CHAPTER III:

REASONS FOR STATE SUPPORT OF SR IN CAPITAL GOODS DESIGN

III.1: Introduction

In the first part of this Chapter (Section 2) we discuss some reasons why the market mechanisms may lead the private capital goods enterprises to invest less in SR in design than it may be desirable from the point of view of the growth of important sectors of the economy, leading the State to support such investment.

Two points deserve being stressed about such arguments, which are a development of some points widely accepted in the literature on R&D as a case for State intervention in this area.[1/]

First, they do not show that SR is preferable to licensing - in fact, the literature on R&D generally ignores the question, a treatment which can be justified only in the context of an autarkic economy, inappropriate, of course, to the case of the LDCs. Second, they are arguments which apply to any capitalist economy, being intrinsic to the system of private property, i.e. because of their level of abstraction they ignore some specific features of the LDCs, Such points are discussed in the concluding part of Section 2.

The second part of the Chapter (Section III.3) is concerned mainly with the two last points mentioned above - with the comparison between SR and licensing with emphasis on the specific conditions of the LDCs. We shall assume that a range of capital goods has to be produced locally at a given point in time (e.g. because of a foreign exchange constraint

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1/ Such arguments are well developed in Nelson (1959) and Arrow (1962a, 1962b). Pavitt (1975) provides a brief survey of the main arguments in favour of State support of R&D, covering also other arguments (such as "strategic supplies") discussed in Section 3.

and because of other projects' requirements) so that the option is about which design strategy to use for their production.

The first part of Section 3 compares the two strategies in terms of their displacement of other projects by their use of foreign exchange and internal savings. The second and third parts of the Section compare the two strategies in terms of risk and time preference and in terms of creation of technical capacity in the economy in the light of the arguments developed in Section 2. The fourth part of Section 3 examines the influence of nationalism on the choice of strategy, a point neglected in the autarkic treatment of the issue. The fifth part examines some specific features of the LDCs for which the licensing alternative may be especially inappropriate, especially the problem of employment. Finally, the last part of the Section discusses briefly the influence of value judgements on the assessment of State support to SR and indicates some obstacles to the implementation of such policies, specific to the LDCs. The latter are taken up again in Chapter VI, after the discussion of the Brazilian case, specifically referred to such country.

III.2: Reasons for State Support to Design Activities because of the Functioning of the Market Mechanisms in a Closed Economy.

(a) Externalities from untraded information

Through its activities of design and production, the capital goods industry performs a role of generating and developing engineering skills. Part of such knowledge is then diffused throughout the economy untraded - especially through informal exchanges of information and movement of technical personnel.

In the case of movement of personnel it has been argued (Johnson, 1970) the existence of externalities will depend on the organisation of the labour market - that labour could pay for its training through lower wages and then be compensated by the firm to which it has moved by higher wages. However, only under very restrictive assumptions will there be no externalities involved in such movement: not only would perfect labour markets be required, but also that the costs of training and the increases in productivity of designers because of such training be perfectly identifiable. As the training in design is based on learning by doing and the production of design (especially preliminary design) is highly dependent on personal creativeness, such assumptions do not hold in practice.

The exchanges of information and movement of personnel are reciprocal among the capital goods enterprises and between them and other enterprises, downstream and upstream the industry. Moreover, because of the role played by design activities, their results affect also the productivity of other factors of production (e g. labour), so that they are "non-separable". As it is known, when externalities are reciprocal and non-separable, Pigovian compensations are not feasible (Nath, 1960).

Moreover, the skills and knowledge developed for one product can be applied to other products as well, which enhance the importance of the externalities above-mentioned.

Such externalities are linked to the person-embodied character of design knowledge, discussed in detail in the preceding Chapter, but externalities may also arise from the product-embodied knowledge, through reverse engineering. Although patent laws and other instruments of making knowledge proprietary limit the externalities from reverse engineering,

they are not, as it is known, totally efficient (see Appendix A).

The externalties discussed here can be seen as the result of differentiated learning processes by individual enterprises (see (b)) and are an important element in evening out the disparities of technological development within the economy.

Although informal exchanges of information, movement of personnel and reverse engineering have an opportunity cost for the firm which originated the knowledge, for the society such knowledge has no opportunity cost, as no further expenses are required for its transmission (Arrow, 1962a).

(b) Externalities from learning

Experience is, as we saw in the preceding Chapter, of critical importance in the capital goods industry's design. Such learning implies that, over time, the performance and reliability of the capital goods are improved and delivery-times shortened (or at least more accurate), while costs often do not rise in the same proportion.

Because the capital goods is the supplier of the means of production to the other sectors in the economy, changes in the design of its products affect the productive process of the other sectors - the improvements above-mentioned normally leading to a higher productivity of labour and better utilisation of raw materials. They are also often essential to the product differentiation on which the competitive success of the users is based (see Chapter II).

Therefore, improvements in the design of capital goods tend to lead to higher profits for their users; sometimes, depending on the structure of markets, to lower prices to the final consumers and, in general, to an increase in quality of the goods produced. Part of such benefits may not be reflected in the price of the capital goods, and represent thus an externality to their purchasers.

The learning involved in the design process of capital goods implies also that the productive capacity of the resources used increases over time. Such resources (especially manpower) in the future can be used not only by the enterprise which bears the cost of design but also by others, and the former cannot usually appropriate all the benefits deriving from such increased productivity (aee (a)): i.e. what are, in the short run and for the individual enterprise, costs, are, in the long run, and for the economy, the building up of productive assets.

As we have shown in Chapter II the investment in technological capacity by the capital goods industry will induce similar investments by its suppliers of design inputs, where analogous learning processes will probably occur. The combined effect of such learning processes, which are mutually supporting, leads to an increase in the general productive capacity of the economy.

However, learning provides external economies <u>in the future.</u> This time-dimension is of critical importance, as in the short run there may be off-setting diseconomies, especially because of higher risks, which are inherent to the early stages of learning.

(c) Private and social risks

As discussed earlier, the greatest private deterrent of SR is the risk of failure. Such risks, which may lead the capital goods enterprise to bankruptcy end-point or to gambler's ruin, are increased by the deficiencies of risk-capital markets (see Chapter II).

Nevertheless, a considerable part of such risks will be absorbed by the purchasers of capital goods, as insurance markets in such cases do not operate [1/] and as the capital goods producers cannot fully compensate the purchasers for losses in case of failure, especially in the case of custom-built equipment (see Chapter II). [2/]

However, in conditions of imperfect knowledge, such risks may be overestimated: because of lack of information about the technical capacity of the producers of capital goods their customers may have an inflated estimate of the risks involved in accepting new designs.

Moreover, because of the cumulative, mutually supporting nature of the SR process, the risks of failure will tend to be reduced

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1/ Insurance markets which would "price" such risks are normally non-existent because of:-

(i) the intrinsic difficulties of estimating the probabilities of the outcomes of SR investment, which depend on the behaviour of other economic agents, which the insurer cannot predict;

(ii) the difficulty of distinguishing between a "state of nature" and a decision of the insured - the "moral factor" problem (see Arrow, 1962a);

(iii) because the base of the market (those who wish to be insured) would probably be small and the risk high, the premium of the insurance would be very high.

2/ Purchasers of capital goods may be partially compensated if the producers charge lower prices for the new (riskier) products.

if several producers are simultaneously developing designs. However, lack of information about the investment of other enterprises may increase the risk-perception of the individual enterprise about its own investment.

Therefore, imperfect knowledge may compound the deficiencies of the capital and insurance markets and make the enterprises' risk discount greater than the social discount.

In this sense, the action of the State as coordinator of economic activities and provider of information to the individual enterprises about the "state of the art" in the industry is of critical importance.

Moreover, in social terms, failures in one producer may be compensated by successes in others. Such approach is, of course, exclusive to the State, as for each individual producer the failure to develop a commercially and technically appropriate design may be highly damaging (see Chapter II); although the State can, as it does in the ACs, reduce the consequences of such failures, e.g., by grants (ibidem). This "portfolio approach" will tend also to be limited to the more standard, general purpose capital goods (e.g. machine tools). 1/

Nevertheless, it is important to stress that the repercussions of failures in the enterprises which use the locally designed capital goods may largely offset the benefits accuring from the local development of SR

1/ Standard products tend to be produced by many firms and consequences of failure are less drastic for the producers (which tend to manufacture a range of models) and for the direct and downstream customers (as such goods are often auxiliary equipment and more easily repairable and replaceable than custom-built equipment).

capacity in the capital goods industry (e.g. the failure in power systems bring the industrial activity of a whole region to a halt).[1/]

Therefore, the eventual difference between social and private risks will depend on the type of product, being probably greater for standard products than for custom-built equipment. It will also depend on the degree of concentration of supply as the fewer are the suppliers in relation to their demand, the greatest will be the effects of their failures on other producers or customers.

(d) Time preference

As several authors have shown, the market mechanisms do not offer normative indications to the State as to what should be the social time-discount rate, so that such rate has to be established in accordance to national policy objectives (e.g. the desired rate of growth) and value judgements.[2/]

Therefore, the State's time-discount rate may be different from that of producers and customers of capital goods[3/] and so will be the evaluation

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1/ Moreover, "downstream" customers may have to pay higher prices as a defence of the purchaser of capital goods against the increased risk.

2/ If the economy was on an optimal growth path, the marginal productivity of capital could be used as a time-discount rate (UNIDO, 1972) but this is of course, a highly restrictive and, in practice, unrealistic assumption. Market interest rates reflect imperfections in such markets, but even if such markets were perfect they would not reflect externalities in savings - the fact that individuals may be willing to save more if others were doing the same (Marglin, 1963; UNIDO, 1972) - although some argue that, in practice they are the best basis available for estimating the time-discount rate. Finally, Government institutions by having their own, differentiated interests, will have specific discount rates (Arrow and Lind, 1970).

3/ Producers and customers of capital goods may also have different time-discount rates, because of differentiated levels of income and wealth and different prospects of income growth.

of the time involved in the development of designs. In case the State's discount rate is lower, this will reinforce the case for its intervention in favour of SR. Such difference may be increased if the producers and customers of capital goods operate in practice with a finite, relatively short-term horizon.

(c) Conclusions

The reasons above discussed may lead to State support of greater SR in design in the capital goods industry, but they are not a sufficient condition to warrant such support.

Although, as pointed out by Nelson (1959) and Arrow (1962a), among others, such reasons apply to any capitalist economy, as they are intrinsic to the system of private property and atomised decision-making, their assessment will probably vary with the conditions of development of the country.

For instance, in a poor economy, the pressure for raising the consumption standards immediately will probably be considerable, increasing the State's time-discount rate. However, at the same time, where the technical capacity of the economy is undeveloped, the relative importance of investments in SR will be probably greater. If the other sectors of the economy are relatively backward technically in comparison with the capital goods industry, the externalities previously discussed will be especially important in raising their technical capacity.

Moreover, our analysis suggests that such support to new designs will vary according to products and the concentration of supply. In some cases, social as well as private considerations may recommend caution in such support. In a poor economy, where there are few producers of capital

goods and other products, the effects of failure in each of them is probably stronger than where each producer accounts for a relatively small portion of total supply. At the same time, in a poor economy, it is probable that the deficiencies of risk-capital and insurance markets will be especially pronounced.

Therefore, in the poorer economies the conflicts in the State support of greater SR above analysed, are probably stronger than in richer countries.

Moreover, the analysis above ignores the opportunity cost of such support. It ignores especially the existence of alternative sources of supply of design from abroad - licensing and imports of capital goods. In fact, the literature on R&D from which the previous discussion in good measure stems, [1/] has normally ignored the possibility of using another country's investment in R&D and design - a treatment which is justifiable only in the context of an autarkic economy, an untenable assumption especially in the case of the LDCs. [2/]

Moreover, by taking a "closed economy" approach the arguments previously developed, omit another important reason for State support of local designs - international competition and protection of local production and nationalism, points which are brought to the fore by an "open economy" analysis, and dealt with in the next Section.

