market of pharmaceutical products and processes. This had been upset by the increased exports of the native Italian companies and even by those of the foreign companies operating in Italy. A case in point is that of the United States government, which bought
Italian pharmaceutical products for the U.S. army at prices substantially lower than those charged by companies holding the privileges of patents. Similarly, the independent companies in this sector were able to sell large quantities of pharmaceutical products at prices affecting sales agreements and prices in the international market. Such sales demonstrated the feasibility of production at competitive terms without the controls inherent in the patentability of pharmaceutical products and processes.

As for the Italian home market, the takeover of Italian companies allowed the purchasers access to distribution systems previously established for the Italian market, thus ensuring their sales volumes and market control. This trend was strengthened by a decrease in the tax on introducing new active principles in the international market.

For all these reasons, a large percentage of the final wave of foreign investments, particularly American, was devoted to the purchase of existing Italian companies. The object of this manoeuvre was no longer that of increasing production capacity but to acquire distribution networks and a share in the market. Having taken over these firms, foreign capital started to "rationalize" production in accordance with monopolist criteria, a development that led both to suppressing the production of certain raw materials in Italy (to concentrate their production in one subsidiary only in another country or in the parent company) and to the closing of laboratories whose maintenance could no longer be justified within the context of the interests of the transnational companies.

The second type of policy lacking in the Italian economy, and which ought to supplement the policy of the nonpatentability of pharmaceutical products and processes, is that of limiting advertising and the use of brand names, both of which are of crucial importance in the pharmaceutical industry. Indeed, in other countries, such as the United Kingdom, government policy regulates the proliferation of trade marks, which in turn generates high promotion and advertising costs and raises the price of the products. The magnitude of the problem may be seen from a comparison of the costs of promotion and of research in this sector. In 1964, advertising costs in Italy were estimated at 50,000 million lire, whereas the expenses incurred in research and technological development were no more than 7.5 million. The total production value amounted to 320,000 million lire.

A case illustrating the above phenomenon is that of Librium. Originally manufactured by Roche, 18 identical products were marketed in Italy by different companies and under different trade names. This proliferation of trade names for identical products made possible in this sector by the policy of nonpatentability generated advertising and propaganda costs, thus increasing the price of the products concerned and with margins that would, had patents been in force, have been absorbed as monopolistic income by their holders. Nevertheless, even under such conditions, as was shown by the investigation undertaken in the United States (by Senator Kefauver) for the Senate, the prices within Italy and even the export prices are lower, often substantially so, than those registered in other countries that do recognize the patentability of pharmaceutical products and/or processes.

To sum up, the lack of a policy governing the takeover of Italian companies by foreign companies and the fact that trade marks and advertising have not been rationalized in this sector, have undermined or counterbalanced any advantages that the policy of nonpatentability might have brought to the Italian pharmaceutical industry, though without negating them altogether.

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7 In England, for instance, a recent decision of the High Court reversed the previously inviolable secrecy of Her Majesty's Customs, which was obliged to indicate those importers who had violated the law governing patents, thus demonstrating the impact of Italian exports on the British market.

8 The following substances are no longer produced in Italy: vitamins (except B₁₂ and K), bismuth salts, choline salts, folic acid, dehydrochloric acid, amidopyrine, phenylethylbarbituric acid, various penicillins, antihistamines, basic hormones, and many sulfamides.
The Petrochemical Industry in Japan

Introduction

The technology policy, implicit as well as explicit, applied to the development of the Japanese petrochemical industry over the past 15 years, has been one of the most significant sectoral experiments in technology policy to have been implemented in Japanese economic development after World War II.

The principal agents in formulating and implementing technology policy in the petrochemical sector have been the Ministry for Industry and Foreign Trade (MITI), operating through its sectoral departments specialized in the chemical industry, the Agency for Industrial Science and Technology (AIST), private organizations representing the sector, particularly the Association of Petrochemical Industries, and, finally, the Japanese petrochemical industries themselves.

The formulation of both industrial and financial or technological sectoral policies has been the result, not of any unilateral action, but of consultation and agreements between the industry and the state organizations involved.

In the initial stages of the development of the Japanese petrochemical industry, this agreement was reached on a basis of favouring the import of the type of technology required for the sector and fostering its assimilation and subsequent adaptation by the industry. This policy prevailed during the first decade of the existence of the Japanese petrochemical industry (1955-65).

During the second half of the 1960's, the first petrochemical techniques to be developed in Japan were originated by means of efforts directed toward research and development by the industry itself. However, at the time of writing, more than 80% of the principal petrochemical products manufactured in Japan are still based on imported technology. Furthermore, royalties in respect of annual exports of petrochemical technology originating in Japan do not account for more than 1% of the industry's investments in research and development.

In spite of these limited achievements in the development of a native technology, the Japanese petrochemical industry has achieved a certain degree of technological interdependence with its opposite numbers in the United States and Western Europe. This is largely due to its satisfactory bargaining power in negotiating the purchase of imported technology, which is backed by government policy and finds subsequent affirmation in the ability of the individual companies to assimilate, adapt, and improve imported technology, thus reducing and in many instances eliminating their legal dependence. They have even managed to achieve a two-way flow of technological information on petrochemical processes.

This may frequently be seen in practice in the case of special licences obtained with foreign firms owning original technological methods. These licences are negotiated on the basis of the capacity of Japanese industry to conduct research to modify and even substantially to improve imported techniques, thus arriving at processes similar to though independent of the original technique developed elsewhere. In this way, the bargaining power of the Japanese firm is strengthened considerably vis-à-vis those offering original technical methods.

Two Japanese petrochemical companies may be adduced as typical examples of the application of technology policies to further the development of the petrochemical industry. Company A is one of the big companies in this sector. Its production is extremely diversified and spread over more than one production centre or petrochemical complex. Its annual sales exceed U.S. $300 million and it has more than 6000 employees. Company A devotes roughly 3% per annum of its total income derived from sales (i.e., approximately U.S. $10 million) to research and development, roughly 15% of its personnel being engaged in these activities.

Petrochemical company B is considered a medium-size chemical and petrochemical company in Japan; it specializes in the manufacture of technologically sophisticated products, either internally developed or adapted from imported technology. Its annual sales are less than U.S. $100 million and it employs a little over 3000 persons. Its outlay in
research and development represents around 7% of its annual sales, some 15% of the company personnel being engaged directly in this type of scientific and technological activity. Some of the technical methods developed by company B have been marketed in other countries all over the world.

Below we shall explain in some detail how technology policy, implicit and explicit, was implemented during the various stages in the development of the Japanese petrochemical industry. In the initial stage, the Japanese industries were entirely dependent on technology imported from the more highly industrialized countries. Later, these techniques were assimilated, adapted, and improved by the industry and, as a third stage, it developed a petrochemical technology that was purely Japanese. Throughout this process, the Japanese government cooperated with industry, granting a variety of incentives, for instance, in the form of credit, with the object of helping the native petrochemical industry to acquire the skills required for its development.

Policy on Technology and Petrochemical Imports

Especially during the first 15 years of the existence of the petrochemical industry in Japan (1955–70), technology policy was developed explicitly by means of measures affecting the process of surveying, selecting, negotiating, and purchasing technology from abroad. In order of importance, the chief suppliers of technology for the petrochemical industry were chemical and petrochemical companies in the United States, West Germany, and the United Kingdom.

The activities necessary for acquiring technology in this sector were undertaken by personnel trained within the Japanese companies themselves, within the context of the industrial programing indicated and supported by the Japanese Government. Thus, for instance, as soon as company A was set up and reached an agreement with the MITI as to the type of petrochemical plant to be installed, the frame of reference for which a MITI memorandum was entitled, “Measures for the Encouragement of the Petrochemical Industry,” it established a planning and development department, initially with a staff of 8–10 professionals. These were entrusted with the responsibility of surveying and selecting the four or five basic techniques required to set up the company’s first petrochemical plant.

Foreign companies offering technological packages were induced, by means of legislation and government rulings and the consequent improvement in the bargaining powers of the Japanese companies, to disaggregate the said packages into their component parts (termed modular and peripheral technology). These laws and rulings apply to those applied by the MITI when licence contracts for the purchase of foreign technology were studied and approved.

In effect, according to the law on foreign investments passed in 1950, any contract involving the expenditure of foreign exchange is to be authorized by an Interministerial Committee, on the basis of a technical report by the official body responsible. In the case of petrochemical contracts, this body was the MITI, working through its sectoral departments and, in particular, the staff of AIST.

Apart from the criteria of a strictly technical nature, which the MITI might employ as a basis for evaluation (technical performance, relative obsolescence, etc.), it also used others of a social and economic nature, chief among which was the use of internal resources, thus limiting payments in foreign exchange by guaranteeing only the payment of rights and services not readily obtainable in Japan. In this way, the technological packages offered by foreign companies were necessarily disaggregated, only the purchase of basic technology and basic engineering services normally being authorized; the supply of peripheral technology and of the engineering services required to incorporate basic technology into new petrochemical products was diverted to Japanese engineering firms.

These Japanese engineering firms arose in the postwar period, and almost always originated in the engineering and construction departments of Japanese petroleum or chemical companies, which were experienced in the construction and assembly of petroleum installations or traditional chemicals plants. Since the peripheral technology required for the petrochemical industry is similar to that involved in petroleum refineries
and certain types of traditional chemicals plants, it was relatively easy for the existing Japanese engineering firms to adapt to the requirements of the new petrochemical industry.

During this process, three or four of the principal independent Japanese engineering firms grew from small companies employing fewer than 50 professionals into large enterprises currently employing over 1000, which are in a position to compete on the international market. These firms offer engineering services connected with basic processes and designs originating in Japan and also serve as intermediaries in marketing technology from abroad. As an illustration of the latter function, five contracts were granted to a Japanese engineering firm for the design and construction of five nitrogenous fertilizer plants in the USSR and the German Democratic Republic, using basic technological methods developed in the USA and Japan itself.

Technology policy in this sector does not entail any attempt at self-sufficiency. On the contrary, over the past decade, about 400 contracts for importing petrochemical technology were registered and approved. During the present decade, the level of development reached by the Japanese petrochemical industry (the second largest in the world) and its innovatory capacity, in conjunction with the extremely favourable balance of payments reached by Japan in its international commercial relations, have contributed to the present situation, in which it is anticipated that the approval of the Japanese government for petrochemical licence contracts will in future no longer be necessary.

**Policies for the Assimilation and Adaptation of Imported Technology**

The most important action taken by the Japanese government in establishing the basis for the development of the petrochemical industry was to introduce a series of measures, among which were the following:

- To lay down minimum requirements for the production volume of basic petrochemical products to ensure the minimum efficiency necessary in relation to production costs. This policy led to the establishing of a cartel of initially only four petrochemical complexes with a minimum production of 20,000 tons of basic products per annum.
- To refrain from imposing an antimonopoly policy obliging these four companies to sell their basic products to other companies, thus allowing them to sell these exclusively to their own subsidiaries as inputs for further processing.
- To grant subsidies and incentives as a protective measure to favour the growth of the infant industry, thus reducing production costs, instead of imposing prohibitive tax barriers.
- To direct competition in the Japanese market only in respect of the tertiary petrochemical products manufactured by Japanese companies.
- To provide incentives and support to encourage exports of petrochemical products to other countries.

In fact, once it was decided to establish a petrochemical industry in Japan, the MITI authorized the installation of four development centres or petrochemical complexes by as many Japanese chemical and petrochemical companies. These were in direct competition only insofar as their end products (plastic resins, detergents, raw materials for synthetic fibres, etc.) were concerned, to supply the growing demand of the Japanese home market. As a result, each of the four companies concerned sought to improve their position vis-à-vis their competitors, chiefly in respect of their end products, either by reducing production costs or by offering an improved product.

They quickly came to the conclusion that this was in fact feasible if the techniques initially imported were modified or improved. To do this, the Japanese petrochemical companies installed laboratories for development and pilot plants within the same complex as the production plants. In this way, the technical staff of the companies, which was in charge of the construction and operation of the first plants and already familiar with the original foreign technology because of the policy of disaggregating technological packages, was enabled to assimilate, modify, and even to improve the basic technology imported and to apply the results of their work when the installed capacity of the plants was expanded. Such modifications of the original technology were given priority in tertiary
petrochemical plants manufacturing end products, understandably in view of the fact that competition between the companies was no longer a question of either primary or intermediate products.

Insofar as the basic petrochemical plants are concerned, for instance those producing ethylene, the principal petrochemical raw material, the policy followed by the great majority of the petrochemical companies was to continue to rely upon modular techniques purchased abroad. These techniques were made more easily available by planning within the sector and by the fact that the four companies cooperated in comparing notes as to their experiences, forming a kind of tacit common front to the outside world. For instance, three out of the four companies originally appointed to manufacture basic petrochemical products during the initial period, negotiated the purchase of the appropriate technology from the same foreign engineering company within a very short space of time.

To support the Japanese petrochemical industry in this kind of strategy, the MITI implemented a protectionist policy through the agency of powerful incentives (the institution of import quotas, temporary suspension of income tax and of taxation on certain inputs and capital assets, the inclusion of petrochemical products on a ‘‘priority’’ list for export (i.e., with state support, etc.)), designed to reduce investment and production costs instead of imposing tax barriers. This kind of nonfiscal measure also represents a policy of protecting local industry, though with different effects on tax receipts, production costs, and flexibility in the handling of policy, and on their susceptibility to pressure from abroad as to the regulation of commercial policies.

In the same way, the MITI’s recommendation to create long-term lines of credit (approximately 8–10 years) at low rates of interest for the benefit of the Japanese petrochemical industry, also proved a very effective instrument of policy. In view of the fact that it is standard practice for the Japanese companies to finance roughly 80% of their operations with long- and short-term bank loans and considering the importance of investments in capital assets in the petrochemical sector, the decisive nature of protective measures of this kind for the development of the sector may be appreciated.

Moreover, when the Japanese petrochemical industry reached a certain degree of maturity, it had the additional support of the MITI to start exporting to the world markets. At this stage in their development, it was important for the Japanese petrochemical companies to achieve a position of relative technological independence with respect to the suppliers of the original technology on which they based their export products to avoid conflicts and restrictions in marketing these products internationally. This represented a new stimulus for the companies involved to seek new ways of modifying and adapting the original imported technology and thus eliminate or reduce the restrictions or dependence of a legal nature imposed by the company holding the original technology. In many cases, this policy of modifying and adapting imported techniques has allowed the Japanese petrochemical companies to participate in a system of cross licensing with transnational petrochemical companies.

Policies for Generating Petrochemical Technology

In Japan, research to develop new petrochemical techniques or variants of imported techniques takes place within the companies themselves. In the 1960s, nearly all the Japanese petrochemical companies established their own central laboratories for research and development, and it is here that both basic research and applied research on new petrochemical products and processes are carried out.

Generally speaking, the Japanese companies endeavour to seek the most effective technological solution to the problem of their industrial and commercial expansion. Sometimes the most suitable solution is to use a technical method developed within the company; on other occasions, it may be best to negotiate for and purchase foreign techniques, whose value has already been established in other plants or installations.

The funds devoted to the generation of petrochemical techniques annually represent some 3.5% of the total sales of the Japanese petrochemical companies. There are exceptions, such as company B, which devotes up to 7% of its total sales value to research and development activities.
Private research in Japan (in all branches of industry) costs around U.S. $24,000 per research worker per annum. In the case of the petrochemical companies investigated, the annual cost per research worker varies between U.S. $10,000 and $13,000.

The figures obtainable for activities required to develop a new petrochemical product or process are variable (and were all given on condition of strict confidentiality), depending on the process or product and on the organization and size of the company. The following figures may serve as an example:

(a) Development of a new product made of plastic, which has had a marked success in Japan and the techniques for which have been exported

| Time required | 36 months |
| Personnel involved | 180 engineer-months |
| Total cost (U.S. $) | $125,000 |

(b) Development of a completely new process for controlling environmental pollution

| Time required | 11 months |
| Personnel involved | 200 engineer-months |
| Total cost (U.S. $) | $180,000 |

(c) Development of a new basic petrochemical process with commercial possibilities in Japan for more than one branch of industry, the characteristics of which have aroused interest in its application in other countries

| Time required | 36 months |
| Personnel involved | 1440 engineer-months |
| Total cost (U.S. $) | $2,000,000 |

The efforts of the Japanese petrochemical companies to generate petrochemical technology were seconded by certain research projects carried out by the National Research and Development Laboratories of the AIST and the MITI, especially the national research and development programs started in 1966. Of the nine national research projects in progress in 1971, two concerned the petrochemical sector, had an expense budget of around U.S. $22 million and were to be completed within 6–7 years. One of the projects was cancelled in 1972 because the results of the new process to be developed proved uneconomical. The two projects in question (new processes for desulfurizing fuels and gases for fuel and new processes for producing basic petrochemicals) were selected by the National System for Research and Development for a number of reasons: firstly, because these projects, connected as they are with the petrochemical industry, are in the national interest; secondly, because the support of various research organizations, official and private, is needed to carry them out; thirdly, because of the scope of the effort required; and, finally, because of the element of risk involved as to the results to be obtained. It has already been said that the policy governing the technological innovations of Japanese private petrochemical companies had the effect of directing and concentrating private research and development activities in the field of tertiary processes and products and the installations required to produce them. The National System has thus provided a mechanism to supplement private research by restricting its efforts to the field of basic petrochemistry and that of environmental pollution control.

Policy Encouraging Petrochemical Technology in Japan

Policy for stimulating the development of industrial technology in general in Japan applies equally to the petrochemical industry in particular. For example, through the agency of the AIST, the MITI subsidizes an annual average of 50 research projects carried out by private Japanese firms, which subsidies may amount to an average of U.S. $7 million per annum. A number of the petrochemical companies interviewed, including company B, acknowledged having received research grants in the past through the AIST.

Of even greater significance are those instances where the MITI has, together with interested chemical and petrochemical companies, established working groups to develop new techniques of nationwide interest. An example is the "Association for Research on Raw Materials for Polymers," which operated from 1959 to 1962. This was formed by a number of private Japanese chemical companies in conjunction with the MITI, for the
The purpose of developing a native technology for the manufacture of basic petrochemical products, which was more in line with the requirements and the Japanese industrial infrastructure. The association was dissolved without having finished its work, which was continued independently, however, by one of the member companies.

In the end, they arrived at a process that could, under certain conditions for raw materials and end products, be used at the industrial level.

In the same way, certain Japanese petrochemical plants using their own technology were granted special loans by the Japanese Development Bank and an accelerated depreciation rate was approved by the Ministry of Finance, the MITI having reported favourably on their activities.

Nevertheless, the indirect policy with the greatest impact in encouraging the development of Japanese petrochemical technology is still the MITI's industrial policy of stimulating industrial and commercial competition between the private Japanese petrochemical companies, once they have passed beyond the stage of "infancy," which is generally regarded as comprising the first 5 years of operation.

Training and Information in the Japanese Petrochemical Industry

The active position adopted from the first by the new Japanese petrochemical companies as to the process of surveying, selecting, importing, assimilating, and adapting imported technology, added to the solid educational and professional basis of the Japanese technicians who took part in this process, laid the foundations for the initial training of the technical staff involved in the development of the Japanese petrochemical industry.

The MITI's decision to authorize the import only of disaggregated technological components otherwise sold in packages provided the great opportunity for the staff of the engineering and construction departments of the Japanese petrochemical companies to become intimately acquainted with new petrochemical processes and the plants to which these gave rise.

Finally, the need for technological innovation in the field of petrochemistry in Japan, whether by adapting and improving imported technology or by creating a new technology, was translated in the first place into on-the-job training of production personnel. This enabled them to understand and manipulate the processes they were using, with the help of the laboratories and pilot plants operating within the production centres themselves. At a later stage, this activity was backed up by the participation of the staff of the central investigation and development laboratories belonging to the same company and which originated the basic research giving rise to new techniques. The staff of these central laboratories was selected and trained by the same means by which an industrial research centre is usually created.

Japanese professional petrochemical technicians were thus, in effect, trained in the course of their professional activities, a type of training that is nowadays continued systematically and permanently in all the Japanese petrochemical companies.

Information as to processes, products, methods, and operations in the petrochemical industry is similarly a matter of individual initiative on the part of the companies and their staff. National information systems, such as the Japanese Information Centre for Science and Technology (JICST), represent only secondary sources of information and are used only to complement the direct sources of information that the companies have at their disposal: personal contacts, travel, technical journals, international congresses, etc.

The Characteristics of Petrochemical Technology Supply and Their Relevance to Activities in the Andean Common Market

Petrochemical plants are usually classified as follows: basic production plants (ethylene, ammonia, benzene, etc.), intermediate plants (styrene, phthalic anhydride, vinyl chloride, monomers in general), and tertiary or final production plants (plastic resins, synthetic resins, synthetic detergents, synthetic rubber, fertilizers, etc.). This classification was based on the level or degree of processing of the petrochemical products in the chain of transformation.
The technology available for the manufacture of basic petrochemical products is usually a matter of simple techniques insofar as the degree of processing, transformation, or synthesis of the petroleum as a raw material into a petrochemical raw material is concerned. The processes involved are well known and have been exhaustively studied, and there are practically no patents protecting them.

The basic and detailed engineering designs of basic petrochemical installations, on the other hand, tend to be fairly complex, their execution requiring a substantial number of engineer-months. The plants also tend to have a large production capacity, which means that the conversion of petroleum-based raw materials into basic petrochemical products, yields significant profits.

It was thus the international engineering companies, working on their own or in combination with certain petroleum or petrochemical companies, which made the greatest efforts to perfect, not so much the processes involved, as the design of the basic petrochemical plants. It is thus these companies that constitute the chief source of supply of technology and of the engineering services required at the international level for installing basic petrochemical plants.

The engineering firms operating on the international market, which are at present in large measure responsible for supplying engineering services for the installation of basic petrochemical plants, are firms like Kellogg, Lummus, and Fluor, with their headquarters in the USA; Power Gas, a British firm; Lurgi and Uhde of West Germany; and TEC and Japan Gasoline of Japan, to name but a few of those most active in recent years.

The chief interest of all these engineering firms is to sell specialized services. In the final analysis these are calculated on the basis of the number of engineer-hours required to carry out each project, plus the sale of the patentable know-how developed through their own activities or those undertaken together with other firms.

The international engineering firms are in a way specialized in certain petrochemical designs, depending on the success of the engineering designs offered by each firm for each basic petrochemical process. For instance, Lummus has been successful in selling its designs for large ethylene plants with a capacity of 300,000 tons per year, whereas Kellogg, Power Gas, and TEC are better known for their designs of ammonia plants with a capacity of 1000 tons per day or over.

What interests the users of this type of technology, who would perhaps in the Andean Subregion tend to be state-owned petroleum or petrochemical companies, is basically the cost of the services, the total sum of investments required, the unit cost of the inputs; in other words, the factors affecting the cost of the final product. The specifications and characteristics of the products to be obtained are of secondary importance because the petrochemical products in question are simple and well known, and therefore these specifications and characteristics are standardized all over the world.

It may be inferred from the foregoing that the principal bargaining point with such suppliers of technology would lie in the extent and sum total of the engineering services offered. In this respect, the fact that the petroleum and petrochemical companies in the Subregion have already acquired experience through similar negotiations may favourably affect contracts to be drawn up in the future for the installation of basic petrochemical plants.

The further consideration that these same engineering companies are also interested in selling their professional services for designing petroleum refineries and plants for processing natural gas should also strengthen the bargaining position of the state-owned petroleum and petrochemical companies in the Subregion, especially if they could establish some kind of coordinated negotiation and information system. Perhaps it is worth pointing out, though, that the principal saving in such concerted action would lie rather in the extent of the services to be contracted than in their unit value, which is already fairly well known and based on standard calculations.

The situation is very different for intermediate and final petrochemical products, or rather, their manufacture and the supply and negotiation of the available techniques. Certain intermediates are produced in large quantities; their production techniques are in widespread use and their processes are not protected by patents. These techniques are,
moreover, offered by the international engineering firms with no restrictions whatsoever, as are those for basic petrochemical products. In the case of certain other intermediates, especially monomers and synthetics of a certain degree of sophistication, the manufacturing techniques have been developed by chemical and petrochemical companies, usually in association with those manufacturing the final products for which the intermediates are destined. In this case, any technology offered originates in the very manufacturing companies that developed or successfully imitated it.

In the case of final petrochemical products (e.g., plastics, synthetic resins, synthetic rubber, etc.), basically those marketed by the petrochemical companies all over the world, a similar distinction may be made between those based on widely known techniques and marketed in large quantities (for instance, low-density polyethylene) and those petrochemicals manufactured on the basis of sophisticated techniques, subject to a high degree of protection, produced in small quantities and with a large margin (such as teflon). In the latter cases, the techniques in question are protected by the privileges conferred by patents and to which the owner may assign arbitrary values, depending on a number of factors: the demand for the process and the product, whether the holder of the licence holds a monopoly or near-monopoly, the gross profit margin of the product using the said process, expected production volume, etc.

In some instances (in fact, quite frequently), access to certain restricted processes in the secondary or tertiary petrochemical sector is possible only by accepting the holder of the patent as partner in a new project, through his contribution to a partly state- and partly privately owned company to be established expressly for this purpose.

Countries like Japan, which has its own financial means and a sufficiently wide home market, tried to discourage the massive influx of foreign capital associated with the necessary imports of petrochemical technology by means of legislation allowing foreign investors only a minority interest in the capital and management of those Japanese companies considered of crucial importance for development, such as the petrochemical industry. This measure made the placing of capital in Japanese industrial companies a relatively unattractive prospect for the foreign investor.

In view of this situation, the chemical and petrochemical companies owning technology of interest to countries like Japan preferred to grant licenses for these, under fairly restrictive conditions, especially insofar as the marketing of the produce abroad was concerned.

The bargaining position of the client industry, even if it had state support during negotiations for technology contracts, is thus evidently considerably lessened in these cases, especially if any particularly interesting technology is available only from one source.

In a situation of this nature, the best course of action is to be able to demonstrate to the owner of the technique one wishes to obtain that one does not really need it, and this was precisely the strategy followed by the Japanese petrochemical industry whenever opportunity arose.

In this way, for instance, during the 1950s, a Japanese company manufacturing rayon was one of the first to obtain a licence to manufacture nylon using the Du Pont process, by demonstrating that it had developed a similar process that would allow it to manufacture nylon, without infringing any of the patents protecting the Du Pont process.

During the 1960s, the Japanese petrochemical industry introduced modifications and improvements for the most important tertiary petrochemical processes, which were originally imported, in order to improve its bargaining position with the holders of licences for the original processes when they wished to increase their production volume (the object of which increase was often to be able to enter the international market).

The only possible way of achieving complete independence of a foreign licence, and a way that is perfectly legal, is that of demonstrating convincingly that the original process has been modified or substantially improved by the user; this allows the user to bargain for an extension of the licence under conditions much more flexible and favourable than those originally granted, and thus to take part in a system of technological information and cooperation.
The Copper Industry in Yugoslavia

During the visit to Yugoslavia, particular attention was devoted to the policy followed in this country for the copper mining and metallurgy industry. Having had to start anew after World War II with its industry totally destroyed and the vast majority of its key technicians and scientists exterminated, Yugoslavia's experience in qualifying and training personnel and in laying down a policy for acquiring and mastering foreign technology is of particular relevance. Yugoslavia may be considered a success in that it has achieved a high standard of industrial efficiency and managed to build up a considerable supply of top-level scientists and technicians with the specialized skills required for this sector.

Below, we have summarized certain aspects of sectoral technology policy in the copper industry in Yugoslavia, especially those concerning the training of personnel and the surveying, disaggregation, and imitation of foreign technology.

Policy for Training Personnel in Scientific and Technological Activities in this Sector

In 1953, the Yugoslav copper mining company, RTB, had on its staff only one engineer who was a specialist in electrolysis, one metallurgist, one mining engineer, and a few dozen workers and specialized technicians. At present, there are about 400 specialized professionals working for the company.

In 1953, in spite of the scarcity of material and human resources available, a number of significant policy measures were introduced that laid the foundations for the training of the numerous technicians and scientists now working for the RTB. The most important of these measures were:

- In spite of the enormous difficulties and scarcity of resources to be countered, all projects for new plants and installations carried out from 1950 to 1957 were designed within Yugoslavia, even if many were handled by other companies. This did not mean that the country was in a position to rely exclusively on its own scientific and technical resources; on the contrary, it was necessary to farm out parallel contracts and to rely on specialized foreign consultants and experts.
- In selecting machinery, equipment, and other installations, which were of necessity imported, the RTB carried out its own studies, had others performed by other Yugoslav companies and, at the same time, had others carried out abroad under contract by firms of specialists. This form of parallel contracting was and is, like that referred to in the preceding paragraph, one of the most important of the channels open to Yugoslavia for training high-level professionals.
- The few scientists and technicians the RTB had at its disposal at that time undertook a campaign to survey the techniques to be used in designing new projects and extending those already in operation. This entailed, as a primary measure, an active review of existing techniques; the extent of this survey may be gauged from the fact that, by the end of 1957, 40 countries had been visited.

