Science and Technology for Development

Case Studies on Technical Change
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Science and Technology
for Development

STPI MODULE 12: CASE STUDIES ON TECHNICAL CHANGE

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This module constitutes an integral part of the Main Comparative Report of the Science and Technology Policy Instruments (STPI) project, a large research effort that examines the design and implementation of science and technology policies in 10 developing countries (Appendixes 1 and 2).

The STPI project generated a large number of reports, essays, and monographs covering a great variety of themes in science and technology for development. More than 250 documents were produced by the country teams and the Field Coordinator's Office, and this proliferation posed rather difficult problems during the comparative phase of the project. It was decided that a Main Comparative Report, covering the substantive aspects of the research work of the country teams would be published, and that several monographs treating specific subjects would complement it.

The Main Comparative Report is organized in three parts. The first consists of a short essay covering the main policy and research issues identified through the research, and the second contains the most relevant results of a comparative nature that were obtained in the project. These first two parts have been published by the International Development Research Centre in a single volume in English, Spanish, and French (109e, 109s, and 109f).

The third part of the Main Comparative Report consists of 12 modules containing material selected from the many reports produced during the STPI project. They provide the supporting material for the findings described and the assertions made in the first two parts of the Main Comparative Report.

The modules were prepared by several consultants, and given the diversity of topics covered, the IDRC staff did not consider it desirable nor possible to impose a single format or structure for their preparation. The reader will find a diversity of styles and structures in the modules and will find that the selection of texts reflects the views of the consultant who compiled the module. However, the modules were prepared in close collaboration with the Field Coordinator and were also submitted to a STPI editorial committee who ensured that they provided a representative sample of STPI material. They should be read in conjunction with the first two parts of the Main Comparative Report.

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INTRODUCTION

The three sets of studies included in this module are extracted from various national reports and refer to the specific orientation and pace of technical change, as well as to the process of technological innovation as viewed through some particular case studies. They represent the most detailed level of analysis of the studies on technical change in the STPI project, and examine aspects such as the diffusion of innovations, the direction of technical change, and the factors conditioning innovation.

The first of the reports considered in this module examines three case studies of diffusion of innovations in the Brazilian industry: shuttleless looms in the textile industry, special presses in the paper industry, and the dry method process in cement manufacturing. The Mexican report extracted here examines the orientation of technical change in three industrial branches: capital goods, petrochemicals, and food processing. Finally, the Venezuelan study deals with some atypical cases of technological innovation.

BRAZIL

DIFFUSION OF INNOVATIONS IN INDUSTRY: THREE CASE STUDIES

Shuttleless Looms in the Textile Industry

Textile Technology: The technological innovations in the textile industry have more commonly been mechanical modifications and perfections of the same basic principles of manufacturing and equipment design and not revolutionary changes in the processes. The automatic loom was invented in England as far back as 1840, and it was perfected around 1900, when they solved the problem of reloading the shuttle without stopping the machine to change the shuttle manually by making the maneuver automatic. Since then, the automatic loom with a shuttle has, on the whole, kept its classic design and way of functioning.

Therefore, for 50 years, the innovations in the loom were progressively to increase its speed and introduce the mechanism whereby it stopped automatically when a warp thread or weft thread (horizontal thread inserted by the shuttle) broke.

But during the last 20 years there have been two types of innovations: (a) the operations carried out by each machine have been made more complex; (b) the number of different operations has been reduced either by uniting previously separate operations as one or by making one particular process more efficient so that several intermediate processes can be eliminated.

At the Hanover Textile Fair in 1963, which marked the beginning of a new era in the history of the technological evolution in textile manufacturing, the following innovations were introduced:

1. The semicontinuous spinning systems were consolidated.
2. The first open-end spinning machines were introduced.
3. The shuttleless loom was proved to be economically viable (it eliminates the shuttle and the spool, it draws the weft threads directly from large bobbins, and it more than doubles the loom's productive capacity).
4. The continuous-finishing systems were automated.
5. New artificial fibers appeared, they became cheaper, and new techniques of mixing them with natural fibers also appeared.
6. The machines producing knitted textiles with artificial and synthetic fibers were perfected mechanically and were automated, so these products expanded greatly.
7. The production of nonwoven textiles was perfected, which makes the spinning and weaving stages continuous.
(8) The machines' productivity was controlled automatically, and production was computer programmed.
(9) New techniques for texturizing (stabilizing) artificial fibers appeared.

This list shows that during the last few years technological research in the textile industry has tried to discover a continuous production process that would eliminate transport, eliminate the need for human operators to participate in the process, and to stop material from accumulating between one process and the next.

Technical Progress in the Brazilian Textile Industry: In the Brazilian textile industry there is a wide range of levels of production costs existing side by side. The companies with greater marketing power do not have to abandon their equipment when there is a drop in demand, as they can resist high margins of machine underuse and they also have more modern equipment with lower operating costs, which, consequently, guarantee satisfactory profits.

The development of technological improvements in the industry means that various generations of equipment incorporating successive technical levels coexist. The difference in the levels is even more marked today.

Whereas the automatic loom with shuttle was introduced into Brazil at least 30 years after its introduction into Europe and the United States, the shuttleless looms and synthetic fibers appeared in Brazil less than a decade after they appeared in the industrial countries and the shuttleless loom appeared almost simultaneously in Brazil and those other areas.

Production Process and Form of Competition: When a particular company has to make technical modifications in the production process to reduce operational costs, a scale of priorities for the investment can be established. This scale includes the following parameters:
- the technological level of the equipment used in each stage of the production process;
- the technological alternatives available for each stage;
- the fact that some different areas where investment might be made have to be linked (1).

If these elements are borne in mind, the investment program chosen will be based on the usual criteria used for selecting a program that will provide the highest rate of cost reduction per unit of fixed capital. So, on account of the solutions found in the past to this type of problem, there are companies within the textile industry with totally dissimilar technological profiles but with relatively similar average production costs.

In recent years the most frequently used mechanisms against competition have been:
(1) Modernizing marketing channels: companies create their own networks of salespeople, subsidies for sales, particular times for launching new products and/or new designs, sales "technical assistance" for special clients, etc.
(2) Consolidating permanent export channels: companies maintain sole agents in other countries, maintain associations with distribution networks that are firmly established in foreign countries, create special products for export only, etc.
(3) Certain parts of the production are regionalized.
(4) Companies specialize in certain areas of consumption, try to create traditional brand names, or open up new markets (Brim Coringa, Lencois Santista, Toalhas Artex, Tapetes Milacrom, etc.).
(5) Vertical integration: companies create associated companies in the area of clothing.

Although these mechanisms seem very weak, the success of a company in this sector seems to be associated more with using tools of competition skillfully than with an aggressive policy of renewing production techniques. This latter strategy only becomes a priority when a company competing in a particular subsector has already exhausted all the other possible "Shumpeterian" innovations not involving large fixed investments.

Patterns of Diffusion: The observations made so far suggest some general results:
The lower levels of diffusion in the large companies confirm that, although renovation of production techniques offers the possibility of reducing operational costs, it may not be the most important competition mechanism.

Most of the companies using this new shuttleless loom are the smaller ones. However, we would suggest that the competition mechanisms listed above tend to be complementary to the expansion policies of these companies and not a substitute for technological renovations; this is the opposite of what happens in the large companies.

Although the pressure to innovate seems to be stronger among the smaller companies in the sample, the style of competition in the sector allows companies that are small and that did not adopt the shuttleless loom to survive in the market, although the possibilities they have of maintaining the volume of their sales without innovations will not be as great as in the large companies.

The interregional differences in the rates of diffusion indicate that, although it was not essential for the Sao Paulo companies to adopt the shuttleless loom to keep their position in the market stable, during the 1960s, the high growth rate of the Santa Catarina companies and their improved position in the domestic and export markets can partly be attributed to their technological dynamism.

These results reinforce the idea that, although technical progress in the textile industry may not tend to centralize the capital, the behaviour of the large companies seems to be an important factor influencing the growth of the medium-size companies when it is accompanied by other instruments in their expansion policies (specializing in certain lines, regionalizing markets, strengthening the marketing channels, etc.).

While the majority of the large companies can use mechanisms other than techniques to modernize production to achieve good results and performance, the shuttleless loom is the basic expansion mechanism for the medium-size firms included in the sample, and with it they often obtain results that are relatively better than the large companies.

It is typical for the large companies to use mechanisms to preserve their markets that are based on aggressive marketing techniques and policies with expensive advertising campaigns. Through their own sales networks in the country and abroad, they try to monopolize certain products, frequently by taking over competitors who are in financial difficulties during crisis periods, etc. Whether these companies adopt new types of machinery that appear on the market is a minor question as they can choose between a wide range of investment alternatives.

Conclusions: Studies on the dissemination of technological innovations generally focus on those factors that influence the individual company's choice of technology: the fixed investment required to implement innovations, the increase in productivity over that obtained with existing methods, the age of equipment in use, the size of the firm, etc.

Although it is frequently possible to obtain a good experimental model for explaining the rate of dissemination by using the characteristics of the new technology as the only independent variables (2), this type of approach does not allow one to consider differences in the rate of technological progress between industries, and this hampers any attempt at a more general interpretation of the phenomenon.

The approach taken in the present work has been to deal with the choosing of technologies and the process of dissemination as two separate problems. It has been shown that the factors that explain the latter process have more to do with the operation of the industrial sector involved than with the particular characteristics of the new technology.

The discussion in the foregoing sections, in addition to explaining the effect of the structural heterogeneity of the textile industry on the rate of technological advancement, also has important implications for a science and technology policy. It has allowed situations to be identified that bear out the commonsense observation that the newest technology is not always the best, even though a textbook analysis might indicate that it is.

As has been seen, heterogeneity is not an obstacle to the growth of the textile industry to be overcome by measures designed to stimulate modernization in general. Rather, it is a mechanism by which the sector can adapt to the broader features of the process of economic growth in Brazil (3). The points cited earlier illustrate this fact: it was precisely during the 1960s, when the textile industry was experiencing a series of violent swings in its overall development, that the rate of technological change took off.
As often happens, the findings of one investigation tend to create a need for further research. In this case, the questions raised for later study concern the style of competition in the textile industry, such as: analysis of the different management strategies employed, in light of other factors not taken up here; the sources of capital in the sector (domestic or foreign? based on agriculture, business, or industry?); policies for determining salary levels; and changes in the composition of the labour force.

Policy recommendations based on the results of this paper are concerned primarily with the possibilities for expanding the markets for textile products, which is the source of greatest difficulty in the sector. As for foreign trade, the outlook for exports is unquestionably optimistic. However, there are still international markets to be conquered and consolidated if good results are to be guaranteed in the medium term. Since these markets are highly competitive, the success of a policy aimed at achieving these objectives does not depend on fiscal incentives and government subsidies, but rather on the creation of selected complementary instruments designed to increase marketing opportunities for individual companies. With regard to the internal market, on the other hand, the problem is more complex. Any increase in growth of the textile industry based on domestic markets would require a restructuring of priorities throughout Brazil's entire process of economic growth.