In the following Section, we shall assume that there is a range of capital goods which must be produced internally (e.g. because of a foreign

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1/ Especially from Nelson (1959) and Arrow (1962a and 1962b).

2/ As it is known, the LDCs' development was from its insertion in the capitalist system oriented towards exports to the more advanced countries, so that closed models are especially inappropriate to their conditions.

Exchange constraint) so that the decision that has to be taken centres around their technological strategy. In other words we shall not consider the imports option, assuming that, if such comparison was made, the local production of capital goods has passed the tests and has been judged necessary.

III.3) Licensing and Self-Reliance Compared

In this Section, we compare the alternatives of licensing and SR, under the assumptions previously stated. We begin by analysing their differences in terms of other projects displaced by their different use of foreign exchange and internal savings. We then compare the two strategies in terms of their respective opportunity costs in terms of learning, risk and time, using the analysis developed in the previous Section. In the third part, we compare them in the light of nationalist considerations. Finally, we discuss some needs, specific mainly to the LDCs, for which there is no licensing alternative but which the market forces may fail to substantiate and which may require State support to design in the capital goods industry.

(a) Other projects displaced - foreign exchange and internal savings use

The two strategies use different resources - licensing uses mainly foreign exchange and SR mainly internal savings - so that the projects affected by them are likely to be different.

Therefore, in terms of growth of the economy, the relative importance of the two strategies will partly depend on what presents the greater constraint to growth: foreign exchange or internal savings.

Under conditions of low trade elasticities and unrealised savings

potential [1] a country may face, in practice a foreign exchange constraint (Stewart, 1976). In such conditions a SP capacity may be desired to alleviate such constraint as it may result in:

(i) import substitution of finished products

(ii) import substitution of licensed technology

(iii) better conditions of bargaining for technology still licensed

(iv) export expansion, via removal of barriers of licensing and of new products.

Because capital goods normally represent a high share of the imports of the more industrialised LDCs (see Chapter V) and because the production of capital goods is generally a highly labour intensive activity, where the LDCs could use to advantage their low-cost manpower, [2] the industry is likely to receive priority for SP if there is a foreign exchange constraint.

It is important to note that because of the role played by the capital goods industry as a locus of development of engineering skills, similar foreign exchange effects may spread to other industries too.

However because of the time-dimension of the process of achieving a design capacity, foreign exchange benefits are likely to occur only in

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1/ Also, as remarked by McKinnon (1964): "the idea of a /foreign exchange/ bottleneck is largely associated with very different levels of economic development among countries so that advanced countries can potentially send complex industrial capital goods to underdeveloped areas. The same conditions would not apply so strongly to Britain at the initial stages of her industrial development....." (p. 371, my emphasis).

2/ Although the industry employs a relatively high percentage of skilled workers, the Brazilian experience suggests that this has not been a bottleneck (see Leff, 1968 for a detailed analysis).

the long run. Moreover, where the resources for design are undeveloped, achieving such capacity may require imports in the short run.

If the country faces an internal savings constraint stronger than the foreign exchange constraint licensing will present relative advantages over SR, as the latter will be financed mainly from internal savings. Nevertheless, even in such case, SR could be justified if it led to future reductions in the relative requirements for internal savings (e.g. by the development of capital-saving techniques); given the appropriate time-preference and magnitudes of present and future internal savings used.

The internal savings constraint will bear more severely upon a strategy of SR in the capital goods industry if there is a bottleneck in in the supply of design inputs (see Chapter II), requiring additional complementary investments (e.g. engineering schools, research institutes), although it is important to note that the result of such investment will be used by many other industries.

Where the supply of design inputs requires considerable investments, as tends to be the case in the LDCs, a strategy of SR in the capital goods industry may be only justifiable if it is concomitant with similar strategies in other industries as well (see Chapter VI).

In countries where there is a lack of infrastructure facilities (transport, energy, etc.) for several reasons [1/] the State has to promote

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1/ Such as the atomisation of savings and the lack of capital markets coupled to the capital intensity, indivisibility and long period of maturation of such projects and to the fact that there is usually a great pressure on suppliers of such products to keep their prices low in order to facilitate general capital accumulation. The same arguments apply to "basic industries", such as steel.

and finance such investment and the internal savings constraint to growth may become, in practice, a fiscal capacity constraint. 1/

Such investment in in rastructure tends to be highly capital intensive, indivisible and with no tradable alternative and it is a necessary condition for the immediate capital accumulation of most capitalists. If the investment in SR requires substantial State resources and if it conflicts with the investment in infrastructure (i.e. if the fiscal constraint has been reached), it is most probable that the entrepreneurs will prefer, from the point of view of growth, to use a licensing strategy.

Although the indivisibility of the investment in SR mitigates this type of conflict, the argument above reinforces the points previously made about the necessary partiality of a strategy of SR. It also suggests that the strategy requires a minimum level of economic development to be implemented.

It is important to stress that the constraints above discussed may not be reflected in the market prices - e.g. a country may have a foreign exchange constraint but nevertheless keep an overvalued exchange rate in order to benefit importers of, say, capital goods - a situation often found in the LDCs (see Chapter V).

1/ The fiscal capacity depends not only on economic conditions but also on political conditions as well; authoritarian regimes being probably more able to increase it quickly than democractic ones. In this sense, it is possible that the literature on economic development may have over-estimated the fiscal constraint in LDCs.

Where the relative prices of foreign exchange and internal savings do not reflect their relative scarcity, the choice of strategies by the enterprises (following market prices) will be biased and may not reflect the social opportunity costs of the resources used.

Although the State may be unwilling or unable to correct this directly, by changes in such relative prices, because of the interests involved in the status-quo, some of its institutions may use shadow-pricing 1/ to compare the total amount of resources used up by each strategy in projects submitted by private enterprises. However, in practice such comparison is very difficult, even when comparing the costs of SR and licensing for a single product's design, i.e. without taking into consideration their use for similar products. 2/

Given that the expenditures on licensing and SR tend to spread over a number of years, especially the former, 3/ when comparing them consideration should also be given to the probable future constraints bearing on the economy. For instance, if a country has at the present moment abundant foreign exchange resources, but it is foreseen that in the future there will be a foreign exchange shortage (e.g. because of technical changes

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1/ See Sen (1972) for an interesting discussion of this point.

2/ If the products are new to the firm and represent a substantial departure from its previous experience the cost of their design may be quite uncertain. On the other hand, the costs of licensing are set through a bargaining process in which the opportunity costs of the licensor are not usually known to the licensee in advance. Moreover, an SR capacity in the licensee's country will reduce the cost of licensing, by providing local enterprises with better bargaining conditions (see Chapter II).

3/ While expenditures for developing a design tend to be concentrated on the near future, expenditures for licensing tend to continue as long as the licensed product is sold.

which may displace its main exports in the international market), it may begin now to implement a strategy of SR, possibly in conjunction with licensing, in order to relieve the foreign exchange constraint in the future. Moreover, because of learning, the costs of SR may decline with time, reducing its use of internal savings.

(b) Risks and time-preference

If the sponsors' requirements (performance, reliability and delivery time) are similar in the two economies, and if the producers of capital goods abroad have more experience of design than the local producers, licensing will probably present relative advantages over SR in terms of satisfying such requirements. Under such conditions the private opportunity cost of SR for the process of capital accumulation of the capital goods producers and their customers may be considerable, especially when the gap in experience between local and foreign producers is great and the requirements are stringent (see Chapter II). Where the risk-capital and insurance markets are especially defective, as is the case in the LDCs, this cost is increased.

Taking into consideration the consequences of the investment of the capital goods enterprises and of their customers in terms of incomes generated and reinvestment, the social opportunity cost of SR may be considerable too, if such strategy leads to failures and delays in investment, which could be avoided by using licensing. This social opportunity cost will be especially high if the industries affected are those which provide essential inputs to the process of accumulation of many other industries, such as electric power and "basic" industries, such as steel and chemicals. In such industries, as we have seen in Chapter II, design requirements tend to be very stringent.

Therefore the existence of a licensing alternative increases the private and social opportunity costs of a strategy of SR if the licensors have a greater design experience than the local enterprises. In such cases, the other advantages of SR over licensing (see next part) will have to be very high to warrant support to SR.

The time-dimension is also critical here. Learning will, with time, reduce not only the costs but also the risks of SR. This may justify an investment in SR even if the costs and risk of local designs 1/ are greater than those of licensing, especially if the gap between the licensee's and the licensor's experiences is not great. In such circumstances the possibility of developing the local designs in conjunction with the use of licensing may reduce the risks of SR further (see (c) below). The wider the gap between the two, the more pronounced would have to be the learning and longer the time-prospect to justify the investment. In the case of the LDCs this probably excludes a wide range of the more complex, custom-built equipment (e.g. heavy electrical generation equipment, large maritime diesel engines).

We have assumed above that the experience of design abroad is greater than the local. In fact, in any diversified economy, it is probable that there will be a range of products for which the experience abroad will be greater than that locally. Conversely, if the local enterprises have been investing in design capacity, it is probable that there is a range of products for which local experience is greater. In other words, from the point of view of efficiency in satisfying sponsors' requirements, if there has

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1/ Costs of design and risks deriving from high performance and reliability requirements are closely associated, as we have seen in Chapter II.

been investment in SP locally and abroad, strategies of autarky or total reliance on licensing are likely to be less efficient than mixed strategies, at the national level as that of the firm (examined in Chapter II).

However, if the economy is growing and diversifying and if there has been no local investment in SP, private and social considerations will tend to restrict the range of products to which this strategy is likely to be applied, since in a growing and diversifying economy the design requirements tend to become more stringent (see Chapter II).

An extensive and growing reliance on licensing may be compatible with high growth rates, but only under certain conditions:

First, that there will be no foreign exchange constraint on the purchase of additional technology from abroad. Second that the necessary technology from abroad will be available. The availability of technology from abroad may be restricted because of political reasons (see (d)) but also because the characteristics of the products designed abroad may be inappropriate to the conditions of the recipient country. This last point implies dropping our assumption that the sponsors' requirements are similar, in which case the experiences of local and foreign producers are less comparable and so are the risks and time of the two strategies (see also ~~Section 4~~ (2)).

(c) Creation of technical capacity and externalities

Licensing per se, we have argued in the preceding Chapter, may lead to the development of manufacturing and detailed design skills in the licensee, but not to the development of preliminary design skills.

However, within the design process the latter are the most necessary skills for the development of innovations and product improvements. In other words, licensing allows the introduction of innovations (developed abroad) but does not create the capacity for introducing innovations. SR, in contrast, leads to the development and diffusion of preliminary design skills.

Therefore, although the private firm's expenditures in licensing do lead to the creation of some productive assets for the economy under the form of increased technical capacity, the importance of such capacity is substantially less than that created by an SR strategy. For the same reasons the externalities of information accruing from a licensing strategy are less important than those deriving from SR expenditures.

In other words, in licensing the difference between the private and social importance of expenditures in terms of creation of technological capacity and diffusion of such capacity through the economy, pushing the production frontier forward, is less than in SR.

Therefore, taking the two strategies separately, even assuming that the foreign designs are more efficient as regards satisfying sponsors' requirements than the local designs, in social terms there is a trade-off in the use of licensing: between the increase in efficiency of accumulation of the purchasers of capital goods and the increase in the efficiency of accumulation of the enterprises affected by the process of creation and diffusion of technical knowledge via SR. A comparison between the two strategies on this account depends on the products affected - their complexity and similarity to other products (i.e. possibility of diffusion) - and on the linkages of the enterprises which use such products.

It also depends on the desired time-path of growth, as the benefits of SR will take longer to materialise than those of licensing.

However, in the context of a mixed strategy, the skills developed through licensing can be used to reinforce those developed through SR, especially if there is a degree of complementarity between the products to which the strategies are being applied. In such case, the technical progress benefits can to some extent be realised without forsaking most of the benefits of licensing. In the long run this may also allow a substitution of SR for licensing (see Chapter II).