1960 saw the beginning of a new phase: RTB's so-called "Development Phase One." The majority of the technology inputs at this stage, particularly essential technology, were still being imported. Insofar as the training of key personnel is concerned, the most salient features of this phase were as follows:

- RTB was by now already in a position to draw on previous experience in the management of its entire mineralogical complex, in spite of the lack of personnel. This experience was coordinated in the form of RTB's Department of Development and Research, later (in 1963) to become the Copper Institute. This department systematically carried out research into techniques to be imported and their assimilation, which necessitated training personnel directly in the course of the industrial projects carried out and selective technology imports.
- The systematic program of the dismantlement, research into, and redesigning of parts and of assembling imported machinery was useful both for training personnel negotiating the purchase of new machinery and, more particularly, as a training ground of enormous importance for key professionals. This training was carried out on the
basis of "‘reversing’" technology, that is, of analyzing the processes necessary for reproducing parts that it no longer intended to import.

- Of an importance at least equal to that of the foregoing was the creation by RTB of the Faculty of Mining and Metallurgy in Bor, a town with the oldest copper mines in the country. Nowadays it has 1500 students at all academic levels, and over 200 staff members, many of whom are also attached to RTB or the Copper Institute.

- For “Phase Two,” RTB developed to the full its policy of using parallel contracting as a system of training and apprenticeship. For instance, when the reduction plant in Bor was extended, RTB and the Copper Institute conducted their own studies, parallel to those carried out at the same time by five foreign firms of consultants (Giroproc Vetnet, Lurgi, Western Knapp, Selection Trust, and a Belgian firm).

- A similar policy was followed during the 1950s with respect to specialized consulting and engineering firms, though not in precisely the same terms. RTB and the Copper Institute were now intending to associate themselves with foreign companies (such as Western Engineering, Venopic, Krupp, Kaiser, etc.) but the focus of interest was now not only to carry out research for RTB, but to apply the know-how gained through experience to exports undertaken jointly to other countries.

The policy systematically applied with respect to technology imports and their integration locally was the crux of the training program for RTB’s key technicians and scientists. In fact, this is still substantially true today. It represents the most important channel for the training of research workers and technical staff. The situation differs only slightly nowadays in that, thanks to the long apprenticeship undergone (for instance, it was not until after 10 years that RTB felt that its technical and economic studies were satisfactory), it is now possible for them to export their experience abroad. The basis of their competitive capacity, moreover, is not merely a question of accumulated technical and scientific know-how, but of the relatively low cost of technical and scientific labour in Yugoslavia.

Exporting technical and scientific know-how is, in effect, a labour-intensive activity using the most sophisticated type of labour. The fact that top-level Yugoslav personnel have a lower income (compared to that of their European or American counterparts), makes their employment an attractive proposition for specialized engineering firms. In this way, the European engineering firm supervises, and in practice retains control of, projects carried out in association with Yugoslav experts in other countries, thus enabled to furnish a guarantee (virtually a hallmark) and at the same time to reduce costs.

It may be said in summary that, in Yugoslavia, practical criteria and experience were of supreme importance in the training of personnel for scientific and technical activities, and that these criteria were undoubtedly of greater importance than the traditional form of university education. The criteria in question hinge upon various forms of association with foreign countries, repositories of the most advanced scientific and technical knowledge in the world, and this association has enabled Yugoslav technicians and scientists gradually to build up their technical level to the point of being able to form equal partnerships. One might say that the "‘apprenticeship’" has been prolonged indefinitely because of the constantly changing character of the technology involved. This does not mean that the Yugoslav specialists have been unable to "‘master’" certain scientific and technological activities, such as the technical and economic studies that, as we said above, it took them 10 years to "‘master,’" but rather that they have set themselves extremely exacting standards.

**Policy on Licences and Patents**

European and American technology is and has been at an advantage compared to that of Yugoslavia in all aspects of the technology of copper and its by-products and semifinished products. This involves many specialized engineering problems, such as the technology of auxiliary processes like the control of contaminants passing through the machinery, equipment, etc., at various stages of the production process.
The RTB, recognizing the realities of the situation and the necessity of making use of more advanced technology, was extremely cautious in the policy it implemented. It did not intend to break its dependence simply by infringing patents, but paid the licences and respected the prevailing norms when necessary. This did not stop it from carrying out a conscious, active search for alternative techniques, disaggregating packages of technological requirements, contracting highly skilled foreign experts to examine and solve specific problems, imitating products to legally avoid patents and, most important, negotiating the purchase of technology (i.e., designs and sufficient information enabling the RTB to reproduce and modify a patented article).

The purchase of foreign technology was carried out principally during the two periods in RTB's "construction and reconstruction" described above, the so-called "Phases One and Two." The elaboration and subsequent performance of the entire complex of operations involved in each phase, during which numerous investment projects were put into action, was entrusted to an ad hoc committee known as the "Investment Commission." This was composed of a Director: the Assistant General Manager of RTB, and members: the Chief Engineers of the departments of Mining, Flotation, Metallurgy, Technology, Machinery, Electricity, and Electronics, and, in addition, three economists.

It was the three economists who were responsible not only for managing the financial aspects of the operations concerned, but also for negotiating contracts with native or foreign companies for all operations involving licences, patents and technical assistance. As a result, only three company officials, the economists, supported by the highest-ranking technical staff in the hierarchy, comprised the nucleus for all technology negotiations.

Once an investment project has been approved as a whole by the RTB Workers' Council and the preliminary negotiations have been conducted, the purchase of technology, equipment, machinery, etc., is carried out by public bidding in which generally bidders take part for each item.

As an illustration of the complexity of the operations necessary in each of these stages, "Phase Two" required the participation of 186 local companies and 20 foreign research institutions in installing 36 new industrial plants. Not one of these 36 plants was the exclusive responsibility of any one foreign company alone. In visiting them it may be seen, for instance, that practically all the work on infrastructures, buildings, and much of the equipment is of local origin and that machinery and equipment from many diverse sources are to be found within each plant. French or Belgian machinery may be seen side-by-side with German, American, or Yugoslav equipment. Electronic control and alarm installations are by IBM, ICL, Honeywell, Electrofilter, etc., a sign not only of increased autonomy, but also of discernment as to which equipment is compatible.

In addition to the comments made above and elsewhere, it is also worth remarking about the RTB's policy regarding markets abroad. The development of its own capabilities has allowed the RTB (or the Copper Institute) to make cooperative agreements with specialist companies to exploit its capacities to the full in other countries. RTB cooperated with Venopic in installing an electrolysis plant in India and with Power Gas and Krupp for a similar plant in Peru. They also worked together with American firms on projects in Greece and Turkey. This form of cooperation is at once a means of enhancing the efficiency and probability of their technological resources and of taking advantage of the experience and information of the most advanced of the companies with which they are associated.

Policy on International Technology Surveys

As we remarked earlier, by 1957 RTB experts had visited some 40 countries. These visits have been continued as a matter of principle and put into intensive practice. Indeed, RTB intends to maintain this policy indefinitely as a fundamental means of staying up-to-date on worldwide technological developments, of keeping up its contacts with a view to possible two-way contracts or directly for consultation and specific contracts. They currently have a file of information on developments in the technology of nonferrous.
metals, derivatives, and by-products, having visited every country in the world except three, which were omitted for political reasons.

During the initial phase, the object of the visits undertaken by the RTB experts was to find appropriate techniques for specific projects for new plants or extensions of existing ones. They thus included visits undertaken for the purpose of conducting direct negotiations. Other visits were made for the purpose of obtaining information on general experience gained in other countries, in other words with no specified aim, whilst yet others were strictly for study purposes. At present, these visits abroad are changing in content with the increasing importance attached to cooperation with specialized industrial engineering companies.

The persons selected for these missions are not only experienced in the particular field concerned, but can also draw on their vast experience on the subject of copper generally. This means that RTB selects personnel capable of interpreting the technological aspects and of gathering valid data in the course of extremely brief visits.

Before each visit is undertaken, an exhaustive work program is prepared on the central problem to be gone into. This does not imply, however, that the object of the visit is to be restricted to an examination of this subject only. After the visit, both written and verbal reports are submitted (a technical forum is always held), including any aspects of the subject observed, however apparently trivial. For instance, after a 1-week visit to Company X, the principal object of which was to discuss certain specific problems connected with smelting, the final report was 150 pages long, with 10 chapters dealing with all aspects of refining.

Policy on the Disaggregation and Purchase of Technology

The disaggregation of technology is an extremely heterogeneous matter in the copper industry, involving as it does elements as diverse as smelting, extraction, control apparatus, chemical processing of by-products, processes involved in the numerous semifinished products, etc.

In the case of the Yugoslav copper industry, disaggregation policy chiefly hinged upon the purchase of extraction machinery and equipment. This is not, of course, the only line of technology imported, but it is of the utmost importance in view of the amounts of foreign exchange involved.

Importing extraction machinery and equipment, including bulldozers and heavy-tonnage diggers and dumping lorries, is a cumbersome and expensive form of importing incorporated technology. The patents protecting the know-how involved in the technology of the above machinery and equipment do not cover the mechanics of the assembly (it is impossible, for instance, to patent an entire dumping lorry), but do cover certain specific mechanisms of the machinery, the manufacturing process for certain parts (these patents may grant monopolies for their use and reproduction), or the design of certain pieces or subassemblies.

The RTB has a department (FOID) specialized in repairs, maintenance, and troubleshooting, which has since 1950 implemented a systematic policy of disaggregating imported equipment and machinery. The form in which this is done depends on the extent to which the technology imported is incorporated. In particular, it involves completely dismantling imported equipment and machinery. The form in which this is done depends on the extent to which the technology imported is incorporated. In particular, it involves completely dismantling imported equipment and machinery, examining all the mechanical and physical principles underlying its functioning, copying all the pieces, parts and subassemblies of which it is composed, and studying the alloys and processes necessary for manufacturing them (machining, thermal treatment, surface protection, etc.).

The above form of disaggregation allows a precise estimate of the parts of the mechanical assembly that it is essential to import, the modifications that may be introduced to improve or adapt it, the technology that could or should be purchased and incorporated, and monopolies that cannot be avoided because of the impossibility of imitation or sales restrictions imposed by the holder.
In certain instances, and the FOID department has indeed managed to do so, it is possible to obtain the designs and manufacturing parameters of many of the parts from the vendor of the equipment, as a part of the bargain concluded for the purchase of incorporated technology. Equally, it is also possible to reproduce a part of a piece or subassembly, since no patent for a design covers all the individual parts of the piece. It is also possible to manufacture a piece by using a slightly different process to that used in the piece patented, even accepting additional costs if necessary and convenient, and a product of inferior durability. This may be done in the case of the caterpillar treads of a bulldozer, the alloys and special thermal treatment used, which make their durability a difficult quality to reproduce. The problem of patents is thus regarded from an extremely pragmatic point of view. On the one hand, where patents are in force, they do not export the article imitated, reserving it exclusively for their own use. On the other, they do not accept, nor does Yugoslav law recognize, any restrictions on the unlimited use of know-how once the licence has been purchased.

The FOID department has managed, by means of disaggregation and by profiting from the experience and resources of the Copper Institute, to achieve its present mastery of production technology in a vast variety of mechanical goods. It is thus in a position not only to husband scarce resources (e.g., foreign exchange) to a significant degree, but also to export goods abroad and to sell them throughout the entire country. The FOID department is able to draw on the engineering knowledge of the RTB and the Copper Institute for the manufacture of parts and also contributes significantly, in its own right, in constructing and equipping entire plants (smelting, electrolytic treatment, etc.), besides cooperating in the construction and assembly of all RTB plants and installations.
The Machine Tools Industry in Czechoslovakia

Introduction

The development of the metalworking industry has been a decisive factor in the structural transformation of the Czechoslovak domestic economy, determining, among other things, policy on investments and foreign trade. Moreover, the output of the metalworking industry represents roughly 30% of total industrial production and includes some 75-80% of the total variety of metal goods of this type available all over the world. Its production volume increases by some 10% per year. Exported machinery and mechanical installations represent 30% of the Czechoslovak output in this sector, 30% of this figure representing the heavy machinery industry.

Czechoslovakia occupies an important position in the world production of machine tools, of which it manufactures approximately 4%; this places it seventh in the list of manufacturing countries. Its export volume makes it the sixth exporter of machine tools in the world, 70% of its exports going to the other socialist countries, 10% to the developing countries, and 20% to the industrialized capitalist countries. Machine tools represent 18% of Czechoslovakia's total machinery exports.

The scientific and technical development of the metalworking industry should be seen against the background of state policy on science and technology. The development and implementation of this policy involves nine state programs of basic research intended to generate the knowledge necessary for scientific and technical development and to encourage science generally. It further includes 18 state programs for technical development geared to the structural development of the national economy.

The study summarized below was intended to furnish a description of the manner in which the scientific and technical activities carried out in the Czechoslovak metalworking industry are organized, the role and position of the latter within the national economy, the principles according to which it is planned (especially from the point of view of social and economic needs), and the minimum effort necessary for the development and implementation of these activities. The summary includes a description of the system used for planning scientific and technical activities in the metalworking industry and some critical comments. The subsector selected for this case study is that of the machine tools industry.

Activities Directed Toward the Scientific and Technical Development of the Machine Tools Industry

An analysis of the organization and use of resources destined for the scientific and technical development of the Czechoslovak machine tools industry allows for a better integration of the experience accrued over the past 25 years. In view of the fact that scientific and technological activities in the machine tools subsector account for 4.9% of the funds allocated for the scientific and technical development of Czechoslovak industry as a whole and roughly 3% of the annual cost of all scientific and technical activities, it is of interest to examine both the nature and content of these activities and the minimum effort required to carry them out. Some of the activities involved are discussed below.

Basic research

The basic-directed research necessitated by the development of the machine tools industry is entrusted to laboratories and centres affiliated with technical colleges, the Machinery Construction Research Institute (MCRI), and other institutions working in association with the Academy of Sciences. The technological development of the machine tools subsector involves solving theoretical problems in a variety of fields, including applied mechanics, hydromechanics, thermomechanics, material resistance, and others. Thus, for instance, a theoretical explanation and solution of the problem of self-generated vibrations during machining was possible only on the basis of a theoretical, experimental solution of problems related to the mechanics of assemblies and the development of calculation methods for establishing resonance frequencies in assemblies and
subassemblies. Similar instances of cooperation between the Machine Tools and Machinery Research Institute (MTMRI) and other centres and institutes, including the MCRI, took place for gear wheels, gearboxes, bank resistance, etc.

In other words, the machine tools industry needs a number of centres of basic-directed research that are in a position to supplement or generate the information necessary for applied research or for the development and design of products. Such centres or institutes would in no case be devoted exclusively to the machine tools subsector. Research conducted by the MCRI has contributed to the development of such industries as textiles machinery, power plants, motors and compressors, and installations for the chemicals and other industries. At the same time, the understanding thus gained has permitted Czechoslovak industry to attain a greater degree of independence, with consequent economic benefit to the country as a whole.

Design and development of machine tools

The Czechoslovak machine tools industry is based on techniques developed within the country or acquired by dispensing with the mechanisms of purchase through licences. From the time of their reorganization onward, after the end of World War II, no company manufacturing machine tools has concluded any passive licence contracts or made any purchases.

In 1946, Czechoslovakia was producing 6000 different types of machine tools that had been developed and designed, generally speaking, by intrapolating and extrapolating from prior solutions. In view of the limited size of the manufacturing companies (200-300 employees), the scarcity of resources for scientific and technical activity, and the acute lack of technicians, it was necessary for the economic reorganization of the Czechoslovak machine tools industry to adopt a number of measures to organize and centralize the scientific and technological infrastructure of the subsector. Many technicians and specialists had left the country as a result of the political changes in the early post-war period, and the rest were dispersed in factories or employed in work that often paralleled or duplicated efforts elsewhere (e.g., in developing machinery with identical parameters or with differences lacking any technical justification).

To centralize and improve the use of available resources for the purpose of carrying out scientific and technical activities, 20 of the best technicians and specialists to be found in the factories (not necessarily technical university graduates) were formed into a working group and commissioned to design and develop new types of machine tools to be manufactured by companies lacking their own design and development facilities. They were further responsible for the design and development of machinery falling under import prohibitions and of that required for the manufacture of parts and assemblies affected by the same prohibitions (e.g., ball bearings).

In addition, the recently established MTMRI was to organize the standardization of the subsector, that is, to develop and design research apparatus and equipment and to train specialists and research workers for future jobs in the MTMRI and in industry. These constituted the chief tasks of the institute during the initial 3 or 4 years of existence. At a later stage, activities connected with design and development were restricted to the design of complex machine tools (including automatic ones) and, latterly, included only the essentials needed for discovering units, systems, and complex assemblies common to various types of machine tools (hydraulic systems, guidance and control elements, copying and loading equipment, etc.).

In all, the MTMRI was responsible for the design of 76 types of machine tool, the total production value of which amounted to 900 million Czech crowns (ca. U.S. $50 million).

Nowadays, each company is responsible for the production of one or more types of machine tool and, similarly, for their design and development. The scientific and technical activities required for the manufacture of machine tools thus involve, at the company level, developing the equipment and its production technology, assimilating the information generated and its use in active production. Information obtained shows that, in terms of the work involved and measured, for instance, in man-hours, there are no fundamental differences, according to the type of machine tool produced, in the relationship between
these two categories of scientific and technological endeavour. The effort required to develop, design, and put into production machine tools of any one type, expressed in terms of man-hours, depends, among other factors, on the technical level or sophistication of the machine. Thus, for instance, in company A, production of a semiautomatic cutter necessitates an effort nearly double that required for a manually operated cutter. The design and development of the new cutter demands an effort 1.7 times that devoted to the development and design of the manual cutter. Furthermore, initiating production requires 2.2 times the effort demanded by the scientific and technological activities required to initiate production of a manually operated cutter.

If we analyze the structure of the effort required for the design and development of a technically more advanced cutter, we shall see (Table 1) that the chief difference lies in the actual design stage, whereas the production technology involved does not represent any great additional effort and is even reduced in the case of the production and testing of the prototype.

Microanalysis of the effort required for initiating production (see Table 2) shows an increase of nearly 100% for the semiautomatic cutter, an increase that is even more marked for the design of tools and other equipment (roughly 300%), their production technology (nearly 400%), and the manufacture of new tools and implements (800%).

The design and development of a machine tool in company A takes an average 12–24 months, from the time of approval of its technical and economic parameters until the delivery of the technical documentation. Production of the prototype requires 9–12 months, and tests and trials a further 6 months, approximately. By the end of the year, series production is already in progress, and any innovations will be introduced when a new series commences. The former of the two above analyses does not take into consideration endeavours to identify market requirements in terms of technical parameters (which are essential prerequisites to the design), nor market volume or quantity (which determine production technology).

Table 1. Design and development of two technically different cutters, manually operated and semiautomatic.

<table>
<thead>
<tr>
<th>Effort</th>
<th>Manual</th>
<th>Semiautomatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total man-hours</td>
<td>49,250</td>
<td>83,750</td>
</tr>
<tr>
<td>% man-hours</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>% spent on: design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>production technology</td>
<td>32.4</td>
<td>40.2</td>
</tr>
<tr>
<td>production and testing of prototype</td>
<td>14.2</td>
<td>18.9</td>
</tr>
<tr>
<td></td>
<td>53.4</td>
<td>40.9</td>
</tr>
</tbody>
</table>

Table 2. Preparing and initiating production of two technically different cutters, manually operated and semiautomatic.

<table>
<thead>
<tr>
<th>Effort</th>
<th>Manual</th>
<th>Semiautomatic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total man-hours</td>
<td>88,250</td>
<td>192,187</td>
</tr>
<tr>
<td>% man-hours</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>% spent on: design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>technology</td>
<td>1.8</td>
<td>5.3</td>
</tr>
<tr>
<td>production of models, etc.</td>
<td>2.3</td>
<td>9.0</td>
</tr>
<tr>
<td>production of tools and special implements</td>
<td>42.7</td>
<td>18.0</td>
</tr>
<tr>
<td>initiating production</td>
<td>50.8</td>
<td>48.6</td>
</tr>
</tbody>
</table>
Testing and trials of machine tools

The testing and trials of machine tools are considered in Czechoslovakia to be the most important activities in the process of accumulating the information and experience necessary for the development, design, and manufacture of machine tools. They therefore constitute one of the main tasks of the institute. Testing and trials of prototypes built in Czechoslovak companies and in the institute allow the latter to undertake a painstaking study of the characteristics and properties of each type of machine tool, and to correct errors and improve its parameters on the basis of test results. Up to 1967, 94 prototypes were submitted to the laboratories of the MTMRI for testing.

The testing and trials of machine tools manufactured abroad allows Czechoslovak specialists to examine and study the design and technology of rival products. Such tests are of particular importance for developing parts and subassemblies that although they are not properly the concern of the machine tools industry, should be developed and designed by it because of the relative backwardness of other industries, such as the electronics industry (control and programming systems). At present, the Trials and Testing Laboratory of the MTMRI annually tests an average 20–25 machines manufactured at home and abroad; in other words, a quarter of the total number of prototypes tested up to 1967. As well, the majority of the companies manufacturing machine tools have their own workshop or laboratory, built specially to conduct tests and trials on prototypes or imported machines.

International surveys of technology

Analysis of the mechanisms used to identify and select techniques to be incorporated, thus avoiding the purchase of licences, is considered of fundamental importance. The activities directed toward the international search for technology in the Czechoslovak machine tools industry include the following:

Gathering and processing of scientific and technological information — Technical and economic information is acquired by taking out subscriptions to specialized journals, bulletins, and other periodicals, through the interchange of information with the major centres generating technology in this field all over the world, the purchase of books and scientific and technological literature generally, and from other sources of written information.

Organizing data-gathering and processing is the responsibility of the Centre of Technical and Economic Information to be found within each institution generating technology. At the MTMRI, for instance, there are 18 persons (roughly 6% of the total employed) occupied with information, whose activities include the feeding of the available information into the memories of electronic classification systems. These help to keep the technicians and research staff of the institute and the industry generally supplied both with complete details and with syntheses of the information available in the world as to any given subject or project. Such syntheses or data include a detailed description of the current state of knowledge and the scientific and technical experience acquired in Czechoslovakia and elsewhere, patents and other forms of industrial rights protecting the information currently held, possible trends in the development, design and production techniques in the machine tools industry, their relationship with market characteristics and requirements (especially export markets), possible market trends, etc.

In this way, at the time he commences research in a particular subject, the research worker has at his disposal the criteria and information he needs to direct his work toward ends and conditions of specific economic and social benefit. The aim of all work carried out at the institute is to develop or design a machine, tool, production process, or other concrete article or means of production.

At the level of the individual company, the technical information required for the development, design, or manufacture of a machine includes a detailed summary of all existing patents, the characteristics of possible rival products, trends in their development and design, the characteristics, requirements, and trends of the market (parameters of the machine and market volumes) and scientific and technical information directly connected with factory production.
In company A, for instance, three persons are in charge of organizing the gathering and processing of information taken from 73 journals and periodicals selected by the heads of the technical departments (design, technology, tools, and maintenance). They further select and summarize information as to the legal status and the characteristics of patents applicable to the machines or tools being developed and designed. Actual use of technical library facilities is a matter of the individual initiative of the research staff. Any attempt to organize systems of exchange between factory and library is considered awkward and inefficient, since the research worker generally has no a priori knowledge of the information to be found in the literature and orientates himself precisely in studying it.

The staff of the technical and economic information centres at the company level generally have intermediate technical education and know at least three languages. Those concerned with industrial rights and patents have followed one to six semesters at the Institute of the National Bureau of Patents.

Traveling and study visits abroad — During the past 10 years alone, experts from the MTMRI have carried out 380 study trips and visits to factories, institutes, exhibitions, seminars, and other events and institutions in 26 countries. The observations and results of these visits are worked out in the form of travel reports and stored in the memory of the computer for subsequent use in the information system, which also includes experience gained through the following activities: international congresses and symposia (organized by the institute) on automation and programing in the machine tools industry, model techniques in the metalworking industry, and other subjects connected with the machine tools industry; scientific cooperation with research centres and institutes abroad; and visits of foreign technicians and experts to the MTMRI, which has, over the past 10 years, received about 1700 visitors from 34 countries.

Immense importance is attached by the machine tools industry to the information and experiences accruing from the traveling, visits, and other activities described above, not only for their effects on scientific and technical advancement, but also because of their implications for the formulation of technology policy and long-term planning of scientific and technological endeavours. For instance, the heads of the technical departments within the institute carry out a relatively large number of missions and study visits abroad because they are responsible for the process of identifying and selecting the scientific and technical activities to be carried out over a considerable period of time. The information obtained by means of travel and visits allows for a better evaluation of their own competing power and possibilities and of those of the other manufacturers, of specialized apprenticeship and training, and of the terms of international scientific and technological cooperation.

There are no indications that traveling and study visits abroad are being conducted at all systematically at the company level. Rather, it may be inferred from the information obtained on the subject that manufacturers undertake these visits for special occasions and very infrequently.

Other scientific and technical activities

As the tasks of design and development of machines were transferred to the industry, the institute devoted its attention increasingly to research into problems connected with techniques of machining, measurement and control, programing and automation of machine tools, the suitability of materials, and other aspects that are indispensable for the development of new principles of machining and new types of machine tools. In other

9 This company is one of the four largest companies in the TST Group (Association of Machine Tools Manufacturers in Czechoslovakia) and one of the largest in Europe in its particular field. Its sales volume is approximately U.S. $15 million.

10 The economic and technical information required for the formulation and development of economic and technical policy at the medium and upper management levels is gathered and processed by 35 specialists at the Technical Development and Information Centre of the Federal Ministry of Metalworking and Metallurgy (FMMM). As a result of their efforts, economic management knows about scientific advances and their possible benefits, and the institutions responsible for technology policy are kept informed as to interdependency and its effects on economic development.
words, the institute generates and accumulates the information and experience necessary for the scientific and technical development of the machine tools industry, which in turn generates and accumulates the information necessary or desirable for the manufacture of the machine tools. The former may be termed strategic information, the latter operational.

To give a clearer idea of the importance of the activities of the institute, and since these cannot be transferred to one or more companies, let us adduce the example of its research into the structure of the complex of subassemblies and parts produced and used by the metalworking industry. The results of such research allow the identification and evaluation of the probable future structure of the stock or supply of machine tools available, the development and use of model techniques, and the probable grouping or classification of machine tools. When we consider that the technology of machining also forms part of the technological structure of the metalworking industry, in some instances decreasingly so, 11 it may be seen that the research described above has the merit of enabling changes to be predicted for the organization of production in the metalworking industry and of allowing guidelines to be established for the latter.

**Educating and training staff**

Czechoslovakia currently produces 25,000 machine tools of 370 different types per annum. One of the major achievements in the development of the industry lies in the education and training of workers, technicians, and highly skilled research workers. Some details are given below.

**Research staff** — The MTMRI was started in 1947 with 20 technicians, many of them with no higher education. It nowadays has a staff of 330, 82% of whom have higher education, 24 have science degrees, and the rest, with the exception of 45 workers, have some form of intermediate technical or economics training. The education and training of technicians and research workers was made possible by work and research carried out by young engineers 12 in the first few years of the institute’s existence, at first under the supervision of more experienced staff, and later in collaboration with technical colleges. At present, research workers are trained within the institute itself, and postgraduate university courses are complementary. One of the more important aspects of the training of scientists and research workers is that the institute coordinates its activities with the technical colleges (which are of university level) in order, with the help of faculty members, to pick out promising students and guide them toward research. This would include work for their theses, possibly on production problems. Generally speaking, students specializing in the following subjects are selected: design of machine tools, hydraulic machines and automation, and control systems. This form of cooperation or coordination in the question of training generally rests on personal friendship or mutual understanding between institute and technical college staff. As a form of recompense to the college concerned, the institute gives it priority in carrying out research that, besides enabling and encouraging the colleges to undertake scientific and technological activities, offers an incentive for students and research workers to undertake work in fields connected with the machine tools industry.

Until 5 years ago, the personnel regulations at the institute forbade the engagement of recently graduated engineers, requiring a minimum of 5 years’ practical experience in the industry. This stipulation has now been cancelled and it is felt that recent graduates possess an understanding of modern developments that in many instances outweighs all the disadvantages of lack of reproduction experience. In any case, certain branches of science and technology have not yet been integrated completely into the production process in Czechoslovakia (e.g., automation, electronics, etc.) and the industries themselves thus have a minimum of experience to draw upon. The amount of time necessary to educate and train a research worker or specialist varies from 10 to 15 years and it takes 20–25 years before he reaches the height of his professional skill. From this point of view, mere extrapolation of accumulated knowledge and experience may even constitute a

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11 The techniques of stamping and casting reduce the minimum effort necessary for producing certain subassemblies by up to 90%.

12 These were graduates and others with a minimum of experience.
disadvantage for certain activities, especially for research. The fundamental criteria applied by the institute for accepting candidates are specialized knowledge and a knowledge of languages. In the absence of these, research becomes awkward.