Special Presses in the Paper Industry

Economic Implications of Technological Aspects: This study shows that, to a great extent, the industrial structure of the paper industry is determined by the fact that the high investments needed for cellulose production make it difficult to integrate and this has acted as a barrier to new companies entering the sector.

Although the industry has managed to produce a wide variety of different types of paper, it uses only a few components as inputs, but these can be used in many combinations. Depending on the type of paper being produced and on the conditions of the inputs market, the machine will be fed different proportions of the elements extracted from the following groups: cellulose, semimechanical pulp, mechanical pulp, and shavings. Furthermore, returns to scale are much higher in the integrated paper and cellulose plants than in the nonintegrated cellulose-producing plants.

Technological Profile of the Sector: As the principal objective of this work is to study the diffusion of a particular machine used in manufacturing paper, it will examine the capital goods sector producing machinery for paper. Nevertheless, it should be borne in mind that the main determinants of the sector's behaviour are associated with vertical interaction between cellulose and paper production.

Transfer and Absorption of Technology: First, it is necessary to identify the agents that were responsible for the process of technological change that occurred at the end of the 1960s. This change was influenced by the nuclei of basic engineering in the large production companies, especially the foreign ones, of international engineering companies and of the producers of capital goods in the country.

Despite the fact that the main technological advances in paper production are widely publicized and although the sector is characterized by capital goods being produced on order, which creates a close interrelationship between the engineering nuclei of the paper and equipment manufacturers that should hinder monopolies of manufacturing know-how, paper-making machines are produced by a small number of companies. By absorbing and developing technology themselves, either by expanding capacity or by internationalization, these companies manage to sell worldwide.

In Brazil there is one dominant company that has a technical body capable of absorbing new technology, and this will probably mean that the gap in technology between it and its potential competitors will get progressively larger as the other major producers of paper-making machines in Brazil use imported know-how obtained under licence and through technical assistance. So when dealing with paper manufacturers with less technological autonomy (4), this dominant company will use its technical body to go further than simply manufacturing capital goods and will use its own engineering and technical assistance as a trump card to conquer the market.

Given these characteristics of this dominant company, the supply of engineering from abroad does not decisively influence the choice of the producer of paper-manufacturing
machines, although it is used to improve the technological model. The transfer and absorption of technology for cellulose production is quite different; for instance, the technology or engineering of the actual process is essential. This distinguishes cellulose from paper production where, basically, the technology becomes incorporated into the machinery.

As the basic engineering is supplied from abroad, it neutralizes any eventual incentives for diversifying the national sector producing equipment for cellulose.

Some Structural Features of the Brazilian Paper Industry: Of all the government measures and incentives aimed explicitly at creating larger units, both in paper and cellulose production, Decision No. 96 of 1968 in the sphere of the National Development Bank (BNDE) should be emphasized. This decision recommends giving financial support to the projects for printing paper and other categories of paper with a planned or installed capacity of over 250 t/day. Later, from 1972, the Industrial Development Corporation (CDI) began to think of granting incentives to factories producing cellulose with industrial equipment whose capacity was at least 500 t/day, and there are plans to expand to 1,000 t/day. Similarly, the minimum capacity to qualify for incentives in the case of paper factories was 300 t/day for printing paper, 200 t/day for kraft paper, and 50 t/day for other papers. Certainly, these dimensional parameters are already influencing the type of projects being implemented at present and they are creating a tendency toward sectoral concentration.

For the companies as a whole, the labour/productive capacity relationship in manufacturing and in maintenance remains the same, while the relationship with administrative labour always increases. The 12 major companies are lowering their manufacturing and maintenance labour/productive capacity relationship, while to offset it they increase the administrative labour/productive capacity relationship and their work/productive capacity relationship has been kept almost stable. This trend was partially compensated for by the other companies, which slightly increased their direct and indirect employment/productive capacity relationship.

In 1974, the eight largest companies in the paper-producing sector in Brazil turned out nearly 50% of the total physical production; the four largest (Klabin, Suzano, Simao, and Santista) produced almost 40% of the total. Cellulose production is even more concentrated: the eight major companies produced 71% of the total production and the four largest produced 53.4% of the total.

Substantial participation in paper production is always accompanied by sizable participation in cellulose production, which proves that integration plays the role of controlling the raw materials in the market structure.

The comparative advantage of these integrated companies means that the dominant groups will control the market, both because their costs are lower and because they supply their surplus raw materials to the nonintegrated companies and this gives them more bargaining power.

At present the meeting of integration has been inverted. As such large investments are needed for manufacturing cellulose, and they generally have to be accompanied by investments in afforestation (5) vis-à-vis the smaller volume of resources required to set up a paper factory, and as the large and medium-size nonintegrated companies are so vulnerable, the investments needed to create a productive capacity in the cellulose sector act as a barrier to the entry of new companies in the paper industry. Therefore, integration is a crucial factor in determining the direction of sectoral concentration.

In 1974, the concentration in invoicing was almost as intense as it was in physical production: the four major companies had around 40%, the eight largest companies 55%, while the 12 largest companies accounted for 61.4% of the total invoicing.

Although, at the moment, the paper and cardboard sector is predominantly nationally owned, the investments being studied or being implemented show that the new companies, mainly cellulose producers, will enter the sector, and among them the foreign-owned companies and joint ventures predominate. By looking at their estimated productive capacity, it can be calculated that once the investments now being made are finished, only the larger national manufacturers will be capable of competing in the sectoral market with them.

From what has been observed in the different branches, the larger companies seem to be diversifying their production as part of their marketing strategy.
Patterns of Competition: From the concepts described, it can be seen that the paper and cardboard sector has, at present, characteristics that are very close to the concept of pure oligopoly, in which the economies of scale, the technological discontinuity, and the barriers to entry appear as relevant elements.

Integrated production provides scale returns by eliminating production operations, transport costs, and storing. But, even more important, the integrated plants can use their supplies of raw materials for the market as a weapon in sectoral competition. Their integration makes the nonintegrated companies vulnerable, not only in terms of their cost differences, but also in terms of the fact that the integrated plants can manipulate the cellulose supplies. Because large investments are needed to install a cellulose plant, the barriers to entry occur in this stage, they stop the smaller companies from being integrated and accentuate the tendency toward concentration that has already been mentioned.

New products are not only introduced to meet the more exacting demand resulting from the country's development, but they are used as a strategy to combat the price controls that make it impossible to raise the prices of existing products.

With diversified production, certain types of products, especially poor quality wrapping paper, are protected by the barriers of transport costs compared with their low unit value. For this reason, the smaller producer who sells to local markets is assured a piece of the market.

In the last few years the producing companies themselves have developed marketing activities aimed at increasing profit margins. These activities are also a result of new price control legislation that tries to create separate producers and distributors, favouring the latter.

Notwithstanding all this, technical progress still plays an essential role in sectoral competition because it both reduces costs and makes viable diversified production and improved product quality. In paper and cellulose industries, technical progress appears in equipment to produce cellulose and in paper-manufacturing machines.

So the special presses, the subject of this study on diffusion, represent a new innovation that reduces costs but does not change the competition patterns in the paper industry. For this reason, the diffusion of this process is more a result and not a cause of sectoral expansion.

Diffusion of Special Presses: A distinction is made below between the diffusion by means of introducing a new machine and the diffusion by modernizing (6) existing equipment.

The diffusion of special presses in Brazil occurred almost a decade after they appeared in industries in the developed countries. To understand this long delay, it is necessary to remember that the national paper industry was very isolated at the end of the 1960s in relation to the technological development in the sector in the rest of the world.

There are now so many new machines in Brazil equipped with special presses because all the companies making equipment, except for D'Andrea, incorporated the new pressing methods into their machines. Today, the plan for a new machine will generally not include the special presses only if it is to have a very limited capacity. But the special presses have already been added to the majority of the machines whenever it was technically justified.

The diffusion process cannot be explained by elements such as defence of a position in the market or barriers to entering the sector. There are four reasons for this:

First, because the special presses are far from being a technological revolution in paper production, their advantages give them a certain importance but only within the wider framework of numerous small innovations that have characterized the relatively slow worldwide process of technological progress in the cellulose and paper sector.

Second, the technology being discussed is very widely diffused all over the world and it does not belong exclusively to any one paper-producing company or to any of the large companies manufacturing equipment for paper and cellulose.

Third, the special press is not expensive when compared with the value of the
machine, and it is approximately the same as a conventional press.

Fourth, the presses can also be used in small machines as long as they have a
given minimum speed. This means that the small and medium-size companies can, in
principle, adopt this more modern technology, either with new machines or by adapting
their equipment.

The motor for the diffusion of special presses in Brazil was an equipment manu-
ufacturer and, basically, the presses were diffused because the capacity to acquire new
machines expanded. For this reason, the diffusion process was by means of purchasing the
new equipment.

This type of diffusion, where the process was adopted by means of new machines
coming into operation, is different from what generally happens in the central countries
where diffusion takes place by modernization of existing machinery; and it is character-
istic of countries where much of the productive capacity was installed, and the high
point of technological development occurred, after the new process had become very
generalized. The Brazilian example of diffusion of the special presses occurred pre-
cisely under these conditions. One of the reasons why the special presses were introduced
into Brazil so fast is that the industry was going through a very dynamic stage when its
technological patterns were changing.

However, the rates of diffusion of this new process were very low. To understand
this, it must be remembered that the industrial equipment in the sector is quite hetero-
gegeneous. As well as the large modern machines, there are numerous small machines whose
technology is totally out of date. Adopting special presses is only technically justified
in machines that operate at over 100 m/min; this is the speed of low-capacity machines,
which are completely obsolete from the technological point of view. As no less than
130 machines, that is 55% of the country's total, had speeds of less than 100 m/min in
1969, diffusion through modernization could not possibly be very great.

When the smaller and more obsolete machines are not included in the calculation,
the rate of diffusion is 40%, which proves that this low rate of diffusion through
modernization is caused mainly by technical considerations.

There is an interesting fact in relation to the national production of special
presses to modernize the machines, and the eventual stimulants to diffusion that the
equipment manufacturers make; it is that the companies producing paper equipment only
received very few direct orders for special presses for modernizing equipment.

The modernization in the sector of presses is due much more to the technical
operations carried out by the engineers within each company (7) than to the producers of
capital goods for the sector supplying already assembled equipment.

Conclusions: The changes in the sector's technological patterns have been making
technical progress an increasingly important element in the survival of the small and
medium-size companies producing for nonlocal markets. The small-scale businesspeople
have themselves been taking part in this effort to modernize, and it is fully justified
as the sector progresses technically with a series of small innovations that can be
adapted to relatively small-scale production.

Nevertheless, the same conditions that make the access to this technique easy,
neutralize it as a technological factor, which can be used as a weapon in sectoral com-
petition. On the other hand, the companies' decision to innovate depends on the global
characteristics of the paper machines they have already installed, or, in the case of
expanding capacity through new equipment, on the specifications of the new equipment.