Therefore, also from the point of view of social learning, a mixed strategy with the two strategies combined in a complementary way is probably the optimal strategy. From the national point of view, the complementarity could be sought for products of different enterprises, so that a mixed strategy would be compatible with some enterprises being totally SR and others totally reliant on licensing.

However, a mixed strategy may not be feasible under free market conditions, especially if there is an initial gap between the sponsors' requirements and the local enterprises' experience and such gap can be satisfied by licensing. In fact, the market mechanisms will stress more the disadvantages of SR in terms of risk and time than its advantages of development of technical skills, which are, to a large extent, transacted outside the market mechanisms (see Section 2).

Under the present supposition that the licensed designs are more efficient than the local designs from the private point of view, under free market conditions, as customers will not accept the local designs the capital goods enterprises will not invest in SR capacity, which, in turn,

will reinforce the advantage of licensing. If the capital goods markets are oligopolistic and the strategies of the enterprises interdependent this process is reinforced - if licensing gives one competitor advantage, the others will follow. Moreover, as under licensing preliminary design skills are not developed, the chances of other competitors developing alternative designs are reduced. Under conditions of high concentration, the producers using licensing may even oppose State policies supporting SR if they can be used by eventual competitors.

As the economy grows, and sponsors' requirements become more stringent the market forces above analysed, will probably lead to an increasing reliance on licensing, with SR being applied only to the simpler and older vintages of products.

Therefore, when there is an initial gap between the sponsors' requirements and the local enterprises' experience and such requirements can be satisfied by licensing, a strategy of investment in SR in conjunttion with licensing, would require State intervention. Given the risk of new designs which the customers will have to absorb, it is probable that an intervention via price mechanisms (e.g. lowering the cost of the locally designed capital goods) will not be enough - a consensus may have to be administratively and politically established between the State, the producers and customers of capital goods as regards the development and use of local designs. Given the time-dimension involved, this consensus has to be structured around a long-term prospect. In a capitalist system divided into Nation States, nationalism provides the best ideological framework for structuring such consensus, as it stresses both the common purpose of the actors involved and the need of the State to protect local economic activities against competition from abroad (see (d) below). The Japanese case, with its high degree of cohesion between State and private enterprises (Barria, 1974)

and its prospect of an independent national development, presents the best example of the implementation of such a policy of investment in SR coupled to licensing.

(d) Nationalism

Nationalism, although not a logical necessity of the capitalist system, 1/ is an intrinsic aspect of the way in which it developed historically, divided into Nation States, and because of the role the State plays in such ideology, it is a prime determinant of its policies, inclusive of its support of local design.

In fact, the internal political cohesion of capitalist societies and the role the State plays there, are based on the idea of the people as a unity - the body of citizens equals in front of the law, mutually responsible and supposedly equally represented by the State. In a world divided in Nation States, for such a concept to be effective requires that each Nation State be sovereign, 2/ that the State will place the interests of its citizens above the interests of the citizens of other States, and that the main allegiance of the citizens of each State will be to their fellow citizens and to their State. Those are also the basic points of a nationalist ideology, as differentiation from nationalism as simply, "a feeling of national consciousness - nationalism in a weak sense" (Kamenka, 1973, p. 15).

1/ From the logical point of view, the capitalist system could operate as a single State, for instance as a federation of different regions.

2/ The concepts of "citizen" and of the "people-nation", date from the French Revolution which, together with the Industrial Revolution (Hobsbawm's "dual revolution"), shaped the historical form of capitalism. "The source of all sovereignty", said the Declaration of the Rights of Man and Citizens, "resides essentially in the nation". And the nation, as a contemporary author put it, "recognises no interest on earth above its own, and accepts no law or authority other than its own" (see Hobsbawm, 1973, p. 80). Such principles, albeit in a mitigated form, still govern the concept of nation

As it is known, scientific and technological resources are among those more heavily concentrated in the advanced countries of the capitalist system. 1/

Several authors (e.g. Palloix, 1975) have emphasised the importance of scientific and technological resources as an instrument of political and economic hegemony of the ACs over the LDCs since such resources, through systematic R&D (Freeman, 1974), have become one of the main elements in the process of expansion and change of capital accumulation. Palloix (1975) has argued that the hegemony exerted through scientific and technological resources tends to increase and it is compatible with the process of industrialisation of the LDCs.

From a nationalist perspective, the control of local enterprises from abroad is undesirable as it weakens the internal political and economic cohesion of the Nation - it undermines the sovereignty of the State and it introduces a different category of citizens which have divided allegiances as regards the local and foreign citizens and State. If carried far, this control may lead to the questioning of the capacity of the State to represent the interests of its citizens internationally and to the questioning of its neutrality vis-a-vis its citizens.

It is possible that such consequences are felt more strongly within the State because of its role in capitalist societies (which may explain

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1/ This concentration is widely documented. The Sussex Group estimated that in the mid-'sixties about 98% of R&D expenditures were concentrated in the ACs. The same pattern is shown by other measures of technical and scientific resources, such as patents (O'Brien, 1974), science abstracts (Price, 1967) or number of scientists and engineers engaged in R&D (Roche, 1972).

why the initiative of nationalist policies comes often from the State), but they tend to introduce tensions in the civil society as well, which will probably be greater, the greatest are the differences between local and foreign enterprises. 1/

Since the capital goods industry produces the means of production and influences the process of technical change of the rest of the system, its control from abroad is especially important as it implies an indirect control over the process of expansion and technical change of other economic activities too - i.e. there are externalities in the control of the capital goods industry.

Therefore, from a nationalist ideology point of view, SR tends to be a better strategy than licensing, as licensing from abroad may lead to a substantial control of the licensee by the licensor, involving economic as well as political decisions, 2/ especially when the asymmetry between the two is marked (see Chapter II). This may provide a strong motivation for the State to intervene in favour of SR, but does not exclude mixed strategies with the purpose of achieving SR in the future, as illustrated by the Japanese case.

In terms of economic policy, nationalism is expressed through the protection of national enterprises against foreign competition.

1/ It is worth stressing that although ideologies fulfil a role of disguising reality, they also provide the political actors with a set of values through which they perceive the reality and act accordingly (Poulantzés, 1968).

2/ Government policies in general are influenced by the support given to them by entrepreneurs, not only economic policies. It is probable that an enterprise which is highly dependent on licensing will abstain from supporting, for instance, Government policies which antagonise foreign capital, or policies which favour, in the case of the capitalist LDCs, stronger links with the socialist bloc.

As the international competition in capital goods is highly dependent on the quality of the goods produced, by supporting the design capacity of the industry, the State supports the industry and associated activities (suppliers, engineering firms, etc.) against foreign competition (see Chapter II).

If the local firms (of State Y) are competing with foreign firms or local suppliers of the latter, and if the foreign firms receive the support of their States for their design activities, if State Y does not support such activities of its own firms, this will reduce their competitiveness in terms of independent designs. If there are licensing alternatives available this will push the local firms to use licensing. If such an alternative is not available, the survival of local firms may be threatened. In any case, licensing will probably limit their possibilities of competing in the international market (see Chapter II).

Where, as in the LDCs, the local firms face structural disadvantages, in terms of availability of design resources and their own experience of design and risk-bearing capacity compared to many of their competitors from the ACs, the support given by the latters' States (see Chapter II) aggravates such disparities if it is not counterposed by measures of support from the LDCs' States.

Where there is an already established design capacity, a subsidy to design abroad could be off-set either by a tariff to increase the cost of licensing or by an equivalent subsidy to reduce the internal cost of SR. However, if the country has no established design capacity, the first solution is likely to be inefficient as it will tend only to increase the costs to the licensee and/or to its customers (depending on the market structure). In the latter case, a subsidy to develop SR capacity will probably be more effective.

A nationalist policy would also require some positive discrimination in favour of national firms in comparison with foreign subsidiaries, if the latter benefit from the subsidies received by their parent companies in their home States.

Such discrimination could be further justified if there is a marked difference between the design strategies of foreign subsidiaries and local firms. If the former adopt a strategy of licensing only, and the latter a mixed strategy with a relatively high share of local design, the externalities arising from the latter are likely to be higher than those from the former, as we have seen above.

Johnson (1970) has argued that if externalities arising from national control of the means of production are greater than those from foreign control, nationalism should be considered a "producers' good". 1/ If the division suggested above, between the design strategies of foreign and national firms holds, then, following Johnson's suggestions, nationalism should be considered a producers' good. If, however, the national enterprises use mainly licensing or the foreign subsidiaries develop their design locally, the argument is weakened - in fact, the crucial distinction here is between technological strategy and not between property, although in the case of foreign subsidiaries the two tend to be closely associated. 2/

1/ For Johnson, however, nationalism is "a collective consumption good that can be invested in by sacrifice of private consumption in order to increase the collective consumption of nationalism" (Johnson, 1970, p. 168).

2/ International companies tend to concentrate their R&D and preliminary design in their home countries and to operate their subsidiaries in the LDCs via licensing from their parent company. See Behrman (1969) and Tugendhat (1973) for a discussion of the technological strategy of multinational companies and Wionczek (1973) and Biato et al. (1972) for their technological activities in, respectively, Mexico and Brazil. See Erber et al. (1974) for a specific discussion of some subsidiaries in capital goods in Brazil.

Self-reliance in some products may also be desired as an insurance against monopoly risks from abroad, as a means of reducing the uncertainty of the process of capital accumulation in the country, independently of the foreign exchange constraints previously discussed.

The State and national enterprises may wish to have an independent technological capacity for products strategic to their investment plans as an insurance against their supply of licensing (or imports) being cut off by decision either of their licensors or of their licensors' States.-- 1/ From this point of view, the capital goods industry would receive a high priority for self-reliance.

Such motivation will depend on the number of alternative suppliers of technology and on the degree of international alignment of the country with its main licensing parties. It might to some extent override, on opportunity cost grounds, considerations of cost of production and efficiency of satisfaction of sponsors' requirements.

Besides providing a strong motivation for State support to local design activities, a nationalist ideology may be a necessary condition to implement such policies.

First, nationalism provides the necessary basis for a long-term prospect and joint action by the State and the entrepreneurs and it is the only ideological structure which allows such common action while preserving the separation of capitals.

1/ Examples of supply sanctions have been reported for the supply of capital goods (by the US against France, Cuba and other socialist countries and, among the latter, by the USSR against China) and probably extend to licensing too. In fact, the flow of licensing from the West to the Eastern Bloc has increased substantially after the thawing of the Cold War.

Second, nationalism legitimises the present sacrifices (unequally distributed - see next point) that such strategy requires, in the interest of the future citizens (benefits which are also unequally distributed). In countries where the wealth and income distribution is particularly uneven, as it is often the case with LDCs, this legitimising function is likely to be especially important. In such cases, nationalism can be interpreted as a "producers' good" for some and as a "consumption good" for the majority. 1/

The less developed countries face a specially contradictory condition as regards nationalism. As an ideology, it is likely to be especially strong there, as a result of their colonial past, their present asymmetry as regards the more advanced countries, and their very skewed distribution of income and power. However, because of their underdevelopment, they have to rely on the more advanced countries for finance, capital goods and technology, which if on one hand, reinforce nationalism, on the other, limits considerably the possibility of nationalist policies being applied in practice. Where such reliance has been internalised through foreign subsidiaries, this has not only led local enterprises to rely on licensing but has also established a common interest between the two groups, in terms of technological strategy and other policies, undermining thus the political and economic basis for nationalist policies. In fact, one of the most important distinguishing traits of the pattern of development of the LDCs in comparison with the ACs is the limited development in the former of a national bourgeoisie, defining itself not only in class terms, but also

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1/ A point normally neglected in the economic analyses of nationalism, is its role of ensuring the political conditions for capital accumulation, inducing the "rule by consent" (Gramsci, 1949).

nationally (in contra-distinction to other national bourgeoisies), which, in most LDCs, has not become the hegemonic partner in the power bloc. 1/

(e) Inexistence of appropriate licensing alternatives

As we have seen in the previous Chapter, the designs of capital goods are linked to the specific conditions of the environment in which the capital goods enterprises and their customers operate. At the same time, some types of experience die out, by the phasing out of models, closure of enterprises and physical extinction of designers. 2/

In other words, technical progress in capital goods design via R&D and learning-by-doing is "localised" around specific conditions of production and demand (Vernón, 1966; Jones, 1970).