The education and training of specialists and research workers at the Machinery Construction Research Institute (MCRI) follow lines similar to these described above. A group of 30 specialists drawn from Skodo and CKD, in collaboration with the staff of technical colleges, directed and led the work of young engineers and research workers. This group has now grown, 25 years later, into an institute with a worldwide reputation employing 580 persons, roughly 140 with higher education and 70 with a science degree. As in the case of MTMRI, theoretical training given by the MCRI and institutions of higher education complemented the research work carried out.

Production personnel — The training of technicians, engineers, and research workers for industry is carried out largely by the MCRI and institutions of higher education. Even though the companies allow their technicians all kinds of facilities to increase their skills, the use made of the facilities depends upon the orientation given to these studies by the MCRI of the school. Besides postgraduate and other courses, all the technical colleges have a special class, parallel to the daytime or normal course, especially geared to the training of workers who desire to be so trained as medium-skilled or skilled technicians. A factory like company A needs 45 employees with higher education for its activities, 30 technicians and 6 economists for its technical-economic management, and 9 production technicians. There are 376 employees with secondary education, of whom 260 have 4 years and the rest 2. Of the 30 technicians employed in the technical management departments, only six are employed in production technology, the rest devoting their time to development and design. As we may see, one of the most noteworthy endeavours of the machine tools industry is that of development and design (see the analysis of labour employed). On the other hand, the total number of medium-skilled technicians is 8.5 times that of skilled technicians and, in the technology department, this figure is 11 times higher. The staff of the technology and design department is not only responsible for its own tasks, but also for the gathering and processing of scientific and technical data in the activities of rival factories.

Interdependence of the educational system and technical training — The average annual growth in the science and technology infrastructure of the machine tools subsector is approximately 5%, in terms of the personnel employed. The educational system and planning for it are geared to the training of technicians and specialists, in accordance with the needs of each subsector. Naturally, the success of the training of technicians and research workers is due largely to the nature of the Czechoslovak university system, which not only provides an education of a high standard but also supplies the industry with hundreds of new engineers and specialists every year. One mechanical engineering faculty, for instance, confers roughly 300 engineering degrees per annum and has over 7000 students specializing in design, production techniques, and production economics.

Activities Involved in the Planning of Scientific and Technological Development in the Machine Tools Industry

Among the principal strategic elements in the Czechoslovak State economic policy are science and technology. Their development is linked to structural changes in the national economy and hence forms part of existing plans for economic development.

Scientific and technological activities directed toward the development of the metalworking industry in Czechoslovakia find solutions for problems or tasks in scientific-technical development, which are, in view of their content and scope, classified as being of national, sectoral, and subsectoral or individual company concern. The national

13 Such facilities include days off for study purposes as well as payment of per diem allowances and other forms of compensation to allow them to attend schools in places other than where they work.
14 This company has roughly 2000 employees and annual sales of U.S. $15 million.
tasks are those seeking to solve scientific and technical problems directly related to structural changes in crucial areas of the national economy and to economic integration with the other socialist countries (National Plan for Scientific and Technical Development). The sectoral tasks involve activities directed toward the solution of problems inherent in the scientific, technical, and economic development of the metalworking sector, taking state economic policy and the economic interests or policy of the companies in the sector into account (Sectoral Plan for Scientific and Technological Development). The subsectoral or company tasks are geared to the economic and technical development of the companies (Subsectoral or Company Plan for Scientific and Technological Development).

The state tasks are government financed out of funds allocated from the national budget. The sectoral tasks are financed out of sectoral funds provided by the companies (contributions), which are handed over to be managed by the Federal Ministry of Metalworking and Metallurgy. The subsectoral or company tasks are financed by the companies themselves.

The planning of scientific and technical activities directed toward the development of the Czechoslovak metalworking industry includes the following:

**Intersectoral activities**
- Establishing or diagnosing trends in the development of science and technology, their possible impact on economic development, and the social changes arising from the latter;
- Designing long-term scientific and technological activities on the basis of predictions, bearing in mind the priorities of economic development and the available resources;
- Identifying and selecting the objectives of scientific and technological development for each of the various sectors of economic activity and bringing these into line with State Programs of Technical Policy intended to solve the complex problems arising from the objectives of economic development.

**Sectoral activities**
- Identifying, selecting, and planning specific tasks that are necessary or appropriate to fulfill the objectives laid down in the State Programs of Technical Policy and those for the development of the sector or company.

The state tasks to be fulfilled in the machine tools subsector are identified, selected, and planned by the Federal Ministry for the Development of Technology and Investments (FMDTI) in collaboration and consultation with the Federal Ministry for Metalworking and Metallurgy (FMMM) and the companies and institutions concerned. Identifying, selecting, and planning the scientific and technological activities required for the development of the machine tools industry in relation to the necessities of the metalworking industry as a whole is the task of the FMMM. The latter has a Department for Technical Development that prepares a sectoral plan including, among other aspects, the tasks to be carried out by companies and institutions in the machine tools subsector, in order to direct its scientific and technological development toward the necessities of the entire metalworking sector. These tasks are actually pinpointed and selected at the instigation of the Ministry and sectoral companies and institutions in consultation with companies and institutions in the subsector. Planning for scientific and technical activities intended to meet the needs and interests of the companies manufacturing machine tools is the responsibility of the Directorate-General of the TST Group or Association of Machine Tools Factories. Planning of the scientific and technical activities required or suitable for the planning, development, and manufacture of machines, tools, or other specific products, is the function and responsibility of the companies. The MTMRI advises and supervises the content of subsectoral and company planning.

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15 This Ministry is responsible for the development and implementation of state policy on science, technology, and investments.
Necessary activities and resources

Part of the research was directed toward classifying the aforementioned activities and the minimum effort required, in terms of resources employed, for their development and implementation. Considering the number of organizations, institutions, and persons involved, not only in developing and manufacturing the machine tools, but also in foreign trade and economic, science, and technology policy, and even scientific and technical information, it is almost impossible to determine the extent of the resources employed for the analysis and formulation of technology policy in the machine tools subsector.

Forecasts — The prediction of trends in technical and economic development and of their impact on employment and income levels in the metalworking sector is coordinated by a commission of specialists drawn from industry, the research institutes of the Federal Ministries of Metalworking and Metallurgy and for the Development of Technology and Investments, and registered with the former. The forecasting of trends in the generation of the scientific information required for technical development in this sector is the responsibility of the Academy of Sciences. Predicting trends in the metalworking and the iron and steel industries necessitates 30 permanent subcommittees or groups.

Trend forecasts in the technical and economic development of the machine tools industry are the responsibility of nine members of the Directorate-General of the TST Group. Four of these are university graduates and have been drawn, like the others, from industry and the MTMRI. All are experienced in the manufacture of machine tools.

Eight persons (2% of the total staff) at the MTMRI are engaged in the analysis and prediction of trends for scientific and technical development in the machine tools subsector. Six of these have higher technical education and are specialists with over 15 years' experience in the design and manufacture of machine tools; they represent 7% of the graduate staff.

State programs for technology policy — There are currently two programs directly concerned with the metal-mechanical sector: "Development of metalworking production processes" and "Improvement of technical quality and reliability of machines and mechanical installations." Both were conceived and drafted by the FMTDI in association with a number of specialists (five to seven to each program) from the Academy of Sciences, the Centre of Higher Education, research institutes, and industry.

The state programs of technology policy connected with the metalworking sector and the planning of long-term scientific and technical activities in it are directed and its content supervised by 18 members of the Sectoral Department for Metalworking of the FMTDI. These not only have university degrees in various specialities in the constituent branches or subsectors of the metalworking and metallurgical industry, but can also draw on 10-30 years' experience in the technical and economic management of industrial production and an understanding of the complexities of the structure and interrelations of the production sectors and the national economy.

Long-term scientific and technological activities in the metalworking sector are planned and directed by eight persons (roughly 29% of the total staff of the FMMM Department of Scientific and Technical Development), five of whom are university graduates with an average 10–20 years experience of production organization and management in industry.

The planning of long-term scientific and technical development in the Czechoslovak machine tools industry is based on the technical requirements of the metalworking industry (analysis of the structural composition of the totality of subassemblies and parts produced) and on the characteristics and requirements of the export markets (60% of the production volume is exported).

Planning of long-term scientific and technical activities is the responsibility of top-level technical management in the MTMRI and, in view of the importance of exports, the exporters also have a voice in this matter.

Plans for scientific and technological development — The study shows that 90% of the tasks connected with the machine tools industry and delegated to the state originated with the MTMRI. Moreover, only 40% of the activities proposed by this institute undergo any
form of change of order or details whilst awaiting approval as a state task. Also, merely identifying tasks does not expressly entail any particular direction of scientific and technological development but rather a statement of variants or alternatives for meeting requirements formulated in long-term ideas and programs for state technical policy.

The planning of activities identified and selected as suitable or necessary for the development of the machine tools industry (during the preparation of predictions, long-term plans, and programs for state technical policy) involves 1% of the staff of the MTMRI, 35% of the staff employed at the Department of Scientific and Technological Development of the General Management of the TST Group, and roughly 21% of the staff of the FMMM's Department of Scientific and Technological Development.

The MTMRI employs four persons in planning scientific and technological activities; one has higher education and the other three come from secondary-level schools and institutes.

All the staff engaged at the subsectoral level in planning and supervising the scientific and technological endeavours and the development of the scientific and technological infrastructure of the machine tools industry has secondary education with supplementary special courses. Only two of the seven persons responsible for drawing up sectoral planning have university degrees (one mechanical engineer and one economist).

Identification and selection of scientific and technological activities at the company level are basically left to the ability and initiative of the staff of the Technology and Design Departments, the quality and technical level of the products being the responsibility of the engineers heading these departments. It is thus for these officials to propose the direction and scope of the scientific and technological activity required for the technical development of the company. Plans for scientific and technological development are drawn up in the Department of Technical and Organizational Development, and later approved by the Technical Management, the company’s Technical and Economic Council, the company management, and the General Management of the TST Group.

In Company A, for instance, one of the four largest in the TST Group and one of the largest in Europe in its specialized field, decisions as to directing and developing scientific and technological activities are based on the judgment of technicians with over 25 years of experience within the same factory. Its departments of design and technology employ 30 graduate technicians and 125 with specialized secondary education. Planning scientific and technological activities identified as necessary or suitable for the technical and economic development of the company is the responsibility of two members of its staff.

Other activities

Economic policymaking bodies are advised by research institutes expressly created to study and solve problems inherent in the planning and supervision of scientific and technological development. Among these are the Institute for the Orientation and Economics of Scientific and Technological Development16 (of the FMTDI), the Technological and Economic Research Institute of the Metalworking industry,17 and the Institute for Technical Development and Information,18 both of the FMMM. Their activities include predicting trends in the technical and economic development in the several branches of the metalworking industry, working out a methodology for sectoral and subsectoral planning of scientific and technological activities, studying and predicting probable future requirements in terms of plants, machinery, and labour, and gathering and processing scientific and technological data for the purposes of the technical and economic management of the industry.

Summary of critical comments

The planning of scientific and technological activities for a metalworking industry that is as highly developed as that in Czechoslovakia has no precedents and is thus inevitably of an experimental nature. It may be concluded from the information available that: 1) the

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16This includes 40 persons, 28 of whom have higher education and 9 university degrees.
17This includes 200 persons, 100 of whom have higher education.
18This includes 300 persons, 120 of whom have higher education and 15 university degrees.
mechanisms for identifying, selecting, and planning scientific and technological activities are undergoing progressive change; 2) there is a tendency to entrust the control and supervision of technological policies to centralized agencies and to attempt to endow these agencies with a scientific infrastructure capable of providing short, intermediate, and long-range solutions for the development and implementation of technology policy.

In spite of the serious handicaps it had to overcome, the Czechoslovak metalworking industry has undoubtedly developed a scientific and technological potential and a production capacity that are not only sufficient for the requirements of the Czechoslovak economy, but that have also placed it in a prominent position with respect to the rest of the world. Although the economic and social costs of these achievements bear a direct relationship, among other factors, to some of the problems discussed here, it cannot be evaluated adequately in view of the relatively limited information available. In spite of this limitation, however, some critical comments on the scientific and technological planning system followed in Czechoslovakia are presented below.

- Although the progressive development of the systems and methodology of identifying, selecting, and planning scientific and technological activities is geared to the link between these and the structural development of the national economy, no combination of realistic objectives has yet been arrived at, whether formal or even merely stated, allowing science and technology to be developed as a function of coherent objectives at the policy making, manufacturing company, or research institute level. The fact that efforts have been made to overcome this situation may be seen, for instance, from recent regulations establishing the joint planning of scientific activities and the use to which its results are to be put, as a condition for approving such planning. In the metalworking sector alone, joint planning for the present 5-year period includes 1200 projects connected with scientific and technological development and is aimed, not only at planning scientific and technological activities as such, but also at incorporating their results into sectoral, subsectoral, and company production planning. The success of such a measure would obviously mean a significant step forward in the search for means and instruments linking scientific and technological activity to the needs of economic development at the national, sectoral, subregional, or company level.

- No evidence has been found of any specific criteria for establishing priorities and allocating resources, whether at the state, sectoral, or even subsectoral or company level. For instance, a report of the Central Commission for Public Control refers to the lack of specifications as to content and characteristics for determining the classification of a task as "state," "principal," "complex," "within a program," "outside a program," etc., and especially emphasizes the frequent changes of name encountered. These, according to this report, not only render supervision more difficult, but do not even affect the content of the projects that are conducted outside the framework of temporarily imposed classifications.

According to certain informants, tasks that have not been assigned to the state are generally delegated to the sectors and are similarly passed on from sector to subsector to company. This situation may be explained by mutual agreements within the scientific community, which is institutionally differentiated and spread out in ministries, companies, and institutes, or by technical and economic reasons. Any evaluation of the matter should, however, be based on analyses of individual cases.

- Actual intervention on the part of the central policymaking bodies and the scientific community in respect of decisions involved in technology policy is a controversial issue. The decisions involved in economic policymaking are contingent upon information as to the suitability or unsuitability of any particular scientific and/or technical activity supplied by the research worker or institute interested. The structure, content, and appropriateness of information passed on may establish some kind of temporary criteria at the higher policymaking levels. The scientific community is thus in a position not only to carry out its scientific and technological activities, but to influence policy and decisions through the agency of the information with which it supplied the policymaking bodies. As an example of this, we may adduce the first few years of economic planning, when the scientific community, which was not as yet, for the most part, in agreement with the goals of the new
economic system, used information to guide scientific and technical activities outside the framework of economic and social needs, and in an improvised manner. Just as pernicious was the reaction of the central policymaking bodies, who attempted to remedy the situation by means of control of the resources utilized in scientific and technological activities or some other administrative channel.

- Central planning of scientific and technological activities allows the use of available resources to be coordinated and precludes duplication of efforts. In spite of all the limitations described above, establishing priorities and allocating resources on the basis of distinctions between state, sectoral, subsectoral, and company levels makes it easier for the various levels of technical and economic policymaking to implement policies that are in their interests.

In this way, for instance, the State Programs of Technical Policy and the State Plan for Scientific and Technological Development are subordinated to the interests of the federal government and thus of the national economy.

The scientific and technological development of any sector is regulated by the appropriate sectoral plan. In this particular case, that of the machine tools industry, the FMMM has included in the tasks to be carried out in this sector a number that, although not of direct benefit to it, are nevertheless indispensable for the development of other industries in the same sector. The development and production of conveyor belts for the automobile industry, for instance, a sectoral task currently being studied by the MTMRI, only benefits the TST Group insofar as the sales product is concerned; on the other hand, it facilitates the development of the automobile industry.

The management of the TST Group has included certain tasks in its planning that are specifically directed toward increasing exports and developing installed production capacities and funds. Moreover, by assigning sectoral tasks to small- and medium-size companies, it enables these to make use of resources for the development of a scientific and technological infrastructure and to carry out activities otherwise only possible for large companies. Their selection for sectoral or subsectoral tasks allows the small companies to subcontract or cooperate with other companies and institutes and thus to improve not only their research and development facilities, but also those for project management and technology policy development.
Chapter III

Institutions of Technology Policy in the Countries Visited

Two central theses related to the institutional problem emerge from the visits conducted abroad. Firstly, government institutions and bodies, explicitly commissioned in all these countries to undertake the formulation and implementation of science and technology policy, concentrated on science policy and only incidentally on technology policy. Secondly, even though there was no explicit institutional framework of technology policy in these countries, there is and was an implicit form based on institutions directly linked to production and economic and social planning. Only in recent years has the institutional problem been directly tackled and the inadequacy of the existing framework recognized. However, the chief way of modifying it has been to make explicit the role of the institutions that carried it out implicitly, and only in a few cases have new institutions been created ad hoc. Of the latter, the ministries of technology have been the least objective because of the power struggles they create and because of a tendency inherent in their creation: "technology for the sake of technology."

All these countries created institutions of science policy, most of them organized as branches of the ministries of education and culture. Normally their objectives were very generally expressed, indicating trends it was considered desirable for them to achieve (e.g., the rate of increase of expenditure for R & D) rather than specific goals and objectives. All this was termed "science policy" and occasionally "science and technology policy."

The institutions of science policy are generally the national research councils; their names may differ, but they are very similar. They are directly responsible to the Prime Minister, President, Council of Ministers, or the Ministry of Education. They are also the institutions officially entrusted with the formulation of "science and technology policy" or with assisting in its formulation. The main pressure group backing them is the so-called "scientific community." In Italy, for instance, the consulting committees of the CNR, i.e., its de facto management, has 140 members, 96 of whom represent the universities.

These institutions have developed science policy and only incidentally technology policy. However, the fact that these institutions handle significant proportions of the government funds available for R & D has over the past few years aroused strong criticism and attempts to modify the institutional structure. These are labouring under many difficulties, particularly because of the relative inertia of the institutional framework.

In Italy, the CNR has responded to this situation by creating a technology front in its activities, the success of which is still very relative. In effect, the CNR created a technology committee for the purpose of stimulating the industrial use of knowledge originating within the academic world. This was reflected in the fact that of 100 applications for research contracts received in 1970, 77 came from university institutes, and of 38 applications approved, 28 were submitted by the same institutes. Industry applied for 13 and obtained only 4. Generally speaking, it may be said that industry shows little or no interest in the technology committee. This is due as much to the shortage of available funds as to the conditions of the research contracts, which are granted only to persons at the individual level and cannot be signed by companies.

The Confederation of Italian Industry (COFININDUSTRIA) suggests that the technology committee plan its activities by concerted action and also suggests, contrary to
current trends, that industry should contribute at least 70 or 80% of the funds allocated for each program.

In Czechoslovakia, between 1952 and 1960, policy on scientific and technological activities was laid down by the Academy of Sciences. This period was characterized by (a) unbalanced growth of the scientific and technical infrastructure; and (b) lack of coherence between the objectives of scientific and technological research and economic and social needs.

In addition to the creation of research institutes, later to be dissolved because of their lack of use to the national interest, many of the existing institutes were committed to the care of prominent scientists. These distinguished men, with the approbation of an "Academy colleague," carried out research with outstanding results from the academic or scientific point of view, but of very limited or no use to the production process. Such was the case of the chemistry institute, 1955–60; in spite of its quality, its work could not be applied because the raw materials involved are not found in Czechoslovakia and would be very difficult to import.

The inertia, in this case dynamic, characteristic of industrial needs and due particularly to the sharpening of international competition, obliged the countries studied to skirt the institutional problem either by ad hoc institutions or by using previously existing institutions that were, however, directly linked to the system of industrial programing or planning.

In Italy, for instance, institutions like the IRI or IMI (the former is a state holding, the second a state financial institution) played an effective, though implicit part in Italian technological development. This role is currently becoming explicit and attempts are being made to systematize it.

The IRI carries out technology in different ways; in the first place as a result of its own industrial policy. For instance, the Italian electronics industry developed under the leadership of the IRI. The IRI has, moreover, through the financial institutions, created a complete infrastructure of consulting services for each sector. It has at the same time combined all these resources in a consulting centre (CITACO) representing the great diversity of specialties of the IRI group, which is capable of generating projects in a complete technology package. It also created the IFAP (Institute for Professional Training) to train top-level personnel, and a training centre for personnel at other levels, in which each of the financial partners has a sectoral research centre. These measures arise out of the requirements of the IRI group.

In Japan, the Ministry of Industries and Foreign Trade (MITI) works through its technological branch (the Agency for Industrial Science and Technology (AIST)) to perform the administration of policies and instruments contributing to the development of technological activities in industry, in accordance with MITI’s own policies and programs for industrial development. The latter apply both to legislation on foreign investments (the established control of licence contracts and the flow of foreign exchange) and to the coordinated programing of industrial development. The latter was developed by MITI technicians with the cooperation of technicians from the industrial sector and consultants, who formed advisory committees to draw up plans for sectoral development. On many occasions, subcommittees were formed within the aforementioned committees, to analyze requirements for the technological inputs in the sector. One or two of the members were engineers from the MITI sectoral industrial department, a further one or two were drawn from the AIST, a similar number of professionals came from company research or planning departments, and there was generally a number of specialists from universities or consulting firms.

The characteristics of the technologies required for the development of new industries and possible sources of supply were defined by these working committees. In some cases, after a top-level revision and consulting process, the MITI published a list of the general types of technology to be required for the development of a specific industrial sector.

The revision of licences and additional information contracts for technology to be introduced was carried out, not so much according to legal-economic criteria, but rather on the basis of technological economic criteria. The analysis and recommendations in the
technology report prepared by the MITI engineer appointed to this task was thus of the utmost importance for the final decision adopted by the Interministerial Committee on Foreign Investments. This expert was usually an engineer from the head office of the AIST, who was in permanent consultation with his colleagues at the MITI sectoral industrial department concerned and obviously requested, whenever necessary, supplementary background details from the Japanese firms interested as well as from independent Japanese engineering firms.

As can be seen from the preceding, no more than a half dozen engineers from industry, MITI, and engineering or consulting firms, working in close coordination, were involved in the search for and the evaluation, disaggregation, and final definition of the type and form of technology to be introduced. The engineers from the Japanese industry interested were responsible for studying the background of the technology and the project, on which they based a technical and economic evaluation for private use. The main responsibility of the MITI engineer or engineers studying the application was to evaluate the project and the technology involved from the social point of view, and to differentiate, within the technology package offered, between the intrinsic elements of the imported technology and those suitable for disaggregation and local development. It was through this type of activity that MITI played a real part in stimulating the Japanese companies, thus enabling them to operate with their present degree of autonomy.

The other Japanese government technology agency, the Science and Technology Agency (STA), is responsible to the Prime Minister's office and for formulating long-term science policies, coordinating the scientific and technological activities of the public sector, and encouraging the development of multisectoral scientific and technological activities such as nuclear, space, and oceanographic research.

During the whole period of accelerated Japanese industrial development, which continued to the beginning of the 1970s, it was the policies and other instruments for encouraging industrial technological development handled by the AIST, on behalf of the MITI, which had the most concrete and immediate effects on the mechanization process of Japanese industry. Only now, with the development of basic research in such areas as pollution and resources (energy), and the development of new processes, was the STA in a position to make its influence felt.

In Yugoslavia, immediately after World War II, the "Commissions of the Plan" in charge of implementing industrial projects, were the first to put a technology policy into practice. The frame of reference, i.e., the social priorities, were set by the overall plan detailing specific investment projects for new investments and extensions. The Commissions of the Plan themselves carried out or commissioned their own technical and economic studies with the main purpose of defining the objectives of each project with respect to types of processes, scale of investments, variety of products, etc., as clearly as possible. No matter how rudimentary the studies carried out during the first stages of Yugoslav development, they played a highly important part in these projects. They enabled identification of native suppliers, thus developing local skills, on which basis they encouraged ad hoc surveys of the technology available in the world market and strengthened negotiations with the support of centralized control.

These Commissions of the Plan found rather limited resources to supply the necessary technological inputs in the existing educational and university infrastructure. The infrastructure was not even capable of carrying out the necessary technical and economic studies. The problem was avoided by introducing ad hoc measures closely related to the actual investment projects. For instance, foreign consulting services were commissioned to carry out studies completely parallel to those carried out in Yugoslavia, either by the Commissions of the Plan themselves, native consultants, or by the companies in which funds were to be invested. As a part of the investment project, development departments were created within these companies, which often later became research and development centres or research institutes. As these research and development centres or institutes originally had to solve the problems involved in entire industrial projects, they nowadays have a multidisciplinary staff and a positive attitude toward the solution of production problems.
While the Commissions of the Plan played such a decisive role in Yugoslavia, the institutions of explicit science policy, such as the Education and Science Committee or subsequently the Ministry of Science and Culture (as of 1950, the Federal Council for Science and Culture), did not greatly affect the relationships between science and production.

Ever since 1960, scientific and technological activities in Czechoslovakia have been planned, organized, and directed by the central institutions of economic policymaking. Until that time the Academy of Sciences was considered the most appropriate institution to direct the scientific and technical development of the country. However, 8 years of experience demonstrated that this policy was a failure. The development and execution of technology policy was consequently entrusted to the centralized state institutions. The development plan for science and technology was thus integrated into the overall national economic plan and hence became a direct function of the needs and perspectives of the structural development of the national economy.

In spite of these changes in the management structure of technological and scientific matters, the Academy of Sciences kept a certain degree of authority in issues related to basic research, since their interdependence with the immediate needs of the national economy was difficult to establish. In these matters, the government institutions confine themselves to bringing Academy proposals into alignment with the immediate requirements in respect of science and technology demanded by the structural development of the economy.

The experiences of the countries visited allow certain general ideas to be formed of conditions favouring, though not necessarily guaranteeing, the significant, positive influence on the economic and social development of a country that may be achieved by institutions responsible for technology policy (implicit or explicit).

The following are regarded as the most important conditions:

1. The ability to control or influence investment decisions (especially by controlling or channelling financing within the context of an industrial and social program or plan; i.e., an effective executive authority). With regard to technology, this control basically concerns the selection of technology and activities, negotiations with foreign suppliers of technology (and hence of foreign investments or capital), the use of native technology inputs, and industrial and technological concentration (possibly specialization).

2. The institution’s own technical resources (engineers, lawyers, economists) permitting it:
   - to aid or conduct negotiations with native and foreign companies;
   - to have a thorough grasp of the technological problems involved in each investment project and its inclusion in social and economic objectives;
   - to ascertain the availability and real costs of native and foreign inputs, as well as the indirect commitments and restrictions involved in their acquisition;
   - to help identify the technology inputs to be imported and those that may be obtained in the country itself by disaggregating technology.

3. The ability to program, control, and coordinate specific projects for technology development; this is enhanced if the institution concerned has stable funds available to finance such projects within a programmed context.

4. The following may be added as contributory factors:
   - its own production capacity, including the production of certain technology inputs;
   - legislative power or influence, which permits the introduction of certain specific incentives; however, this factor is considered of minor importance;
   - access to information and documentation services on technical, technological, and economic matters;
   - the support of the scientific community.
Chapter IV

Instruments of Technology Policy: Financial Instruments and Tax Incentives

Because most of the countries visited do not differentiate between technology and science policy, the instruments used to stimulate technological development are applicable within both fields. For this reason, the present summary of these instruments includes both objectives.

Explicit science and technology uses instruments that may be termed direct or indirect according to whether they interfere directly in scientific and technical activities.

Tax incentives and certain financial incentives are regarded as indirect instruments according to whether they affect overall company decisions as to the allocation of resources, favouring scientific and technical activities basically by reducing costs. Instruments such as research contracts and specific subsidies for applied research on the other hand, apply to specifically defined scientific and technical activities. The latter enable the state institutions not only to influence the sum of the resources allocated for scientific and technical activities but also to exert a more specific influence on these activities themselves, thus allowing the implementation of a more selective policy. On the other hand, all the instruments of technology policy described above are “direct” in the sense that they are explicitly concerned with encouraging or programming scientific and technical activities, and are not merely indirectly linked with technology development, as would be the case for industrial policy, for instance.

Credit and Other Financial Instruments for Encouraging the Industrial Use of Research

As in the Subregion, research units or institutes in the countries visited are often established with the aid of state subsidies, and are more closely linked to educational and university than to industrial requirements. The fact that their activities were subsidiary was in itself an impediment to the formation of links with industry, though not necessarily to the fulfillment of certain overall social requirements. The latter, since they constitute a demand for activities that are not directly profitable, have not been fulfilled in any of these countries merely by the creation of a market demand. Moreover, state pressures for their fulfillment have frequently brought about conflict with other activities competing for investment funds. One of the mechanisms used to overcome this difficulty with respect to the demand for technological inputs for social objectives and encouraging that for technological inputs for industry has been the implementation of financial measures linking basic and applied research (academic, university, or research institutes) and later developing it for specific practical ends. Italy and Japan, in particular, are seeking new investment possibilities for companies affected by strong competitive pressures on the international market and that do not have sufficient financial resources for investment purposes.