For other reasons, not the created business power structures, the decision to
introduce new techniques has been, in the case of already existing equipment, a function
of a wider decision on modernization in general. This decision is limited by the other
stages of the process.

In the case of expanding capacity by introducing new machinery, the technological
jump imposed by the manufacturers of machines incorporated the new pressing system into
the normal paper-making machines. In this situation, the introduction of special presses
depended on the demand for new machines, and this is an isolated investment decision.

The principal weapon in sectoral competition has been integration to control the
raw materials that can be used to reduce costs, and to control the supply of raw materials
to nonintegrated companies.
The economics of fuel oil in the dry method of cement production is the principal factor responsible for the growing use of the dry process kilns in the last few years. On the whole, these kilns consume 25% less fuel than the wet method and this is a considerable reduction, especially considering the importance of this input in the unit cost of cement.

Although the useful life of the refractories is not a very important item in the costs, it is very important in the profitability of a cement plant; since the kiln cannot be used while they are being replaced, the useful life of the refractories can have a significant effect on the plant's productive capacity.

However, there are indications that the economies of scale are more marked in the dry method kilns.

The increase in the scale of the kilns with the suspension preheaters decreases the surface/daily production of clinker relationship and consequently, it lowers the losses from radiation through the surface of the kiln. And obviously, the consumption of heat per unit of weight of clinker also drops. Furthermore, the reduced heat consumption means that the gases escaping from the kiln in the preheater in the high-scale units are better used.

The heat consumption per kilogram of clinker generally increases with the size of the wet method kiln. This trend is caused by the decreased efficiency in the heat exchange in the drying and calcination areas, and it is reflected in increased heat loss through escaping gases.

As has already been pointed out, the economics of the appropriate fuel for the dry method process, which is the principal advantage of using this process, becomes even more marked when the operation scale of the kiln increases.

More investments are needed for the dry process, principally because equipment to control the process is necessary and because of the raw materials.

It is technically viable to introduce the dry method into a plant operating with wet kilns either by adding a new kiln or by converting the existing kilns. The investment necessary to install a dry method kiln in a wet method plant is the same as the investment needed to make a similar expansion by building a new wet method kiln. Thus, to expand the capacity by installing a dry method kiln is a cheaper alternative.

It would be advisable to make this change when small wet kilns will be replaced by one large kiln with a larger capacity, because, in that case, the reduced cost variables would result not only from savings because of the dry process itself, but also from the increased scale of production of the kilns.

The other alternative is to convert the wet method kiln to the dry method. In this case, the kilns and the cooler can be adapted by merely installing the homogenizing equipment and the right preheaters for the dry process. With this conversion, the kiln's capacity can be increased 30% to 40% and at the same time the costs can be reduced to levels similar to dry method plants. The investment needed for the conversion is the same as would be needed if the capacity was going to be expanded by as much by building a new kiln.

However, these indications should be considered with caution. When the kiln and cooler capacities are balanced, converting a wet method kiln to the dry method would result in it being impossible to expand the kiln's production because of the limitations imposed by the cooler's capacity or because significant investments would have to be made to change the cooler. Rises in the scales will increase the advantages of adopting the dry method.

During periods when demand is growing rapidly, it becomes viable for new companies (six between 1950 and 1955 and eight since 1970) to enter the sector, and, as a result, the degree of concentration in the industry would decrease.

Although the largest companies in the sector have increased their capacity considerably, during the periods when demand was growing rapidly the consumption expanded enough so that new companies could be founded also, and consequently the industry became less concentrated.

Yet, from the point of view of characterizing the sector's structure, it should
be pointed out that the participation of foreign capital has decreased. Although the first two plants installed in Brazil were foreign owned (Peru, later transferred to Brazilian ownership, and Nacional de Cemento Portland-Lone Star), the subsequent growth in the nationally owned groups reduced the foreign-owned companies' share to between 18% and 20% in the last 20 years.

**Commercialization of Technology:** Technologically the sector has been relatively undynamic, especially when compared with other areas of industry, as there have been few innovations that have had an appreciable influence on the productive process. Ever since the rotary kilns were introduced in 1895, the most important innovations have been the two variations of the dry method in cement production.

On the whole, the technological development in the cement industry has characteristically been aimed at reducing costs, making the inputs cheaper and adopting increasingly large production scales. Two types of behaviour have caused so much emphasis to be put on these two basic selection criteria; they are a desire to minimize risks in the productive operation and to minimize the investment costs.

If a company feels that its own technological abilities are not sufficient, it usually delegates the task of selecting, building, setting up, and installing the principal equipment to the entity supplying the technology. Thus it is free from any responsibility for the technical aspects of the machinery's operation and performance. Then a large and well-established foreign supplier is responsible for the selection and the company's tradition can guarantee success, even though the price is higher. This trend has been observed not only when a new company in the sector opens, but also when new units are installed in established companies or when they expand their working plants. In the first case, the companies generally had no previous experience; in the second case, this same behavioural pattern is encouraged, sometimes on account of the success of similar operations in the past, and sometimes on account of the wish to accept the special treatment the supplier of the machinery offers (good attention and service, promptitude, etc.).

On the other hand, when a company has a good technical team and it is prepared to take the risks of choosing technology, then it is possible to make the purchase agreement for know-how and equipment more advantageous. In these cases, the basic layout of a plant is done by specialized teams working for the technical department of the cement-producing company; and, in general, they are backed by the knowledge acquired from the experience of working with their engineering sections. This way of developing a project gives the company relatively more autonomy in choosing and purchasing technology - particularly in the case of auxiliary equipment in a plant - and creates better and more advantageous conditions for making the investment. Furthermore, this makes it more probable that the technology will be absorbed and adapted to local conditions, with all the advantages that result from the available resources in the country being used.

Thus, these experiences show that the conditions necessary to carry out this basic project in the country do exist, although it cannot be guaranteed that the principal equipment will be marketed successfully. The main difficulty national engineering must overcome in this respect is connected to the size of the heavy equipment, because the prototypes must be developed and, at the same time, the companies must be prepared to use the machinery built by the project. However, the national engineers have proved themselves capable of building every type of civil building or construction project, and all the parts of a cement-producing unit, in the country.

Furthermore, apart from the efforts being made by more autonomous businesses, it is no longer possible to set up plants by buying complete packages because CACEX (Foreign Trade Department of the Bank of Brazil) allows foreign equipment to be no more than 40% of the value of the total project.

**Diffusion of the Process:** After two kilns were installed in 1966 and 2 years when nothing was done in this sector, the process of diffusion speeded up considerably from 1972 onward. In that year all the new kilns installed used the dry process and sometimes they substituted old equipment. Nevertheless, because this substitution occurred only occasionally, and because when new kilns were installed the new method absolutely had to be chosen, the rate of diffusion was determined by the speed at which installed capacity in the industry expanded. From the point of view of the diffusion between companies, the process was almost completed. As for intracompany diffusion, in 1974 almost 30% of the kilns and almost 50% of the installed capacity were using the new
dry method; and as demand seems to be growing, it is probable that intercompany diffusion will grow faster in installed capacity than in the number of kilns.

From the point of view of the diffusion of the kilns with suspension preheaters, one should distinguish between the factors that condition this process, the firm's capacity to innovate, and the reasons that cause a firm to choose the innovation.

Although the Brazilian cement industry had easy access to information on the new process, this did not cause the industry to make a favourable decision immediately. Nevertheless, it would be too much of a simplification to put this down to the conservatism of the companies in the sector and to their dislike of taking risks. In reality, these behavioural patterns can be explained by the characteristics of the world market of technology to produce cement, and the dependent links that were established throughout the period when the sector in the country was being structured between the suppliers of technology and the cement producers.

The companies supplying this technology - although in general they also produce equipment for the industry - operate principally as engineering offices. As they are very few and they keep control over the know-how of particular basic equipment, their position in the market is guaranteed.

Even when it is not a turn-key installation, the suppliers of basic engineering and technology always keep the basic secrets of the process when retailing them, and also the specifications to build the equipment. Besides, the transfer of the know-how to the cement producers aims to train them to operate the industrial units efficiently.

In this sense, the cement producers are dependent on the international suppliers of technology as far as choosing the process and equipment, and the availability of the innovations introduced into the productive process, are concerned.

The F.L. Smidth kilns dominate for two apparent reasons: one is the dynamism of this international technology supplier itself and the fact that other European suppliers have concentrated their activities in particular areas of the world market; the second is that the kilns installed before have given good results, the quality of the technical assistance has been good, the marketing has played a part, and the national cement producers are averse to taking risks - this explains, principally, why the guarantees given by the supplier of the equipment and the project are considered to be so important.

In this context of almost exclusive links with one specific supplier of technology, it is to be expected that the national cement producers' evaluations of the kilns with suspension preheaters will, to a great extent, reflect those of the supplier. In 1965, of the companies most active in promoting the sale of their kilns - Polysisus and Humbolt - only the first had a unit working in Brazil: a single kiln with a preheater with bars in the Jose Ermirio Group factory at Esteio.

It should be examined why there are no pressures on the national producers to innovate, which, consequently, means that the policy of the foreign supplier of technology and the interests and needs of the cement producers in Brazil coincide. The reasons are to be found in the context of the structure and dynamics of the market and the industry during the period.

It could not be expected that the new kilns installed between 1960 and 1965 would use the new method. In a period that looked so dismal for the industry and when the market was protected by the underuse of the capacity, it was unlikely that the companies would be prepared to take the risks of adopting a new technology or that they would feel any pressures to innovate.

However, a different picture appeared as a result of the rise in the price of oil products after 1964. With the new government policies on the prices of oil products and the control on cement prices, the dry method offered the industry a way to reestablish its profit margins.

This change in the price of an input, which played such an important role in the production costs, did not by itself cause the dry method kilns to be diffused in the Brazilian cement industry. It seems fair to say that the reduced costs of this method were not enough by themselves to persuade new industries to enter the sector at a time when the market was growing slowly and when much of the industry's capacity was idle. Similarly, the investments needed to convert or substitute the wet kilns discouraged any changes in the productive processes of the already installed units.
So it seems that the stimulus to innovate, which was discussed before and which came from the very dynamics of the expansion process in the sector after 1967, was stronger than the possible disincentives to adopting the process of the lower fuel oil prices. It is unnecessary to characterize the first phase of the diffusion process, which ended when the fuel oil prices dropped.

The period of rapid expansion in consumption certainly created opportunities for new companies to enter the market and possibilities for the industry's structure to change.

Conclusion: The companies that already existed, and above all the largest ones, needed some way to meet the increased demand rapidly and to guarantee their position in the industry. In fact these companies' delay in meeting the growing demand not only cleared the way for new firms to enter the sector but it also permitted future attempts to win back lost portions of the market that might cause undesirable frictions and imbalances in the industry. Furthermore, the CDI policy of physical incentives during the period was to grant them only when there were markets to be attended and this meant that the tardy companies had to make too large investments to compete with their more speedy competitors.