If the local economy presents substantially different conditions from abroad as regards demand conditions and cost and availability of productive factors, 3/ there may be a case for developing an independent capacity, in terms of achieving faster growth and in the light of distributional considerations.

1/ Hegemony implies ideological as well as economic dominance (see Gramsci, 1949 and Anderson, 1977). If a national bourgeoisie were the hegemonic group in the LDCs, a "national project" in the sense of a relatively autonomous capitalist development would have been the dominant ideology there.

2/ The fact that the design experience for some goods disappears is often overlooked in the discussion of "intermediate technologies" by those who suggest the LDCs should use the old technologies of the ACs. Such use would often require considerable technical capacity.

3/ I am using factors of production in the sense of any requisite of production that has no perfect substitutes, as in Robinson, (1934).

The possibilities of licensing alternatives being inappropriate are especially important in the case of the LDCs because of the differences between some of their conditions of demand and production and those of the ACs.

In conditions of imperfect mobility of factors, or foreign exchange constraints and local bottlenecks of supply of some factors, faster growth may be achieved through a different technology which saves the use of such factor. Alternatively, a different technology may be required to use factors of production specific to a country.

Also, as the use of factors in part determines income distribution and the latter affects growth (Harrod, 1976), changes in the use of factors via changes in the use of technology may produce faster growth this way too.

In such cases a local design capacity in capital goods may be required: for instance, some raw materials specific to the LDCs may require special machines to process them, which may not be available in the ACs.[1/] In such cases the interchange of knowledge between the capital goods enterprises and the firms developing the process of production (see Chapter II) can be very important.

The appropriateness of the design of capital goods from the ACs in the LDCs is especially questionable as regards the use of labour.

1/ The natural resources of ACs and LDCs are, as it is known, substantially different. The argument that such resources would have been exploited in the LDCs if it were efficient to do so requires very stringent and unrealistic assumptions to be accepted a priori. Not only is technical progress "local" (see above) and information about the possible use of natural resources of the LDCs highly imperfect, but also there may be substantial differences about efficiency between the firms of the ACs, especially MNCs, and the State of the LDCs

As it is known, one of the main problems of the LDCs is the chronic unemployment or underemployment of its labour force, in proportions far superior to those prevailing in the ACs.[1/] In many countries, unemployment or underemployment extends to university graduates, including engineers (Streeten, 1970; Coombs, 1968; Blaug, 1970).

The issues related to the problem of employment in the LDCs are too many and too complex to be possible to discuss properly here. They certainly go beyond the problem of the type of technology adopted,[2/] although some authors (e.g. Baer and Herve, 1966) have put great emphasis on the use of capital-intensive techniques to explain the low labour absorption by manufacturing industry in the LDCs.

Notwithstanding such qualifications the employment of workers is deeply influenced by the design of capital goods, which in the ACs has stressed the reduction of number of workers employed and the simplification of tasks performed[3/] (see Chapter II). Design activities represent also an important source of direct employment for skilled personnel, especially engineers, as we have seen in Chapter II.

1/ The differences in the employment problem in ACs and LDCs has been extensively treated in the literature on economic development. See, for instance, Streeten (1970) Weeks (1971) and Jolly et al. (1973) and references therein.

2/ For example, the employment problem in LDCs cannot be treated separately from the problems of land ownership in the countryside and of income distribution. I have discussed this, for the Brazilian case, in Erber (1972).

3/ For the unskilled labour of the LDCs the last trend could be considered an advantage. Nevertheless, in the case of capital goods production, where skills for workers are above average, Leff (1968) has shown that in Brazil they were nolimitation to the local production of such goods.

As the literature on economic development has often stressed, in the LDCs there is often a substantial difference between the private and social opportunity costs of employment, especially if people are moving from parts of agricultural and tertiary occupations to industry (Lewis, 1954; Little and Mirrlees, 1969; Sen, 1972). Such difference arises not only from the underemployment of the persons in their original occupation, but also from externalities via learning-by-working and through the effects on the other members of the family of the persons employed (e.g. education).

Moreover, as other authors have argued (e.g. Stewart and Streeten, 1971) if additional employment leads to an increase in income of workers above the minimal subsistence level at which many of them live in the LDCs, this will increase their productivity.

Policies of extensive employment can also be desired as a means to alleviate the abject misery in which the majority of the population of the LDCs live; although, as Weeks (1971) has argued, to focus on employment for such purposes may be analytically misguided, the real issue being the uneven distribution of property and income in such countries.

It is possible that, as hoped by many economists, workers would benefit from more jobs being available, *if* design was oriented towards using more extensively the abundant supply of manpower available in the LDCs. The role played by the capital goods industry in the economy would give it pre-eminence if the objective were developing more labour-intensive techniques.

However, under free market conditions, it is doubtful whether an increase in the design capacity of the capital goods industry in the LDCs will, *per se*, have any important impact on employment of workers.

First, partly because of their highly skewed distribution of income and power and partly because of the influence the patterns of consumption and production of the ACs play in the LDCs, the latter have taken the pattern of consumers' requirements and their technical solutions developed in the ACs as the only acceptable ones.

As a consequence the type of consumer goods demanded in the LDCs tends to be the same as those demanded in the ACs and so are the specifications of the capital goods needed to produce them. In fact, the contradiction in the LDCs is that exactly those groups which have more specific needs requiring specific technological solutions are those which are the weakest politically and economically, and, as Kapp (1976) has remarked, "the price mechanism is ... essentially a non-egalitarian and elitist mechanism of evaluating goods" (p. 100).

In fact, as many authors have noted (e.g. Furtado, 1968) the market mechanism in the LDCs produces a vicious circle in which the skewed income distribution leads to the use of highly capital-intensive techniques, reducing the opportunities of employment and reinforcing thus the unequal income distribution. It also leads to the pressure on the use of State resources and credit to the benefit of the higher income groups (e.g. building of motorways for individual car users instead of mass-transit systems and use of credit for financing durable consumer goods) 1/

Second, there is the possibility that the entrepreneurs, following the pattern of the ACs, will use their design capacity to produce machines more automated, which, besides increasing the productivity of labour and raw materials, augment the control exerted over the labour-force (see Chapter II).

1/ For the Brazilian case, for instance, see Abouchar (1973) for the transport policy, and Pereira (1974) for the credit policy.

Finally, there is the argument often put forward that in the LDCs, labour (especially industrial labour) is too expensive in relation to capital in terms of market prices (e.g. Ranis, 1971)[1/] because of a combination of relatively high wages and social security costs with subsidies given to capital in the form of low interest rates, fiscal incentives, etc. Under such circumstances, a switch to labour-intensive techniques would require substantial changes in policies by the State (which seem hardly feasible in the political conditions of the LDCs) or at least an extensive use of shadow pricing by the State institutions.

Moreover, as regards the conditions of work, it can be argued that the workers, to some extent, in fact benefit from a technological dependence, as the machines or designs imported embody standards of work-intensity and, especially, of safety, developed in the ACs as a result of the organisation of workers in those countries and of their political weight; conditions that are largely absent in the LDCs.

In other words, although a greater SR in the capital goods industry offers opportunities for an increase in the welfare of workers in the form of more opportunities of employment and better conditions of work, there are reasons to doubt whether this would be a substantial result of such policy in the LDCs in their present condition, especially in the short run. Nevertheless, this may certainly be a reason for those who assess such prospects more optimistically to support such policy; as it may also be argued that if the workers in the LDCs increase their organisation and political weight within the countries, a pre-existing capacity of design there could, in such event, be used for such welfare gains.

1/ See Goodman *et al.* (1972) and especially Bacha *et al.* (1974) for a discussion *a propos* the Brazilian case. I have commented on their proposals in Erber (1972).

In terms of employment, probably the main direct beneficiaries of the State's support of greater self-reliance in capital goods design will be the technico-professional groups. Their employment opportunities will be increased as probably will their relative power within the State and the enterprises (see Chapter II) - an objective which may be desirable in itself, but which also tends to bring along more material rewards too. In fact, such groups have often pioneered the support of such policies in the LDCs, within and outside the State.

In more general terms, if one were contemplating a change in the mode of production, the mastery of design skills would then take a much greater importance for the workers and parts of the middle class committed to such change; as such change, to be effective, would probably require new forms of organisation of production (Bettelheim, 1968; Pignon and Querzola, 1974, among others). Presently, such concern has, however, probably little bearing on the adoption of policies of greater technological self-reliance in the capitalist LDCs we are discussing. Although it is an important theoretical and practical question, we shall not pursue it here in more detail.

III.4 (f) Conclusions

We have argued in this Section that even considering the alternative of licensing, the State has important political and economic reasons to support SR in design in the local industry. In fact, we have argued that from the point of view of growth of the economy, the best national strategy would be one of combining SR and licensing - in some cases for different products and in others in parallel, with the objective of substituting SR for licensing in the future.

Although probably in any country, there is a degree of mixture, some products being locally designed (eventually based on reverse engineering) the arguments previously developed suggest that in the LDCs the working of the market mechanisms will lead to an increasing reliance on licensing.

Therefore, in such countries, the intervention of the State in support of local designs seems to be especially necessary if a better balanced mix is to be obtained. This mix will be the result not only of the technical and economic conditions of the country but also of the objectives desired by a strategy of SR (e.g. an objective of increasing employment may lead to support SR in different products from those favoured by an objective of saving foreign exchange) - i.e. the mix will also be the result of the political weight of different groups within the State.

Apart from the reasons previously discussed which may lead the State to intervene in favour of SR, the intervention itself may be a motivation for some State institutions as a means of implementing their ideas about the desired prospect for the country and as a means of strengthening their power within the State.

Given that different groups across the society and through time are affected in different ways by the amount of resources and the type of products to which the State support is directed, any normative statement about, first, the desirability of such support and, second, about to which products should such support be directed, depends on the opinion of the comment-maker on the relative importance of such groups, now and in the future. In other words, the assessment of the desirability of the State support of SR in capital goods design is inextricably bound to value judgements, especially as regards the desired prospect of the society one is considering. For instance, in an LDC, as we have seen, a desired prospect

of a more autonomous capitalist development will give more emphasis to SR than a prospect which sees as a desirable development, an increasing integration of the local economy with the hegemonic economies of the system.

Such values can be scrutinised on the basis of rational arguments, so that normative assessments of the policy, although subjective, are not irrational. Although space precludes here further discussion of the issue, I suppose the preceding analysis indicates that the values of the author favour a policy of greater SR in the LDCs.

It is important to distinguish the assessment of the desirability of a policy of more SR in capital goods design in the LDCs, from the assessment of its feasibility in the LDCs . Our analysis suggested that although the objective of using a policy of greater SR for the purposes of more employment creation may be highly desirable in the LDCs, the economic and political conditions of such countries make this an unlikely result.

In our analysis, we suggested that a policy of more SR in the LDCs would require some achieved level of economic development expressed in the existence of a local capital goods industry and related industries, and a minimal technological infrastructure (e.g. engineering schools), but stricter conditions may be required if the pressure of the market forces is in the direction of an expanded use of licensing and if there is no foreign exchange shortage. In such cases, a dominant natinnalist ideology and a strong national bourgeoisie may be required.

Our analysis suggests, however, that the pattern of development of the LDCs - their relative industrial and technical undevelopment, and their dependence on the ACs on consumption patterns, capital goods, finance and

technology, often internalised via foreign subsidiaries - may lead to the constitution of a powerful bloc of interests, strongly represented within the State, that may not favour or may oppose such policy altogether. To this issue we return in Chapter VI, after examining the Brazilian case.