Implementing these policies for stimulating scientific and technological activities geared to specific economic and social needs does not merely mean that undifferentiated

19Poland and Czechoslovakia are the only countries of those visited that distinguish a so-called policy on basic research from that on science and technology policy.
funds should be made available. Nor does it entail any action involving the general and frequently vague concepts that may be attributed to the so-called “Plans for Technological Development.” On the contrary, it involves policies that are less ambitious but realistic and well defined, demanding minimum requirements for identifying areas of economic and social interest in need of the support of scientific and technological knowledge. Further requirements include specific criteria for the evaluation, duration, control, and approval of projects and their budget. The experience thus gained, duly adapted to conditions prevailing in the Subregion, could be turned to account in programing activities connected with these issues in the Andean countries.

It was of particular interest to study three different systems of credit or subsidies for research in operation in the countries visited. These are: the Japanese Research and Development Corporation (JRDC) fund; the so-called “Research and Development System” in Japan; and the “IMI Research and Development System” in Italy.

The JRDC fund advances risk capital to further the industrial application of the results of scientific and technological research. In pursuance of this purpose, JRDC carries out the following activities:

1. Meticulous selection of basic research, carried out by universities, research institutes or individuals, offering a possibility of conversion into an industrial process or design of practical usefulness for the country.

2. Selection, by means of competitive offers, of one of several companies concerned with a particular subject of basic research to carry out the development activities required to enable use of the results of pure basic research in the design of an industrial process. This usually includes testing in a pilot plant or the construction of an industrial prototype.

3. Financing of all the expenses incurred by the company while carrying out development activities; if the results are negative, no reimbursement of JRDC funds is required. If the results are positive and the firm interested puts the results of its development research into industrial production, the company must reimburse the funds provided by JRDC over a relatively long period and without interest. At the same time, the company must commit itself to pay previously agreed to royalties over the basic research in question and to JRDC.

Over its 10 years of experience, JRDC has shown that, of some 100 basic research projects, it was possible to select 55 for development, 90% of which were successful.

Nowadays, half of the funds annually provided by JRDC for research contracts are recovered through the reimbursement of funds when projects are successful and the payment of royalties for industrializing the results. The balance is contributed by the government.

The “Research and Development System” in Japan is more directly a fund for industrial research with programed objectives, similar to those discussed at the beginning of this section. The group responsible for “managing the system” has its offices in the MITI’s Agency of Industrial Science and Technology (AIST). It carries out a wide range of advisory activities to official institutes of scientific and technological research and technology departments in various ministries and government agencies, industrial sectors, etc., to identify projects of great importance and urgency for the country. Then an order of priorities is established for these projects according to such criteria as their contribution to the solution of national problems, such as improvement of living conditions, use of natural resources, contribution to economic development, improvement of efficiency in using available resources, etc.

Any research program finally selected is previously evaluated with regard to cost, duration, resources required, and the degree of industry-wide application of the research results. Once the programs are thus defined, they are granted specific government financing for their duration, which may vary from 3 to 8 years.

The AIST coordinating group contracts out or commissions specific parts of the research work to either research laboratories or industry. A manager or director is appointed to each project, the progress of which is analyzed half-yearly by a National Industrial Research and Development Council, the members of which represent the
government, industry, and the universities. The industrialization of the results of successful projects included is furthered and given financial support by MITI with the purpose of optimizing the results of the system.

In Italy, an institution known as the IMI was authorized in 1968 to create a "Fund for Applied Research." When it started active operations in 1971, its resources amounted to 150,000 million lire (about U.S. $260 million). The purpose of this fund is to provide financial support for industrial technology development activities (called by the Director "industrialization of research").

Basically the IMI fund is used in three ways: (1) loans at a low rate of interest; (2) shares in research societies; (3) risk capital.

Loans at a low rate of interest are granted when there is little risk of failure of the research undertaken by a company and the prospective profits from the investment would allow relatively early commercial application of the results. In this case, the IMI fund supplies up to 70% of the costs at an interest of 3%, to be refunded within 3–10 years. Under no circumstances does the IMI require any company to furnish capital guarantees, which are usually, under the normal terms of credit, three times the amount provided.

The risk capital is provided if there is a greater degree of uncertainty as to the possible success of a research project but where the prospective profits in case of success are reasonably favourable. In this case, too, the financing covers a maximum of 70% of the costs at an interest of 3% but again unlike the usual terms of credits, the company only refunds the loan if the research program is successful. If a project proves a definitive failure, the debt is written off and the results become the property of the IMI, their manner of use being decided by the Interministerial Committee for Economic Programming (CIPE). If a project is successful, the debt may be amortized in the usual manner (payments every 6 months, 3% interest, repayment over 3–10 years) or in the form of royalties, proportionate to the production value of the goods incorporating the technical and scientific improvements developed.

The third form of financing undertaken by the IMI is to put up capital in research societies. These research societies represent a sort of cooperative effort on the part of many companies to carry out specific research projects, in which IMI joins as a partner. They do not have their own plants, but operate with those of the partners. They are entitled to request credit at a low rate of interest or risk capital from the IMI like any other company.

One example of such cooperation is TECNOMARE S.A., a group comprising the biggest Italian companies (e.g., Fiat, Pirelli, ENI, IRI), and in which the IMI holds 40% of the shares. This society was formed for the purpose of research on "new operational techniques for the exploration and exploitation of the marine waters and sea floor." The SAGO project, in which Fiat and IRI again participated, together with Montedison and other pharmaceutical companies, and in which the IMI also holds 40% of the shares, does research work for all these companies on the application of electronics to public health and hospitals. Similarly, Tecnotessile is studying the development of textiles and textiles engineering for the purpose of helping and restructuring this sector. The members of this research society include not only companies in the sector, but also banks.

In the final analysis, all contract proposals of any kind must be approved by CIPE, which has issued the following instructions to the IMI:

- to include among the projects to be processed for approval all those that appear, on first examination, to be of particular value for their public interest, their potential for fostering the growth of the advanced technology sectors, and their intrinsic technical and scientific value;
- to give priority to applications submitted by medium-size and small companies and to those companies operating in the south of the country;
- to guarantee the sectoral distribution of the projects, in accordance with the importance and priority of the various sectors within the framework of the indications planned.

CIPE is in a position to demand that the text of agreements include clauses linking the use of research results to problems of national importance. All the sectors of industry interviewed and the available company publications agree that the IMI Fund for Applied
Research is the wisest measure taken by the Italian government to further technology development. The most frequent criticisms expressed are the need to extend the IMI fund, particularly with respect to its support in the form of risk capital, and the lack of programing similar to the JRDC's governing the use of funds. Another criticism is that in spite of the decision to allocate 40% of the funds to the south of Italy, the percentage requested was about 8% during the first year; moreover, the funds requested for medium-size and small companies represent only 7% of the total funds requested to date.

In addition to the forms of financing described above, IMI handles the administration of another fund destined to further research. In effect, public or private industrial firms and research institutes may, in order to import scientific instruments and sophisticated industrial equipment not produced within the country, apply to the Ministry of the Treasury fund of U.S.$150 million, handled by the IMI. An interministerial committee presided over by the Minister of the Treasury established the rate of interest and term of the loan, in some instances approving financing up to the total cost, depending on the recommendations of CIPE.

The loan usually covers 70% of the cost at an annual rate of interest of 6%, to be repaid within 3–6 years. Only in the case of nonprofit institutions mainly devoted to scientific and technical activities or that of companies located in the south of Italy (Mezzogiorno) may financing cover 100% of the costs, in which case the rate of interest is 4% per year. The Ministry of the Treasury issues a decree authorizing the financing, to be dealt with by the IMI. Once financing has been approved, no significant taxation is levied over the operations concerned. Prevailing procedures as to the use of credit or financing in general as an instrument for promoting technological development may be summarized as follows:

1. Direct use of industrial credit to finance industrial activities and profitable applied research within the context of a strategy for technological development.
2. Use of credit to finance scientific and technical activities in companies under particularly favourable conditions (no capital guarantees required, low, zero, or negative rates of interest, risk capital, shares, etc.).
3. Use of the financing power of credit institutions to support scientific and technical activities in companies, on the basis of specific requirements such as preinvestment and feasibility studies, design analysis, selection of technology, content of imports, use of technological inputs, employment of native scientists, suitability for plans for industrial and technological development, etc.
4. Use of credit to finance scientific and technical activities carried out jointly by native companies and/or research institutes within the context of national research and development programs prepared jointly with industry.
5. Use of credit to create research societies with national or international objectives, the banking capital of which forms part of the social capital of the research society (which may be autonomous, tied to associations of companies, ministries, or directly controlled and managed by international organizations).
6. Use of the financing power of state corporations for objectives similar to those given in points 1 to 5, including the purchase of 'shares' by the state holding with the specific purpose of furthering scientific and technological activities with preestablished programed objectives or of promotions as such.
7. Use of credit to finance the native component of a disaggregated technological package. If an industrial project involving the import of technology has adequate credit abroad at its disposal to finance the component, it becomes very difficult to disaggregate the technology package, since the user of the technology involved would already have the financial resources to purchase the complete package and not the disaggregated component, which may be obtained locally.
8. Another direct financing activity that may affect the capacity of a company to generate scientific and technological activities is that of granting credits and subsidies so that the company may establish research and development centres capable of identifying and clearly stating technology problems, efficiently solve some of these, and subcontract others to specialized firms.
These forms of the use of credit as an instrument of encouragement are less likely than subsidies to generate nonapplicable data, since they instill purpose in scientific and technical endeavours and lead to the definition of efficiency criteria for the use of the resources allocated. However, credit would not completely exclude subsidies. This should strongly discourage basic research (directed and nondirected), tend to encourage very short-term development, and limit the perspectives necessary for research.

It has been estimated in various quarters that native scientific and technological endeavours ought to be subsidized to an extent of approximately 30% if a healthy relationship between various levels of research is to be maintained and if social objectives are not to suffer a diminution in technological and scientific inputs.

At the same time, the system of encouraging research by means of credit, as in the case of subsidies, is more effective if it covers only a certain percentage of the financial requirements of scientific and technical projects. The commitment of a company contributing its own capital, or of a research institute risking its own resources, is usually considered to have a positive effect, since it encourages efforts to achieve specific, applicable objectives. Similarly, the idea that any form of credit be conditional upon a technical development program with specific industrial and social objectives is considered more profitable, from the point of view of the results, than merely extending credit to those requesting it.

In the countries visited, the use of research contracts for all credit operations or even subsidies is becoming very popular, since it allows the financing institutions to impose policy, guidance, and control of the funds used. Similarly, the use of contracts oblige those undertaking research to arrive at as accurate a definition as possible of the cost, duration, resources, etc., of the specific project or projects for which the funds are allocated and the contract signed.

**Tax Incentives for Scientific and Technical Activities**

All the countries visited grant exemptions from income tax, customs duties, or some other form of tax exemptions to companies or research organizations (institutes or other types of experimental centres) for their scientific and technical activities. It was not possible to carry out full studies of such measures, that is, a complete study of the behaviour of the companies in relation to existing levels of taxation and previously granted incentives for other activities such as promotion of exports, foreign exchange savings, etc.

The opinions quoted here are based on interviews with research workers, businessmen, and government officials. The people interviewed were rather sceptical about the effectiveness of these incentives, arguing that usually tax exemptions in these areas were useful merely as an additional factor and scarcely affected company decisions, which are in any case dependent on a large number of variables. Their indiscriminate, horizontal application makes it more difficult to evaluate their effectiveness without the context of a fairly extensive theoretical framework and a large quantity of empirical material, all of which are defined for a specific market.

Yugoslavia does not levy income tax as such, but instead levies a series of taxes for specific purposes such as education, social security, housing, defence, etc. In no case is an organisation or individual exempt from these taxes. There are two taxes on the other hand, one on sales and the other on the "use of social capital," forming the bulk of state income and funds for new investments, for which exemptions are granted. As an incentive, no research institute pays taxes on the sale of its services or the purchase of materials, equipment, raw materials, etc. The value of this incentive, however, is lessened in two ways. Firstly, companies do not pay sales tax in any case when buying production equipment, thus largely eliminating the effect of the "incentive." Secondly, the conditions required for legal recognition of a research institute, a prerequisite for obtaining legal prerogatives, are too strict. This difficulty is illustrated by the fact that in Serbia, for example, only 20% of the research and development centres maintained by companies are officially recognized. To be recognized as such, a research institute must prove before a special registration commission (of the Federal and Republican Council of Science) that it

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has the necessary infrastructure to carry out research and has a minimum of personnel including at least three professionals with science doctorates.

The banks must pay the state 2.5% annual interest over the social capital assigned to them as fixed assets. Depending on the sector in which they operate, the companies pay 1.7% or 3.5% interest. Research institutes, on the other hand, do not pay any interest over the fixed assets at their disposal. This also includes that part of their fixed assets (equipment, buildings) allocated by the companies to their research centres. In fact, this incentive means a valid change only for those companies that manage to register their research and development centres, since for a long time independent research institutes did not have to pay interest over social capital.

The validity of the incentive is thus subject to the same limitations as the sales tax exemption, since it is the companies who have the greatest difficulties in qualifying for registration and in obtaining recognition for their research centres or institutes.

On the other hand, in Yugoslavia the recognized research institutions do not pay any duties for importing any raw materials, semimanufactured goods, or equipment required for their operations. Apart from involving the aforementioned limitations of registration, importing equipment or other material for scientific and technical research is only possible if foreign exchange is available, and this is and has always been very scarce.

In Italy, reports obtained from company associations also demonstrate that direct tax incentives have only a limited impact. Companies with expenses incurred for studies, scientific and technical research, and experiments are entitled to deduct, per fiscal year, 50% of the expenses for the above items, regardless of the results obtained (by decree of the Ministry of Finances, 10 December 1965). Should this expenditure yield positive results for the company, the rest (50%) may be repaid over 5 years, starting from the year in which the results are first operationalized, and in proportional payments. If no positive results are obtained, the total expenditure may be deducted as costs for tax purposes for the year during which the experiment is stopped and the negative nature of the results is confirmed.

The companies interviewed demonstrated limited knowledge of this incentive, especially the administrative staff of research and development departments, and those who were aware of its existence attached little importance to it. The higher levels of management responsible for the budget for research and development expenditure regard tax deductions as an additional item in the costs and benefits columns, but they do not consider them very important. Tax-free imports of sophisticated scientific instruments and industrial equipment not produced in Italy also enjoy customs facilities, including the elimination of prohibitions or limitations. This policy involves other special incentives of a financial nature.
Characteristics of the Market of Technology Commercialization

The literature concerned with evaluating issues related to the process of importing know-how in the developing countries generally classifies the subject under the heading of "technology transfer." Terminology, although an inadequate index, often throws light on the extent to which concepts that it represents have been adequately analyzed and understood. The term "transfer" as applied to the Subregion indicates the very limited comprehension prevailing about the technology market. In commercial or economic terms we do not talk about the "transfer" of copper, cotton, or television sets. We refer instead to the sale (or purchase) of these commodities. Similarly, in the case of production inputs, meaningful analysis distinguishing and evaluating the characteristics of direct foreign investment, portfolio investments, international indebtedness, worker migration, etc., has been undertaken. The term "transfer" could represent a rather loose usage of the word; or it could be an indication of insufficient knowledge of the phenomena involved; it could even fall under what Myrdal called "diplomacy by terminology." In the present paper we thus prefer the term "technology commercialization" and it is our purpose to evaluate the characteristics of its market. In that sense, technology is removed from the R & D laboratory and from the sphere of national policies for education, science, and technology, to enter the arena of the commercial world. Technology viewed in economic terms, as merchandise, has a special market (even a market "place") with a particular structure and properties, mechanisms governing prices and "quantities", rules of exchange and market imperfections. The general principles of price determination based on relative scarcities and the definition of market performance (number and size of buyers and sellers, relative bargaining power, degree of information available, etc.) also govern the market of technology commercialization, give its own peculiar characteristics. We shall evaluate these characteristics by dividing our presentation into two broad areas of analysis: (A) properties of technology as an object of trade; (B) concentration as a market structure.

(A) Three properties of technology and their economic implications

(1) During the process of its commercialization, technology is usually embodied in intermediate products, machinery and equipment, labour skills, whole systems of production (e.g., turnkey plants), even systems of distribution or marketing (e.g., cryogenic technology in ships transporting liquid gas), etc. Know-how thus represents a part integrated into a larger whole. As a result, the market of the former is not independent but constitutes part of the market of the latter. This market integration of various inputs creates noncompetitive conditions for each of these since they are sold in the form of a package.

(2) In order to formulate the demand for information, as in all other markets, a prospective buyer needs information on the properties of the item he intends to purchase so as to be able to make the appropriate decisions. In the case of technology, however, what is needed is information about information, which could in fact be one and the same thing. Thus, the prospective buyer is confronted with a structural weakness inherent in his
position as a purchaser, with consequent imperfections in the corresponding market operations.

(3) The use of information or technology by a company or individual does not in itself reduce its availability, present or future. Thus, the relevant cost for the use or sale of an already existing technology is close to zero for an individual who already has access to that technology. In cases of minor adaptation (based on differences in scale, taste, local conditions, etc.) the firm incurs certain costs that may be estimated and do not usually exceed a figure in the tens of thousands of dollars. From the point of view of the prospective purchaser, though, the cost of using his own technical capacity to develop an alternative technology of the same type might amount to millions of dollars. Given market availabilities, the price may lie anywhere between zero and tens of thousands of dollars on the one hand, and millions of dollars on the other, and is determined solely on the basis of crude bargaining power. The range in the corresponding cost considerations is so wide that any price between these extremes can be claimed to be more or less appropriate.

The above three properties indicate that prospective buyers are confronted with structural weaknesses in the formulation of their respective demand for know-how; and that relative bargaining power is the determining factor of the terms of exchange. Policies directed toward the regulation and improvement of the mechanisms of technology commercialization must explicitly consider the implications of such properties on the behaviour of the firms involved.

(B) Concentration as a market structure

In complement to the properties mentioned above, reference must be made to some additional characteristics of the structure of the market within which technology is traded and their implications for the requisite policies. These characteristics are related to particular forms of market concentration, which in turn result in behaviour characterizing markets of sequential and interdependent oligopolies. Using the case of Chile as an example, we shall analyze three forms of market concentration that throw further light on the phenomena involved. First, there is a concentration in the total payments involved per sector with respect to the country of destination of such payments. Chilean licensees (national and foreign owned), 339 of whose contracts were analyzed, paid royalties, profit remissions, intermediates, etc., amounting to the following percentages of the total outlay per sector to the following countries.\(^{20}\)

<table>
<thead>
<tr>
<th>Sector</th>
<th>Countries</th>
<th>Percentages of total payments by the whole sector going to the countries listed in the previous column</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food and beverages</td>
<td>Switzerland and USA</td>
<td>96.6</td>
</tr>
<tr>
<td>Tobacco</td>
<td>United Kingdom</td>
<td>100.</td>
</tr>
<tr>
<td>Industrial chemicals</td>
<td>W. Germany and Switzerland</td>
<td>96.6</td>
</tr>
<tr>
<td>Other chemicals</td>
<td>USA, W. Germany, &amp; Switzerland</td>
<td>92.</td>
</tr>
<tr>
<td>Petroleum &amp; coal products</td>
<td>USA and United Kingdom</td>
<td>100.</td>
</tr>
<tr>
<td>Rubber products</td>
<td>USA</td>
<td>99.9</td>
</tr>
<tr>
<td>Nonmetallic minerals</td>
<td>USA</td>
<td>97.</td>
</tr>
<tr>
<td>Metallic products (except equipment)</td>
<td>USA</td>
<td>94.</td>
</tr>
<tr>
<td>Nonelectric machinery</td>
<td>USA</td>
<td>98.7</td>
</tr>
<tr>
<td>Electric equipment</td>
<td>Holland, USA, Spain</td>
<td>92.</td>
</tr>
<tr>
<td>Transport equipment</td>
<td>France, Switzerland</td>
<td>89.</td>
</tr>
</tbody>
</table>

This type of very high concentration in the countries of destination of payments made by the various sectors (which in turn is the mirror image of the concentration of the origin of resources in technology-producing countries) basically reflects two interrelated causal factors. On the other hand, it indicates the lack of diversification or lack of attempts to

\(^{20}\)Research in this area was undertaken in CORFO under the supervision of G. Oxman.
diversify potential sources of supply on the part of the purchaser. Quite often he prefers to receive resources in a package form from the same origin since an alternative strategy of diversification would entail the costs of obtaining information, use of other scarce resources, etc. A rational decision would have necessitated a comparison between costs of this type and those involved in purchasing inputs in a noncompetitive manner from the same origin. The second causal factor involved stems from the fact that the country concentration per country described above often reflects a concentration per company. Arrangements of patent cross-licensing between transnational corporations, cartel agreements, tacit segmentation of markets (particularly of developing countries whose size prompts such arrangements) often constitute common behaviour rather than the exception.

A second type of concentration involved reflects the joint presence of technology contracts, foreign investments (direct as well as loans), and the purchasing of intermediates and capital goods. These three types of inputs are jointly sold to developing countries in the form of a package. Analysis of any one of these immediately implies analysis of each of the others and even of all of them in the package they constitute. See, for example, the following table for Chile, which lists, in order of importance, the countries that have the highest number of technology contracts, the greatest volume of direct foreign investments in Chile, the most credit extended by foreign private firms, and the highest receipts from the sale of intermediates and capital goods to their Chilean licensees, from whom payment of royalties and/or receipts of dividends are also obtained.

<table>
<thead>
<tr>
<th>No. licenses</th>
<th>Total volume of direct foreign investments between 1964-68, inclusive</th>
<th>Total volume of foreign private loans between 1964-68, inclusive</th>
<th>Total receipts from international and capital goods, from royalties and profits in 1969, for 399 technology contracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>178 43.103</td>
<td>120.299</td>
<td>16.849</td>
</tr>
<tr>
<td>West Germany</td>
<td>46 14.517</td>
<td>28.181</td>
<td>4.238</td>
</tr>
<tr>
<td>Switzerland</td>
<td>35 2.941</td>
<td>18.250</td>
<td>3.949</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>30 2.264</td>
<td>8.121</td>
<td>3.896</td>
</tr>
<tr>
<td>France</td>
<td>17 2.264</td>
<td>6.051</td>
<td>2.606</td>
</tr>
<tr>
<td>Italy</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holland</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>25.181</td>
<td>4.789</td>
<td>2.575</td>
</tr>
</tbody>
</table>

*Millions of dollars.

Since the listing of countries in practice reflects the firms involved, the above table illustrates the existence of a collective exchange of factors of production and intermediates in package form. Direct foreign investment implies the concomitant "sale" of technology from parent company to subsidiary. Also, the tendency to use technology commercially prompts direct foreign investment. Furthermore, the sale of technology and capital generates the sale of products embodying the former or tied to them. This concentration of resources in package form creates special monopolistic conditions due to the absence of competitive forces for each one of the inputs involved, which are exchanged jointly in a collective unit.

The third form of concentration concerns the market structure of the recipient countries. In a sample of foreign-owned subsidiaries in Chile, 50% had a monopoly or duopoly position in the host market. Another 36.4% were operating in an oligopoly market in which they had a leading position. Only 13.6% of the foreign subsidiaries in the sample controlled less than 25% of the local market. Similar concentration indices were noted in Colombia. Thus, foreign resource suppliers operating within high protective tariff barriers are able to pass to the final consumer, through market domination, monopoly

21 The "infant industry" argument and tariff protection certainly need reevaluation if "infancy" is ascribed to companies like General Motors, ICI, Philips Int., Mitsubishi, etc., whose subsidiaries dominate the market of key industrial sectors in developing countries.
costs that are related to the other two types of concentration examined above. The three kinds of concentration are thus seen to be intimately connected. Market concentration and control in the host country, coupled with high tariff protection, enable the realization of high cash returns in such markets. These returns, then, are passed on through tied arrangements of inputs to foreign suppliers of collective units, often resulting in domestic tax avoidance. Furthermore, country or firm concentration prevents competitive forces even among alternative packages of inputs. Thus, the market of technology commercialization and of foreign direct investments, due to the serious imperfections compounded by various forms of concentration, necessitates particular counter-policies on the part of the host governments so as to protect their national interests.

**Empirical Results and Their Interpretation**

In order to understand the terms of technology commercialization, diverse studies were undertaken on the subject in the Andean countries between 1969-73. These studies included, among others, an evaluation of contracts for the purchase of know-how, a study on the structure and implications of the present patents system, and a financial analysis of the price effects of technology embodying imported intermediate products. The results of these studies are summarized below.

**Analysis of Contracts of Technology Commercialization**

A total of 451 contracts pertaining to various sectors in the five Andean countries were evaluated. The per country breakdown is as follows:

<table>
<thead>
<tr>
<th>Country</th>
<th>No. contracts</th>
<th>No. sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>35</td>
<td>4 including &quot;others&quot;</td>
</tr>
<tr>
<td>Colombia</td>
<td>140</td>
<td>4</td>
</tr>
<tr>
<td>Chile</td>
<td>175</td>
<td>13</td>
</tr>
<tr>
<td>Ecuador</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Peru</td>
<td>89</td>
<td>2 including &quot;others&quot;</td>
</tr>
</tbody>
</table>

The clauses analyzed in these contracts raise important economic and legal issues about the degree to which private contracting is extended into areas where the private economic benefits derived by some or all of the parties involved are in conflict with the overall economic and social interests of the country in which they operate. Some answers to this type of question have long been provided in the industrialized world through antimonopoly and antitrust legislation as well as through the establishment of public regulatory agencies. Many developing countries have still to demonstrate an awareness of these issues and their implications for private and public economic interests. Furthermore, the terms to be discussed below raise questions about the concept of the liberty or sovereignty to contract among nonequals. In a bargaining structure with highly unequal participants, with limited information and imperfect overall market conditions, the "sovereignty of the technology consumers" becomes a concept with very limited applicability.

**Export Restrictive Clauses**

One of the most frequent types of clause encountered in contracts for technology commercialization is that prohibiting exports. Such restrictive practices generally limit the production and sale of goods utilizing foreign technology solely within the national boundaries of the receiving country. Some allow export only to specific neighbouring countries. Of the total of 451 contracts evaluated in the Andean Pact, 409 yielded information on exports, summarized below.
In Chile, of 162 contracts that contained information on the subject, 117 totally prohibited any form of support. Of the remaining 45, the majority limited export permits to certain countries. It was not possible to estimate the exact number of these partial export permits from the data offered by Chile. In the four countries for which precise figures were available, about 81% of the contracts prohibited exports totally and 86% had some restrictive clause on exports. In Chile about 73% of the contracts prohibited exports totally.

Analysis of the above data indicates that there are no significant differences among countries. For example, contracts with a complete prohibition of exports, as a percentage of the total number of contracts with relevant information, were: Bolivia 77%; Colombia 77%; Chile 73%; Ecuador 75%; and Peru 89%.

With the exception of Peru, where the figures in the sample taken were biased upward by the large number of cases in the pharmaceutical sector, the rest indicate similar percentages. In terms of sectoral comparison, the following figures were noted for the various forms of export restrictions: textiles 88%; pharmaceuticals 89%; chemicals 78%; food and beverages 73%; and others 91%.

Restrictive clauses on exports are set on the basis of relative bargaining power, given market conditions for alternative sources of technology supply. Despite the divergent size and relative strength of firms belonging to countries like those in the Andean Subregion, such firms do not achieve major differential concessions in their negotiations with the foreign transnational corporations selling industrial technology. The bargaining power of a relatively large firm in Medellín, Colombia, in confronting a transnational corporation, does not seem to differ that much from a smaller firm in Cochabamba, Bolivia. It would appear that one needs to have a critical mass of bargaining power. This power will depend, among other factors, on concomitant government policies.

Analysis according to ownership structure indicated that 92% of the contracts prohibited the exportations of goods produced with foreign technology where the technology-purchasing firms belonged to nationals from the Andean countries. And this was at a time when the Andean countries were trying, with the establishment of their common market, to integrate their economies, among other means, by increasing intercountry trade. Agreements reached between governments are, in the case of technology commercialization, greatly dependent upon the terms reached among private firms whose relative bargaining power is totally unequal. The efforts of UNCTAD and individual governments to achieve preferential treatment for the export of manufactured goods from developing countries also have to be considered within a market structure that explicitly prohibits such exports by means of restrictive clauses. The process of its present form of commercialization converts technology, an indispensable input in industrial development, into a major factor limiting such development.

The nonexistence of such export-prohibitive clauses would not, of course, necessarily mean the realization of exports. This would depend on the production and marketing capacity of the firms, their relative competitive position in external markets, their export horizon, etc. Nevertheless, even if contractually assumed export possibilities do not constitute a sufficient condition, they represent a necessary one for such export capacities. Indeed, they can even create a critical prohibitive element in the long process necessary for firms to develop export orientation and capacities.
Tie-In Clauses on Intermediate Products and Price Effects

A large percentage of contracts in the commercialization of technology include clauses stipulating the purchase of intermediates and capital goods from the same source as that of the know-how. For example, more than two-thirds of the contracts concerning technology in Bolivia, Colombia, Ecuador, and Peru had tie-in clauses.