Therefore, in their expansion plans these companies had to attempt to reduce their production costs by increasing their scales of production and by adopting technologies that would reduce costs and especially processes that would reduce the costs of the capital inputs.

The companies in the sector responded successfully to the new demands. The new kilns installed during these years were much larger; and excepting three, all the kilns installed after 1968 used the dry method and they almost always used the version with the suspension preheaters (two of the three wet method kilns seem to have been indispensable on account of the characteristics of the raw materials).

It was mentioned before that except for when the old equipment is obsolete, the effect on costs of going from one method to another is not absolutely clear as the rise in fixed unit costs resulting from the investment needed to convert or substitute the kilns may be greater than the reduced costs gained from the dry method, but when the change in the method includes substituting several small kilns for a kiln with more capacity, it is probable that the modification will be more profitable because the reduced costs resulting from increasing the scale of operations will be added to those of the dry method.

In this sense, substituting the wet process for the dry seems to be more viable during periods of market expansion when it is a good idea to enlarge installed capacity. However, during periods when market demand is growing very rapidly, when the companies' expansion plans are hard put to keep up with the consumption, and when their main worry is to conquer additional markets and strengthen their position in the industry, it is not advisable for the company to close operating kilns and reduce their participation in the market.

However, it is likely that when the present phase of market expansion ends and the growth rate of the demand slows down, the companies in the sector will begin to substitute their wet method kilns for larger dry method ones and in this way adjust their capacity to the slower market growth and also further reduce their operational costs.

As the external factors that were delaying the use of new productive processes were modified simultaneously with the appearance of internal pressures to adopt the dry process, it is difficult to weigh the importance of the different factors.

The rise in the domestic price of fuel oil, the price controls imposed on cement, and the growing demand - which made it possible for new companies, without the same links to foreign suppliers, to enter the sector and they were oriented toward the new process - seem to be by themselves sufficient pressures to make the established companies adopt the dry method and break their loyalty to the traditional supplier.

The pressures that the government agencies' incentives and financing for industrial development, especially BNDE and CDI, had on the national cement manufacturers was a relevant factor in the adoption of the dry method process. At first the government action was informal, but in 1970 a BNDE resolution confirmed it and limited financing to projects that planned to use dry method kilns. The CDI action was less specific; the 1971 resolution laid down guidelines for giving the incentives to the cement industry and
only limited them to firms whose capacity was over 1,000 t/day, and they planned to raise this to 2,000 t/day later.

This study presupposed that the diffusion process of the new technology depends on two basic conditions: first, the technical specifications of the innovation determine to what extent it can be used by the industry, and second, the characteristics of the industry and the market form the framework that determines the companies’ discussions on adopting new technologies.

The advantages of the new processes are undeniable as far as installing new plants or enlargements are concerned. Nevertheless, it is not advisable to convert wet method kilns or to substitute them for suspension preheaters because the increased fixed cost as a result of the investment needed can cancel out the reduced costs of the dry method kiln.

The study shows that in the cement industry in Brazil there is a concentrated oligopolistic structure, with very few companies (the four largest have 60% of the installed capacity) producing a homogeneous product. The industry’s expansion pattern is characterized by reduced concentration when demand grows quickly, when it is viable for new companies to enter, and by increased concentration when consumption increases more slowly, when increased supply comes from established companies expanding their capacity. Usually, supply responds late to the growing demand, and the investments to expand installed capacity are made after there is a certain level of demand that is not satisfied by national production.

The cement manufacturers are dependent on the world suppliers of know-how both when choosing the techniques and carrying out the projects and when selecting the equipment to be purchased. The Danish firm F.L. Smidth is dominant in Brazil in supplying the technology and equipment needed by the cement industry.

The time and rate of the diffusion process reflects both the external conditions, as the Brazilian cement producers have strong ties to the foreign technology suppliers, and the internal determinants resulting from the evolution of the market and the industry during that period.

As the dominant company, F.L. Smidth was late in developing the kilns with suspension preheaters, and as the Brazilian producers are so closely linked to the firm it seems fair to say that their caution over the new process was caused by their links to this company.

As demand was low during the first half of the 1960s and as much of the cement-producing capacity was idle, it was improbable that the firms would take the risk at that moment of adopting a new technology or that they felt any pressure to innovate.

The rise in the price of fuel oil was a stimulus, but not by itself enough to determine the diffusion of the dry method kilns in the cement industry in the country because during 1967-1970 this trend in the oil price was reversed.

In fact the launching of the diffusion process corresponded to the increased growth rate of demand, and the industry saw that this rate would last owing to the public works programs and the progressive implementation of the housing program unveiled during the previous years. The evolution opened up the possibility for new companies to enter the sector and promised to change its structure. The established industries needed a quick answer to the expanded demand to guarantee their positions in the industry. As the new competitors would install the most efficient technology, the established companies would have to include cost-reducing technologies in their expansion plans. The companies in the sector, especially the largest ones, responded successfully to the demands by enlarging their capacity rapidly and reducing costs by installing large-scale kilns and dry method processes. Similarly, the new firms entering the sector also used the new process.

In summary, it seems that just as the coincidence of the lack of internal pressures and the caution caused by the links with the foreign country delayed the introduction of the suspension preheaters into Brazil, the simultaneous modification of both these deterrents explains why the new process was completely accepted and was diffused rapidly.
This section is aimed at providing a background for the analysis of the policy instruments and their impact on the trends or orientations of technical change at the firm level.

Information was drawn from a survey involving 67 firms in the capital goods, petrochemical, and food industries. This section does not attempt to generalize or to draw results leading to a theory or similar construction. Rather, its purpose is to provide some insights as to the assessment of the impact of policy instruments.

General Approach

The effort to examine the orientations of technical change at the firm level involved going beyond the formal categories of technological decisions. On the other hand, the approach that was followed did not allow a focus on a single innovation in the industrial branches mentioned above, because emphasis was not placed on the measurement of the rate of diffusion of specific innovations.

The technical changes that were identified are related to one or more of the following three dimensions of technology in a given enterprise: production technology, product technology, and materials technology. These were defined as levels or dimensions in which technical change can take place. In the first level all technical changes in processes are included, whether or not they are embodied (related to plant and equipment). In the second level all technical changes related to product design are included, whether or not they imply diversifying or differentiating a given product. And in the third level all technical modifications in raw materials and inputs are considered.

Obviously, these three dimensions or levels are closely related in most instances. Changes in product technology normally imply modifications in production technology or materials technology and vice versa. But for analytical purposes these three dimensions were considered as separate levels of technology within productive units.

The main orientations of technical change considered were the following:
- cost-reducing changes (or their corollary, productive increases);
- product differentiation (and diversification);
- adaptation of production technology to factor endowment;
- adaptation of production technology to size of market;
- adaptation of product technology to local consumer preferences.

In a sense, the last three types of changes are specific cases of the first two types, which are more general. However, given the importance that technology adaptation has for an economy relying heavily on imports of foreign technology, it was decided that these technical changes would be examined separately.

The factors that affected technical changes (or caused them) were the following:
(1) Structural characteristics of the branch
- degree of concentration (i.e., volume of production or fixed assets controlled by the top four firms in each branch);
- foreign investment (presence of multinational firms);
- distribution by size of firms;
- capital-output, capital-labour, and labour-output ratios;
- predominant channels of competition (prices, product diversification, cost reduction, salesmanship, etc.);
- size of market and barriers to entry.

(2) Characteristics of the enterprise
- ownership;
- size (by number of workers, by amount of equity);
- regional location;
- volume of exports.

The characteristics of the production technology were considered as part of the
characteristics of the industrial branches and intimately related to the capital-output and capital-labour ratios. The basic distinction was made between continuous flow, intermittent, and discrete processes. In the continuous flow process, raw materials and other inputs cannot be divided into separate units, distinguishable from one another. Therefore, transporting these materials from one reactor or recipient must be carried out by means of heavier outlays of equipment (tubes and piping, conveyor belts, etc.). The intermittent processes are characterized by the fact that the physicochemical reactions can take place in containers that can be charged and discharged; outlays may be smaller, and more flexibility for the use of labour exists. Finally, the discrete processes are those in which raw materials, intermediate goods, and final products are distinguishable from one another and can be manipulated separately. Of course, some processes combine two or more features at one stage or another: for example, dairy products like cheese start as a continuous flow process and end as a discrete process with clearly distinguishable units. These characteristics are also closely related to scales of production, because an intermittent process may be feasible at small scales of production (8).

One very important point is the following: during the course of the analysis it was considered that the characteristics of the processes condition the orientation of certain technical changes. For example, it is well known that discrete processes have a higher elasticity of substitution between primary factors of production than continuous flow processes. However, changes in one direction or another were not dictated by the technical characteristics of the process but rather by the characteristics of the branches and enterprises.

Capital Goods Industries

At the level of production technology no important effort was identified to increase the use of labour in the three subbranches that were analyzed. It must be pointed out that these branches use discrete processes that allow for a greater flexibility in substituting among factors. In the subbranches, 10 firms considered that from the technical point of view it was possible to increase the use of labour, whereas 15 considered that this was not possible. Nevertheless, the first 10 firms stated clearly that they did not make efforts to increase the use of labour for several reasons: the cost of labour was mentioned only in two cases, financial bottlenecks in another two, and the lack of trained personnel in five firms. Of course, the last reason is closely related to the cost of labour; but in theory, trained labour does have a greater productivity and the results can be appropriated by the enterprise. However, these firms were not ready to meet the costs of training workers and this fact simply points to a major trend in industry: most firms consider that labour-training expenditures should be covered by organizations belonging to the state, trade unions, or productivity centres. The relevant question here is the following: how should the gains derived from the technical skills embodied in trained workers be distributed?

The few training courses that were identified were very short (lasting between 2 and 3 weeks) and were basically oriented toward training labour in auxiliary tasks of low technical complexity. The emphasis is on a training-by-doing approach, which saves costs for a firm and immediately puts beginners on the production lines as assistants to the more qualified personnel. This did not prevent some firms from trying to optimize the use of their plant facilities by organizing workers and production lines in what was considered more efficient layouts. Some of the firms in this branch had spent considerable amounts in carrying out time-and-motion studies to optimize the output of their workers. In a firm producing agricultural implements, the plant layout had been reorganized so that workers' teams could put together the parts and components without the need of an assembly plant (and without increasing the number of workers). This case is revealing because it shows how important cost-reducing, productivity-increasing changes can take place in this particular branch.