CHAPTER IV:

AN ANALYSIS OF THE RESULTS OF THE INTERVIEWS

IV-1 Introduction.

The data presented in this Chapter about the Brazilian capital goods enterprises come mainly from the records of the interviews made at the end of 1972 with 27 Brazilian producers. The procedures followed to obtain such information and its limitations have already been discussed in Chapter I.

In some cases the information of the interviews was complemented by data about the enterprises producing custom-built equipment from Technometal (1971) (see Chapter I); from the 1974 catalogue of the ABDIB (Brazilian Association for the Development of Basic Industries) 1/ and from statements made by the Brazilian entrepreneurs during a symposium on the technological problems of the capital goods industry held in Sao Paulo, in 1975, under the auspices of the Ministry of Trade and Industry (MIC, 1975).

1/ The ABDIB, founded in 1955 to coordinate the supply of equipment for one of Petrobras' refineries, congregated, in 1974, 83 associates, of which 18 were producers of metals (mainly steel and aluminium) or engineering firms and the rest producers of capital goods, mainly custom-built equipment. Although its presidency has been traditionally held by Brazilian entrepreneurs, foreign firms are heavily represented in it.

At the time of the interviews, the ABDIB played already an important role in lobbying for the interests of the capital goods producers located in Brazil (i.e. both national and foreign producers), exerting pressure against those policies which went, according to its executives, against the interests of the industry; pressing mainly for less imports and for more participation of the producers located in Brazil in the supply of local demand and, at the time of the interviews, very strongly against the recently increased limitation and control of payments for licensing agreements (see Section 4).

Of our enterprises, 15 belonged to the ABDIB, including some of the most important participants of the latter, which have provided the main executives of the Association.

In order to better understand and evaluate the opinions expressed by the interviewees, it is necessary to present also some contextual information about the conditions prevailing in Brazil at the time of the interviews and in the period preceding them. Such information comes from a variety of sources, indicated in the text, as well as from my experience at the BNDE and at FINEP. In the recent years, especially since 1974, some of these conditions have changed considerably, but since those changes are treated in the next Chapter, the present one focusses on the situation at the time of the interviews.

Because of the nature of the information available, its treatment is mainly qualitative, with emphasis on the identification of general patterns of behaviour for all the enterprises or for groups of them and on specific cases which present instances of such behaviour or which, alternatively, present an important departure from the observed norm.

The next Section analyses for which products the firms use a licensing strategy and which are developed independently of licensing. In view of our arguments on the need for the enterprises to invest in SR even if they have a licensing relationship in order to benefit fully from the latter, and because of the constraints in the LDCs on such investment, we have also analysed how the enterprises developed the knowledge used for the lines independent of licensing (mainly copying-and-adaptation) and examined their strategies in terms of purpose, i.e. whether an increase in SR in at least some lines of production was deliberately sought. We found only three enterprises which were following a deliberate strategy of developing their own technical capacity in order to retain and achieve self-reliance in design in some lines of production. We have called them "deliberately self-reliant enterprises" and their main characteristics are analysed in Section 3.

Finally, Section 5 discusses briefly the role of the State and that of the enterprises in the situation found.

IV-2 The Strategy of the Enterprises

The results of preceding studies of the Brazilian capital goods industry (MPCG, 1967; 1968; Leff, 1968; and especially Tecnometal, 1971) suggested that we would find a considerable degree of reliance on licensing. Our evidence confirmed the important role played by licensing agreements as a strategy for design and it suggests that such importance tended to increase, as discussed in detail below.

Nevertheless, our interviews showed also that the degree of reliance on licensing varied considerably. Among the 27 firms interviewed, we found 7 that at the time of the interviews had no licensing agreements at all; of the remaining 20, which did use licensing agreements as a source of designs, 7 depended on such agreements for less than 50% of their sales, 4 for circa 50% and the remaining 9 for more than 50% of their sales.(see Table IV-1). Of the latter, 8 depended on licensing agreements for more than 80% of their sales.

In the following discussion, to abbreviate, we shall call the first group "without licensing" (WL), the second "mainly local development" (MLD), the third, "intermediate" (IE) and the last, "mainly licensing" (ML).

TABLE IV-1: ENTERPRISES STUDIED ACCORDING TO THEIR RELIANCE ON LICENSING

Sales Percentage Dependent on Licensing	Number of Enterprises
0% (No licensing agreement (WL)	7
Less than 50% (MLD)	7
Approximately 50% (IE)	4
More than 50% (ML)	9
	27

Almost half of the contracts were held by the ML enterprises (see Table IV-2). Although the average number of contracts per enterprise is not substantially different between the three groups of enterprises (ML, MLD and IE), especially between the first two (see same Table), this is rather misleading as three enterprises have 37% of the contracts (see below).

TABLE IV-2: LICENSING CONTRACTS BY TYPE OF ENTERPRISE

Enterprise	Contracts		Average Contracts per Enterprise
	Number	Percentage	
MLD	29	36.7	4.14
IE	13	16.5	3.25
ML	37	46.8	4.11
Total	79	100.0	3.95

In Table IV-3 we show the distribution of the capital, value of production and number of workers [1] of 24 of our enterprises according to their reliance on licensing. [2] As it can be seen, the share in the three aggregates of the ML and MLD groups is far superior to their share in the number of enterprises, reflecting their larger size. The same Table shows the average size of the three variables for the four groups, although such averages have to be taken with caution, as there is a wide range of sizes within each group. Nevertheless there seems to be a close association between size and and number of contracts - the Spearman rank correlation coefficient for the three measures adopted for size are significant at the 5% level and them (value of production and number of workers) at the 1% level (see Table IV-4). As we shall see, such association can be understood in the light of the complexity and diversity of the products the enterprises manufacture,

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1/ Excludes management, administrative and technical staff.

2/ For three enterprises, two WL and one IE, we had not the data available, although we know they are relatively small enterprises.

combined to their commitment of resources to SR in design. 1/

TABLE IV-3: DISTRIBUTION OF CAPITAL, VALUE OF PRODUCTION AND NUMBER OF WORKERS ACCORDING TO DEGREE OF RELIANCE ON LICENSING

Enterprise 1/	No.	%	Capital 2/ Average	%	Value of Prod. 2/ Average	%	Workers Average	%
WL	5	20.8	4010	4.8	8572	5.8	214	8.2
MLD	7	29.2	27305	45.8	47570	45.0	991	53.2
ML	9	37.5	19772	42.7	34250	41.7	453	31.3
IE	3	12.5	9231	6.7	18540	7.5	316	7.3
TOTAL	24	100.0		100.0		100.0		100.0

Notes: 1/ Data not available for two ML enterprises and one IE.

2/ Cr. $ 1000 of 1970

TABLE IV-4: SPEARMAN RANK CORRELATION (R) 1/ BETWEEN SIZE AND NUMBER OF CONTRACTS 2/

Measure of Size		R
Value of Production		0.629
Capital		0.483
Workers		0.639
n = 18	= 0.01	0.564
	= 0.05	0.399
n = 20	= 0.01	0.534
	= 0.05	0.377

Notes: 1/ $R = 1 - 6 \dfrac{(x_i - y_i)^2}{n(n^2 - 1)}$

- Significant value for hypothesis that there is no correlation.

2/ One enterprise IE excluded for lack of data, has only one contract and is a small enterprise, i.e. n = 19.

1/ It is worth recalling from Chapter I that none of the enterprises interviewed is very small, either in Brazilian or international terms. (none has less than 100 employees). It is also worth noting that among our interviewees were the 5 largest Brazilian producers of custom-built equipment and the largest producer of machine tools. Among the former, 3 were ML enterprises and 2 MLD. The latter is an MLD enterprise, whose case is

Table IV-5 shows the number of enterprises interviewed, the number of enterprises with licensing contracts and the number of contracts held by the enterprise with the highest number of contracts, for the main lines of production of the enterprises interviewed: However, it is important to note that since each line of production includes several products (see Table), even such level of disaggregation conceals important differences, especially as regards the complexity of the goods included in each line. 1/

TABLE IV-5: ENTERPRISES AND LICENSING CONTRACTS BY PRODUCT LINES

Products	Ent. Int.	Ent. with Lic. Con.	No of Conts.	Cont. of Ent with largest No. of Contracts
Equ. for Chemical and Petrochemical Ind. (boilers, heat exchangers, fractioning towers, etc.)	5	5	15	5
Equ. for Railways (mainly rolling stock and related equipment and parts)	4	3	7	3
Materials Handling Equipment (mainly custom-built cranes) 3/	4	4	10	3
Machine Tools	5	3	10	
Standard	5	3	8	5
Custom-built	1	1	2	2
Electric Power Equipment	4	2	4	
Equipment for hydro-plants (generation)	2	2	4	2
Equipment for distribution and electric motors 4/	2	-	-	
Cement and Mining Equipment	3	3	4	
Custom-Built	2	2	2	1
Standard (concrete truck mixers)	2	2	2	1
Agricultural Equipment, except Sugar	3	2	7	
Agric. implements for burrowing, ploughing, etc.	2	2	3	2
Equipment for processing agric. products (mills, crushers, etc.)	3	2	4	3
Equipment for Sugar Plants	2	2	5	3

1/ A line of production comprehends several products, fulfilling the same function - e.g. metal-working machine tools.

(TABLE IV-5 CONT'D)

Products	Ent. Int.	Ent. with Lic. Cont.	No. of Conts.	Cont. of Ent. with largest No. of Contracts.
Equipment for Ships	3	3	4	
Diesel Engines	1	1	1	1
Other equipment (rudder mach., deck equipment)	2	2	3	2
Oil Extraction (mainly for drilling)	3	3	5	3
Auxiliary equipment for steel plants	2	2	3	2
Paper and Celulosis Equipment	2	1	1	1
Roadbuilding Equipment	2	1	1	1
Others	2	2	3	
Custom-Built Equipment (Sub-total)			64	
Standard Equipment (Sub-total)			15	
TOTAL	27	20	79	

NOTES: 1/ Includes Equipment for steel plants; excludes conveyors etc. for mining and cement, included in the latter.

2/ Excludes specialised motors for steel rolls, included in the "Steel Equipment"

Comparing the lines of production and products therein which depend on licensing and those which do not, we find that (see Table IV-6):-

(i) Two enterprises used licensing only for products in lines of production in which they had other products developed independently. One is a producer of machine tools and the other a producer of equipment for sugar cane production. Both tended to use licensing for the more complex goods of their product range. The two belong to the MLD group.

ii) One enterprise used licensing for lines of production completely different from those in which it had its own designs. Originally a producer of railway equipment, it branched off into mining and cement machinery for which it uses licensing. It is an IE.

iii) Six enterprises had some lines of production totally independent from licensing, while in other lines they combined products for which they had some independent design and products for which they depended on licensing. The latter tended to be more complex products. Three of the enterprises are involved mainly with the production of process plant equipment, occupying a leadership position

in the sector. one is a producer of electronics equipment for telecommunications, the fifth is a producer of road-building equipment, and the last one, a producer of mining equipment (especially materials handling - conveyor belts, etc.). The first three and the last are MLD enterprises, the fourth, an IE, and the last one an ML enterprise.

iv) Eleven enterprises had some lines of production in wh ch they depended on licensing exclusively and other lines in which were combined products depending on licensing and products developed independently. Those are mainly the ML enterprises, where the products developed indepandently of licensing are relatively unimportant. They produce mainly heavy engineering equipment, usually over a wide range of products.

In terms of contracts of licensing, the majority (c. 60%) refer to lines of production where the enterprises have no products independent of licensing. This result is of course heavily influenced by the eight enterprises which depend almost exclusively on licensing. If we exclude them, the result is a match: 26 contracts refer to lines of production in which co-exist licensing and independent development, and 27 to lines where there is licensing only.