Even in the absence of such explicit clauses, control through ownership or technological requirements and specifications, stemming from the nature of the know-how sold, could unequivocally determine the source of intermediate products. Thus, as in the case of tie-in arrangements in loans, benefits to the supplier and costs for the purchaser are limited not only to explicit payments such as royalties or interest rates; they also include implicit charges through the various forms of margins in the concomitant or tied sale of other goods and services. Furthermore, at the aggregate level, the flow of technology between countries directionally implies the joint flow of intermediates, equipment, and capital.

This type of market structure in intermediates and other inputs tied to the sources of technology and/or capital, has significant repercussions if evaluated within the strategy of final product import substitution pursued by the majority of developing countries. Such a strategy has in fact implied an increasing dependence on imports of capital goods and intermediate products. Only a few countries well ahead in their development process, like Argentina, Mexico, and Brazil, have in certain sectors achieved significant backward linkages in domestic production. Others, though, find an increasing share of inputs on their total imports bill as industrialization advances.

For example, in Colombia, two-thirds of the total imports bill in 1968 comprised imports of materials, machinery, and equipment for the industrial sector, while the other third included final products for consumption and intermediate goods for the agricultural sector. A similar dependence and structure of imports may be expected for Chile and Peru and other countries of comparable industrial development.

For the whole of Latin America it has been estimated that, during the period 1960–65, about U.S. $1870 million were spent annually for the importation of machinery and equipment. These imports amounted to 31% of the total import bill of the area. They also constituted about 45% of the total amount spent by Latin America on capital goods during the same period. For individual countries, this relationship amounted to 28% for Argentina, 35% for Brazil, 61% for Colombia, 80% for Chile, and 80% for Peru. As far as intermediates are concerned, samples for Colombian industry have indicated that in 1968 imported materials represented between 52–80% of total materials used by firms in parts of the chemical industry. In rubber products, the corresponding figure was 57.5% and in pharmaceuticals, 76.7%. It was only in textiles that the figure for imported intermediates fell to 2.5% of total materials used. Similar figures were reported for Chile. For example, imported intermediate products amounted to more than 80% of total materials used in the pharmaceutical industry and between 35–50% of total sales of the Chilean firms involved. This heavy dependence on imports of intermediates and capital goods has significant repercussions for the recipient countries if one considers the fact that the majority of such imports are either exchanged between affiliated firms and/or are tied to the purchase of technology. For example, it has been estimated that about one-third of the total imports of machinery and equipment in Latin America are carried out by foreign subsidiaries.

As a result of the above described absence of arms-length relations in the sale of goods and services, foreign firms often overprice their exports to or underprice their imports from their affiliates and/or licensees in host countries. If “overpricing” is represented by the following equation:

\[ \text{Overpricing} = \frac{\text{Foreign Price} - \text{Domestic Price}}{\text{Domestic Price}} \times 100 \]

22 See data from Banco de la República, tabulated by INCOMEX, *Clasificación Económica de las Importaciones (Economic Classification of Imports)*, 1969.

FOB prices on imports in Andean countries minus FOB prices in different world markets

\[ 100 \times \frac{\text{FOB prices on imports in Andean countries}}{\text{FOB prices in different world markets}} \]

The results per country in the Andean Pact presented the following indications:

In the Colombian pharmaceutical industry, a sample covering about 40% of the national market indicated that the weighted average overpricing of products imported by foreign-owned subsidiaries amounted to 155% whereas that of national firms was 19%. The absolute amount of overpricing for the foreign firms studied amounted to a figure of six times the royalties and 24 times the declared profits. For national firms the absolute amount of overpricing did not exceed one-fifth of the declared profits. Smaller samples undertaken in the same industry in Chile indicated an overpricing of imported products in some cases exceeding 500%, although the majority of them ranged between 30 and 500%. Similarly, in Peru, samples for the same industry showed that overpricing in most instances ranged between 20 and 300%, although for certain products it was more than 300%. In all three countries, the overpricing noted in the imports of foreign-owned firms was considerably higher than that of nationally owned ones. Foreign technology and capital suppliers evidently indicated in these cases a preference for receiving their returns in an implicit form by means of transfer pricing rather than explicitly by means of royalty payments and/or profit remittances.

Similarly, in the electronics industry in Colombia, representative samples of firms controlling about 90% of the market indicated that overpricing ranged between 6 and 69%. In the Ecuadorian electronics industry, 29 imported products, evaluated in relation to the Colombian registered prices, indicated the following results: 16 of them were imported at prices comparable to the Colombian ones, 7 showed overpricing of up to 75%, and 6 of them were overpriced by about 200%. Earlier studies undertaken only in Colombia presented a weighted average of 40% overpricing for imports by foreign-owned subsidiaries in the rubber industry and zero overpricing for nationally owned firms. Also, smaller samples in the Colombian chemicals industry indicated weighted average overpricing of between 20 and 25%.24

In the case of imports in developing countries, returns to the foreign factor suppliers are realized by, among other mechanisms, the overpricing of such products. In the case of exports from one of these countries, similar returns can be realized through the underpricing of the products sold by companies to their foreign affiliates. Preliminary research in Colombia, still in progress, has presented indications of significant underpricing of products in the timber, fish processing, and precious metals industries, which are exported by foreign subsidiaries to their parents. Similarly, foreign industrialists with an interest in entering the fishing industry in Peru have expressed their preference for breaking even in their operations in Peru and making their profits "at the marketing end abroad." Considerable interest has been aroused in the past in the deteriorating terms of trade of the developing countries due to their specialization in the production and exportation of primary products. It is not improbable that the present process of industrialization, given the existing mechanisms of technology and foreign capital supply, may have resulted in a further worsening of the terms of trade for these countries. Such a deterioration might have been due to the fact that the markets within which production factors (such as technology and capital) are traded, jointly with intermediate products and capital goods, are even more imperfect than the markets of final industrial products.

A further significant point should be raised. The aforementioned investigations and their results were based on comparisons of "overpricing" (or "underpricing"), which in turn implies a comparison between two different prices. Yet, income flows occur on the basis of pricing and not just of "overpricing." The former implies a comparison between price and costs whereas the latter that between prices. In addition to aspects of relative magnitude, important conceptual and measurement considerations are involved. In areas of

standardized products, such as natural or synthetic rubber, certain chemicals, specific synthetic fibres, various electronic components specified by nomenclature, etc., ‘‘overpricing’’ may be assessed. In the case of highly differentiated goods, however, attempts at estimates are extremely difficult and, in practice, probably meaningless. Furthermore, one may well ask what is the relevance of ‘‘overpricing’’ in the case of a monopoly or a cartel market structure, where prices or markups are fixed accordingly. On the other hand, a comparison between prices and costs to determine net generated income begs the question of what the costs are. How should overheads be allocated at the international level?

These perplexing questions indicate the need for further work on the subject to place the issue of technology purchase and direct foreign investment within a bargaining framework. Diverse and complementary policies, such as top price limits on standardized products or direct negotiation as to the pricing of diversified ones, etc., constitute some of the necessary steps to be taken by recipient countries. There is a major indirect mechanism that appears to reduce overpricing: the tariff levels for the imported intermediate products that are then used by foreign firms for further processing in their host countries. These tariff levels cannot, however, be considered independently of those set for the final product or of the overall commercial policies, which, through the effective protection they create, generate returns and determine the competitiveness of domestic production. What remains evident, though, from our analysis is that the cost of technology (particularly if it is obtained through foreign-owned subsidiaries) cannot be regarded as limited to explicit payments such as royalties, but that it should also include the often much more important implicit charges applied through import or export product pricing.

Other Types of Restrictive Clauses

In order for the meaning and repercussions of a contract to be understood, it has to be evaluated in its entirety. Often terms that are defined in clause X are conditioned or modified in clause Y. Furthermore, it is possible to achieve ends by indirect, legally accepted means by not stating them explicitly so as not to violate local legislation. For example, by including certain quality clauses it is possible indirectly to affect production volume or control sources of intermediates; or by controlling the production volume (which is permissible under certain patents legislation) one can control the volume of exports (which is not permitted by the same patents legislation). Restrictive clauses in contracts for technology commercialization are of various types. In Bolivia, for instance, 35 contracts analyzed (and in addition to the export restrictions and tie-in clauses on intermediates referred to above) included the following terms; 24 contracts tied technical assistance of patents or trade-marks and vice-versa; 22 tied any additional know-how needed to the present contracts; 3 fixed prices of final goods; 11 prohibited production or sale of similar products; 19 stipulated the secrecy of know-how for the duration of the contract and 16 after the end of the contract; 5 specified that any controversy or arbitrage should be settled in the courts of the country of the licensor. Furthermore, 28 out of the 35 cases contractually placed quality control under the direction of the licensor. Similarly, in Chile out of 175 contracts, 98 included clauses placing quality control under the direction of the licensor, 45 controlled the sales volume, and 27 the production volume. In Peru, out of 89 contracts, 66 controlled the sales volume of the licensee. Some clauses prohibited the sale of similar or of the same products after the end of the contract. Others tied the sale of technology to the appointment of key personnel by the licensor.

The list of clauses included in contracts for technology commercialization and their impact on business decisions prompt the question as to which crucial policies are left under the control of the ownership or management of the recipient firm. If the volume, markets, prices, and quality of what a firm sells; the sources, prices, and quality of its intermediates and capital goods; the key personnel to be hired and the type of technology used, etc.; if all of these are left under the control of the licensor, then the only basic decision left to the licensee is whether or not to enter upon an agreement of technology purchase. Through the present process of its commercialization, technology thus becomes a mechanism for
controlling the recipient firms. Such control supersedes, complements, or is substituted for that conferred by ownership of the capital of a firm. The political and economic preoccupations voiced in Latin America concerning the high degree of foreign control of domestic industry should properly be evaluated not only within the direct foreign investment model but also within the mechanism of technology commercialization. It is for this reason that the term "technology transfer" is regarded in this chapter as inadequately representing the phenomena involved and their implications.

An additional issue needs to be mentioned. The type of clauses encountered in contracts for technology commercialization violates basic antimonopoly or antitrust legislation in the home countries of the licensors. Since laws do not in general apply extraterritorially, it behooves the technology-receiving countries to legislate and regulate accordingly so as to protect the interests of the purchasing firms. The industrialized countries have, over the past half century or even more, undertaken in one way or another to define in their legal structure the extent to which private contracting and the exercise of business power may operate within a market mechanism. The developing countries have still to show an adequate understanding of the issues involved in their commercial laws, those regulating the application of industrial property, etc. The mechanisms of technology commercialization cannot function adequately so as to protect the interests of the comparatively smaller and weaker national firms without the existence of concomitant legislation that defines the extent of acceptance of the terms negotiated by large foreign transnational corporations.

The Role of Government Negotiating Committees

On various previous occasions in this chapter, it has been pointed out that the market of technology commercialization is best described within a bargaining framework. Given this premise and the fact that a large part of foreign know-how is introduced by establishing foreign-owned subsidiaries, it may be concluded that such firms lack even a minimum negotiating position since their interests are, presumably, identified with those of their parent corporation and not with the host country. For example, it is not uncommon for an entirely foreign-owned subsidiary to capitalize technology originating from the parent corporation in its books. As a result, it could be (a) paying royalties; (b) reducing its tax payments through depreciation "charges" of intangible assets; (c) decreasing its tax coefficients in countries where taxable profits are related to "invested" capital; and (d) claiming higher capital repatriations, all for the same know-how. Clearly, a foreign-owned subsidiary does not need to capitalize technology since 100% of its capital is already owned by its parent company. Thus, unless a government body intervenes between the "private contracting" of a parent and a subsidiary, the distribution of returns from the use of technology is likely to be only one-sided.

Similarly, even among independent firms, the relative size of transnational corporations and companies in developing countries is such, and the relative cost considerations are so different, that the bargaining power of the purchaser can only be strengthened through appropriate government action. Such action is based on the power of a government to permit or prohibit access to the domestic market. This type of power seldom rests with private firms and its exercise can be quite effective in confronting the different types of power at the disposal of the transnational corporations. From the second half of 1967 to June 1971, the Colombian Royalties Committee (Comité de Regalías) evaluated 395 contracts for technology commercialization. Of these, 334 were negotiated, modified, and finally approved, and 61 were rejected. In the process of negotiations, payments of royalties were reduced by about 40% or about U.S. $8 million annually. (The extent of the reduction in annual royalties in Colombia brought about through government

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25 As far as tie-in restrictions are concerned, see Section 1 of the Sherman Act and Section 3 of the Clayton Act in the U.S. On similar and related issues (such as export restrictions) see Article 85 (1) of the Rome Treaty establishing the European Economic Community, Article 37 of the 1945 Price Ordinance in France, the Economic Competition Act of 1958 in the Netherlands, the Antimonopoly Law in Japan, etc.
negotiation is equivalent to the total annual payments for technology reported for the entire Chilean economy.) Also, during the latter part of 1970 and the beginning of 1971, negotiations conducted by the Colombian Royalties Committee led to the following results: (1) a 90% reduction of the tie-in clauses in the purchase of intermediates; (2) elimination of the restrictive export clauses; (3) reduction by 80% of clauses on minimum royalty payments; (4) prohibition of tax payments by the licensee on royalties remitted to the licensor; (5) establishment of a maximum percentage for the royalty rates per sector.

These significant achievements by the Royalties Committee need the following qualification. Insofar as foreign-owned subsidiaries are concerned, reduction in royalty payments could result either in higher profits, which could be remitted after payment of local taxes, or could be passed on to the parent firm through interaffiliate transfer pricing. Furthermore, the exclusion of such clauses from a contract held by a subsidiary does not mean that the practices involved will be abolished, since control through ownership could still dictate the same practices. Insofar as nationally owned firms are concerned, it has been known for “gentlemen’s agreements” to be made extra-contractually after such government intervention, between licensors and licensees. Nevertheless, in other cases government intervention has resulted in known benefits for nationally owned firms.

Up to the end of 1970, when Decision 24 of the Andean Pact was approved, only Colombia and Chile had government negotiating committees for technology, patents, and trademarks, while Bolivia, Ecuador, and Peru lacked such bodies. The Colombian and Chilean committees, had certain major negotiating deficiencies, among which were the following.

Firstly, such committees lacked adequate legal backing to confront the restrictive business practices imposed through bargaining by foreign know-how and patent licensors. Thus, up to 1969, the Colombian Royalties Committee was not geared to control the major restrictive practices in the contracts negotiated.

In 1970, specific government action reinforced by the provisions on commercial and other practices included in Decision 24 at the end of that year, enabled the Royalties Committee to enhance its negotiating scope and power, as it did with the similar Chilean committee. The very names of these committees, however, indicate their initial limitations. They were directed only toward control of payments or fees and even then only with respect to considerations of the balance of payments, thus excluding the broader and more important effects of other clauses on technology commercialization or of technological development itself.

Secondly, as an evaluation of contracts in the other Andean Pact countries has confirmed, in more than 95% of the cases examined, payments of royalties were set as a percentage of sales and not with respect to profits of “value added.” One result of this practice is that the more an inefficient firm passes its inefficiency on to the consumer through higher prices and/or the higher the protective tariff levels on the goods produced, the higher the royalties will be for foreign technology. Articles incorporated in Decision 24 (as in recent legislation in Argentina) have attempted to correct this situation.

Finally, a major limitation of existing government negotiating committees rests on the fact that their bargaining power is significantly limited by very inadequate information systems. For example, no prior survey is ever institutionally used to search for alternative sources of technology supply by combing international market availabilities. Similarly, the conditions for evaluating the technological and broader economic impact of the technology imported are minimal.

Some Considerations in the Structure and Effects of Patents

The economic impact of patents stems from the monopoly privileges granted by the State for innovations that are of industrial use. Such privileges are granted on the basis of the traditional assumption that patents provide a necessary incentive and/or compensation for inventive activity. It is also assumed that sufficient incentives are given through patent disclosure, the guarantee of monopoly, etc., so as to introduce innovations into commercially beneficial industrial activities. In addition, in terms of overall country effects (leaving distributional effects aside), it is assumed that the monopoly costs to
consumers and to other producers are less than the benefits accruing from the encouragement of inventive and investment activities through patents. It is important to clarify that the above arguments do not apply to inventions and investments as such, but to the role of monopoly privileges on such activities. Monopoly privileges granted by patents are clearly intended to place the production of inventions within a market price framework. Prices are a function of scarcity. Patents, by granting a monopoly of use (or use under licence), create a scarcity by limiting the availability of inventions, although an invention is by its nature "inexhaustible" in terms of number or times of use. To a certain extent, prices are put on the use of inventions not because of their scarcity but in order to make them scarce to possible users. A patent diminishes the possible use of an innovation so as to generate benefits. 26 To allow an understanding of the effects of patents in developing countries the following three aspects should be stressed:

(1) The patents granted in developing countries are almost all of foreign origin

The following table presents comparative data on the number of patents of foreign origin as a percentage of the total number of patents granted by various countries between 1957 and 1961.

<table>
<thead>
<tr>
<th>&quot;Large&quot; industrial countries</th>
<th>&quot;Smaller&quot; industrialized countries</th>
<th>Developing countries</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Italy</td>
<td>India</td>
</tr>
<tr>
<td>15.72%</td>
<td>62.85%</td>
<td>89.38%</td>
</tr>
<tr>
<td>Japan</td>
<td>Switzerland</td>
<td>Turkey</td>
</tr>
<tr>
<td>34.02%</td>
<td>64.08%</td>
<td>91.73%</td>
</tr>
<tr>
<td>West Germany</td>
<td>Sweden</td>
<td>Arab Rep.</td>
</tr>
<tr>
<td>37.14%</td>
<td>69.30%</td>
<td>93.01%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Netherlands</td>
<td>Trinidad &amp; Tobago</td>
</tr>
<tr>
<td>47.00%</td>
<td>69.83%</td>
<td>94.18%</td>
</tr>
<tr>
<td>France</td>
<td>Luxembourg</td>
<td>Pakistan</td>
</tr>
<tr>
<td>59.36%</td>
<td>80.48%</td>
<td>95.75%</td>
</tr>
<tr>
<td></td>
<td>Belgium</td>
<td>Ireland</td>
</tr>
<tr>
<td></td>
<td>85.55%</td>
<td>96.51%</td>
</tr>
</tbody>
</table>

(Source: United Nations, "The Role of Patents in the Transfer of Technology to Developing Countries," New York, 94-95.)

Furthermore, if the number of patents granted by developing countries is weighted by their economic value (for example, by the sales volume they represent or their "value added"), the percentage of patents of national origin so weighted will probably be less than 1%. Whenever we talk about patents granted by developing countries and the policies that should regulate them, we are thus really referring to patents belonging to foreign companies or foreign nationals.

The experience of the large industrialized countries has not indicated any major change in the percentage of patents of foreign origin. For example, the following table depicts the patents of foreign origin as a percentage of the total number of patents granted by:

<table>
<thead>
<tr>
<th>Countries</th>
<th>1940&lt;sup&gt;a&lt;/sup&gt;</th>
<th>1957–61&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>10%</td>
<td>16%</td>
</tr>
<tr>
<td>Japan</td>
<td>25%</td>
<td>34%</td>
</tr>
<tr>
<td>Germany</td>
<td>25%</td>
<td>37%</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>50%</td>
<td>47%</td>
</tr>
<tr>
<td>France</td>
<td>50%</td>
<td>59%</td>
</tr>
</tbody>
</table>

<sup>b</sup>Date of Table 1 of the present paper.

In the developing countries, on the other hand, the proportion of patents granted has progressively been taken up by foreign countries, as the following figures for Chile show.

<table>
<thead>
<tr>
<th>Year</th>
<th>National</th>
<th>Foreign</th>
</tr>
</thead>
<tbody>
<tr>
<td>1937</td>
<td>34.5%</td>
<td>65.5%</td>
</tr>
<tr>
<td>1947</td>
<td>20.0%</td>
<td>90.0%</td>
</tr>
<tr>
<td>1958</td>
<td>11.0%</td>
<td>89.0%</td>
</tr>
<tr>
<td>1967</td>
<td>5.5%</td>
<td>94.5%</td>
</tr>
</tbody>
</table>

Source: CORFO, "La Propiedad Industrial en Chile y su Impacto en el Desarrollo Industrial" (Patent rights in Chile and their effects on industrial development). Santiago 1970.

2) Patents and concentration of economic power

An important change has taken place in the structure of ownership of patents in the industrialized as well as in developing countries. The majority of patents have left the world of the individual inventor and belong to that of the large transnational corporations. The latter use patents for their global business policy. This change in the ownership structure of patents has, in turn, led to the concentration of patents in the hands of a relatively very small number of transnational firms. For example, 50% of all patents obtained by companies between 1946 and 1962, and whose respective research efforts were financed by the U.S. Federal Government, belong to 20 firms. Furthermore, of all patents resulting from research in the U.S. financed by private firms as well as by the Federal Government during the same period, 35.7% belonged to less than 100 firms. Since almost all of the patents granted in developing countries are of foreign origin, they reflect the same type of concentration. In 1970, less than 10% of all the firms owning patents in the pharmaceutical industry in Colombia controlled more than 60% of all the patents in that sector. The same percentage was found for patents for synthetic fibres and chemicals.

The concentration of patents in the hands of a small number of firms means that patents are to a large extent oriented toward control of the market so as to maximize the overall interests of a small number of firms holding industrial property privileges. This form of market control and monopoly concentration is reinforced by the system of cross licencing between companies, which in turn reduces a world-wide oligopoly structure into a regional monopoly.

(3) Lack of direct exploitation of patents in developing countries

Patents granted by developing countries not only almost all belong to foreign companies but they are, moreover, scarcely exploited in these countries. For example, in Peru, of 4872 patents granted between 1960 and 1970 in the electronics, textiles, machinery and equipment, chemicals, food processing, pharmaceuticals, fishing, metal processing, transport equipment, etc., sectors, only 54 were registered as under exploitation. Working or exploitation of patents was thus less than 1.1% of the total. Similarly, in Colombia, out of a total of 3513 patents evaluated (2534 of which belong to the pharmaceutical sector and the rest to textiles and chemicals), only 10 were exploited. The lack of exploitation of patents in developing countries substantially contributes to the preservation of secure import markets for transnational corporations, thus limiting any possible competition with other companies, foreign or national. This absence of competitive forces could involve significant price increases with negative effects on incomes and the balance of payments in the recipient countries.

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28Deduced from data obtained by Timoléon López and F. Castaño from the Colombian Bureau of Patent Rights for the present studies of technology transfer commissioned for the Andean Common Market.
Technology is to a large extent sold to developing countries, and foreign investments are made as a defensive strategy to avoid loss of markets for the owners of technology and capital. A company will thus tend to sell technology to a given country not because of assured monopoly privileges but because, if it did not, another company would, thus supplanting the former. In view of the fact that monopoly privileges, granted by means of patents, restrict competition and since scarcely any of the patents appear to be exploited in the developing countries granting patents, these, in a sense, restrict the flow of technology and limit the factors encouraging investments.

Up to 1974, the mechanisms that were present in the legal systems of the Andean countries (and which reflected more or less worldwide practices) so as to correct the existing policies governing the patents system, have proved quite inefficient or inoperative. One of the basic reasons for their inefficiency (e.g., that of the process of obligatory licensing) is that the legal procedures through which the present patents system operates are lengthy and expensive. This, together with the fact that the corrective measures are not instituted automatically, tends to favour the transnational corporations, which are financially stronger than the relatively weak national firms in the recipient countries. The above considerations have led to the conclusion that the present patents system needs a total reevaluation if its inadequacies, which appear to have negative effects particularly on the economies and interests of developing countries, are to be corrected.

Policies on the Technology Commercialization Included in Decision 24 of the Andean Pact

In December 1970, the Board of the Andean Pact, having considered the experiences of the five member countries in the purchase of foreign technology, established a series of policies that will, through legislative procedures as well as institutional building, regulate the mechanisms of the acquisition of technology. These policies on technology were, correctly, presented jointly and in accordance with the overall philosophy and procedures governing direct foreign investments, since a large part of the contractually obtained know-how is channelled through foreign-owned companies. The overall orientation of technology policies cannot therefore be adequately analyzed without a concomitant understanding of the policies on foreign investments. For example, progressive national participation in the ownership of foreign subsidiaries operating in the Andean market will enable national investors progressively to share in the use of foreign technology within the Subregion. Ownership of a firm does not mean nonfunctional participation in its assets, but rather control and a share in the profits of the operations and use of such assets.

Similarly, the policies on technology and foreign investments in the Andean Subregion can be understood properly only within the context of the overall economic formulations and objectives of Andean integration. The scope offered by an enlarged market for instance, encouraged by special policies, changes the relative opportunities and hence affects the bargaining power of the Andean countries. This in turn leads to new formulations on related policies confronting the rest of the world. Equally, explicit common planning by the five countries for complementary industrial projects permits collective bargaining with foreign investors and technology suppliers.

An evaluation of these broader economic issues and their underlying political circumstances necessitates much more space than that afforded in this chapter. We shall thus limit ourselves to a brief description of the scope of policies that were explicitly directed toward technology, realizing that their understanding necessitates a wider comprehension of interrelated political and economic phenomena. Our analysis falls into the following three parts: (A) institutional structure for the import of technology; (B) the management of technology commercialization; and (C) supplementary policies and programs for the future.

\[\text{In the middle of that year, the Andean Pact approved a new common policy on industrial property matters.}\]
(A) Institutional structure for the importation of technology

Article 6 of Decision 24 refers to the creation of competent government agencies that will, in each of the countries, regulate and implement all policies concerning technology imports together with those on foreign investments. Previous relevant policies in Chile and Colombia that were primarily, through the agency of the respective Royalties Committees, directed toward the balance of payments, will be extended to incorporate the much broader considerations related to technology commercialization and foreign investments. For Bolivia, Ecuador, Peru, and Venezuela, Article 6 involves the creation of completely new government organizations that were lacking until Decision 24 was approved.

These government agencies are authorized under Article 18 to evaluate and approve all contracts for technology commercialization and those concerning the licencing of industrial property privileges (patents, trademarks, industrial models, and designs, etc.). Article 18 will thus enable the governments concerned to strengthen and extend the bargaining power of nationally owned firms by approving access to foreign technology of the local market. Equally, in any negotiations for technology contracts between foreign-owned subsidiaries and their parent companies, the governments will represent the overall national interest. During the negotiating process, in accordance with Article 19, imported technology will be itemized as to its respective components (production manuals, factory specifications, know-how incorporated in products, expert technical assistance etc.) so as to evaluate the contractual value of each of these components or of groups of them.

(B) The management of technology commercialization

The importation of intermediate products and capital goods in the commercialization of technology and direct foreign investments was identified as a key element of overall procedures in present industrialized programs. As stated in Article 6, paragraph c), the Andean countries will establish an information and control system intended to bring the prices of such imports within acceptable ranges, approaching the international market prices. In so doing, monopolistic structures arising from the joint transfer of products tied to technology and/or capital imports will be regulated. Insofar as nationally owned firms are concerned, these provisions, applied to standardized imported products, will have extremely significant effects on bargaining by excluding the prices of such imports from the negotiable terms. In the case of highly differentiated products for which quotations in other markets are lacking, progressive national participation in the ownership of foreign companies could achieve similar results through intracompany bargaining.

The importation of know-how is compensated for under the terms of Article 21 by payment of royalties on the part of nationally owned firms to their foreign licensors and by increasing the profitability of foreign-owned subsidiaries in the Andean countries. Capitalization of imported know-how is not permitted as such. For the foreign-owned subsidiaries, the capitalization of know-how was leading, among other effects, to domestic tax reductions through depreciation "charges" on intangibles as well as capital repatriation claims. Thus, in the latter event, the capitalization of technology represented a depletion in the capital of the host country because of the repatriation of "investments" instead of contributing to capital formation.

In addition, Article 21 prohibits the payment of royalties from a subsidiary to its parent or its affiliates. This policy, which is also applied in various other countries, is based on the principle that the effects of technological inputs on a foreign-owned subsidiary should be reflected in its declared profitability instead of being transferred to a foreign tax jurisdiction. Royalty payments between affiliated firms mean tax reductions in the royalty-paying country and could also result in an overall tax reduction for the whole system of a transnational corporation. Tax avoidance and the economic and overall political issues involved in underdeclaring true profitability run counter to the interests of the host countries of foreign-owned subsidiaries.

In order to increase the amount of information available on technology commercialization and thus enhance the bargaining power of the recipient countries, besides improving its conditions of use, Article 48 establishes the need for a permanent
system for the exchange of information between the five Andean countries on the terms and impact of technology purchase. This constitutes a first step in the application of the principle of the "most favoured nation" in the purchase of technology. It is so formulated as to abolish monopoly profits accruing from the segmentation of the market with various degrees of elasticity in the demand for technology, unequal availability of knowledge, and varying degrees of bargaining power held by the firms acquiring technology.

For the first time in the Andean Pact, Articles 20 and 25 establish a legal basis for dealing with restrictive business practices resulting from the purchase of technology and the licencing of patents and trademarks. They also regulate export restrictions, tie-in arrangements, control of production scale and structure, the hiring of personnel, use of alternative technologies, etc. In the absence of overall, comprehensive antimonopoly legislation, partly due to the lack of adequate analyses of the effects of monopolies and economic concentration in developing countries (where market size is often conducive to the formation of monopolies), specific legislation is necessary in view of restrictive business practices in the sale of technology.