As was expected, in all the lines of capital goods a constant trend toward higher automatization (and hence, more capital intensity) was identified in the larger firms. The capital-output and capital-labour ratios in the three subbranches are not the highest in the metal-mechanical branches (and they are not much higher than the general averages for all of industry), but they are higher in the largest firms (10). Their production volumes allow for important economies of scale, the possibilities open for substituting labour by capital equipment are higher, and access to credit and better terms from equipment and capital goods producers are also available to them. The result is that important technical changes take place at the level of production technology and they are a function of the scale of production, size of market, and the types of the clients of the firms involved.
At the level of product technology the most important change was related to product diversification, especially in the manufacturing of machine tools. The need to diversify arises primarily from the size of the market (and the fact that important incentives exist for importing capital goods plays a major role here). Specialization in a given line of machine tools is difficult to attain. The vast majority of the firms that were visited were producing more than two different types of machine tools and their production was primarily determined by a demand suffering from strong cyclical variations. Some producers of horizontal or parallel lathes, milling machines, drills, and circular saws were manufacturing only one of these types of machine tools at the time of the survey because the orders from several technical education centres were absorbing their entire plant capacity. Once this demand would be satisfied, the manufacturers would turn their attention to other clients and orders on different types of machine tools. This was a characteristic not only of the machine tools producers. Out of the 25 firms in the capital goods branches, 17 considered that the size of the market was small and 13 of them had diversified their lines of production to meet this limitation. Incidentally, the flexibility in diversifying and changing lines of production was considerable, especially in those firms manufacturing light models of machine tools.

Most of the firms producing agricultural machinery had fully standardized lines of production and did not diversify products. However, a certain degree of product adaptation was identified. Some changes in agricultural implements had to be incorporated because the soil in Mexico is much harder than most of the tilled soil in Europe and North America.

Another example illustrates the changes that take place in this branch: one of the large manufacturers of tractors had increased the oil deposits' capacity of the units so as to avoid too frequent servicing in regions where service stations are not abundant. (However, it must also be emphasized that none of the producers of tractors had tried to develop a design of a vehicle more suitable for the average size of land units and the slope of hills in Mexico.) The predominant channel of competition in this branch is through salesmanship (including the distributor's network and sales financing), after-sales services, and prestige of trademarks. Price controls over agricultural machinery prevent firms from using price differences as an important channel of competition.

An additional point regarding product adaptation in these subbranches is the number of implements or tools that may be attached to tractors or certain types of construction machinery to increase their versatility. A hydraulic crane or excavator can be adapted with a particular type of drill or different kinds of shovels; the energy source in a tractor can be applied to water pumps, drills, and other attachments. These optional tools or items do not imply changes in the design of the product and must be considered as special cases of product diversification (especially since the tools themselves are manufactured in fairly large numbers for on-the-shelf display).

It is interesting to compare these subbranches with the production of capital goods for process industries. In this case the production is normally carried out once specific orders have been placed for the corresponding equipment. Besides, the design of the equipment is carried out taking into consideration plant layout, process design, and detail engineering specifications. So in this case, product adaptation to the specific request of the client does take place (as in the case of the production of bridge cranes); but this does not necessarily mean that the product is adapted to the size of the market or the endowment of primary factors of production.

Finally, at the level of materials technology there was a strong motivation to adapt the technology that was being used to the characteristics of local raw materials and inputs. From the sample of 25 firms in the capital goods branches, 16 firms had carried out this type of adaptation. It appears that the possibility of substituting materials is rather restricted in this branch; therefore, it is not surprising that during the 1973-74 shortages of inputs (basically steel plates) many lines of production had to be abandoned. At least 10 firms in the capital goods branches had abandoned lines of production because of factors related to costs of inputs, irregular deliveries, and poor quality of raw materials (11). Nevertheless, adaptations to local raw materials or intermediate inputs did not seem to generate any important changes in production or product technology.

Petrochemical Industries (12)

Within the dimension of production technology, it was expected that in the
petrochemical industries the rigidity imposed by the use of continuous flow processes would strongly limit the use of labour. This was confirmed for the production of synthetic resins, synthetic fibers (polyester, acrylic), and fertilizers of petrochemical origin, where the continuous flow process implies a very high capital intensity (13). Production flows must be maintained at constant levels and interruptions must be kept at a minimum because of the high overheads (start-up time in some processes is lengthy and the cost of stopping production is of course higher). Therefore, it was not surprising that 15 firms (out of 18 in these subbranches) reported using three shifts to run their plants. (This contrasted rather strongly with the capital goods and food industries, where only three and six firms respectively used three shifts). However, it must be pointed out that certain intermittent processes do exist for the production of resins and they involve lower capital costs and more use of labour. (These processes not only allow for using more labour in charging and discharging reactors and other recipients, but also in maintenance techniques. In the continuous flow industries, maintenance is carried out in a more capital-intensive manner: either by channeling flows through installed replacements or by expensive cleaning-in-place techniques). These intermittent processes were in use in the smaller firms involved in the production of resins and plastics. Apparently, the production of these resins in larger scales called for heavy investments and higher capital-output ratios. At this point it is relevant to mention that the intermittent processes save on the consumption of critical services such as water and energy. But given the present subsidies on the prices of these inputs there is no real urge or need to save on their cost.

The adaptation of production technology to the size of the market was identified in eight companies in these petrochemical subbranches. Most of these firms had carried out the adaptations (usually through some kind of descaling) by themselves: only in two cases were local engineering firms contracted for the task. However, it was very difficult to evaluate the extent to which these adaptations implied major changes in plant layout or in the proportion of capital goods of national origin in each project.

In contrast with the fact that adaptations had taken place, the most frequent criterion for the selection of technology was "the most modern technology" (this was considered by eight firms as the key criterion guiding their selection of processes from different sources); only two firms responded that the "cost of the technology" played a fundamental role in selecting between alternative sources of process technology.

An interesting point here is the utilization of capital goods and equipment of national origin. On the average, the firms in these subbranches responded that approximately 66% of their equipment was of Mexican origin. This percentage is not a low one, but it merely reflects the fact that for the production of resins the national component in plant equipment is higher; but this percentage goes down for more sophisticated plants (for example, ammonia plants have a national component lower than 40%).

In relation to materials technology, 14 of the 18 firms in these branches had adapted their technology to local inputs. These adaptations were probably minor ones because none of them implied changes in the processes or plant and equipment. On the other hand, the supply of raw materials through the state-owned oil monopoly Petroleos Mexicanos is very regular, as far as both deliveries and specifications are concerned. Therefore, in only very few cases have product lines been abandoned due to changes or deficiencies in the quality or specifications of raw materials and intermediate inputs.

Food Industries

The industries analyzed under this heading were the processing and packing of fruits and vegetables, as well as the dairy products industry. They share some common characteristics. First, they involve process technologies that are in the public domain either because they are very old or because patents are not granted to food-processing technologies in many countries. Second, both of these subbranches allow for the use of labour in considerable amounts, as their capital-labour ratios clearly point out: 27.9 and 87.8 for fruits and vegetables and dairy products respectively (14). Third, they are strongly affected by seasonal variations in the supply of their raw materials and they are also affected by the geographical location of their sources of raw materials.

However, in spite of the fact that the elasticity for substituting among factors of production is greater than in many other industrial branches, at the level of production technology no effort was identified to increase the use of labour. For 12 of the 24 firms that were analyzed in these subbranches, the labour-saving capacity of new
equipment was an important criterion in the selection of capital goods for their plants. And for nine firms this had been the main criterion. It may be possible that the desire to reduce costs in these firms is a consequence of the existence of official prices for their products, which prevent the use of price competition to maintain levels of profit margins. In any case, the use of labour by these firms was very much dependent on the scale of production and had reached a technical ceiling: only six firms considered that it was possible (from the purely technical point of view) to increase or intensify the use of labour, and all of them were small-scale firms. Plants in the fruit- and vegetable-processing subbranch used mainly female labour with very important gains in productivity and without additional costs in terms of wards or other installations (in fact, important violations of labour legislation were clearly identified).

Adaptations of the technology to the scale of the market are not present in this subbranch in the form of descaling because the market is not small. However, a large spectrum of alternatives is open in terms of size of plants and a key element is the geographical location of a plant.

Even though key innovations have taken place in the equipment and capital goods used in these subbranches (particularly in dairy products), the most important technical changes taking place were identified at the level of product technology. It is at this level that the main trend or thrust of technical changes in these subbranches is found: product diversification and differentiation. In spite of the fact that the technology embodied in capital goods plays a key role in these subbranches, competition through product differentiation has meant that technical change has had to be oriented in this direction. Product differentiation has been so important in the past that today one of the most important barriers to entry lies in the prestige of a given trademark (and its corollary: advertising expenditures). Most of the firms in this subbranch tended to introduce innovations that can be easily spotted by consumers (15). Diversification was more frequent in the fruit- and vegetable-processing industries; diversifying products does not imply changes in process or production technology in general. In the majority of cases the same type of machinery and equipment can be used and the same number of workers carries out very similar tasks without changing places in front of a conveyor belt. In the case of dairy products, diversification is predominant in products such as cheese, while differentiation is more important in the marketing of milk and cream in disposable containers (approximately 25% of the national production of milk is sold in this type of container). Aside from the fact that disposable containers are an important innovation in the presentation of the product (and they are thus a channel of competition in a subbranch where it is impossible to alter the essential characteristics of the product), they also imply higher prices and therefore a higher return (their sales price is 35% to 40% higher). Diversification in dairy products does not imply transforming the production technology because it mainly takes place in those stages of the production process where the alterations can be introduced without touching the core technology.

Finally, at the level of materials technology the firms that were examined also showed a considerable propensity to adapt their technology to raw materials of Mexican origin: 13 firms in these two subbranches had carried out some kind of adaptation to local inputs. However, as in the other subbranches, these adaptations did not seem to imply changes in production or product technology. On the other hand, firms are very vulnerable to seasonal variations in the supply of their raw materials, changes in quality, or simply to lack of uniformity. Nineteen firms (out of the 24) reported that at one point or another they had had to abandon lines of production because of the above-mentioned reasons. If these reasons appear at a time when other raw materials are also available, the problem is reduced; otherwise, the production line will be closed, with the ensuing rise in costs.

**Implications of Policy Instruments for the Orientation of Technical Change**

The analysis of the impact of over 20 policy instruments showed that in general terms the main orientations of technical change as they have been briefly discussed above are seldom affected by the contents or mechanics of these policy instruments. These instruments are analyzed in detail in the Second Part of the Final STPI Report presented at the Sussex meeting. The general conclusion then is that intensification of the use of capital (labour-saving innovations), product differentiation, and adaptations (i.e., lack of adaptations) are explained by the dynamics of the branch in which firms are operating and to a lesser extent they can be conditioned by the characteristics of the firms and the type of process being used (although, in fact, this last element can be considered part
of the characteristics of the branch).

The individual analysis of policy instruments shows, however, some interesting facts. Their effects may be negligible, but in some cases they can be considered as an unnecessary incentive (a redundant effect) and they imply important fiscal sacrifices for the state. For example, the Registry of the Transfer of Technology does not have an impact on firms operating in the food industries because their links with suppliers of technology outside the firm are through the purchase of machinery and equipment (and not through licencing or technical assistance agreements). Patents and trademarks also have very different effects in these different branches: patents may have a role to play in some petrochemical processes, less importance in the capital goods industries, and almost no importance in the food industries. However, trademarks play a key role in food industries (where product differentiation is very important) and have no relevance in the petrochemical industries (where product specifications are more important). They may play a role in the production of capital goods, but product performance is judged on stricter terms and with more information.