TABLE IV-6: COMBINATION OF LICENSED AND NON-LICENSED PRODUCTS IN THE LINES OF PRODUCTION OF THE ENTERPRISES ACCORDING TO THEIR DEGREE OF SALES' DEPENDENCE ON LICENSING

Lines of Production and Products	Enterprises			
	MLD	IE	ML	Total
Licensed products only in lines of production where there are also non-licensed products	2			2
Some lines of production wholly independent of licensing. Others combining licensed and non-licensed products.	4	1	1	6
Some lines of production totally dependent on licensing. Others combining licensed and non-licensed products.	1	2	8	11
Lines dependent on licensing totally different from lines independent of licensing.		1		1

The enterprises which did not use licensing (WL) tended to produce a narrower range of products, normally relatively simple, standard products. Two were producers of universal machine-tools, one a producer of machinery for processing agricultural products (grinders, crushers, etc.), one a producer of road-paving equipment, one a producer for process plant equipment and two producers of equipment for electric power distribution (transformers, alternators, etc.) and generation (electric power motors). Among the last three, two signed licensing agreements later on, for more complex products, and the last one is an enterprise with a strong commitment to self-reliance, whose case is discussed in more detail in Section 3, Case 4).

The strategy of design adopted by the majority of the enterprises interviewed, for those lines of production for which they did not use licensing, can be characterised as "copying", but with some qualifications.

It is not, in the majority of cases, necessarily an exact duplication of the product of another enterprise - it often involves some adaptation of the product to local conditions and/or to the requirements of specific customers. Nevertheless, it is still a copying strategy, in the sense that the enterprises depend on the existence of the finished product of another enterprise as a model and are not capable (or willing to) of developing their own products based on their own design effort.

Our interviews also showed that none of the enterprises which used licensing agreements used them from their inception. In fact, for this group as a whole, an average of twenty-one years lapsed between the foundation of the enterprises and their first use of licensing (see Table IV-7). It is therefore important to analyse their evolution towards licensing.

TABLE IV-7: TIME INTERVAL BETWEEN FOUNDATION OF ENTERPRISES AND FIRST USE OF LICENSING

Group of Enterprises	Average Number of Years
ML	25.38
MLD	16.43
IE	18.33
All	21.28

In practice, all enterprises began by copying machines produced either in Brazil or abroad. Most frequently, they copied machines that were already available in the Brazilian market, largely through imports (see Table IV-8). In some cases (for example, railway rolling stock, boilers for process industry, etc. cranes), the design capability was developed through activities of maintenance, repair and then eventual replacement of worn-out machines, a pattern of development which was rather common in Brazil (Leff, 1968) as well as in other countries such as the US (Rosenberg, 1972). In other cases (for example, machine tools and cranes), we found that enterprises that had copied machines for their own internal use found that they could also produce them for sale (see same Table).

TABLE IV-8: MAIN SOURCES OF LOCAL DESIGN CAPACITY[1/]

Source	No. of Enterprises[2/]
Embodied in immigrants	2
Maintenance and replacement of worn-out machines	5
Copying of machines for use within the enterprise	3
Copying of machines already existent in the Brazilian market or especially imported	18
Internal Development	3[3/]

NOTES: 1/ This applies mainly to equipment currently produced in 1972.

2/ Some enterprises use more than one source, so the sum is greater than the number of enterprises.

3/ See Section 3.

The copying was not strictly limited to what was available in the Brazilian market. Quite often, there was a reliance on the experience of immigrant entrepreneurs which reproduced in Brazil the machines they knew from their countries of origin. (A typical example is that of an entrepreneur who had been a road-building contractor in other countries and who became a producer of road-building equipment in Brazil.)

The role of immigrants, especially of Italian origin, which were often skilled workers in their countries, and who became entrepreneurs in Brazil has been emphasised by all the historians of Brazilian industrialisation (Leff, 1968; Dean 1971) and a simple perusal of the names of capital goods producers in Brazil confirms this (Romi, Dedini, Zanini, Micheletto, Clemente Cifalli, Rocco, D'Andrea, etc.).

The enterprises we interviewed showed several examples of such pattern of imported knowledge, but they also confirm (see Leff, 1968) its dwindling importance in the present day, reflecting the changes in the immigration flows as well as probably greater barriers to entry in the industry. In fact, only two of the enterprises interviewed (both WL) were still directed by first-generation immigrants, which had brought the basic design skills with them.

The prevalence of copying at the origin of an industry based on local entrepreneurship in a less-developed country is probably not surprising. It is a pattern observed in other latecomer countries, in industries where copying is feasible, as shown by Rosenberg (1972) for the US and Landes (1972) for Western Europe.

Resorting to copying as a way of beginning production becomes even more a "natural" solution if one bears in mind that 20 of our enterprises were

founded before 1950, that is, before the large investments in infrastructure and heavy industry began in Brazil. In other words, the majority of the enterprises began by producing relatively simple machines, relatively easy to copy (see Chapter II, Appendix), for rather undemanding customers, in a context in which there was little competition from subsidiaries of traditional producers (which came in mainly in the fifties) and where the legal system for the production of property rights worked precariously (see Section 4). In such conditions, copying was probably the easiest, cheapest and less risky alternative to follow.

However, when the enterprises moved into the production of more complex products within their original lines of production, they have tended to rely on licensing, especially if, concomitantly they diversified their range of lines of production. Nevertheless, they have often retained an independent design capacity in the simpler products of their original lines of production (normally based on copying-and-adaptation) as indicated by our preceding comparison between the lines of production based on licensing and those developed independently. It is nonetheless worth examining such points in more detail.

As mentioned in the first Chapter, with the help of sectorial specialists, we classified the enterprises in three categories, mainly in accordance with the quality of their products, before we knew their degree of reliance on licensing. We had then nine enterprises "A", ten "B", and eight "C", the quality going from A to C decreasingly. It is indicative of the differences in the quality of the products that the WL enterprises accounted for five of the Cs, two of the Bs [1/] and none of the As. (See Table IV-9).

1/ One of the two enterprises WL classified as "B" is one of our deliberately self-reliant enterprises (Case 4 below).

The WL enterprises tend also to be more labour-intensive than the others - compare their share of workers with that of capital in Table IV-3.

TABLE IV-9:- CLASSIFICATION OF THE ENTERPRISES ACCORDING TO QUALITY OF PRODUCTS

Enterprises	A	B	C	n
WL	-	2	5	7
MLD	4	2	1	7
IE	-	3	1	4
ML	5	3	1	9
Total	9	10	8	27

The greater complexity of the lines for which the enterprises generally use licensing was later confirmed during the visits to the enterprises by the engineer of FINEP, Sergio F. Alves, who participated in the study. 1/

It is also important to note that circa 80% of the licensing contracts refer to equipment for sectors which require custom-built equipment (e.g. petrochemical industry) or to special machines such as transfer machines or special cranes for steel-works (see Table IV-5).

As regards diversification, among the twenty enterprises which relied on licensing, only three had not diversified considerably from their original lines of production and one of those was planning to diversify (a sugar-cane equipment producer, included in i) above). (See Table IV-10). Among those twenty enterprises, only seven had their lines of production oriented towards only one purchasing sector and all seven were in the process of diversification or planning to do so. Of the 79 contracts found

1/ Sergio F. Alves is an engineer with a wide experience in consulting and production, with a fine flare for economics. I am deeply indebted to him for the analysis above.

in our sample, 29 were concentrated in three enterprises, each of which produced for at least five different sectors (see Table IV-11).

TABLE IV-10:- DIVERSIFICATION FROM ORIGINAL LINES OF PRODUCTION. 1/

Diversification	WL	MLD	IE	ML
Yes	2	6	4	7
No	5	1	-	2

NOTE : 1/ Based on the question: "Since the establishment of your enterprise, was there any significant change in your line of production?"

TABLE IV-11:- DIVERSIFICATION OF THE ENTERPRISES WHICH HAVE THE GREATEST NUMBER OF LICENSING CONTRACTS

Enterprise (Case Number)	Number of Contracts	Number of Sectors for which it Produces
8	11	5
7	9	6
6	9	6

In contrast, the enterprises which did not use licensing at all, not only produced relatively simple products, as already mentioned, but also stuck to their original lines of production. Only two out of the seven diversified their production, one shifting from wood-working machines to metal-working and the other adding up paper machinery to their line of agricultural processing machines.

It is also important to note that three of the seven enterprises WL were seriously considering signing licensing contracts for more complex products; apparently following the same pattern of the other enterprises which at the time of the interviews, already relied on licensing.

The interviews indicated that the further the enterprises interviewed drifted from their original lines of production (based on copying), the more they tended to rely on licensing. It is, therefore, worth examining the more detail what led those enterprises to diversify their production.

Examining the questionnaires, we identify different reasons for diversification, as well as different patterns:

a) A small WL enterprise, producing wood-working machine tools, which found the market for metal-working machines more attractive and switched over to this type of machines. As it produced relatively simple machines it faced relatively little competition from imports or from foreign subsidiaries, conditions which apply to its present range of machines too. The switchover was complete (i.e. they abandoned the original lines of production).

b) Enterprises producing agricultural equipment, whose markets tended to grow slowly and/or irregularly - three enterprises, which have partially diversified mainly to process industries' equipment, maintaining however, their original lines of production. One is an WL enterprise, the other an IE, and the third, which now relies little on its original line of production, is an ML enterprise. Another enterprise which specialised in sugar cane equipment was planning to diversify its production.

c) Enterprises which found it impossible to compete with imports - two enterprises (one MLD, the other IE) producing standard, series-manufactured goods, where scale economies are relatively important, which found they could not compete in costs with imports. In Brazil, as discussed in more detail in the next Chapter, tariff protection for capital goods tends to be low and is often waived. The two enterprises changed over to simplar products, where the

competition was not so strong.

d) Enterprises which formerly specialised in goods demanded by the State (railway equipment and oil exploration equipment) whose demand grew slowly and/or irregularly. Two enterprises (ML), producing equipment for oil exploration, diversified into products complementary to their original lines and three others, (two MLD, one IE), producing railway equipment, diversified into different lines, but which bore some affinity to the original lines - process industries' equipment and metallic structures. The market for the latter three has been, over the years, severely disrupted by imports originating from bilateral trade agreements (see Section 4 below and next Chapter) and was further restricted by the competition of foreign subsidiaries.

e) Enterprises which were and are producers of custom-built equipment, mainly heavy-engineering products, predominantly for the State Enterprises-eight enterprises. Their diversification is a response to several, combined stimuli:- the opening up of new and profitable markets, especially by the creation and expansion of the State Enterprises, the relative ease of entry in those markets, provided they had licensing agreements (see Section 4), and the pressure of competition from foreign subsidiaries, as well as from other Brazilian competitors, including those mentioned in (b) and (d) above.

As we can see, the State played an important role in those processes of diversification. Indirectly, through its industries policies, espe ally in terms of incentives given to imports of capital goods and in terms of incentives to investment in the capital goods industry, especially to the entry of foreign enterprises, points which are discussed in detail in the next Chapter, more directly, as a purchaser of capital goods. It is

important to stress that, in the latter role, up to the time of the interviews, it had not tried to establish some degree of specialisation among its suppliers, which, presumably, would have been to the benefit of both customers and suppliers, especially the latter. Quite the contrary, the field had been left open to any new entrant, provided it had the necessary technical and financial conditions, with little concern to the other suppliers. In many cases, especially Petrobras, had actively encouraged the entry of new suppliers, which provoked complaints from some of its established suppliers which we interviewed, who, although praising Petrobras' policies in general (see Section 4 and next Chapter), were highly critical of this aspect.

As regards the strategy of the enterprises, it is important to note the ad hoc nature of their process of diversification - it rarely followed a planned product-mix, tending to be a reaction to short-term market opportunities: when such an opportunity was presented, most of the firms rushed to participate, signing licensing agreements in order to be able to compete, reflecting, in part, the over-investment in relation to the market capacity which characterised the capital goods industry, especially the custom-built producers, from the early 'sixties until 1973/1974 (see Chapter V).