Articles 26 and 54 refer to the requirement of establishing new legislation governing patent rights. The well-known inadequacy of the present patents system and the international agreements that regulate it (the fundamentals of which were laid down in the last century to meet completely different circumstances and needs) means that a new approach to these matters is imperative. The interests of developing countries should be defended at least in their own legislation.

Finally, Article 51 establishes the important principle that any controversy or conflict in the purchase of technology or in direct foreign investments should fall within the jurisdiction and competency of the legal apparatus of the host country. Article 51 further deals with subrogation and related issues.

(C) Supplementary policies and programs for the future

Articles 22, 23, and 55 established a mandate for the Andean countries to approve, by November 1972, a comprehensive legislative and institutional program on technology policies. The objectives of this program stem from the need to link policies on the importation of technology to the development and encouragement of domestic technological activities. This involves setting priorities and defining categories and projects related to diverse technological activities. These activities will moreover be encouraged by means of fiscal, monetary, and direct incentives. Various institutional instruments will be required, including a continuous, systematic search in the international market for alternative technology, information systems, incentives for local efforts in the field of technological development, and an appropriate infrastructure to direct and promote related activities. One of the key points of the program is the effect of the development and use of technology on employment and on the exploitation of natural resources in the Andean Subregion.
Chapter VI

Breaking up the Technology Package

Introduction

Notwithstanding Subregional efforts to create technology, technological resources for the socioeconomic development of member countries will for a long time depend heavily on technological imports. Furthermore, even in the more distant future it will still be advisable to exploit the technology available on the international market. It is important, therefore, that member countries agree on common criteria and approaches to obtain maximum benefit from imported technology, since only then will they reach the targets set by the subregional program on technology policy.

There are two fundamental ways to acquire foreign technology for the Subregional socioeconomic development projects:

(a) Different technological elements appear as a package and thus are negotiated as one complete unit, which also comprise foreign provision of other services, equipment, financing, etc., to enter the productive process as a larger package. Here the user has no direct access to the different parts of the imported technology and cannot assimilate, adapt, or improve them in keeping with his own needs. As a result, the opportunity to make use of imported technology as an instrument or means for one's own future technological activity passes by unused. This is the overall present picture for technology when it is imported into the Subregion: it is generally neither absorbed nor assimilated, but only superimposed on the Subregional productive process.

(b) Technology is acquired element by element: first, the technological package is separated from the rest of the project components (equipment, financing, capital contributions, etc.) and, second, the technological package itself is broken up into its different elements: basic process licenses, basic designs, detailed engineering, specific engineering services, technical assistance for start up and plant operations, etc.

When, in order to promote manufacturing activities, several of these inputs are imported as packages, there are negative repercussions in technological development and in the overall economic progress of the Subregion. The acquisition of packaged inputs has four main consequences:

(1) The interrelation or ties existing between inputs give the suppliers monopolistic power since the purchasers cannot obtain part of these inputs from other sources. Thus the purchaser's relative bargaining power weakens and higher prices are paid. Furthermore, the import of inputs in packages makes it difficult to evaluate and negotiate the best adaptations to local conditions.

(2) The package of inputs acquired includes technological components and other inputs that could be found or produced locally. As a result, the importing of package contributions reduces the potential demand for several domestic activities — not because these would lack efficiency or availability, but because of the implicit or explicit ties within the imported package.

30The terms "breaking up," "disaggregation," "breakdown," "unpackaging," and "unbundling" are all meant to convey the same meaning of separation and identification of elements of a technology present in a production process.
(3) In technology, the import of components in a set combination impedes proper understanding of its parts and leads to a pseudo-transference of knowledge that, although imported, is not understood. As was said before, this process further obstructs the adaptation or improvement of foreign technology and thus restrains the development of domestic technology.

(4) Finally, the essence itself of a package includes the additional capacity to combine the different cognitive elements. This faculty constitutes a special innovative capacity needed to translate different types of knowledge into economically feasible or socially useful processes. It follows that an importer lacks the incentives or even the need to develop his own capacity for combining and applying this knowledge in productive activities.

Core and Peripheral Technology

The separation of the technology package from the rest of the project's components and the breakdown of the package into its main technological elements identifies two main types of technologies or technological services: the core and the peripheral technologies of a product or process.

Core technologies correspond to that body of knowledge that is inherent in, or specific to, a project, product, or process. Such knowledge identifies the activity through its basic characteristics and requirements. This type of technology is normally materialized in basic process designs, in general equipment or product specifications, in operation or performance data, prototypes, pilot plant data, and certain types of engineering designs pertaining to products or processes.

Peripheral technologies correspond to a body of elements of knowledge nonspecific to the manufacturing of a product or to a process but needed for application of the core technologies in producing goods, service activities, or even in the generation of further knowledge. Peripheral technologies relate to general engineering services that are not specific to a process or product and may be common to various projects such as calculations in different areas of engineering: soil, foundations and structures, civil, electrical, mechanical, and others.

Peripheral technologies relate also to detailed designs of production equipment based on data contained in the basic process engineering, which in turn belongs to core technology; the layout of equipment and plants, as well as industrial and systems engineering inputs for the materialization of the project, its start up and later operation; etc. Keeping in mind these definitions and illustrations about core and peripheral technologies, a few special characteristics that differentiate these two categories of technological inputs in operation may now be introduced:

(1) Very often the exclusiveness or capacity of knowledge (caused by legal means like patents, or other) refers mainly to core technologies. The price for acquiring such core technologies includes monopolistic incomes and a sales power that easily extends to other inputs (technological or not). The latter, under other conditions, would therefore have a much more competitive market. On the other hand, peripheral technologies in general are not exclusive but exist only as an extension of the powers created by the critical technologies.

(2) Inventions (that is, scientific and technological principles) are embedded in core technologies. Their application in various productive activities is possible. However, innovations (that is the translation, development, and application of scientific and technological principles in products and in concrete processes) in the case of core technologies are by definition only applicable and specific to certain products and processes. On the contrary, peripheral technologies are not specific by sector, product, or process, but by activities: for instance, the understanding of soil engineering comes through studies and applying the knowledge in activities where this knowledge is useful, such as in the construction of petrochemical plants, schools, bridges, assembly plants, etc. Therefore, the availability in a society of this peripheral knowledge and of technological capacity has, because of its manifold uses, large multiplying effects or externalities.
(3) Even if (already developed) core technologies are applied over and over to the same activities, skilled labour or other additional resources are generally not required (there are some exceptions, though, such as some skills of basic engineering, which are repeatedly required). Investments and the creation of opportunities for skilled labour are more related to the discovery or purchase of core technologies than to their repeated application. With this we do not mean to say that the use of resources in the case of discovery or acquisition is small, but rather state that the "social cost" for the further and additional use of such technologies is small. On the other hand, the application of peripheral technologies requires the utilization of qualified personnel and other resources over and over when new projects are tackled, for in each of these projects qualified job opportunities are created. For instance, if the basic process for synthesis of a pharmaceutical product is known and mastered there is no need to rediscover it each time it is reused. However, detailed engineering for the construction of a specific pharmaceutical plant, or the piping work in a factory, or the marketing study for the sale of given products — these must be made anew, or at least copied, even when there is already a basic knowledge about such engineering or marketing. In conclusion, peripheral technologies create opportunities for skilled labour in two ways: in the generation and application of knowledge.

Complexity and Varying Degrees in the Breakdown of Technology Packages

As a productive process is progressively opened there is an almost continuous "gradation" regarding the level of complexity that the technology requirements and related activities may have. There is a similar gradation as to the extent to which it is feasible to subdivide the production or the technological package of a project.

A country or a company may choose the activity best suited to further or to specialize its efforts, needing only to consider its own resources and the resulting benefits. Furthermore, the process and work of "unpackaging" implies evolving capabilities that, as time goes by, develop, so that much more difficult jobs may be tackled. Consequently, this is a cumulative process and the experience in one phase may be useful in the next and more complex phase.

Regarding complexity, a case study undertaken by the Board differentiated six large industrial categories, which are described in terms of (a) personnel skills, (b) required equipment, (c) production activity. In this breakdown, the first category refers to illiterate personnel trainable within 6 months, using simple low-cost equipment where manufacturing is performed in simple workshops found in all countries of the Subregion. The highest and more advanced categories require university-trained technicians with 5–10 years experience; their specialized equipment is not necessarily available in the Subregion and their productive systems use rather complicated technologies from abroad. From the point of view of dynamics the important achievement is not so much the level where the learning starts but rather the cumulative improvement and the course taken. In the field of knowledge, comparative advantages are not given but rather created.

A country or a productive agent may choose different levels regarding the depth of the breakdown, depending upon capacity and the technical and economical feasibility. The term "depth," regarding activities in a productive project, refers at the same time to their place in time or space. However, greater depth does not necessarily mean more complexity, since all depends on the corresponding activities. There are three fields that together define different levels that may be chosen in the process of subdividing a productive activity: First, there is the breakdown of a project's different *phases*, which include:

(a) conception and preparation of a project (such as feasibility studies, evaluation and selection of inputs and suppliers, bargaining, etc.);

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See *Desagregacion del Paquete Tecnologico*, Junta de Acuerdo de Cartagena, J/GT-11/Rev. 1, 4 Mar 1974 (mimeo.).
(b) construction and start-up of a plant or project (such as knowledge about basic engineering or processes to be used, about design and detailed engineering, architectural and construction engineering, equipment selection and installation); and

(c) production (such as basic process technology management; physical, chemical, and mechanical features; internal material transport systems, quality control, etc.)

Second, we have the breakdown according to different units or processes or operations, which may or may not be included in each one of the aforementioned phases. For instance, an activity like the chemical or metalworking industry might include unit operations for storage, heating, annealing, blending, cooling, etc.

Third, there is a breakdown of intermediate components or components of a productive activity or a product. In terms of local production this concept is generally described as the "degree of vertical integration" of a product (for instance in the assembly of a car there are: chassis, engine, and within this, valves, generator, distributor, etc.) For any project, product, or component a company or country may choose the degree of breakdown it considers feasible according to the different phases in its execution as well as according to the corresponding processes or operations. The combination of these two factors and their evaluation eventually determine which of these phases is economically feasible to perform inside the plant, which may be carried out or purchased nationally, and which must be acquired abroad. Figure 1 shows the interrelation between the three fields.

How can Fig. 1 be interpreted in terms of the core and peripheral technologies defined in the first part of this document? The production of a product or component (axis C) requires for each single phase of its development or transformation (axis A) certain technological activities, which include the different unit operations of axis B. Such technological activities might be subdivided into core and peripheral activities, according to the characteristics described on page 74. For instance in the construction of a plant the knowledge of basic engineering belongs to the "core" technology whereas the design and detailed engineering needed for this activity are "peripheral." Another example: in a specific phase the annealing process might be the "core process" whereas the heating and storage activities would be "peripheral" technology. However, within the heating process there are activities that are for this process "core technology" whereas others are only peripheral. Thus we go step by step to greater depths in progressively more open technology while differentiating between core and peripheral technologies.

Table 3 shows the difference between the core and the peripheral technologies. However, the table refers to only one of several levels and for each activity there are still further levels with their own core and peripheral technologies.

Two more aspects ought to be highlighted: first, the act of unpackaging or of disaggregating projects needs to be undertaken by qualified personnel and the information generated can be utilized by various and diverse types of users. The depth and degree of taking advantage of the process of disaggregation will depend on the complexity involved in each level as compared to the capabilities of the users.

Secondly, the act of synthesis or of combining the segregated elements so as to undertake a productive activity could often require more qualified capabilities than those necessary for the segregation process. This capability of synthesis can be elevated in a proper innovative activity and constitutes a necessary element for the technological development of a society. The activities involved in the synthesis are directly linked with the user of technology and, in contrast to the process of the segregation, should not be delegated to third parties.

Technology Policy and the Consequences of the Breakdown of Technology Packages

The immediate consequence of the technology unbundling is to improve the bargaining power of the user at the time of importing the technology. Among other advantages, this means a saving of foreign exchange since part of the demand for technological services for projects can then be channeled into the Subregion. For this process to take place efficiently it is essential that there be an information system that
Fig. 1. Phases of a project.
Table 3. Various phases of a technology project.

<table>
<thead>
<tr>
<th>Phases of a project</th>
<th>Core technologies</th>
<th>Peripheral technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project preparation</td>
<td>specific knowledge for technical and economic feasibility studies</td>
<td>financial analysis techniques or others</td>
</tr>
<tr>
<td></td>
<td>specific bargaining knowledge</td>
<td>project evaluation criteria</td>
</tr>
<tr>
<td>Plant construction and</td>
<td>specific knowledge about basic process technology</td>
<td>information systems as to technological alternatives and their sources, and concerning</td>
</tr>
<tr>
<td>start-up</td>
<td>selection, location, and coordination of equipment in space and time</td>
<td>other inputs</td>
</tr>
<tr>
<td></td>
<td>technical assistance for start-up</td>
<td>data processing techniques</td>
</tr>
<tr>
<td>Production</td>
<td>basic process technology</td>
<td>foundation, soil, structural engineering, etc.</td>
</tr>
<tr>
<td></td>
<td>physical and mechanical properties of materials</td>
<td>design and detailed engineering</td>
</tr>
<tr>
<td></td>
<td></td>
<td>architectural design and engineering</td>
</tr>
<tr>
<td></td>
<td></td>
<td>equipment design</td>
</tr>
<tr>
<td></td>
<td></td>
<td>information systems concerning availability and characteristics of inputs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ability to read blueprints including some knowledge of foreign languages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>detailed engineering, training in use of instruments and quality control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>inventory and supply control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mechanical engineering; transport, blending, storage systems</td>
</tr>
</tbody>
</table>

supplies the data on the availability and capacity of the subregional infrastructure understood as a complement to the foreign inputs. This information system could also furnish data about alternatives for selective purchasing on the international market.

Even more important than the direct saving of foreign exchange through a systematic breakdown of technological packages is the generation of subregional engineering services whose existence would be economically justified. Such engineering services could function on the level of consulting engineering in close cooperation with the users: for the selection and preparation of projects and for the search, selection, and breakdown of technologies. Such engineering services could also function at the level of service engineering and backup of design details, selection and supply of equipment, construction of plants, supervision of their start-up, technical assistance in operation, etc.

In addition, a gradual subregional orientation with respect to handling of contracts for certain technologies will have the very important result of a greater participation of local equipment and supplies in the projects. Indeed, if important parts of the detailed engineering are performed within the Subregion and carried out by local engineering companies, some of the purchasers of capital goods can be channeled toward subregional suppliers. There is already experience of this in some of the member countries.

Another important effect of a systematic users policy in the purchase of unpackaged technology is the training of the user in the efficient handling of the technological factor in the productive process, which means that he can commence to assimilate the technological elements. Indeed, when taking an active part in several projects, being active in the search,
selection, breakdown, and adaptation of a project's technological components, the user acquires a wide range of experience in the handling of these instruments and factors and thus he will really understand and begin to assimilate the technological factor involved in his productive activity.

As a consequence of this, but only if he has had some preparation beforehand, the user may progressively come to know, in depth, the process and the purchased product, and will thus be able to understand the essence of the technology he uses and that he himself has separated from the rest of the technological package. Later on, when the moment comes to expand or modify the productive process, the user will be in a position to apply this technology for a second time, but with much more independence.

To progress, from here to the next phase, which is the generation of technology by adaptation, modification, or creation, requires the development of the professional groups that will eventually be in charge of handling the technological factor in their institutions or manufacturing companies. These groups could be from applied research laboratories, planning and development departments, engineering and productivity departments, etc. It will also be necessary to call on specialized technological development services as offered by research institutions that would have to progress simultaneously in various fields, once the breakdown, assimilation, or adaptation of the imported technologies has started.

The aims of technology unpackaging coupled with a technology policy are therefore an increase of the purchasers' bargaining power, the creation of a demand for an efficient and timely supply of local contributions, an understanding of — and the capacity for — the adaptation of knowledge from other sources and, finally, the promotion of native technological capacity in those countries that at the beginning depend heavily on inputs from abroad.
Chapter VII

Consultant Needs and Services in the Andean Subregion

In 1972, the Board undertook a study on consultant services in the Andean Subregion\footnote{This study excludes consultant services given by commercial agencies or others representing foreign companies. Nevertheless, the study did cover consultant services conducted by foreign companies in the Subregion that are specialized in the subject.} that showed that the Andean demand, excluding Venezuela, represented some U.S. $53 million per annum. Of this market, less than 50% is accounted for by contracts with Subregional engineering firms. By 1975, the demand will be nearly U.S. $100 million and, according to the aforementioned study, it will exceed U.S. $150 million in 1980. In spite of the relatively high rate of increase foreseen in the demand for such services, and assuming an increase in the Subregional share, the demand for engineers devoted exclusively to consultant engineering and to services will never exceed 10% of the total number of engineers available in the Subregion.

The chief reason for this lies in the limited ability of consultants in the Subregion to cover the following two important aspects of the execution of industrial projects:

- In the short run, to give supporting services for the definition and “arming” of important industrial projects with a high technological content.
- In the long run, to carry out engineering-based operations on new fundamental techniques, whether imported, adapted, or developed in the Subregion.

It must be pointed out that both types of technical activity may be carried out by highly specialized departments within the same industrial firms, but experience in the Subregion has indicated that exceptionally few industrial firms are acquiring the expertise to be self-sufficient with respect to this type of service.

Stages in an Industrial Project and Consultant Services

When the opportunity of developing an industrial project presents itself, whether at the State or private level, so, automatically, does the need to carry out a series of activities that are common to nearly all industrial projects. These activities are as follows:

1. Technical-economic feasibility study of the project

This study is intended to confirm the economic viability of the project and to identify its principal elements, such as the market; the approximate scale of the project, both as to physical production and the investments required; labour, raw materials, and other necessary inputs; possible profits, social consequences, alternative sites and preliminary information as to possible alternative techniques to be incorporated in the project.

If the organization or firm has the necessary technical personnel (generally speaking, a planning or development department is involved), this feasibility study is carried out internally.

The feasibility study is conducted for the purposes of orientation. The sum required for investment is calculated with a margin of error of at least 20%; the sales projections are based on a preliminary market survey, not a marketing study. Its principal aim is to serve as a...
guideline for investors or sources of funds (the State, banks), informing them of the suitability or otherwise of continuing the project, in accordance with certain established criteria.

(2) "Arming" the project

Once it has been decided to carry out the project, the critical stage of the project is its "arming." The judgment and understanding of the persons responsible for carrying out this stage will determine whether the project to be carried out will be a good or a bad one. Numerous elements and decisions are involved in "arming" the project, the most important of which are as follows:

- Final determination of the products to be produced, with a clear description of their specifications, the manner in which they are to be marketed, prices and quantities to be produced (commercial component).

- Determining the technological layout of the project, in other words, a preselection of the technical methods involved in each step or phase of the production process. This is of fundamental importance in orientating the search for and selection of the necessary techniques to be incorporated into the project and in order to be able to integrate them into the final project as efficiently as possible. It is in the course of this selection that the user may first preselect and discard the sources of supply of techniques, engineering services and key equipment (technological component).

- Determining the final capacity of the production plants or units to be included in the project, its final location or alternative sites, and the definition, qualification, and quantification of the requirements as to labour and such inputs as raw materials, energy, etc. (industrial component).

- Economic-financial study and evaluation of the project, in a much more detailed form than was the case for the feasibility study, and consequently with a considerably reduced margin of error. Alternative sources of supply of the principal investment components, such as equipment of native or foreign origin, engineering services, sources of funds, etc., are now included in this evaluation (financial component).

The responsibility for "arming" the project ought to be entrusted to the person who undertakes its execution, although in many instances this responsibility is shared with individual consultants or outside firms of consultants. There are still many instances in which this decision is handed to firms of consultants in the form of a package, which obviously means that the investor loses control of the project.

(3) Execution of the project

The execution of the project comprises all the steps and measures to be adopted. This includes bargaining for and purchasing the technology and operations engineering designs required in order to start construction of the production units, and later putting these into action and their reception by the client.

Among the various elements or decisions involved in the execution of the project, the following should be mentioned particularly:

- Selection of and decisive bargaining for the techniques and/or basic engineering designs of the processes required for the project.

- Selection and contracting of the various engineering services required for the project. These may vary according to the type of industrial project but include such services as structural calculation; layout of machinery; detailed engineering designs; complementary engineering services; calculations for soil; structural, civil, and electrical engineering, etc.

- Selection and contracting of the suppliers of the machinery and other elements required for setting up an industrial plant. The process of selecting the machinery, like that of supervising its construction and control, is a specialized engineering service.
Selection and contracting of the personnel or the industrial engineering firm to install the machinery and construct the production plant.

Determination and supervision of the trial runs and of the trials guaranteeing the output and specifications of the product.

These five principal components of an industrial project must be perfectly coordinated and must, in projects of any magnitude, be handled with certain critical concepts in mind in order to reduce the major investment costs as much as possible and for as long as possible, within the time allowed for the execution of the project.

The Internal Capacity of the Companies

The engineering services required for an industrial project may be undertaken by the same company wishing to carry out the project or contracted out by this company to specialized firms of consultants. In no case, however, should the consultants be simply hired without the company interested being able to use its own judgment, or even to conduct complete parallel studies, for each of the phases of the industrial project.

Nevertheless, it frequently happens that all the stages in the execution of an industrial project, including the search for financial support, are entrusted to an engineering firm from outside the Subregion on the basis of a contract giving it a free hand, and that neither the client, his technical staff, nor local engineering firms have a say in technological, industrial, or financial decisions related to the project.

The drawbacks of the system are obvious, but its immediate "convenience" for the client renders it sufficiently attractive to ensure the continued granting of contracts of this type in the Subregion. However, the internal capacity of each company must be developed in order to put a stop to this practice.

Internal capacity is becoming more and more important as the companies increase in size (e.g., the State-owned companies) or as the industrial projects in question increase in international scope. The internal capacity to carry out international technological surveys, bargain for technology, disaggregate it, and, even more, the precise definition of the tasks of generating technology, are becoming increasingly important as the range of alternatives and the social and economic repercussions of the industrial projects increase.

This means that it would not be desirable, nor even possible, for the companies in the Subregion to be capable of dealing with all the aspects involved in the formulation and implementation of their projects. In fact, it would be better for many of these services to be shared among firms of consultants. No more is it usual that any one firm of consultants be capable of handling all the engineering and consultant services required during the formulation and implementation of an industrial project. There are various types of consultant services, for instance: soil engineering, in which certain firms of consultants tend to specialize; this specialization permits them to maintain a far lower underutilization index of their capacity. They are specialized but at the same time "multisectoral," in the sense that they can work for very different types of industrial plants. It would not make sense to develop this type of ability within companies that would very infrequently use it for their own purposes.

On the other hand, consultants from outside the Subregion cannot and should not be excluded because the Subregion does not have sufficient facilities for engineering and consultant services at its disposal to meet all of the internal demand.

Types of Engineering Services in the Subregion

The engineering firms in the Subregion are best separated into two main groups, depending on the most representative type of service they have to offer: (1) firms of consultant engineering (or consultant engineers); (2) firms of service engineering.

The firms of consultant engineering generally take part in the first two stages in the implementation of a project (feasibility study and "arming" of the project) and also in supervising, coordinating, and advising the client during its execution. During the latter
stage, a particular consultant engineer usually acts as director or codirector of the project (if the client company does not have its own engineering department).

Experience has shown that, in projects of any magnitude and with a considerable technological content, the consultant engineering firms in the Subregion do not have sufficient experience and skill to be able to cope, with complete confidence, with all the elements comprising the first two stages of a project. Generally speaking, these firms are able to carry out perfectly adequate and reliable feasibility studies but, when it comes to defining the technological and industrial components of the “arming” stage of a project, they usually lack the thorough understanding required to be able to weigh, analyze, and recommend the most suitable alternatives. It would thus be more difficult for them to take on the consultancy or management of the execution of the project.

The service engineering firms are those engineers or engineering firms who undertake specialized engineering services such as designing; calculating foundations and structures; drawing up blueprints; layout of production plants; mechanical, civil, and electrical engineering, etc., and also including construction services, the construction of industrial plants, and, in some instances, the manufacture of machinery of greater or lesser sophistication. The analysis undertaken in the Andean countries leads one to conclude that there is a considerable basic installed human capacity in the Subregion in these services, although, for a number of reasons, it is inadequately utilized within the Subregion.

The engineering services offered by these firms in the execution of major industrial projects constitute peripheral technology, which supplements modular technology. (See Chap. VI for a description of these concepts.) All these engineering services have fairly similar characteristics and are, up to a certain point, independent of the type of project or of the type of modular technology employed in the project. Thus, for instance, soil and foundations engineering applies the same calculating criteria whether designing a petroleum refinery, a petrochemical plant or a steel mill. The system of electrical distribution and process control is similar for all three types of project. A similar situation operates in other types of engineering services. There is a tendency for the engineering services firms to specialize in certain branches, such as soil engineering, foundations and structures, or construction and assembly engineering. Consultant engineering in the Subregion is a fundamentally different problem. It involves a very limited number of professionals (perhaps only one consultant engineer), who should be highly trained rather than highly specialized, but with sufficient understanding and mastery of the problems involved in “arming” and coordinating an industrial project, so as to be able to give sufficient guarantees and inspire sufficient confidence with the customer and the financial organizations granting credit to finance the various stages of the industrial project.

Up to now, the functions of consultancy and control have normally been fulfilled by outside firms of consultant engineers registered with international and inter-American credit organizations and whose technical-economic feasibility reports on a project tend to determine approval of the financing concerned. In many instances, these outside firms of consultant engineers give subcontracts for large parts of the feasibility study to firms in the Subregion, but it is their name that guarantees the reliability of the study.

Supply and Demand of Engineering Services in the Subregion

Consultant engineering and service engineering started to develop in the 1950s in Colombia and Chile and more recently, during the 1960s, in other countries in the Subregion.

According to the results of the study commissioned by the Board, a total of 180 independent firms of local origin offer consultant and engineering services, and these permanently employ 1380 professionals and 1350 technicians. This number includes 1280 engineers, a figure that represents approximately 4% of the total number of engineers available in the Subregion.

The study calculated that the current demand for the consultant and engineering services offered by independent firms specialized in these activities amounted in 1971 to a total value of U.S. $53.5 million, 48% ($25.8 million) of which represented contracts handled by engineering firms from the Subregion.
The situation may be summed up as follows:\textsuperscript{33}

<table>
<thead>
<tr>
<th>Country</th>
<th>Total demand (U.S. $ millions)</th>
<th>Local contracts (U.S. $ millions)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>4.5</td>
<td>2.0</td>
<td>44</td>
</tr>
<tr>
<td>Colombia</td>
<td>19.4</td>
<td>14.5</td>
<td>76</td>
</tr>
<tr>
<td>Chile</td>
<td>8.6</td>
<td>3.7</td>
<td>44</td>
</tr>
<tr>
<td>Ecuador</td>
<td>7.0</td>
<td>1.4</td>
<td>20</td>
</tr>
<tr>
<td>Peru</td>
<td>14.0</td>
<td>4.2</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>53.5</td>
<td>25.8</td>
<td>48</td>
</tr>
</tbody>
</table>

The situation in each country may be summarized as follows:

\textbf{Bolivia}

Bolivian private engineering firms devote their efforts chiefly to the field of physical infrastructures, which represents approximately 60% of all contracts; feasibility studies and industrial engineering services represent a further 30% of their activity and the remaining 10% is accounted for by studies on natural resources, especially for farming.

There are no private consultants in Bolivia specialized in operations engineering and, even though a certain amount of expertise is available to carry out the engineering details of industrial projects, the lack of projects of any magnitude has meant that up to the present, inadequate use has been made of the resources available. Foreign companies are legally required to associate themselves with native companies if they wish to work in the country.

\textbf{Colombia}

Of the activities of Colombian engineering firms, 80% is related to physical infrastructures, which at present represent a considerable volume of contracts for the official organizations concerned. The second place is occupied by industrial contracts for feasibility studies and detail engineering for industrial projects (10%).

In Colombia, the field of engineering for physical infrastructures has developed enormously in the past 20 years, having reached the point where companies have been formed that are in a position to compete on equal terms with well-known foreign firms.

On the other hand, the contribution of Colombian engineers to industrial projects has been very limited; no contribution has been made in the execution of projects involving basic processes, any more than in detail engineering for such major projects as refineries and petrochemical plants.

\textbf{Chile}

The Chilean private engineering firms chiefly offer engineering services for the design of industrial projects; this constitutes 50% of their activities. Projects for physical infrastructures represent 40% of the contracts, and the remaining 10% represents feasibility studies for industrial projects.

In contrast to Colombia, the Chilean government institutions and companies prefer to carry out the necessary studies themselves, as they do design engineering and works supervision, using their own staff of engineers. Hence the relatively small number of contracts granted to private firms, especially for physical infrastructures.

In Chile, no contracts for basic operations engineering for industrial projects are farmed out either, although a significant contribution has been made by Chilean engineering firms in carrying out detail engineering in major industrial and mining projects undertaken by government-owned Chilean companies.