Depreciation coefficients also have different effects on each of these branches: the higher coefficients allowed for machine tools have caused much speculation and have stimulated the imports of these capital goods (together with other promotion instruments).

Social charges and other instruments normally considered to increase the cost of labour (and therefore promote the selection of capital-intensive techniques) were found to have no important effects in this direction. The cost of labour rises only 15% as a result of these instruments and it is difficult to conclude that this increment is responsible for orienting the choice of techniques in one direction or another. On the other hand, labour costs were mentioned in a very limited number of cases by the firms that were studied; clearly, the increase in capital intensity is due to more complex reasons than the simple rise in labour costs.

Some fiscal incentives, like the Decree for Industrial Development and Decentralization, have proved to be unnecessary fiscal sacrifices: on the one hand, one finds firms that cannot respond to its benefits because they must remain close to final markets or suppliers of intermediate inputs (typical case of capital goods producers); on the other hand, one finds industrial plants that are located in the less-developed regions because they had to do it in the first place (a typical example is food-processing plants that have to be close to the sources of raw materials).

VENEZUELA

A STUDY OF ATYPCAL CASES OF TECHNOCAL INNOVATION

The following fundamental points can be derived from the study of several atypical cases of innovation:

(1) The productive enterprises that carry out innovations have a monopolistic or exclusive position in the market. If one considers that prices are not the main focus of attention, given the control of the market by these enterprises, it must be concluded that the interest in innovations would turn toward the introduction of new products or toward differentiation. However, and as will be seen, this is not the case.

(2) The decision to carry out the innovation was taken because either the existing technology in the world market did not adjust itself fully to the specific production characteristics of the enterprise or the terms of acquisition were unacceptable. The situation appeared almost in the terms of an ultimatum: the innovation had to be developed with the means available or it would be abandoned.

(3) The decision was made, similarly, because from the beginning it was believed that there was the capacity to carry it through.

(4) Everything seems to indicate that the innovations carried out can be defined, in Katz's terms, as minor, even in those enterprises in which the innovation was developed under foreign supervision.

(5) It is interesting that in 17 of the 20 cases examined there is a technician of foreign origin who, if he cannot support any kind of generalization, should stimulate
reflection.

(6) Little interest was seen on the part of the entrepreneurs to patent. Only one case made efforts to register the innovation. Apparently this fact can be explained by the nature of the innovations carried out, their lack of relevance to the competition between businesses, and the ignorance of the patent system, its characteristics, and objectives.

The first conclusion is that, as was said before, the innovations dealt with here are minor ones that cannot by definition be considered in the same manner as those that are commonly called major innovations. Other considerations must be taken into account according to this circumstance.

The roots of the development of the innovations examined have shown the difficulty or impossibility of depending on foreign sources. This is, obviously, a crucial fact, but one that can in no way explain the fullness to which this development reached. From the available information and taking into account what more extensive studies could conclude, it can be said that, apart from this central fact, others were found that played a definite and important role in the generation of innovations:

(1) The innovative enterprises were shown to maintain a systematic search for technical information within their respective areas of operation. As is obvious, the possession of information is a key factor in the negotiation of technology: information destroys what has been called a virtual monopoly, due to the misinformation of buyers. In what affects the generation of innovations, information permits the modernization of the technological art. In this, Freeman places it as one of the essential conditions for innovative development (16).

(2) It was also shown that there existed in innovative organizations of human resources a capacity for creation - with its complementary support by management and leadership. In this regard, two elements must be pointed out: one is the existence, in nearly all of the 20 cases studied, of one or more foreign professionals coordinating the work; the other is that it appears, as inferred from the given information, that more than technical capacity inspires innovative work and the resolving of problems.

(3) The innovative organisms had a basic infrastructure that protected them from extra expenses or significant sums when undertaking the development of an innovation. Thus, with two exceptions, local developments were carried out on the basis of normal resources in workshops and laboratories of the organization, with some cases having to complement or repair certain equipment but, definitely, with no special amounts of money involved.

Naturally these aspects are far removed in explaining by themselves the situation under study. Very few cases were reviewed, and it should be added that there are certain unknown psychosocial and cultural variables that surely play an important part in the decision to innovate on the part of entrepreneurs and technicians in Venezuela. These variables are more important in dealing with atypical behaviour; otherwise they would be diluted within the configurating power of the economic structure.

Everything expressed here allows greater generalizations but also some approximations that would give a basis to an explanation, although tentative, as to local innovation.

In the first place, it is useful to compare what Freeman establishes as essential conditions for innovative activity with the characteristics that this activity possesses in the present study. Thus it is useful to clarify here that a comparison is to be made between the reserves established in the model used by Freeman and the model applied here: the first refers to the work of ID (industrial development) in the context of industrialized countries, which presupposes a series of concepts, and the second - shown by Katz - tries to deal specifically with the conditions of underdevelopment.

Of the list established by Freeman, a total of 10 basic conditions can produce two that synthesize the optimum parameters for innovation; these are an intense professional ID and a good knowledge of the real and potential market. In the first of the cases studied, this ID activity is not clearly shown. If in most of these there are departments shown clearly to have ID, from the reading of declarations by sources two things stand out: on the one hand, what is noted as an ID department is often no more than a quality-control or repair laboratory; on the other hand, the relation is not very clear as to what exists between this ID department and the innovation studied. Given the
type of resources used and the cost of development, it appears that, except in two cases of large businesses, the activities declared as ID are not of this type.

As for knowledge of the market, as there are no data here, it can be inferred that in some way the type of innovations developed has no specific incidence in the market because most of them refer to the adaptation of national product conditions or processes already in existence.

In the second place, an explanation can be attempted of the particular character acquired by the innovation in the cases studied. The variables analyzed must be examined from the point of their inclusion in the axis that determines and forms technological activity: production. This means production within the framework of a developing and dependent capitalism. Therefore, these observations must end at the point that sustains this system: the earning of capital. Definitely, we are dealing with that which permits - in conditions of easy importation, with an importer of strongly refined qualities, without a tradition of technological development, and, finally, with a collection of variables that conspire against the supposed risks of innovations - the achievement of a process of technological generation, having nothing to do with minor innovations. The answer appears to be precisely in that the development carried out - clearly in at least 18 of the cases - held no risks for the enterprise. The two cases that are an exception refer to a regional development entity and to a business of prefabricated houses, in which development was relatively vital, inclusive, and produced losses.

Besides the points mentioned above, the results of the three atypical cases of technological development organizations should be mentioned (17). This refers to three units with different institutional characteristics that, in the areas of electronics and telecommunications, sustain intensive research activities. The first of these is a business, MCM of Venezuela, dedicated to the manufacture of central and closed telephone circuits. Starting with a totally national design, this enterprise achieved the manufacture of a central telephone circuit accepted on the world market, making it an absolutely unique and demonstrable case precisely for being so atypical. In this sense, the factors that made this development possible must be explained. First, this is a case in which the major conditions for all innovation are present: an intense ID and a thorough knowledge of the market. Second, highly trained technical personnel are found, as indicated by the ratio of professionals-technicians to other personnel (40/195). Finally, the government, through CONICIT, has contributed part of the financing of the developed circuit.

The other case is that of the Centre for Telecommunication Studies (CET), part of CANTV, a government telecommunications enterprise. This is an entity that arose as part of an agreement with the United Nations, which had the goal of training technicians in telecommunications. What is illustrative in this case is the contradiction between the atypical nature of the organization and the usual type of technological policies of the Venezuelan government. Thus, CET was born at the initiative of a group of technicians and, in its functions, demonstrates the possibility of creating laboratories and research centres for the development and adaptation of products to the conditions and necessities of the country and national industry; but, at the same time, this develops within a framework of institutional instruments and mechanisms that, if not obstructing, distort technological efforts. While the government, through the creation of CET, proposes institutional solutions to technological problems, it blocks the effectiveness of these solutions by not presenting developmental policies that presuppose concrete objectives and goals.

The final conclusion is that limits for innovation must be delineated within the context described. That is, limits must be defined that suppose the possibility of developing innovations with a minimum of risk, both technical and economic.

A first aspect relates to the two conditions shown by Freeman as necessary for all innovation - that is, intense ID activity and knowledge of the market. As for the first, the experience described shows that in the conditions of a dependent and captive market such as that of Venezuela, ID activities within businesses work uphill: the ease of importation and the risks to all creative processes, besides of course the technological dependence present, conspire against this possibility. This leads to the conclusion that all innovative strategy must confront these obstacles and, consequently, define the margins of innovative conduct that respond to an innovation-risk relationship adequately.

On the other hand, knowledge of the market, specifically the market of the business undertaking development, reveals an essential fact: the presence of large monopolies that control technical progress and that, in the same sense, obstruct innovative efforts.
on the part of other enterprises.

The presence of these monopolies is a fact that cannot be avoided; neither can it simply be accepted through the easy recourse to importation. The alternative would come through a definition of the framework that places circuits of innovation (18) within which could be outlined the means and conditions in which national industry can act, adapting or creating new technologies. Moreover, this framework and circuits of innovation would extend the limits of enterprises and make up a chain in which they would participate together with research centres, institutes for technological development, government offices, etc. What is meant here is the separation of two systems within the S and T planning, which, we believe, are not completely correct. The first concerns the concept of the S and T system, a confusing notion in that it presents the following false alternatives: either the system would have to be strengthened, presupposing that one exists, or one would have to be created to deal with its problems as part of a whole - the system - which is unknown and which runs the risk of copying models from industrialized nations. The second, and more pertinent, is that of the offer-demand relationship in technology, a strict and rigid system that clouds the fact that in the terrain of the S and T both parts, especially in this context, do not designate precise and clearly determined places.

The view from the perspective of innovation circuits could be inserted in the interaction of risk-benefits, previously defining those frameworks where the risks - in terms of technology, human resources, degree of competition - are predetermined and controlled.

Finally, the definition and design of these circuits of innovation demands, besides an overall policy of stimulating local technological training, that the government be the one in charge of this, noting that private enterprise is reticent toward innovative strategy. On the other hand, only a central power such as the government could function as coordinator of such a complex field of institutions and activities, besides the fact that this would assure social rationalism over and above the short-term, quantity strategies that have been criticized throughout this work.
NOTES

(1) In certain cases, depending on the company's technological profile, benefits can be obtained when certain stages are modernized, only if investments are made in other stages too, although these stages might not be continuous.

(2) See, for example, the various works by E. Mansfield in this area, particularly Technical change and the rate of imitation, Econometrica, October 1961.