In fact, the design strategy of most of the enterprises mirrors their process of product selection, lacking a cohesive long-term prospect and a concern with the development of a SR capacity - the exceptions being discussed in the next Section .

In short, the strategy used by the majority of the enterprises interviewed, with the exceptions discussed in the next Section, can be characterised as one of "copying or licensing" - where copying was not feasible, the enterprises tended to use licensing and the trend suggested by the

interviews was in the direction of increasing the relative importance of the latter; i.e. a distinctive trait of the strategy of the majority of the enterprises interviewed, was the limited commitment of their resources to the development of their own designs. In Section 4 we discuss the reasons for such strategy.

IV-3: The Deliberately Self-Reliant Enterprises

We have already mentioned that we found only three firms following a strategy of self-reliance in design. In all three cases, as we shall see below such self-reliance is partial, in the sense that the firms use copying, licensing and (in one case) their clients as sources of basic design. Neverthless, such firms are distinct from the others in that they pursue a strategy of deliberately building up a capacity for design (basic and detailed) which allows them to conceptualise and prepare a product for manufacturing based on their own resources.

Before discussing the advantages and disadvantages of such strategy (see Section 4), we present some of the main features of the three enterprises which follow a strategy of partial self-reliance:

Case 3 - A leading producer of machine tools, the Enterprise, at the time of the interview, depended on licensing for circa 30% of its sales, the remaining 70% being based on copying and adaptation and on their own designs (i.e. it belongs to the MLD group). It had, in 1972, over thirty years of experience of machine-tool production, where they started through copying. Products which are based on their own designs include turret and parallel lathes, copying lathes up to 10 HP and cylinder rolling lathes.

The development of technological capacity has been a prime concern of the Enterprise, over time and at all levels. In the post-War period the

founder of the Enterprise sent one of his sons, presently the main executive of the firm, to the U.S. for a post-graduate training period in matters related to the technological development of machine tools. This involved not only practical but academic training as well. Following this, in 1951, they introduced substantial changes in their line of production.

Later on, in 1958, they hired an American firm of engineering to conduct a critical appraisal of the Enterprise, comparing it to similar firms in the U.S. following which new modifications were introduced. Among the decisions taken at that time was that of developing lathes for cylinder rolls for steel plants with their own design.

According to their assessment, then, in 1958, they were forty years behind in terms of international technology of such lathes, which are a technically complex product. Presently, they claim to be "twenty years ahead". Such claims, as with every manufacturer's, have of course to be taken with due reservation, but, nevertheless, the fact is that they are exporting such machines; largely on technology grounds as, on their own admission, they tend to cost more and have longer delivery time than those of their competitors. Moreover, they are licensing such machines too. They estimate that out of the revenue of about US $1,000,000.00 they received for the machines about one-fourth is "technological rent".

Their work, in this project as well as in the others, tends to be incremental - continuous improvements involving considerable amounts of trial-and-error, carried forth by small teams in charge of a different project. At the time of the interviews they employed circa 80 persons in their design department, of which circa 20% were allocated to the development of projects exclusively. In a more recent estimate (1974) they spent approximately 4% of their revenue for technological development

activities and another 2% on manpower training.

At the time of the interview they were planning a major expansion, to produce special machines, completed in 1975. In that year they began to get ready to enter the field of numerically controlled machines (including direct numerical control) by incorporating a specialist from abroad into their staff.

Case 5 - An enterprise with a wide range of products (complete cotton ginning outfits, vegetable oil processing mills, compact feed grinding and mixing mills, hydraulic presses for various purposes, garbage compacting collectors, concrete truck transit mixers, plow and harrow agricultural discs), which depends on licensing for about 50% of its sales (an IE enterprise). Here we concentrate on cotton ginning equipment, its main line of production.

The Enterprise was founded in 1935 and began by producing equipment for cotton ginning. During the War they practically doubled their output using largely copying and adaptation of machines available in the market. At the same time, they began to receive technical assistance from one producer from abroad of this type of equipment.

This relationship was maintained during almost thirty years, during which time they introduced significant adaptations in the licensed equipment. Then, in 1971, they purchased the technical assets (archives, blueprints, etc.) of their licensor for this line of production and became the sole responsible for their design and production

At the time of the interview, they were planning to develop new equipments for this line of production. For this purpose they had brought a specialist from abroad to train their staff, which, at the time was not big

(circa 30 persons employed in design), and they were planning to set up, together with an institute of agronomic research, a pilot plant to develop and test their equipment.

Their technological strategy is best summarised by a quote from their main executive during the interview: "/first/ to master the technology imported. Only after this stage it is possible to innovate".

While still partially based on the knowledge of their former licensor they have been quite successful, both internally and abroad - they have exported to several countries, including the U.S. (estimate for 1973: over US $1,500,000.00) and, according to them, are among the four largest producers in the world.

Such case of "emancipation" from licensing-unique in our sample - is interesting per se. Nevertheless, what seems even more important is the awareness of the Enterprise that it must develop its own research basis, as shown by the initiatives taken - that it cannot rest on the "acquired laurels" of the past experience of its former licensor.

Case 4 - A small enterprise producing electrical equipment, especially electric motors. It does not hold any licensing agreements. According to the entrepreneurs, as it produces custom-built equipment, if it had to rely on technical assistance from abroad this would require a different contract for each order, which would be commissioned after they had been granted the supply order. This would lead to great delays in their delivery times and therefore they considered it to be more economical to maintain a technical staff of good quality and develop their own projects internally. Nevertheless, in some cases they receive the basic design and detailed specifications from a larger firm and manufacture products in the name of this firm.

They started producing electric motors in 1937, based on the knowledge of its present main executives - one whm had had manufacturing experience in Europe, and the other a professor in a Brazilian university - combining thus academic and practical knowledge. About 1960 they set up a technical department, so as not to rely any more on the knowledge of relatively dispersed persons. Such department (23 persons, not counting the executives above-mentioned - who however, tend to be still involved in technical problems) is not insignificant to the size of the enterprise (9% of its manpower) and is often supplemented by resource to the electrotechnics research institute of the university where one of the directors teaches.

It is an enterprise oriented towards the internal market exclusively, where it has been operating successfully in a fairly competitive market, including some multinational corporations, expanding their production "at a relatively constant rate of 20% per year".

Although they operate in different sectors, with different problems, the three enterprises considered above have some common traits that are worth mentioning:

1) Experience in manufacturing - as we have seen, all three have been active in their fields for over thirty years. Experience, as discussed in Chapter II, is a critical element in the design and manufacture of capital goods.

2) A management that is highly sensitive and aware of technical problems - in the three enterprises the main executives have first-hand technical knowledge and are aware of its importance for the growth of the firms.

3) Capacity to use knowledge from abroad - the three enterprises have used extensively knowledge from abroad, through training of technical

staff and management, import of personnel, and licensing agreements, in order to supplement their internal resources.

4) Cappcity to use local technical resources - all three use the resources available from research institutes in Brazil to complement their own resources.

5) An aggressive attitude towards the market - best summarised in the identical comment of enterprises 3 and 5 as regards patents - "the best patent is to launch the product first and dominate the market".

6) A long-term prospective in terms of product mix and a willingness to take risks based on the technical resources available - all three enterprises have shown a disposition to take considerable risks, committing themselves to courses of action of uncertain results, that would pay off only in the relatively long run and which relied heavily on their technical capacity for success.

Although several of the other enterprises have some of those characteristics in common (e.g. experience and technical awareness of the entrepreneurs) it is the last point that differentiates the self-reliant enterprises from the others.

We have restricted our discussion to self-reliance in design. However, given that half of the contracts of licensing involve some transfer of technology of manufacturing (see Section 4), it could be possible that the Brazilian enterprises had deliberately abandoned self-reliance in design and were trying to achieve self-reliance in manufacturing techniques.

In fact, in our interviews, we found one enterprise which had deliberately adopted such strategy: an enterprise producing process industries' equipment, which had set up a small research team and its own

laboratories concerned only with manufacturing techniques. They also had imported a specialist from abroad to supplement their own resources and had tried, rather unsuccessfully, to use the local research institutes (see below). In this process, which began in 1957, with the setting up of an engineering department, they had achieved some successful results, especially in the area of metallic welding. As they pointed out, they had deliberately forsaken self-reliance on design, relying on licensing or copying, when feasible, in exchange for "autonomy" in manufacturing technology.

Their success in the latter enabled them to cut down delivery times by not having to rely upon the licensor to provide them with assistance during manufacturing as well as providing them with a high quality product; but hardly served as a defence against the threat of entry of their licensors and, in fact, the enterprise was, at the time of the interview, contemplating the possibility of having to abandon one of its main lines of production as its licensor had decided to set up a subsidiary in Brazil (see Section 4).

IV-4 Factors Conditioning the Choice of Strategies in Brazil at the Time of the Interviews.

4.1) Introduction

This Section analyses the main factors conditioning the choice of strategies at the time of the interviews and the reaction of the enterprises interviewed to them. Where such factors are the result of State policies (e.g. import policies) they are examined in more detail in the next Chapter, which discusses also the changes introduced in such policies after the interviews. The factors examined here were selected based on the analysis of Chapters II and III.

The Section is divided into four additional sub-sections. In the first two (4.2 and 4.3) we examine some aspects of the demand for design in Brazil, especially from the State Enterprises and the competition from imported technology. The policies underlying such characteristics are examined in detail in Chapter V.

Sub-section 4.4 analyses some of the local conditions for design, especially the availability of resources for design (manpower, research institutes, etc.) and their use by the enterprises, the learning from licensing and copying and the risks of an SR strategy.

The final sub-section, 4.5, analyses the main conditions for licensing as found in the interviews - the availability of licensors and the main conditions of the relationship of the Brazilian firms with their licensors, including the risks of entry of the licensor as a partner, or as competitor, and it concludes by comparing such risks with those deriving from a self-reliant strategy.

4.2) Demand Conditions

(a) Acceptance of local design by Brazilian customers

The interviews suggest that the customers of the least complex products tend to accept the products locally designed. They often provide the machines to be copied, "to have another of that".

The situation is quite different as regards the more complex products. The interviews indicate that while in the less complex lines the competition depends considerably on price, the customers being rather undemanding in terms of quality, for the more complex goods there is a strong emphasis on quality, price competition being contingent on equivalent quality.

This applies strongly to the State Enterprises, on which the majority of the enterprises inverviewed (21) are highly dependent for their sales.

Our interviews with the capital goods producers as well as our subsequent study of the purchasing policies of the State Enterprises (see next Chapter), show that the State Enterprises in Brazil are highly reluctant to accept locally designed products, especially for important components of their productive process, largely on reliability grounds.

Such a policy is normally implemented through pre-bidding screening, where often only enterprises with access to a "reliable" licensor are accepted. In some cases, the State Enterprises suggest the name of a potential licensor.

To give an example, the bidding proposals for the Stage II of the National Plan for Steel were divided in two steps, and the producers of capital goods were asked to present separately the technical specifications of the proposed equipment and their prices. Only after the former were examined were the latter considered, and even then only for equipments of equivalent quality and which had passed the technical screening, when licensing was often required for Brazilian producers. Simplar procedures are widely applied throughout the State Enterprises. (See Chapter V.)

The role played by the State Enterprises in the Brazilian economy as suppliers of essential inputs for the rest of the economy (oil, steel, electric power, etc. - see next Chapter) combined to the complexity of their custom-built equipment and to the relative lack of experience of the Brazilian capital goods enterprises in designing similar goods, justify, to a considerable extent, the caution of the State Enterprises.

In fact, a policy of total self-reliance in design in Brazil is, in practice, unfeasible as well as unjustifiable from the arguments developed in the preceding Chapters.