\textsuperscript{33}These data do not include consultant services given by commercial agencies or other representatives of foreign companies, whose payment is included in the prices of products, machinery, and plants or other services sold by these companies in the Subregion.
Ecuador

Private engineering firms are a relatively recent phenomenon in Ecuador. However, they are developing very quickly, especially in the field of physical infrastructures (80%) and in that of feasibility studies for industrial projects (15%). Design and even detail engineering are just beginning, but they are developing hand-in-hand with the industrial development of the country. Ecuadorian engineers do not carry out any basic operations engineering.

As in the case of Colombia, the official Ecuadorian institutions are more inclined to farm out contracts for their projects to private engineering firms than to carry these out themselves, even though some possess a suitable internal organization. The foreign companies active in Ecuador work in association with local firms, which tend rapidly to increase their share in the projects.

Peru

It may be said that Peru is the country in which native consultancy is at present developing most rapidly, both in private and in state-owned firms. The characteristic fields of activity of Peruvian engineering firms are currently, in order of importance, physical infrastructures (50%), feasibility studies for industrial projects (25%), design engineering for buildings and industry (15%), and, to a lesser degree, other consultant activities in the agricultural sector. Peruvian engineers do not undertake basic operations engineering.

Up to the present time, the Peruvian government has preferred to carry out the majority of its projects through the agency of private engineering firms, increasing importance being attached to the contribution of local firms.

Participation of Local Engineers in Projects in the Subregion

It has already been mentioned that the engineering firms in the Subregion take part in slightly less than 50% of the contracts for engineering services originating in the Subregion.

The study commissioned by the Board provided evidence to show that there is a wide disparity in the degree of local participation in engineering projects in the Subregion, depending on the type of activity in question and on the country concerned.

This participation or integration may be expressed as a percentage of the total number of contracts granted to engineering firms in the Subregion per type of project and per country. The figures are given in Table 4.

A critical analysis of these figures infers that there is a sufficiently developed potential of engineering services for physical infrastructure projects to be undertaken successfully,

<table>
<thead>
<tr>
<th>Type of project</th>
<th>Bolivia</th>
<th>Colombia</th>
<th>Chile</th>
<th>Ecuador</th>
<th>Peru</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical infrastructures engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport infrastructures</td>
<td>50</td>
<td>90</td>
<td>40</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>Generation and transport of electricity</td>
<td>50</td>
<td>80</td>
<td>100</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Sanitation engineering</td>
<td>60</td>
<td>90</td>
<td>100</td>
<td>( . . )</td>
<td>40</td>
</tr>
<tr>
<td>Constructing engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design and calculations for buildings</td>
<td>90</td>
<td>90</td>
<td>100</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Industrial engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feasibility studies</td>
<td>40</td>
<td>60</td>
<td>90</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Design engineering for large-scale projects</td>
<td>(p)</td>
<td>( . . )</td>
<td>50</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Operations engineering</td>
<td>(n.s.)</td>
<td>(n.s.)</td>
<td>(n.s.)</td>
<td>(n.s.)</td>
<td>(n.s.)</td>
</tr>
</tbody>
</table>

*Key: ( . . ) no data available; (p) low percentage; (n.s.) not significant.

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although it would appear that the human resources available are not being used efficiently within the Subregion.

Engineering services for industry appear to be in a more critical situation. The only activity that appears to have been developed to any significant degree is that of carrying out feasibility studies for industrial projects.

The position of design engineering for large-scale projects is particularly relevant. It is precisely this type of technological activity that allows the development in the Subregion of the peripheral technology required for the assimilation and absorption of an imported modular technology, or one of local origin, into the production process. Also, design engineering and detail engineering for an industrial project is that part of the process involving the largest proportion of the engineer/hours required for carrying out a major project, and the utilization of local engineering services for this purpose therefore represents a marked saving of foreign exchange.

Finally, the development of operations engineering in the Subregion, whether carried out by the manufacturing companies themselves or by local engineering firms, will facilitate the use of new techniques developed locally and their incorporation into the production process.

Scope of the Consultant Firms in the Subregion

The range of optimum scope of the consultant services (consultant engineering or services engineering) varies as much as the types of consultancy available. A firm of consultants in the Subregion with five professionals or less may be highly specialized, with a maximum of two disciplines represented. The areas that these firms usually cover are architecture, soil engineering, constructional calculation, the agricultural industry, the food industry, etc.

Local firms with a permanent staff of some 5-25 professionals at their disposal usually work under contract for other companies (local or foreign) in certain fields or specialized areas. Their most common fields of activity are as follows:

- feasibility studies (both for physical infrastructure and industrial projects);
- design engineering, the most usual speciality of which is industrial design engineering, i.e., working out in detail the diagrams supplied by basic engineering;
- supervision of civil and assembly projects.

These medium-size firms (by local standards) may be efficient, but they lack the facilities to be able to compete with firms from the outside. The latter are not only larger, but they can draw on much greater reserves of experience and are in a much better position to present multidisciplinary proposals.

The country with the largest number of consultant firms with over 25 professionals is Colombia. These have major interdisciplinary groups at their disposal, capable of carrying out large-scale projects on their own or in association with foreign companies.

The principal field of activity on which this type of firm concentrates is that of physical infrastructures, i.e., transport (roads, railways, airports, gas and oil pipelines, etc.); electrical energy supply (generation, transmission, and distribution); sanitation engineering (drinking water and sewage systems); irrigation projects; telecommunications and urban installations; housing projects; and structures in general.

The process of Subregional integration will be to the benefit of companies of this type. It is possible that the largest firms in this group, which may employ 50–150 experts, are interested not so much in increasing the number of professionals employed but prefer rather to seek integration with other firms, whether native or multinational, in order to carry out projects outside their country of origin.

More detailed studies on the consultancy resources of all the aforementioned types available in the Andean Subregion, based on the knowledgeable, disaggregated demand that may arise in the immediate future, could in turn serve as a basis for specific recommendations concerning services of this type. It is unnecessary to add that these studies and recommendations should apply equally to state-owned and private consultant firms.
Another subject that needs to be studied is the presence, in the Subregion, of subsidiary companies or commercial agencies of foreign corporations that provide consultant services without being registered as consultants, and that make use of the services offered as a means of promoting sales.

Future Demand for Engineering Services, Problems Involved and Proposed Measures to be Taken

The study commissioned by the Board indicates that, in the next few years, the demand for engineering services may be expected to rise sharply. This conclusion is based on the investment plans submitted by the countries concerned. Thus, by 1974, the following total demand was expected for each country, expressed as the total amounts represented by possible contracts:

<table>
<thead>
<tr>
<th>Country</th>
<th>Demand (U.S. $1000/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolivia</td>
<td>9000</td>
</tr>
<tr>
<td>Colombia</td>
<td>26400</td>
</tr>
<tr>
<td>Chile</td>
<td>17700</td>
</tr>
<tr>
<td>Ecuador</td>
<td>13500</td>
</tr>
<tr>
<td>Peru</td>
<td>28100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>94700</strong></td>
</tr>
</tbody>
</table>

Taking current percentages for the participation of local engineers as a basis, the total sum of the contracts to be placed within the Andean Subregion was thus calculated as U.S. $45 million for that year.

The effect of an accelerated investment process in each of the Andean countries, together with the increased degree of participation of local engineering firms, will undoubtedly result in a demand for engineering services amounting to over U.S. $100 million by the beginning of the 1980s. This is a really significant and even impressive figure.

The service engineering and consultant firms in the Subregion face a series of problems arising from inherent shortcomings in their structure and from the present market situation. Special attention was devoted to these in the study carried out for the Board, and some of the most significant are listed below.

1. **Limitation and fluctuation of demand within the countries**

   It is a well-known fact that service engineering and consultant engineering firms are able to work only intermittently, chiefly because of the scarcity of local demand and its marked fluctuations. The possibility of a wider Subregional market undoubtedly opens favourable perspectives for private and state-owned engineering firms in the Subregion, since this would be one way of reducing fluctuations and discontinuity in the demand.

   In the same way, the engineering services in the Subregion may be rationalized by means of the effective implementation in each country of Decisions 40 and 46 of the Commission of the Cartagena Agreement, which deal with the elimination of double taxation and multinational companies, respectively, and also by establishing common criteria for the recognition of professional titles, in accordance with the aims of the Andres Bello Agreement.

2. **Competition of engineering services from outside the Subregion**

   A large number of the major projects carried out in the Subregion are usually financed by foreign exchange credits extended by international credit organizations, loans tied by intergovernmental agreements or by credit supplied only for "turnkey" projects. These forms of credit cover the costs of research, detailed engineering, and supervision, which are carried out by engineering firms from the country of origin of the credit extended, and usually leave no room or possibility for financing local engineering services.

   The proposal for a common technology policy prepared by the Board envisages a series of measures to be implemented within each country, aimed at facilitating the increasing contribution of Andean engineering firms by disaggregating packages of imported technology, contracting engineering services from the Subregion, and opening lines of credit in order to finance these contracts.
(3) Limitations in the credit facilities and guarantees available to engineering firms

It often happens in the Andean countries that local engineering firms do not possess the backing or adequate financial resources to be able to undertake major contracts for the execution of projects of any magnitude. Under these conditions, the local firms are supplanted by foreign firms that do have the financial backing allowing them to accept large-scale enterprises and to furnish the working capital and guarantees required.

The Board could propose provisions that if adopted and implemented, would create instruments of specialized financing for the consulting sector in the Subregion. These could, in turn, help the local engineering firms to take on the responsibility of handling important contracts.
Chapter VIII

The International Search for Technology: the Iron and Steel Industry

Introduction

In the previous chapters we discussed some of the key characteristics of the importation of technology into the Subregion. Among these characteristics the most important and relevant to the international search for technology as instruments of policy are the following:

(1) There is a tendency to import technology from abroad in the form of an undifferentiated "package," a complex of elements including not only techniques but also financial inputs, intermediate products, and capital assets. In many instances, these inputs are all channeled and centralized by one single agent.

(2) Technology proper is also imported, generally speaking without being disaggregated and therefore includes elements of modular technology or processes as well as peripheral technology (e.g., engineering designs, the design of details, etc.), all in the same undifferentiated package.

(3) Both of the aforementioned trends reflect a strong concentration of the sources of technical skills, financial credit, equipment, machinery, raw materials, and intermediate products in a very few countries of origin. The same marked tendency was encountered in analyzing the data available per sector (see Chapter V).

(4) The studies carried out also show that significant advantages could be obtained by gaining more reliable information on alternative sources of technology, credit, machinery, services, etc., and thus place the buyers in a better bargaining position. In addition, more reliable information on different forms of technology and their sources would facilitate a more appropriate use of available resources in the country importing knowledge of this nature.

In the Andean Subregion, these factors have only rarely been taken into account in their entirety in an attempt to undertake an international search for technology in a systematic and consistent manner. The attitude most frequently encountered was either passive or expressed the hope that foreign companies would offer the technical methods for specific projects, methods that might or might not be appropriate to local conditions and that might or might not coincide with national or Subregional priorities. An active attitude, on the other hand, involves conscious weighing of technology alternatives in accordance with the requirements and priorities at the national or Subregional level: in other words, an attitude that directs the technology consumer toward the international market of technology suppliers and leads to an increased understanding of the alternative techniques and sources available, their market conditions, and technology proper.

The generally prevailing passivity with regard to the search for and use of alternative technology and sources available does not necessarily mean that the companies with this attitude act irrationally. As long as high tariff protection or other advantages ensure sufficient (individual) profits, there will not be enough incentives to stimulate additional efforts to find means of taking advantage of other possibilities offered by the international market. Nevertheless, such an attitude, although consonant with the interests of the manufacturing companies, is in significant contradiction with the rest of the economy of the importing
country. Moreover, it clashes with the private interests of other companies or customers contemplating the purchase of products or services that are relatively high in price, owing to the inappropriate use made of technology and its market conditions.

Nevertheless, in view of the following factors, i.e., the delay in obtaining and using information, the segmentation of the markets, the economic power of transnational enterprises and their behaviour within oligopolistic markets, and the conditions characterizing the companies starting in the developing countries, mere amelioration of the conditions of competition would not necessarily ensure automatic improvement of the present situation. Survival in a competitive market entails initiating and carrying out a series of activities enabling companies and policymakers in general to make use of factors enhancing their efficiency and adequate functioning and to take advantage of the opportunities and resources available at the international level. One of these factors is the international search for information and experience relevant for production activities that have been planned or are already in progress.

Types of International Search for Technology

The search for information can be conducted in three ways. Firstly, the users of the techniques, in this case the Andean Subregion, including both the countries and the companies, need general information on the following subjects in order to plan and carry out production activities: (a) the technology available on the international market and its trends; (b) the various sources of origin, whether manufacturers of equipment, firms of consultants, other companies in the same field, research institutions, etc.; and (c) an initial appraisal of the effects of the use of each technological method, such as its degree of suitability and efficiency, its use of local production factors and inputs, training required, complexity, and the degree and manner in which it is dependent on outside sources.

Secondly, the users have to find out how to pinpoint the purchasing conditions of technological inputs in order to carry out specific projects.

Thirdly, experts specialized in the subject must seek information in order to understand, assess, copy, and improve the technology available on the international market.

Each of these forms of international search or survey has its own peculiarities, depending on the specific composition of the teams undertaking it, their training, the time they have at their disposal, their methods, how deeply they wish to investigate the subject in question, etc. However, the differences inherent in each of these forms of research does not mean that they have to be carried out separately. The aims, personnel, and methods appropriate to each may be combined in joint tasks, depending on the purpose of the research and the nature of the institution sponsoring it.

To attain a fuller understanding of the factors involved and the possible advantages of a directed, systematic program of international research, the Board of the Cartagena Agreement sent a mission to various countries as a pilot experiment in the subject.

Aims of the Study

The inquiry undertaken in this area had two principal objects: firstly, to study the various forms in which other countries or companies abroad organize international surveys of information in various fields; secondly, to carry out a specific survey project to identify the sources of technology in the iron and steel sector and make an initial assessment of the possible effects on interests in the Subregion of the internationally available techniques.

The iron and steel industry was selected for its importance in the development of other branches in industry, such as metallurgy and the automobile industry; in addition, it is one of the branches selected for industrial programing under the Cartagena Agreement. As a result of these considerations, the mission was entrusted with the following specific objectives:

(1) to find out the procedures by which international surveys of technology are conducted in various countries;
(2) to obtain as much information as possible on the sources of iron and steel technology;
(3) to assess the technological level attained in the iron and steel industry in the countries visited;
(4) to analyze new techniques applicable to the Subregion;
(5) to make an inventory of research in progress on iron and steel;
(6) to make recommendations on which to base the policies to be followed in surveying and acquiring technology.

The countries selected for the above enquiry were Mexico, Japan, India, Italy, Spain, West Germany, and Sweden.

Institutional Procedures for Investigating Iron and Steel Technology

Various institutional procedures were encountered in this international survey. The most significant of the findings of the mission are summarized below, according to the countries visited.

Mexico

With the exception of some isolated efforts on the part of native companies, no systematic investigations have even been attempted, nor are they subject to any policy since the technology involved is in almost all instances imported from the USA. It is the companies themselves who, for the most part with the aid of foreign investments carry out technology surveys. As is to be expected, these are directed by the head offices of the transnational companies.

Japan

This country was virtually isolated from outside technological influences during the years 1935 to 1945, since its frontiers were closed for the importation of technology, especially from the West. After World War II, in order to bring about its economic recovery, Japan introduced new measures to facilitate the importing of technology in sectors considered of major importance, such as food, coal, steel, etc. Nevertheless, during the 1950s, the possibilities of importing technology were severely restricted by problems connected with the balance of payments. The surveys therefore had to be conducted very cautiously and subject to many limitations, remaining under the general direction of a state institution, the MITI.

This institution designed projects for industrial development and determined priorities. It was in permanent liaison between the government and industry, generally in the form of advisory committees composed of experts drawn from the government, industry, and the universities. These committees reached an agreement as to the most suitable measures to be taken for the development of any particular sector, in particular the technological field, and as to the most suitable technological possibilities.

Its aims were thus, on the one hand, to use resources in short supply to better advantage and, on the other, to stimulate a certain degree of competition between companies. To emphasize the latter point, during the 1950s the MITI prevented the establishing of monopolies of certain techniques by insisting that groups of companies join forces in importing certain basic processes. A case in point was the incorporation of the L.D. process in the Japanese iron and steel industry, the success of which in the production of steel is largely due to this process. Its introduction was due to the efforts not just of one company, but of the major ones combined, which naturally led to the rapid adoption of the process by all the companies.

The companies financed surveys on technology, sending experts to a number of countries. In addition, the MITI sent its specialists on frequent missions to survey the technological field in each of the sectors given priority. The MITI specialists chiefly conducted surveys of the first and second types mentioned above whereas the companies preferred their engineers to make specific enquiries in connection with specific projects. Very important surveys were conducted by the Japanese embassies, which had high quality technical information services at their disposal in all the most important countries.
Later, by the time monetary conditions had stabilized and the companies had achieved an increased rate of progress, import restrictions were relaxed generally, in particular those governing the importing of technology.

One of the most important factors enabling Japanese companies to purchase more suitable technical methods on more favourable terms was the kind of competition they had to face on the international market. It is also worth emphasizing the efforts made by Japanese companies in general, and particularly those in the iron and steel industry, to limit their interest in foreign technology to the strictly necessary. These efforts were absolutely essential in the 1950s owing to the foreign exchange restrictions. Only essentials could be imported, preferably of a purely theoretical nature, so that all the rest could be produced in Japan. The result of these restrictions on foreign technology imports has been to enhance the present technological progress of the country (which has in turn rendered further imports unnecessary) and its impressive efficiency in producing machinery and equipping production plants.

In conclusion, the importance Japan attaches to various forms of local scientific and technological activity must be mentioned, not merely as alternatives to imported technology but as an intrinsic part of the process of investigating and importing technology.

India

After Independence in 1947, India relied almost exclusively on foreign technical experience, accepting unconditionally any “aid” offered by more highly developed countries. Indeed, the steel mills of Bhilai, Rourkela, and Durgapur are clear evidence of the influence of Soviet, West German, and British technology. However, foreign “aid” did absolutely nothing to further the development of local technology. For many years India was totally dependent on foreign iron and steel technology. Technology surveys for the above projects were conducted by the same foreign companies that constructed the mills, with little consideration for local needs or for the development of native resources.

The Indian government responded to this situation by fostering the establishment of an Indian private firm of consultants that was entrusted with the task of surveying technology, selecting technological alternatives, disaggregating technological packages, suggesting measures for developing local iron and steel resources, etc. The Durgapur works producing special steel, studied and planned through the agency of the aforementioned firm of consultants, are an example of the effectiveness of the new system. This steelworks was specially planned for India and took full account of how to make the best possible use of the available resources by means of the most appropriate modern techniques. It was built and started functioning even sooner than anticipated and permitted the training of key native engineers and designers, which not one of the earlier plants had been able to do.

This firm of private consultants was founded in 1955 and has since exercised a marked influence both on technological research for the development of the Indian iron and steel industry and on the construction and initiation of new steelworks. Besides the aforementioned steelworks of Durgapur, these consultants have carried out further important work in other special steelworks. They have, moreover, successfully taken part in other projects for plants using other processes for the production of iron and steel.

The directing force that created and developed this company was an engineer with wide experience in the iron and steel industry. After studying and gaining experience abroad, he returned to his own country and founded the company Dastur & Co. At first, he invited a number of foreign experts and the most prominent Indian engineers to join his company. Similarly, he selected young professionals who underwent rigorous training, particularly in production plants both at home and abroad, and who then replaced the foreign staff.

Nowadays the entire staff of his company is Indian. The company grew rapidly and currently numbers some 600 employees. It is one of the largest consulting firms of this type and has offices in various cities in India and in Dusseldorf and Tokyo.

Italy

The most important instrument of technological research in Italy is an engineering firm, ITALIMPIANTI, which forms part of the IRI group and whose headquarters are in Genoa. This firm, which includes some of the most eminent specialists in the iron and steel industry,
has various sections for study and design, which reflects the basic structure of an iron and steel company. Among others, it has sections for sintering, pelletizing, coke ovens, blast furnaces, converters, rolling, services, etc.

ITALIMPIANTI sends its engineers to study the most recent methods and is supporting the development of research both at home and abroad. It selects the most suitable techniques and designs iron and steel works down to the last detail, including those involving civil engineering. In some instances, it develops its own designs, such as those for blast furnaces and sintering plants. This company is beyond any doubt one of the most efficient in the field of iron and steel, having also carried out projects and conducted technology surveys for other countries. For instance, at the time of writing, it is building a steelyard for the Zaire government.

Once the suitability of a foreign technical method has been established for any of the state-owned iron and steel companies, it is the ITALIMPIANTI experts who undertake direct consultations, discuss terms, and, having obtained the most favourable conditions, pass the contract on to the companies.

Spain

The iron and steel companies, whether state- or privately owned, are at liberty to investigate technological methods where they please. However, the acquisition of any techniques is coordinated through an institution called UNESID, Unión de Empresas y Entidades Siderúrgicas (Association of Iron and Steel Companies and Agencies). Apart from this, the companies are entitled to carry out their technological surveys, directly or through a number of Spanish or foreign firms of consultants, the only limitation imposed being that of registering the information obtained. The most important and most frequently used firm of consultants on the iron and steel industry is "Sidetecnia," which has also carried out consulting projects abroad, including one, for instance, for Siderperú.

West German Federal Republic

This country has an old established tradition of iron and steel works and the biggest plants in Western Europe, and the companies are sufficiently powerful to be able to engage in technological research at their own expense and to develop their own techniques. An example is a new process for producing steel, known as Q-BOP, furnaces for which have been installed in the USA.

Sweden

Like West Germany, Sweden has an old tradition of iron and steel works due to its rich deposits of iron ore. These allowed Swedish steel to acquire an international reputation for its quality, and for some years Sweden was the major steel-producing country in Europe.

Because Sweden is relatively underpopulated with 8 million inhabitants, the domestic market absorbs only part of its total production. Most of the steel produced is exported as machinery, vehicles, ball bearings, etc., or else in the form of steel as such. At the same time, the Swedish market, in contrast to the other countries visited, is offered little protection and is therefore to a large extent open to foreign competition. The combination of these factors means that to maintain their position both in the home market and abroad, the Swedish companies must offer products of increasing complexity and perfection. This necessarily entails a continual search for new techniques on the one hand and, on the other, extensive scientific research.

The search for new techniques is carried out by the companies with no restrictions and is often stimulated by the state, especially in the form of tax incentives. In the search for new techniques and related research in the Swedish iron and steel industry, a number of instances of international cooperation were found in extremely important fields, for example, the Rotovert rotatory steelmaking furnace, which is being developed in collaboration with Italy.
Technological Level Attained in the Countries Visited and Evaluation of New Techniques Suitable for Application in the Andean Subregion

The investigation carried out by the Board includes a description of the technological level attained in the iron and steel industry in each country visited, with particular attention to the following processes: agglomeration; coking; direct reduction; blast furnace reduction; steelmaking; continuous steel casting; rolling; finishing; automation.

This report is not the place to synthesize all the aspects observed of the technology level of the countries visited. Nevertheless, certain of the technical details of the study considered of relevance for the Subregion and particularly for policymaking in this industrial sector, ought to be mentioned. No detailed economic evaluation of the consequences of their application, their effects on the use of labour, and the training of workers shall be given here. The relevant technical details of each phase of production are as follows.

Agglomeration

Sintering — The presence of fines (less than 3 mm) in the ores stoked in blast furnaces has always been a problem in smelting ores, particularly because they decrease the capacity of the load to allow the free passage of gases. For the past 40 years, methods have therefore been sought to eliminate fines by means of agglomeration processes and prior sieving. This led to the use of the sintering process, which is widely used in the countries visited and in the developed countries generally. The advantages of using sinter rather than ore can be seen from a study carried out in the USA, which showed that the use of this process saves approximately 23 kg of coke per ton of pig iron. An important improvement in the sintering process was the addition of lime or dolomite to the mixture, thus producing a type known as "self-flux sinter," which decreases the temperatures needed for the blast furnace whilst enhancing the reducing power of the gases. World production of sinter increased from 50 million tons in 1950 to 360 million tons in 1965. The furnace most used is the Dwight Lloyd type of continuous grid furnace, which is produced in a wide variety of sizes, up to a maximum of 500 m² by 5 m in width, in use at Nippon Steel's KIMUTSU plant.

Innovations in sintering that may be applicable in the Subregion are given below, together with their respective efficiency:

- New seals, with less wear of the baffle plate and improved hermetic closure: reduced maintenance costs and increased thermal efficiency
- Loading devices ensuring layers of equal depth: uniform sintering
- Circular sintering (application of a design by McKee in the blast furnaces of the Monclova plant in Mexico): reduced operational costs, since only half of the elements of the grid are necessary over the same area.

Pelletizing — Pelletizing or nodulation is a more recent process than sintering, and was first used industrially in 1955. Its initial purpose was to agglomerate ultrafines produced by the concentration of ores requiring a high degree of grinding because of their low iron content. Pelletizing transforms the fines into granules approximately 12 mm in diameter (pellets).

The only pelletizing installation in the Andean Subregion is the Marcona plant in southern Peru. Several studies have been carried out in Chile with a view to establishing a pelletizing plant that could make use of the fines extracted from the many iron ore deposits in the north of the country.

The most recent development in pelletizing, which could be of interest for the Subregion, is a combination of the grid and a rotatory furnace for baking the pellets. The grid is of the traditional type, but the rotatory furnace was invented by Allis Chalmers of the USA and modified by Kobe Steel. The fundamental advantage of this system is that it allows the production of pellets with a resistance of 350 kg, whereas pellets baked only on a grid have a resistance of 200 kg. This difference in resistance allows the blast furnace to function better.
Coking

Innovations in this field are still at the experimental stage but are all aimed at the development of a process allowing the extensive use of carbons traditionally considered unsuitable for coking. The increasing worldwide shortage of carbons that are suitable for coking has created a need for new techniques to be able to use carbons with a high volatile content. However, the past 30 years have not produced any significant technological progress in this direction.

Innovations that are of interest for the Andean Subregion are: larger retorts; thinner walls of higher conductivity; preheating and drying of the coking mixtures; the addition of small quantities of petroleum; the use of such ingredients as petroleum coke, semicoke, coke fines.

Direct reduction

At least 100 reduction processes other than the classic blast furnace or electric furnace have been patented. Of all these, however, only a small number have proved successful. The most important, which has been in commercial use since 1957, is the Mexican H & L process, based on the use of natural gas. There are currently four Mexican plants using this process, producing 1700 tonnes (t) per day.

A further H & L installation with a projected capacity of 500 t per day is being planned for the USIBA plant in Bahia and another of 1000 t per day for the H & L plant in Monterrey. The H & L process results in a form known as “sponge iron,” with an iron content of roughly 87%.

If the plants in Chile and Peru are not assured of a regular supply of coal for coke from Colombia, this process could be of great importance for the Subregion. Indeed, the presence of natural gas in northern Peru and in Ecuador could make the installation of plants producing sponge iron a viable proposition. Sponge iron is used instead of scrap iron in many steelmaking furnaces, which is a decided advantage in the Andean Subregion, considering that scrap iron is scarce and that the world market price is subject to great fluctuations.

Moreover, the H & L and other direct reduction systems facilitate the construction of smaller plants and require a substantially reduced investment per annual tonnage. For a plant producing 300,000 t of sponge iron per year, the investment per tonne produced is in the region of U.S. $30-35, whereas the investment for a blast furnace producing a comparable tonnage would be more than double that amount. Finally, the production of sponge iron should be seen as an interim solution to the reasonable desire of the countries in the Subregion to enhance the value of their iron exports. Existing plans for the construction of plants producing semifinished products are subject to many contingencies, especially those concerning the amounts to be invested and the instability of the international market. Sponge iron could represent a more feasible alternative and could in any event represent a first step toward more ambitious projects.

Yet another process for direct reduction of interest for the Subregion is the SR/LN process, which uses solid fuel. This could offer interesting possibilities in regions where natural gas is scarce or expensive.

Blast furnace reduction

Blast furnaces have become increasingly sophisticated, to the point where the most advanced models can afford even the highest prices charged for coke, seeing that they use less. In Japan, thanks to continuous research and improved processes, consumption of coke at Kobe Steel decreased from 900 kg/t of pig iron in 1950 to 398 kg/t in 1972. A similar phenomenon was observed in the other countries visited.

Improvements observed in the performance of blast furnaces that could be of use in our own plants include the buildup of pressure in the head. The greater the buildup of pressure in the blast furnace the faster the reduction process, provided that more of the reducing agent is in contact with the ore. Of course, perfect sealing systems in the loading zones are necessary to withstand such pressures. Special systems based on valves and loading caps have been evolved for this purpose. A pressure of 1.5 atmosphere has been reached, which allows a production of 2.5 t of pig iron per day per cubic metre of the total capacity of the blast
furnace. Future blast furnaces to be built in the Andean Subregion ought certainly to include these and similar features such as modification of the temperature of the air injected, enrichment of the air by the addition of oxygen and the injection of additional fuel.