(3) The failure of certain studies to understand the complex nature of the inequalities that exist in the textile industry has often led them to advocate economic measures that have little or nothing to do with the real needs of the sector. Such proposals usually consider how to deal with "traditional branches" of the sector in which owners are "old-fashioned" and the technology used is "obsolete" and where it is assumed that the possibilities for growth depend directly on the implementation of measures to stimulate modernization. Interestingly enough, these preconceived notions regarding modernization seem to foster a vicious circle of technological backwardness, because the measures aimed at stimulating such modernization not only fail to solve the problems of overall growth in the sector, but also tend to exacerbate existing inequalities, as seen in this paper.

(4) Protected from foreign competition by the Similarity Law and from domestic competition by the characteristics of their machines.

(5) Stimulated since 1967 by the physical incentives for afforestation and reforestation.

(6) In this section modernization should be understood as the process of introducing special presses when the machinery is completely or partially reformed or when conventional presses are simply substituted for special presses.

(7) By simply introducing grooved rollers or rollers covered with combination-type felts and by making the small modifications in the machines necessary for these more modern pressing systems.

(8) Other studies have emphasized the importance of the characteristics of the products: size, finishing of surfaces, complexity of form, etc.

(9) Machine tools (chip forming, chipless, cutting or deforming), agricultural machinery and implements, construction machinery.

(10) Capital-output ratios for machine tools (1.24), agricultural machinery (1.46), and construction machinery (0.96) are not very different from the overall ratio of manufacturing industry as a whole (1.22).

(11) In the capital goods subbranches this datum was not available for all of the 25 firms.

(12) The definition used in the research does not coincide with the classification of the Industrial Census, so some adjustments were made in processing data from the industrial statistics.

(13) K/Y ratios for resins, fibers, and fertilizers are 2.08, 2.28, and 4.20 (K/Y ratio for all branches of manufacturing industries is 1.22). K/L ratios for resins, fibers, and fertilizers are 289.5, 321.2, and 410.3 (K/L ratio for all industrial branches is 62.32). Source: Industrial Census, 1971. (For further details see Table I, page 13 of the Spanish version, Chapter III, distributed in New Delhi.)
(14) Of course, these ratios vary in relation to the size of each plant.


(17) Giordani, Giner, and Genova, Analysis of the electronics and telecommunications industry, Caracas, 1976 (part of the project, Instruments for scientific and technological policy).

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Appendix 2
SURVEY OF THE COUNTRY TEAM'S WORK

The organization, composition, and orientation of each of the country teams reflected the own interests and those of the institutions that hosted them, always within the framework of the STPI project concerns. A brief review of the approach and the work of each team may help to place the STPI project and the comparative reports in perspective. To complete the survey, a description of the field coordinator's office work is given.

ARGENTINA: The initial location for the Argentine team was the Department of Economics of the Catholic University. However, after some months, the university decided to withdraw its application and the country coordinator moved to the Argentine branch of the executive secretariat of the Latin American Social Science Council (CLACSO). The team was headed by Eduardo Amadeo, an economist, and two other members were appointed to work full time on the project. An advisory committee of several researchers and policymakers active in science and technology policy was formed. To carry out the research, the team relied on consultants who wrote reports on specific subjects that were integrated into a final report.

A significant change took place when the country coordinator was named president of the Instituto Nacional de Tecnología Industrial (INTI), the national industrial technology institute, which is the largest and most important industrial research organization in Argentina. Mr. Amadeo never relinquished his formal role as coordinator; after 6 months, he left his new post and resumed his position as country coordinator. Because most of the work was well under way, his absence did not substantially alter the team's pace, although the preparation of the Argentine synthesis report was postponed. Part of the team's work was reoriented to be most useful to the coordinator in his new position.

The Argentines focused on two branches of industry - machine tools and petrochemicals - but studied many broader issues. For instance, the reports include a document on the technological content of the 3-year development plan (1974-77), a study of the Argentine industrial structure, a description and brief analysis of technology policy instruments in Argentina, a study of the system for regulating technology imports, and several short reports on international technical assistance as an instrument of technology policy.

The structure of the Argentine scientific and technological system was studied in detail, as were the conditions under which it could be made more responsive to industry's needs. The Argentines covered the public sector, examining the possible role of the public sector as promoter of scientific and technological development. Detailed studies were carried out at two enterprises: one in charge of generating electricity in Buenos Aires (SEGBA) and the other in charge of generating and distributing gas for household and industrial consumption. Other contributions of the Argentine team were a study of the emergence and development of engineering and consulting firms in the chemical process industries, a detailed analysis of two research centres within the national industrial technology institute (INTI), and two short papers on capital accumulation and on the crisis of capitalism.

The Argentine team followed the methods guidelines; however, they produced a series of thematic reports on issues of actual and potential interest to policymakers in the country, coinciding with the themes selected for study in STPI.

BRAZIL: The Brazilian team was hosted at the research group of the Financiadora de Estudos e Projetos (FINEP), the state agency in charge of financing studies for investment projects and also the executive arm of the national fund for scientific and technological development. The first coordinator was the director of the research group,
Fabio Erber. When he took a leave of absence from FINEP in September 1974, he was replaced by José Tavares, the new head of the research group. The group at FINEP had been carrying out research on science and technology policy for some time, and the STPI assignment was one of its tasks for 1973-76. Practically all of the work was done by members of the FINEP research group, although two or three reports were contracted to professionals outside FINEP.

From the beginning, the Brazilians decided to concentrate on the role of state enterprises in technology policy. They chose branches of industry that were dominated by state enterprises (oil and petrochemicals, steel, and electricity), conducting detailed interviews, analyzing existing data, and testing hypotheses systematically to cover issues such as the selection of equipment and processes, the purchase of engineering services, the performance of research and development, and the planning activities at these state enterprises.

In addition to the new material generated by the Brazilian team during STPI, several reports based on past research carried out by FINEP were made available to the STPI network. These included background reports on the organization and structure of the Brazilian science and technology system, a study on the machine tool industry, a report on the demand for services of 12 research institutes, and a background report on industrial policies in Brazil during the last 2 decades.

In parallel with the work for STPI, the FINEP team was also engaged in a research project on the diffusion of technical innovations in three industrial branches (pulp and paper, cement, and textiles) and they agreed to put their results at the disposal of the STPI network as an additional contribution.

The Brazilian team used the guidelines only as a general reference, given that most of their work went along different lines from those originally envisaged for the project. Nevertheless, the richness and variety of their material effectively upgraded the comparative reports.

COLOMBIA: No Colombian participant was present at the initial organizing meeting, and the Colombian application to join the STPI network was received later and formally accepted at the Rio meeting of the coordinating committee. The team was hosted by the Colombian Council for Science and Technology, COLCIENCIAS, and was headed by a sociologist, Fernando Chaparro. In spite of joining the STPI network late, the Colombian team caught up with the pace of work and finished all its work by the deadline.

COLCIENCIAS organized a special team with five members who devoted practically all their time to research in STPI. Several other consultants were also asked to prepare reports on issues of specific interest such as selected policy instruments. For example, a study was commissioned on the impact of tariff mechanisms; a report was prepared on the influence of price controls; and a preliminary analysis of the possible use of the state's purchasing power as an instrument of technology policy was also prepared. The branches chosen for study were all linked to agriculture: fertilizers and pesticides, agricultural machinery, and food processing, taking into consideration the interests of Colombian policymakers as perceived by the team. In these branch studies, the methods guidelines were closely followed.

Other reports prepared by the Colombian team include a study of science and technology planning, an analysis of implicit industrial technology policies, a conceptual framework for the study of consulting and engineering organizations, a series of reports on industrial branches based on discussions with panels of experts, a study of science and technology policies in the agricultural sector (to complement the analysis done for industry), and two essays on the process of industrialization in Colombia and its technological implications.

Five groups of policy instruments were studied in detail, and their impact on each branch was examined through interviews at various enterprises. All of the findings were integrated into the final report of the Colombian team.

EGYPT: Although an Egyptian representative participated in the initial deliberations leading to the STPI project, it was not possible to organize the team to carry out
research and prepare inputs for the international comparison. There were several admin-
istrative difficulties and staffing problems that prevented the organization of a work-
ing team. The host institution was the Academy of Scientific Research and Technology
and the first coordinator was Adel Sabet, who was replaced by Gamal A. Samie in July
1975. The Egyptian team presented papers that were personal contributions based on
past experience rather than the result of research carried out by a team; and research
was not begun at the academy until the second half of 1976.

INDIA: The host organization in India was the National Committee on Science and Tech-
nology, and the first coordinator was Anil Malhotra, who was replaced in June 1975 by
S.K. Subramanian. Mr Subramanian resigned in March 1976, and no one replaced him. No
funds were requested to set up a country team in India, and the Indians provided back-
ground material that had already been collected as background for a new science and tech-
nology plan.

Three background documents were distributed along with the final S & T plan to
all the teams in STPI. In addition, a report on foreign collaboration, a note on
science and technology planning in India, a survey of engineering consultancy services,
a report on the development of the electronics industry, and two papers on small-scale
industries and technology transfer were distributed by the Indian coordinator. No em-
pirical research was done following the methods guidelines, and the Indian contribution
to the comparative reports reflects this.

SOUTH KOREA: The South Korean team was one of the first to be organized and was esta-
lished at the Korean Advanced Institute of Science, KAIS, as part of the activities of
its science, technology, and society program. KunMo Chung was named country coordinator
and the team consisted of five other members. All but one of them had other academic
duties and could allocate only a portion of their time to STPI research. Then, Graham
Jones was hired to advise in the preparation of the report for phase 1.

The South Korean team advanced rapidly and completed its work in time for the
Sussex workshop, following the methods guidelines and introducing modifications only
where necessary. Two reports were produced corresponding to the requirements for phases
1 and 2 of the project.

The branches chosen for study were electronics, petrochemicals, and powder
metallurgy, and a report was prepared for each one. In addition, the team prepared
documents on engineering services and industrialization in South Korea, on the Korean
Institute of Science and Technology, on transfer of technology in the electronics indus-
try, on the interface between the science and technology plan and the economic develop-
ment plan, and on state enterprises in technical development.

Although most of the work was done by the team located at KAIS, consultants
were asked to deal with specifics. The team predominantly represented engineering and
physical sciences, but an economist who was a senior governement official, helped to
relate the results to South Korean policymakers and to balance the other team members' biases.

MEXICO: The Mexican team was among the first to start working in STPI and was located
at El Colegio de Mexico, an academic and social research and graduate training organiza-
tion. Alejandro Nadal was country coordinator and there were four other members of the
team who worked full time on STPI. The Mexican team initially followed the guidelines
rather closely and was one of the first in suggesting modifications and changes as a
result of contrasting concepts with preliminary research findings. In particular, the
team found it difficult to interpret the results of interviews in enterprises using the
schema proposed to study technological behaviour. The branches chosen for detailed
study were capital goods, food processing, and petrochemicals.

A background report on the structure and evolution of the Mexican scientific
and technological system was prepared, together with a description of the industrial-
ization process and of agricultural development. Documents on particular subjects
included a report on engineering firms, a study of the technology policy of PEMEX (the
state oil monopoly), and progress reports dealing with hypotheses on the impact of policy
instruments on technical behaviour at the enterprise level, a description of policy ins-
truments in Mexico, etc.
Most of the findings of the Mexican team were integrated into the main final report, part of which was delivered at the coordinating committee in New Delhi (January 1976) and the rest at the Sussex workshop (June 1976). The work of the Mexican team covered practically all the research topics considered in STPI, and its contribution to the comparative report reflects this. The Mexican report was published in Spanish in 1977 and was awarded second prize in a contest for the best works in economics.

For various reasons, the Mexican team chose to limit its direct interaction with policymakers and followed its own research program. Results were made available to policymakers in the form of draft reports, and through the participation of the coordinator in one of the committees established to prepare the Mexican plan for science and technology.

PERU: The Peruvian team was established within the research group of the National Planning Institute. A series of administrative difficulties affected the progress of the team, including a change of technical director, when Fernando Gonzales Vigil was replaced by Roberto Wangeman in February 1975. Approximately two-thirds of the research was completed in time for the Sussex workshop.

From the beginning, the team decided to adopt a sectorial approach to the research. Efforts were focused on the study of industrial branches connected with the extraction and processing of minerals and with the provision of machinery for the mining industry. The steel industry was also studied, with emphasis on the state enterprise in charge of the largest steelworks. This meant that the guidelines were used primarily in sectorial studies and in the analysis of policy instruments.

Background reports on the situation of the scientific and technological system and on the evolution of Peruvian industry were prepared following the general framework put forward in the guidelines. In addition to these and the sectorial reports, the team prepared other documents, dealing with issues such as explicit and implicit science and technology policies, consulting and engineering capabilities, the possible use of state enterprises as instruments of technology, and the government administrative machinery for science and technology policy.

The Peruvian team was located within an official government organization, but its direct impact on policymaking is difficult to assess because it took the form of daily contact with government officials. On the basis of the sectorial reports on mining, a committee has been set up to review the findings of the STPI team.

VENEZUELA: The Venezuelan team was hosted by the national council of science and technology (CONICIT) and was among the first to start working. The team was initially dominated by sociologists, although economists increased their participation at later stages. The first coordinator, Dulce de Uzcategui, was replaced by Luis Matos, who was soon followed by Ignacio Avalos. Three other members worked full time, and the team was biased toward sociology and economics.

They progressed through two stages punctuated by a change in government. In the first stage, most of the background reports corresponding to phases 1 and 2 of the STPI methods were prepared, covering the science and technology, the political, the educational, and the economic systems. These reports were made obsolete by the change in government. In the second stage, the team tried to adjust to the new situation, repeating some of the earlier studies and continuing the research. However, the organization of a national congress on science and technology, which mobilized all the staff working at CONICIT, affected the team’s progress.

The branches chosen for study were capital goods, electronics, and petrochemicals. In addition, reports were written on specific issues such as the government organizational structure for science and technology policy, instruments for industrial science and technology policy, economic and financial policy instruments and their impact on technology, the purchase of capital goods in two industrial branches, and the relations between the financial system and technology policy. The Venezuelan team concluded its research shortly after the Sussex workshop.

The fact that the Venezuelan team was located in a government agency that took
a very active role in science and technology policy after the change in government created both opportunities and problems. As a result of the new tasks undertaken by CONICIT, the pace and continuity of the STPI work was frequently altered. On the other hand, there was more possibility for actively contributing to policymaking. The Venezuelan contribution to the comparative reports reflects this situation.

YUGOSLAVIA (MACEDONIA): The Macedonian team was organized at the faculty of economics of the University of Skopje. A senior faculty member, Nikola Kljusev, was appointed coordinator. The team was composed of a very large number of faculty members and researchers who devoted part of their time to STPI. The tasks were subdivided and individual reports requested from various members of the team, although at a later stage two team members were asked to work full time on STPI.

The Macedonian team did not follow the guidelines, except in the preparation of a background report for phase 1. Individual reports were submitted on issues of interest to the STPI network, covering topics such as the problems of research and development in industrial enterprises, aspects of science and technology policy in Yugoslavia, the metallurgical industry in Macedonia, and the growth of engineering firms in Yugoslavia.

The Macedonian team's specificity is reflected in their relatively limited contribution to the comparative reports. At any rate, given the high degree of participation of professionals at all levels in policymaking in the Yugoslav self-managed economy, it is rather difficult to assess their contribution toward policymaking in conventional terms.

THE FIELD COORDINATOR'S OFFICE: In August 1973, at the first meeting of the coordinating committee, Francisco Sagasti was appointed field coordinator of the project and his office was established shortly thereafter and began operating in a limited way. Staffing was completed in April 1974 with the addition of two members.

The field coordinator's office was independent from the teams and was not engaged directly in empirical research. It offered organizational and technical support and contracted consultants to prepare reports on topics defined by the coordinating committee.

The field coordinator, first, drew up methods guidelines for phases 1 and 2 of the project. Background reports on technology policy in China, on technological dependence/self-reliance, on science and technology planning, on technology policies in Japan, and on technology transfer were also prepared, either by staff members of the field coordinator's office or by consultants. The guidelines for phases 3 and 4 of the project were prepared jointly by the field coordinator and a consultant. The office also organized the Sussex workshop and drafted the comparative reports. The field coordinator was also active in the board of the Peruvian Industrial Technology Institute (ITINTEC).

With the exception of the teams that were engaged in science and technology policy research as part of the activities of their institutions (the Brazilian and South Korean teams, for example), the teams were dismantled after the STPI project was completed. The field coordinator's office was closed in December 1976, and the comparative reports were prepared during 1977-1978, although some teams had not finished their work by April 1978. Even though most teams had concluded their STPI activities by the end of 1977, this does not mean that the team members left the field of S & T policy research and that their effort in STPI was not followed up. What was dismantled, as planned from the beginning, was the formal structure of the STPI project. The network of personal contacts remains in operation and most of the former team members are active in the field of science and technology policy, carrying the experience accumulated in STPI to their new positions.
Key to STPI Publications

Primary
(1) The STPI Project
(2) Methodological Guidelines
(3) Main Comparative Report
(4) Planning
(5) Chinese Technology Policy/Industrialization

Country Papers
(30) Mexico
(31) Korea
(32) Peru
(33) Colombia

Background Papers
(22) El INTI en la Industria Argentina
(23) El Sector Maquinas Herramientas en la Argentina
(24) Los Instrumentos de Politica Cientifica y Tecnologica en Argentina
(25) Brazilian Machine-Tool Industry
(26) Los Bancos y Comercializacion de Tecnologia
(27) La Industria Petroquimica
(28) La Variable Tecnologica y las Variables Horizontales
(29) Indian Electronics Industry

Modules
(6) S&T: Differing Schools of Thought
(7) Evolution of Industry
(8) Evolution of S&T
(9) S&T - Present Status
(10) Policy & Generation of Technology
(11) Policy for Imports
(12) Policy for Technology Demand
(13) Policy to Promote Industrial S&T
(14) Policy for Industrial S&T Support
(15) Industrial Technical Changes
(16) Industrial Technology Behaviour
(17) Technical Change Studies

Selections
(18) S&T Policy & Development
(19) Engineering Consulting & Design in LDCs
(20) Technology Transfer in LDCs
(21) State Enterprises & Technological Development
A GUIDE TO THE
SCIENCE AND TECHNOLOGY POLICY INSTRUMENTS
(STPI) PUBLICATIONS

A. Primary Publications
(1) The Science and Technology Policy Instruments (STPI) Project (IDRC-050e) (out of print)
(2) Science and Technology Policy Implementation in Less-Developed Countries: Methodological Guidelines for the STPI Project (IDRC-067e) (out of print)
(3) Science and Technology for Development: Main Comparative Report of the STPI Project (IDRC-109e).
   (Also available in French (IDRC-109f) and Spanish (IDRC-109s).)
(4) Science and Technology for Development: Planning in STPI Countries (IDRC-133e)
(5) Science and Technology for Development: Technology Policy and Industrialization in the People’s Republic of China (IDRC-130e)

B. Modules
These constitute the third part of (3) above and provide supporting material for the findings described and the assertions made in (3).
(6) STPI Module 1: A Review of Schools of Thought on Science, Technology, Development, and Technical Change (IDRC-TS18e)
(7) STPI Module 2: The Evolution of Industry in STPI Countries (IDRC-TS19e)
(8) STPI Module 3: The Evolution of Science and Technology in STPI Countries (IDRC-TS20e)
(9) STPI Module 4: The Present Situation of Science and Technology in the STPI Countries (IDRC-TS22e)
(10) STPI Module 5: Policy Instruments to Build up an Infrastructure for the Generation of Technology (IDRC-TS26e)
(11) STPI Module 6: Policy Instruments for the Regulation of Technology Imports (IDRC-TS33e)
(12) STPI Module 7: Policy Instruments to Define the Pattern of Demand for Technology (IDRC-TS27e)
(13) STPI Module 8: Policy Instruments to Promote the Performance of S and T Activities in Industrial Enterprises (IDRC-TS28e)
(14) STPI Module 9: Policy Instruments for the Support of Industrial Science and Technology Activities (IDRC-TS29e)
(15) STPI Module 10: Technical Changes in Industrial Branches (IDRC-TS31e)
(16) STPI Module 11: Technology Behaviour of Industrial Enterprises (IDRC-TS32e)
(17) STPI Module 12: Case Studies on Technical Change (IDRC-TS34e)

C. Selections
These are a selection of the numerous reports prepared for the STPI Project chosen as a representative sample of the various topics covered by the STPI Project in the course of the main research effort on policy design and implementation.
Science and Technology for Development: A Selection of Background Papers for the Main Comparative Report.
(18) Part A: Science and Technology Policy and Development (IDRC-MR21)
(19) Part B: Consulting and Design Engineering Capabilities in Developing Countries (IDRC-MR22)
(20) Part C: Technology Transfer in Developing Countries (IDRC-MR23)
(21) Part D: State Enterprises and Technological Development (IDRC-MR24)

D. Background Papers
(22) El INTI y el Desarrollo Tecnologico en la Industria Argentina (In press)
(23) El Sector Maquinas Herramientas en la Argentina (In press)
(24) Los Instrumentos de Politica Cientifica y Tecnologica en Argentina (In press)
(26) Rol de los Bancos en la Comercializacion de Tecnologia (In press)
(27) Comportamiento Tecnologico de las Empresas Mixtas en la Industria Petroquimica (In press)
(28) Interrelacion Entre la Variable Tecnologica y las Variables Horizontales: Comercio Exterior, Financiamiento e Inversion (In press)
(29) A Planned Approach for the Growth of the Electronics Industry — A Case Study for India (In press)

E. Country Reports
(30) Instruments of Science and Technology Policy in Mexico (In press)
(31) Technology and Industrial Development in Korea (In press)
(32) Los Instrumentos de Politica Cientifica y Tecnologica en el Peru: Sintesis Final (In press)
(33) STPI Country Report for Colombia (In press)