**Steelmaking**

The new Q-BOP process is beyond any doubt an attractive technique to apply in the conversion plant currently being installed in Colombia by Thompson and in future remodelling of the Siemens-Martin steel mill in Chile. (At present, L.D. converters are being installed in Huachipato.) In the absence of particular reasons to the contrary, such as the use of existing facilities for installing an additional L.D. converter, it seems feasible to use the Q-BOP process in new steel mills for the conversion of pig iron especially if, at the time of deciding, experience gained in other countries confirms the usefulness of the method.

The process was recently developed by the German firm of Maximilians Hutte and the first Q-BOP furnaces will be built in the USA in the near future. Seeing that the countries in the Andean Subregion do not command significant resources of scrap iron, large electric steelmaking furnaces would necessitate extensive imports of scrap iron unless local sources of equivalent amounts of sponge iron at competitive prices were found. In view of the favourable prospects of the latter possibility, the Subregion may become the scene of relatively extensive developments in the use of the techniques of the arc furnace. In spite of its high energy consumption of around 600 kwh/t, the normal rate of U.S. $0.01/kwh does not render the cost of the electric steelmaking furnace prohibitive, as in the case of the electric reduction furnace, which consumes 2000 – 2500 kwh/t of pig iron.

An integral plant using sponge iron with installations of small or medium capacity requires significantly less capital than do blast furnaces or converters. At all stages up to the production of steel, where the dividing line falls, investment in the former system may be between 40 and 50% less and allow far greater use of local resources in the manufacture of machinery. Another factor to be taken into account in considering the installation of electric furnaces is the favourable experiences gained in Veracruz (Mexico) with continuous feeding, and it is precisely the use of sponge iron that has made this possible.

**Continuous casting**

This is a process created recently in response to the wish of iron and steel technologists for continuous instead of intermittent operation. In spite of its novelty, the obvious inherent advantages of the system have resulted in a multiplicity of continuous casting installations all over the world. By 1969, there were already over 200 in operation.

The casting process traditionally involved the following stages: casting the steel in ingot moulds, conveying the ingots to the cooling zones, cooling them, taking them to pit furnaces to reheat them, smoothing them, and then rolling them into rods or bars. Continuous casting allows the molten metal to be poured from ladles into special moulds, which are kept at extremely low temperatures, where the process of solidifying is started. The metal then emerges, ready formed and solidified, in the form of rods or bars. This process allows economy of investment and operational costs and, above all, it ensures a higher percentage yield in the ratio metal to semifinished product. This is normally in the order of 85%, whereas in continuous casting a percentage of 95% can be obtained.

Much research has been devoted to the moulds, since these, to a large extent, determine the success of the process. The current trend is to used curved moulds, which significantly reduce the height of the machinery and hence of the entire installation. The cracks sometimes produced in curved metal are being eliminated in new machine designs. Four of the most important manufacturers of machinery of this type are Concast in Switzerland, Mitsubishi Heavy Industries in Japan, Continua in Italy, and Manesman Demag in West Germany.

The machinery for continuous casting ought to be installed in the near future in the Andean Subregion. There is already an installation producing rods in Peru and the development program of CAP is considering the installation of machinery for the continuous casting of thick sheets. However, this machinery need not necessarily be installed only in integral plants. Continuous casting is an essential element in the miniplants to be installed in...
the future. Innovations in continuous casting that are of practical use in the Subregion are:

- Automatic control of the level of the metal
- Use of powder lubricants in the moulds, rather than oil
- Centring the stream of metal by moving the mould
- The Tundish swing distributor
- The hydraulic mechanism for changing the nozzles on the Tundish

Inclined cutters, so that the rods are cut diagonally, thus obtaining a smoother surface.

**Rolling**

In order to reheat the semifinished products, the walking beamtype furnace is coming into more general use. Compared to the thrust type, this allows more uniform heating of the material on all sides, possibly resulting in a better-quality product and increased productivity of the furnace. It also avoids the piling up that can occur with rods of small diameter (60–80 mm).

Up to now the best results have been obtained with electric reheating, which has the following advantages over the normal system using fuel: reduced decarburation and increased metal yield; installations requiring less space; more uniform quality; greatly decreased environmental pollution.

The deciding factor in the adoption of this system of heating is the cost of electricity, although naturally the aforementioned advantages warrant some additional expenditure. The type of roller producing bars in continuous series has been adapted to produce "X" bars and to the system of alternate horizontal and vertical boxes. Systems such as these render torsion guides unnecessary and permit higher production velocity without fear of blocking the machinery.

During high-speed operations such as the modern system for rolling wire, it can happen that loops are formed. In this event, the detection apparatus evolved by the Swedish firm ASEA is particularly useful. This consists of a photoelectric cell, sensitive to thermal radiation, mounted on a rotating drum equipped with lenses, which seeks out the position of the loop. An electronic circuit produces an electric charge proportional to the angle, as measured against the axis of the apparatus, at which the loop is detected. This charge is applied to the speed control circuit of the box rolling the wire in which the loop appears.

Improvements in machinery producing sheets have been directed toward increasing productivity by means of various control mechanisms, more rapid change of rollers, and higher rolling speeds. The firm of Hitachi in Japan has developed a hydraulic roller control system, which has been well received, particularly for tandem cold-rollers. Various devices have been developed for automatic control of the thickness of the sheets, the pressure of the rollers, the tension in the sheet and its smoothness in the case of cold-rolling. Thanks to such devices, it is now possible to use computers for automatic operation, which permit the machinery to be used to better advantage and ensure a better-quality product. The use of SENDZIMIR rollers in the production of special steels is almost universal and has been reported for strips up to 1,600 mm wide.

**Finishing**

In this field, various products have been evolved in addition to the already classic tin plate, galvanized sheet, enameling sheet, and the "tough" sheet. Reliable and competitive products are now available, in some cases derived from those mentioned above, such as tin-free, aluminium, vinyl, and copper steels. Furthermore, sheets are also being produced with designs (e.g., wood finish) photoengraved onto a galvanized sheet.

**Automation**

The above list of innovations in the field of iron and steel technology would be incomplete without some reference to automation. The progress involved should be considered, however, in the light of its effects on the use of labour and the degree of training involved for the latter.

In the production of pig iron, most of the blast furnaces visited in Japan, Italy, West Germany, and Sweden work on the basis of computers. In many instances, they are used not only for operating the furnace itself but also to determine optimum loading mixtures in order to produce pig iron with predetermined characteristics.
The effects of automation have also been decisive in the case of converters. In Spain, for instance, in the Avilés Steel Mills, the converters are equipped with so-called static control. This control consists of the regulation of operations on the basis of mathematical models that in a minimum amount of time, tell the operator the exact quantities of materials to be added and the amount of oxygen to be injected. The operator receives this information on his control panel and activates the control mechanism of the loading hopper and oxygen tank, until the amounts indicated by the computer have been reached.

Another step already taken in the more highly industrialized countries, and which is being installed in the Avilés converters, is so-called “dynamic control.” In this, the computer works on the basis of a theoretical model allowing it to calculate the ratio of temperature and injection time. This system ensures that an exact final temperature be reached and increases the likelihood that the composition of the steel be as desired.

Possibilities of Acquiring the Technology Involved in the Above Processes

One of the aims of the mission was to alert the manufacturers of machinery to the necessity of incorporating these processes in installations in the Subregion. In particular, they wished to find out the position of the major manufacturers in respect of the sale only of designs or of the most essential parts of their machinery so that this could be manufactured in the Subregion if feasible.

In nearly every case the response was favourable. The situation in the countries involved may be summarized as follows. Japan, Italy and West Germany are all equally in a position to satisfy any possible request from the Subregion in respect of the iron and steel industry. The same is true of Sweden insofar as electrical processes are concerned but its possibilities are limited as to the mechanics of certain machines such as rollers for producing sheet metal and assembly belts, which incorporate elements manufactured abroad. India and Spain are in a position to have about 60% of the equipment for an integral plant produced locally. Mexico is also making great efforts toward home production of iron and steel installation. All of the manufacturers consulted, without exception, were willing to supply the designs of any parts that could be manufactured within the country purchasing machinery from them.

Some Final Comments

In all the information obtained by the mission, one factor stands out clearly: the importance that the various countries visited attach to international surveys of technology. As the foregoing illustrates, the solutions adopted vary greatly, depending ultimately on conditions prevailing within each country. In Japan, it is the iron and steel companies themselves who conduct these surveys under the direction and with the support of the MITI, whilst possessing, however, sufficient technical and financial means to investigate, adapt, and create technology. In India, these surveys are carried out chiefly through the agency of local firms of consultants. In Italy, they are undertaken by a highly qualified state engineering institute. In Spain, the companies themselves carry them out, but in accordance with planning guidelines laid down by the state. In West Germany and Sweden, the companies are free to undertake them themselves, with possible government support.

In addition to information gathered by research already undertaken, and in view of its peculiar input and marketing characteristics, it will be necessary to undertake various types of scientific and technological activity in the Andean Subregion itself. Action is recommended in the following areas: direct reduction; use of the Q-BOP converter; production of pig iron for casting; mixtures of carbons and special processes for coking; prereduction of integral pellets; operation of blast furnaces making 100% use of pellets; noncontaminative desulfurization of ore fines for sinter.
Chapter IX

Economic Development, Technological Dependence, and Andean Integration

Development, Infant Activities, and Protectionism

The development process of a society is characterized by the change of its structures and its progress through such qualitative improvements as the promotion of higher level capabilities of its people, institutions, and production units. It is also characterized by the offer to all its citizens of the opportunity to share, under conditions of social justice, in the fruits of progress and the improved quality of life. Development lays the foundations for sustained and equitable economic growth. Moreover, it enables a nation to enjoy a more autonomous participation in activities of the international community, including a more adequate international division of labour.

During the last two decades most of the Latin American effort to advance the process of economic development, particularly in industry, used protectionism as the main instrument. As the internal production sector was weak and embryonic, it was believed that protection from various forms of external competition would create the conditions necessary for economic development.34

In Latin America, protectionism had two main features. Firstly, it reached very high levels, which led to grave inefficiency, affecting the proper allocation of the available resources, creating distortions in the economic structure, and having regressive effects on the distribution of income. Secondly, the products themselves were protected, by direct and selective means, rather than those indigenous infant activities in which the enterprises would have required differential treatment during their gestation and formation period. As a result, the benefits of protectionism largely went to foreign factors of production and foreign enterprises. Several studies show that the true profits of foreign subsidiaries in Latin America (if discriminatory transfer pricing payments between subsidiaries are included) reach multiples of the average profits declared in the home country.35 Instead of stimulating internal production factors, protectionism generated high profits for foreign factors, and these came to dominate the industrial structure of Latin America.

Possibly even more important in the long run was the fact that the lack of direct encouragement and adequate protection to several local inputs led to their displacement by foreign factors of production and foreign enterprises. This displacement took several forms.

34The application of various protectionist measures with relative success characterized part of the development process of Western Europe and the USA in the last century. Similarly, protectionism played a critical part in the development of the Japanese economy and also in European reconstruction after World War II.

35A recent study for the U.S. Department of State, published by the RAND Corporation, registered average rates of return on capital for foreign investment in Latin America as high as 40%. (RAND, Latin America in the 1970's, Santa Barbara, California, RAND, R-1067-DOS, Dec 1972, 127–146.)
On the one hand, many local enterprises were bought by foreign concerns. On the other hand, the foreign enterprises use many critical and scarce local resources, including the local savings. As a result, domestically owned or controlled activities may suffer serious supply problems. In addition, the acquisition of some necessary inputs is often tied to the import of others, which displace existing national inputs or limit the development possibilities for other (new) activities. Some of these tied inputs (for example, engineering services) are not exclusively used in projects in which the foreign companies specialize, but have applications in many other economic and social areas. Therefore, the lack of development has a high opportunity cost, a cost that exceeds the benefits that could be obtained through direct participation in projects with foreign factors.

In conclusion, it can be said that despite the fact that the development process requires special protection for indigenous infant activities until they become efficient, the selection of methods of protection and their application are critical for development. If they are inadequate, society pays the costs of protection in vain. Moreover, the use of the protection margin by foreign enterprises not only generates losses by high remittances abroad, but also displaces local factors and keeps them in permanent backwardness. In the case of the Subregion, technological capacity may be considered as the least developed factor of production.

**Technological Dependence and the Development Process**

The capacity of a society to assimilate, adapt, improve, and create scientific and technological knowledge, and to use it efficiently in production activities, is based on three interdependent elements. In the first place, there is the knowledge to which a society has access and can use. This knowledge, defined in its broadest sense, encompasses 'to know-what, to know-how, to know-why.' The second element is the availability of people able to understand and use the knowledge in production activities. And the third element is the structure and efficiency of the institutions concerned with scientific and technical progress and its application, namely:

(a) centres that generate or assimilate knowledge (institutes, research and engineering departments, etc.) and those that disseminate knowledge (consultancy firms, information and industrial extension centres, etc.);

(b) users of such knowledge (production enterprises) and their functional link (via the market or in other ways) with the centres mentioned under (a); and

(c) the institutional and legal framework or system, predominantly in the government sector, whose functions include the establishment of priorities, the allocation of resources, and the regulation of, or direct participation in, the interaction between the factors mentioned under (a) and (b).

This complex set of factors is at an early level of development in most of the Subregion. The resulting gap has led to marked technological dependence, with serious economic and political repercussions.

The systems of this dependence are, among other things: (a) the ratio of imported knowledge to the production needs of the Andean Group; (b) the need to import this knowledge, not as a result of a selection based on relative efficiency but as an absolute need; and (c) the one-way flow of knowledge without the ability to engage in its exchange, which arises from the lack of specialization in development and management of such knowledge.

The effects of the unsatisfactory relationship with other countries as regards technology are: (a) the loss of control of decision-making in programming, production, and marketing; (b)
the frequent import of inappropriate knowledge — inappropriate in terms of inputs and the
type of demand created; and (c) the reduced negotiating power of member countries in the
purchase of technology.

There are many causes of the present situation and they must be understood within the
general context of the constraints to development. However, there are specific issues that are
related to policies (or the lack of policies) for science and technology in the Andean countries,
and these contribute heavily to the scarcity and inefficiency of the qualitative changes and use
of knowledge in production activities. These issues can be grouped in the following three
related categories:

(A) Orientation of technological development efforts

The scientific and technological activities carried out in the Andean countries have
been concentrated on the exact sciences and pure research, which, although important, do not
cover the whole spectrum of the components of technological development required to satisfy
specific social and economic needs. There are instances within the Andean Group where
roughly two-thirds of the total research and development personnel are in the universities or
centres that carry out academic research, particularly in the natural and medical sciences. On
the other hand, less than 9% of the total are working in industrial research.

The process has created important and essential human resources that, however, are not
being properly utilized in the member countries. As a result of this, and of the relatively low
aggregate demand for local technology originating in production activities in the Subregion,
two types of brain drain are occurring: an “external brain drain” (for example, the Andean
countries export engineers and import engineering); and secondly, an “internal brain drain”
due to the employment of professionals in activities little related to the economic and social
development effort.

Therefore, a policy for correcting the current state of affairs cannot simply be reduced to
increasing funds for scientific and technological activities, even though they are at present
insufficient. It is necessary to attach more importance to: (a) where such funds are spent; (b)
developing the capacity of the people, enterprises, and institutions that utilize scientific and
 technological knowledge to solve concrete economic and social problems; and (c) the specific
consideration of scientific and technological inputs by those who plan the economic and
social development policy.

In the past 2 or 3 years, important steps have been taken in some Andean Pact countries
toward a more suitable orientation of technological development efforts. For example,
legislation, administrative processes, and operations by special organizations are
promoting the incorporation of science and technology into the efforts to attain economic and
social goals.

(B) Importation of technology

The lack of internal technological capacity has resulted in the importation of a significant
flow of foreign technology. The absolute volume of technology that enters a country does not
necessarily imply a disadvantage to the importer, even if the volume is considerable. For
proper evaluation of the effects of foreign technology, two additional structural elements need
consideration. Firstly, whether the imported knowledge has encouraged or substituted local technological efforts must be ascertained. Secondly, the uses of foreign technology and its net effects must be examined. The answers to these questions, in turn, determine the capacity of a society to attain the level of technological development that will satisfy its economic and social needs.

A key feature of importing technology into the countries of the Andean Group is the "packaging" of knowledge. In many instances although it would be necessary to import some knowledge from abroad, the remainder already exists or could be internally developed. As a result, the technical inventive capabilities of the importers are displaced, or do not develop, through lack of technological diversification in the local economy. More than specific skills, the capacity to innovate, by synthesizing different technologies so that they become appropriate for local production processes, is displaced.

Consequently, foreign knowledge is applied without being absorbed by the internal technological infrastructure. This present process of technology importation can be considered to be a pseudotransfer of know-how.

The use of imported knowledge has several effects. In the first place, it frequently ignores the internal factors of production and resources available locally. The increases in production achieved with inappropriate technology — inappropriate means to inappropriate products — tend to conflict with certain basic development objectives, such as the level of employment. Likewise, the export of products manufactured with imported technology (essential to integrating the national economies with the rest of the world) is severely restricted by the terms under which technology is made available. Moreover, the need to import essential knowledge from abroad (without having adequate legislation on foreign investment), when added to the present patents system, leads to economic and political power being concentrated in foreign centres, whose objectives and interests do not coincide with those of the recipient countries.

If the different forms of economic relationships of the member countries with the rest of the world are evaluated, we may conclude that the technological factor is the key element in this dependence. For example, between 1961 and 1969 the financial contribution of direct foreign investment was less than 5% of total investment registered in Latin America.
remainder was basically provided from local savings. On the other hand, in 1971 more than half the Andean Market consultancy services were provided by foreign consulting firms. In the manufacturing sector and in large mines, external technological inputs frequently exceeded 90% of those utilized.

In addition, there are many direct economic costs to the Subregion resulting from the high degree of dependence on foreign technology.

Firstly, the forecast for explicit payments for technology (royalties for licences and patents) going outside the Subregion in 1980 are put at approximately U.S. $290 million. If payments for foreign consultancies are included, the amount would exceed $350 million. To these payments should be added remittances of profits by subsidiaries of foreign companies and whose incomes are not based so much on their capital contribution (see the above figures) but on their contribution of technological, managerial, and marketing expertise. To the extent that integration might result in the development of new industries with a high technological content, explicit payments for technology would increase more rapidly. For example, it is estimated that cumulative payments up to 1985 for licences and services for petrochemical development would amount to somewhere between U.S. $200 and $300 million.

Secondly, indirect payments for technology included in the price of intermediate products and capital goods (whose purchase is often a condition of the sale of the technology) seem to be even larger than the direct payments for licences and patents. In 1970, the capital goods and intermediate inputs imported by the Subregion totaled U.S. $3500 million. A considerable proportion of these imports can be attributed to two sources directly or indirectly connected with technology: (a) payments for the professional services and knowledge used to produce these goods, which seriously affect the terms of trade for countries that import raw materials and semiprocessed products, using unskilled cheap manpower to obtain goods of high technological content; (b) differential payments stemming from the monopolistic profits the suppliers can obtain through their technological dominance. Several studies carried out by government agencies in the member countries and the Junta have confirmed severe overpricing of inputs imported by, and underpricing of exports coming from, the Subregion in those instances where foreign technology and control were dominant.

(C) Relationship between the technological infrastructure, sectors of the economy, and governmental activity

Knowledge-based comparative advantages are created, not given. One of the main determinants of how successfully technological knowledge is generated and applied to production activities is the type of commitment and institutional relationship between those who define policies for development, those who carry them out, and those who produce and absorb the technological inputs that development requires.

Studies carried out in the Subregion indicate that, in many instances, the technological infrastructure is isolated from the other two parts of the production system. The planners and executors of economic and social policies have seldom consciously and explicitly introduced and utilized science and technology policy as a critical instrument to reach development goals, as has been the case with monetary policies, fiscal policies, the physical infrastructure, etc. Institutionally, science and technology policy is divorced from direct economic and social development efforts.

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49 Again, according to data from the U.S. Department of Commerce, in 1968 only 12.5% of the finance for foreign subsidiaries operating in Latin America came from the parent company. The rest was financed with funds generated within the host country.

50 This figure is reached by assuming an average of 0.5% of GNP as direct payment for technology. The rate applied for Brazil is 0.75%.

51 Overpricing in 1969 of the imported inputs for one sector alone (pharmaceuticals) of one member country almost equaled the total direct payments for technology made by all manufacturing sectors in that country.
Andean enterprises, because of structural and orientation problems and their relatively small size, have not always developed their own engineering capacity or that of assimilating, generating, and managing technology. (See the above comparative figures for costs of research and development.) The resulting vacuum creates a demand not for local professionals or consultants (and even less for Andean technology institutes) but for foreign technology. (This technology is directly linked to, or even promotes, specific patterns of consumption; is associated with internationally recognized manufacturers; enjoys preferential treatment from licensees; is bound by financial ties; etc.)

Owing to the lack of both local demand and clear objectives, technological institutes frequently function as "island institutes," having more links with academic activities in other countries than with local economic and social needs. Studies undertaken by the Junta indicated that, although the professional skills exist, most of the institutes have few links with government or industrial planning. In exceptional cases (for example INTEC in Chile, IIT in Colombia, ITINTEC (Instituto de Investigación Tecnológica y Normas Técnicas) in Peru) the reorientation came about through specific measures and institutions which created a concrete demand for the services of such institutes, so that they became directly concerned with carrying out specific (socioeconomic) development activities.

Finally, there exists an important factor that does not so much refer to "production technology" (i.e., the knowledge essential to transform inputs into products or services) but more to "consumption technology." This refers to the characteristics of the goods and services that satisfy, or induce, requirements at the consumer level.

Every product or service has features that reflect the multiplicity of consumer or investor motivations. These result from cultural patterns and historical evolution, from revenue and market size, views on what constitutes a high quality of life, status within the social or economic unit, etc. The consumption patterns, or the type of industrial structure, just as other elements of "knowledge," can be learned.

The formation of preference patterns is partly influenced by the relations between people, societies, and countries. Moreover, countries importing production technology also receive the suppliers' "consumption technology." In this way, both types of technology (production and consumption) are interrelated and each creates the conditions for the other.

In conclusion, the three broad categories mentioned above — namely, the inappropriate orientation and type of internal technological development; the indiscriminate importing of foreign technology with its associated costs; the very limited links between the technological infrastructure and the government and economic sectors; and what we have referred to as "consumption technology" — have created a severe technological dependence that holds back the development process. As a result, the Subregion must carry a high opportunity cost in a factor that is critical to growth: the mastering and application of science and technology in production activities. Internally, this indicates that urgent needs are going unfulfilled. Externally, the Subregion maintains its dependence, and exchanges products that have a small added value for those complex products that involve paying for sophisticated production factors that enjoy monopolistic profits.

The Need to Program Technological Development

World advances in knowledge are so profound, multiple, and complex that no small country can hope to master all aspects of it. Also, knowledge and particularly that used in the production sector, is not created in a vacuum, but is generated as a function of the conditions

[52] For example, the creation of contractual relationships for undertaking specific technological projects between the Government or enterprises and technological institutes; the participation of representatives of these institutes on committees that negotiate imports of foreign technology; the strong participation of government and industrial representatives on the boards of institutes; the evaluation of research projects with regard to their impact on social and economic needs; etc.

[53] For example, a food product has characteristics beyond nutritional value and flavor, such as presentation, packaging, advertising image, status implications for the consumer in relation to others who also use the product, etc.

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and characteristics of the societies that wish to use it. They result from consumer requirements, from the structure of production factors, from market size, from the need to have commercial and political power — i.e., from the characteristics of the countries themselves that create it. It is estimated that, of the total worldwide expenditure on research and development (which represents only a part of the resources channelled into generating scientific and technological knowledge), less than 1% is specifically channelled into the solution of the problems of poor countries. The remaining 99% is accounted for by the requirements and demands of advanced countries, which may or may not be related to the needs of developing countries.

The scarcity of resources inevitably leads to the need to identify priority technology sectors. And these sectors must, of course, be connected with the primary requirements of the country, its development goals, and the types of specialized production it has chosen. In other words, the order of priorities for action in the technology field must be defined as a function of decisions that are implicit in the general development plans.

Apart from the factors previously mentioned, the lengthy periods of time required to train specialized staff and to fully develop the capability within institutions to manage, assimilate, and produce knowledge lend weight to the need of global planned efforts in the technology field. Unless technological activities are related to production as a part of the overall development plan, serious discrepancies could arise between their goals.

Moreover, as the process of "learning by doing" occurs in infant activities that require protection in order to grow, explicitly defined and programmable support areas must be identified so that protection generates efficient capabilities to work toward selected goals.

Lastly, the market imperfections in the technology generation and trade are not of the type to be corrected with the traditional self-correcting mechanisms; special policies are called for. Some of the most important imperfections are as follows. Knowledge as such does not fade with use; on the contrary, once acquired, its usefulness can increase with an enhanced understanding of the principles involved. These characteristics lead to severe differences in relative cost and power between, on the one hand, those who do not have (and wish to acquire) knowledge, and on the other hand, those who have knowledge and can use it over and over again without it fading.

The presence of this type of difference in the relative cost structure, added to the great differences in the possession and exercise of economic power in the world, are critically important to countries that basically depend on foreign contributions for technological inputs. Because current market forces frequently tend to accentuate differences between countries, it is necessary to make the corrective measures explicit.

At the same time, this "nonwearing" aspect of knowledge brings with it the implications of fixed and concentrated expenditure to develop, adapt, and assimilate knowledge. Later, the additional costs for repeated use are minimal. For this reason, as in the case of national security or the building of a bridge, there are specific areas of technological development into which society should channel resources for an initial effort, thus in turn generating capabilities or knowledge for the benefit of its citizens.

There is nothing automatic about selection of these areas; selection employs criteria and decisions reflecting the order of priorities for a country's development. Also, decisions involve commitments, political and otherwise, long before the benefits can materialize. Finally, the existence of requirements (other than those of technological development) that compete for scarce resources implies the need for programming.

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54 In a survey in the USA in 1964, 28 of 2130 enterprises investing in research and development accounted for 62.7% of total expenditure of the enterprises; 1500 accounted for only 3.7%.

55 Studies of the 1960s done by the OECD indicate that, in the USA, enterprises devoted only 6.5% of their total research and development budgets to basic research. Moreover, 35% of the funds used by U.S. enterprises for basic research were provided by the federal government.
Technology Policy and Subregional Integration

The member countries have adopted a joint policy for development in several areas that, because of their content and scope, imply a geometric progression in the need for science and technology. The process of Andean integration not only aims at bringing together national markets and generating new scope for production, but also aims at putting the capabilities derived from this joint action at the disposal of each of the member countries, particularly the least developed. In this way new possibilities are opened for the utilization of technology that were previously denied to each country because of the small market and level of economic activity.

The subregional technology policy arises not only from a need to attain the objectives of economic and social development, but also from the opportunity presented by the process of integration itself. Developing countries face common problems with technology, and the growing interdependence of the Andean economies, especially in the areas covered by subregional integration projects, creates common interests and specialization requirements at the national level.

Thanks to integration, industrial possibilities arise for each member country that would not be possible if each one were developing alone. These industries are, in most instances, more complex and technically demanding than those that existed before, and consequently provoke a greater demand for knowledge. This demand can be more easily met if member countries pool their resources and capabilities.

The six countries together have more resources at their disposal, not only in terms of quantity but also in terms of range. One of the key elements in the technical development process in industrialized countries is the diversification of their technical capabilities and resources. The existence in a country of specialists in one type of knowledge can be very useful in carrying out projects in others, even in areas that might appear at first sight to be alien to their specialization. Integration of the technological capacity of the Andean Subregion would have far-reaching effects that would exceed the apparent sum of the component factors. This integration would also make possible the training of specialists who would be redundant if trained for one country alone. In addition, the execution of some scientific and technological activities implies high fixed costs, whereas only a minimal additional effort would be necessary to extend their use to several countries.

A subregional technology policy would avoid the duplication of resources in each of the member countries. (Decision 24 has already stressed the importance of information systems regarding technology and foreign investments.) There are also scientific and technological activities that, through their requirement for scarce resources, might not be feasible for one country alone, regardless of their importance to the development process. Combined efforts, shared costs, and coordination at a Subregional level would help to overcome these individual constraints. The realization of multiple intercountry projects in the Subregion, as a whole, would reduce the risks and uncertainties that go with the search for new knowledge.

Finally, a subregional technology policy would increase the negotiating power of each of the member countries, which could present a united front when purchasing foreign technology. Technology represents a key part of the knowledge necessary for many industrial activities, and proper means for its acquisition are an important element in the advancement of both the internal technological capacity and the total development process.

56 Decisions 86, 87, and 89 of the Commission of the Andean Pact. These Decisions refer to the Andean Projects for Technological Development in the areas of the hydrometallurgy of copper and of the tropical forest resources.
Credits

Editor: Marilyn Campbell
Cover design: Planned Graphics Limited