This caution was probably strengthened by the limited efforts of the Brazilian enterprises to develop their own design capacity but, on the other hand, it was a powerful deterrent to the latter's investment in such capacity, creating thus, a vicious circle as regards SR in design, which is the more difficult to break by the difficulty of distinguishing between realistic risk assessment and excessive caution and prejudice - a point to which we return in the next Chapter. Nevertheless, there are indications from the interviews and other sources (Tecnometal, 1971; MIC, 1975) that in some cases the Brazilian capital goods producers would probably have a technical capacity to design the products for the State Enterprises, but have been pressed to use licensing (e.g. stop-logs for hydro-power, tanks for oil refineries). It has also been reported that the special lathes for cylinder rolls of steel mills which Enterprise 3 has been exporting (see Section 3) had been previously refused by a State company in Brazil (Visao, 13/10/75).

Furthermore, our interviews with the capital goods producers and with the State Enterprises indicate that the latter had not any policy of incentive to the former to master the preliminary design of the licensed products, so that in the future they could substitute SR for licensing. Petrobras, for instance, in some cases purchased the preliminary design of smme products abroad and passed it on to the Brazilian producers but did not seem to have any programme to help them to develop such design locally. One of its suppliers, a leading producer of heat exchangers, remarked that "given the preliminary design, we are able to do everything ... We would like to absorb this knowledge (basic design) but we do not know how to do it". Such type of limitation could probably be overcome by an investment by the

enterprise in SR, parallel to licensing, supported by the State Enterprise purchasing the equipment.

Although we do not have data similar to that regarding the State Enterprises for the private customers, our interviews with the capital goods producers indicate that the behaviour of the latter is very similar to that of the State Enterprises; especially for custom-built equipment (e.g. paper-making machinery, and cement equipment) but including also more standard equipment. In the latter, for instance, we found a contract, for plough discs, where it was explicitly stated that it was maintained for trade-mark purposes only, although for a very low price (1% of the sales).

The constraints above discussed, are reflected in the criteria of choice of licensors by the firms interviewed: the enterprises look for a licensor that is, at the same time, technically reliable and which has a "good name" in Brazil. The former is assessed through several means: following up the specialised literature (mainly technical journals), by visits to international exhibitions and by direct contact with possible licensors, visiting them in their countries. For the latter, they rely not only on their observation of the Brazilian market but also often on direct suggestions from their customers (see Table IV-12). In fact, in the markets of licensed products, good international standing and acceptability in the Brazilian market are normally coincident.

TABLE IV-12: MAIN CRITERIA USED FOR CHOOSING A LICENSOR 1/

Criteria	Enterprises
Best known trade mark in Brazil & abroad	11
Initiative of the licensors	9
Technical literature	8
Visits to enterprises abroad	7
Suggestions of the customers	5

NOTE: 1/ Some enterprises use more than one criterion so the sum of rows exceed the total number of enterprises.

(b) Lead time

Although the interviews were conducted in a period of boom, largely based on big State investments, especially in steel, mining, oil and petrochmmicals, several enterprises interviewed complained about the "imprevisibility" of State investments, on account of their past experiences.

The enterprises which depend directly on the State investment, are faced, in fact, with considerable uncertainty about the realisation of such investments. As discussed in more detail in the next Chapter, the decisions about such investment are often delayed for considerable periods, normally for financial and political problems and then, when the pressure for the supply of the inputs provided by the State enterprises mounts and the decision to make such investments is finally made, the time pressure on delivery is very great and, consequently, no time is left for the local development of designs, prototypes, etc. Alternatively, on account of anti-inflation policy, and balance of payments problems, State investments already decided upon are sometimes postponed, as was the case in the early 'sixties and more recently in 1976 (see Chapter V).

4.2) Competition from Imported Technology

(a) Imports of capital goods

Even if the local suppliers have the necessary technical conditions to design and produce the required products, there is a strong uncertainty about whether they will be allowed to supply them, mainly on account of the financial backing of such projects. When the financing of such projects is linked to foreign suppliers' credits or to Government-to-Government bilateral trade agreements, the local producers are excluded from the supply.

At the time of the interviews, this had recently happened in several State sectors, such as oil refining, electric power generation and railways,

the former two linked to foreign suppliers' credits, normally backed by their Governments, and the latter to bilateral trade agreements. It was deeply resented by at least a third of the enterprises interviewed, which saw such exclusion as their main problem at the time. Especially bitter were the producers of railway equipment, who argued that imports had been made from Eastern Europe, under one of the bilateral trade agreements (of wagons in exchange for coffee), for a price that was the double of theirs, at a time in which they had considerable idle capacity at their plants.

To the problems arising from tied-loans and barter-trade agreements we have to add the great fiscal incentives given to imports of capital goods during the years preceding the interviews (see Chapter V), which applied especially to the more complex goods and which were widely used by the State Enterprises (ibidem).

In fact, during the interviews, there was widespread complaint about the purchasing policies of the State enterprises as regards their preference for imports, the great exception being Petrobras, the State oil company and, to a lesser extent, CESP, the State of Sao Paulo electric power utility (see next Chapter). The enterprises interviewed, especially the producers of heavy-engineering equipment, also pointed out the uncertainty of State purchases as one of the main causes of their widely diversified range of production, as discussed in Section 2 above. Such diversification, as already noted, is an important obstacle to a strategy of self-reliance. On the other hand, the graater protection against imports enjoyed by the simpler products probably favoured the process of copying and adaptation in those areas.

(b) Local production with imported technology

The problems for a self-reliant company are compounded by the existence in the Brazilian market of alternative suppliers with access to foreign

technology. These are, in the first place, the subsidiaries of the multinational companies, which, stimulated by free-entry policies and several incentives (see next Chapter), have entered the Brazilian market in great numbers and presently dominate several segments of the capital goods industry, particularly in electric machinery (see Chapter I).

In terms of design, such subsidiaries have a double advantage over a potential self-reliant Brazilian competitor - they use a "proven" technology and this technology, even if not "off the shelf" is more quickly available because of the greater experience of their parent's design staffs. 1/

Given the pre erences of the State Enterprises (as well as other customers) for foreign technology and for quick delivery, the competition from foreign subsidiaries from within the Brazilian market is a strong incentive for the Brazilian companies to rely on licensing - with is equally "proven" and presumably almost as quick (assuming that communication between subsidiaries and parent companies is easier than between licensor and licensee) - even if the purchases of the State Enterprises are oriented towards the internal suppliers; unless a preference would be given to Brazilian firms over foreign subsidiaries, a point o which we shall return in Chapter VI.

In fact, comparing our list of contracts of the enterprises interviewed with the ABDIB catalogue, we find that for 70% of the contracts there is at least one foreign subsidiary competing in that line of production - and this is probably an underestimate, as the ABDIB congregates only part of the producers.

1/ Those companies, as shown by other studies (e.g. Biato et al., 1972) and confirmed by our interviews with some of them, receive their technology from abroad, from their parents, other subsidiaries or affiliates, doing in Brazil only minor adaptations fro local supplies of raw materials or, in some cases, for the smaller Brazilian market.

The evidence available shows that at the time of the interviews foreign companies had entered mainly the heavy engineering sectors (Leff, 1968; MPCG, 1967) and where standard products are relatively mass-produced (tractors, road-building equipment, pumps and compressors) [1/] leaving relatively open some markets such as lighter process equipment (boilers, tanks) and machine tools. [2/] This probably contributed too to the possibility of successfully copying-and-adapting some of the latter products.

In the second place, even where there are no foreign subsidiaries competing, a potentially self-reliant firm can find as a competitor another Brazilian firm which has a licensing agreement, enjoying thus the advantages above described, which would probably prompt the first firm to use licensing too. In fact, for all lines of production in which our firms held licensing agreements there was at least another Brazilian licensor and/or a foreign subsidiary.

If carried to its ultimate consequences this process would lead to a division of markets - one in which there were only licensed companies and/or foreign subsidiaries and another in which there were only Brazilian

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1/ The difficulty of Brazilian firms to survive in the latter markets, even if they have some technical capacity is illustrated by one of our WL enterprises - a producer of road-building equipment which, based on the technical skills of a highly ingenious entrepreneur (who copied and adapted machines available in the Brazilian market or which he knew from his past experience as a contractor abroad), at the time of the interviews was competing successfully with two multinational companies. Nevertheless, in 1974 it was bought out by another MNC when it entered the Brazilian market. Had it been supported by the Government and such purchases limited, it was an enterprise with high growth potential.

2/ It is indicative of this process that while in custom-built equipment the foreign companies accounted for circa half of the value of production (see Chapter I) in 1970, in the production of machine tools, where relatively simple models predominate (IPEA, 1974), they were responsible for only 13% of the value of production in the same year (Magalhaes, 1976).

producers based on copying and/or their own designs.

There is, as already remarked, some interpenetration of the two systems - i.e. one finds Brazilian producers based on copying competing with other Brazilian producers using licensing and/or with subsidiaries; but this tends to happen only in the simpler lines of custom-built equipment and in some of the standard, series-produced, goods (e.g. machine tools), the more complex goods remaining mainly the preserve of licensed companies and/or foreign subsidiaries.

4.4) Local Conditions for Design

In this sub-section, we examine first the availability of design inputs (see Chapter II) and their use by the firms interviewed (manpower, research institutes, etc.). We then discuss the risks involved in copying in Brazil and the availability of financial resources for design and related activities at the time of the interviews (including sources of risk-capital) and their use by the enterprises. In the last part we then discuss the learning from copying-and-adaptation and from licensing and the risks of failure of a strategy of SR in the light of preceding analysis and that of the two previous sub-sections.

(a) Manpower

As pointed out in Chapters II labour is the main input used in design activities and the main cost of such activities. Engineers are the main component of this labour-force and here we concentrate our analysis on them.

Leff, in his detailed analysis of the use of engineers by the heavy-engineering firms in Brazil in 1964, with a sample which overlaps with ours, concludes that "evidence indicates that firms have been satisfied

with the flow of skilled personnel available. ... Training programmes rank low within the hierarchy of the firm's concerns, and are generally under the administration of low-echelon executives" (Leff, 1968, p. 84). Since then, the number of engineers graduated in the country increased over three times in the period 1964/1971, from 2351 to 8425, an output, in the latter year, greater than that of Italy and circa 70% of that of the UK, countries with a strong engineering tradition (see Table IV-13).

TABLE IV-13: ENGINEERING GRADUATES IN SEVERAL COUNTRIES - 1974/1971

Country	1965	1971
Brazil	2351 1/	8425
U.S.	51822	70735 2/
Japan	42391 3/	46027
F.R. Germany	21264	21137 4/
U.K.	8732	12296
Italy	2807	5766

NOTES: 1/ 1964
2/ 1970
3/ 1966
4/ 1969

SOURCE: UNESCO (1975).

Moreover, since the mid-sixties, there had been a great expansion in opportunities for post-graduate education in engineering, inclusive in terms of Master and Doctoral programmes. At the time of the interviews, almost one thousand students had received their degree from such programmes and a similar number had completed their courses but had not written their dissertation. 1/

The composition of the engineering population has also changed favourably, in terms of design inputs - from an overwhelming predominance of civil

1/ However a considerable part of these students, especially those who had received their degrees (about half of them), continued academic careers without entering industry (MEC/DAU, 1974). Data refer to 1973, the year for which

engineers in the fifties, specialisations such as mechanical, electrical, electronics and industrial engineering now have an important share (Mascarenhas, 1975), a process which, in Sao Paulo, where most of our enterprises are located, was well advanced in the early sixties. 1/

However, as we have seen in Chapter II, design skills are developed mainly through experience, so that if the firms do not use the engineers available in such tasks the design expertise is not developed, even if there is a relatively abundant supply of engineers. 2/

Table IV-14 shows the average number of persons (engineers and otherwise) employed by the firms interviewed as design staff, and what such staff represents in terms of persons employed directly in production.

TABLE IV-14: AVERAGE SIZE OF DESIGN STAFFS COMPARED WITH NUMBER OF EMPLOYEES IN PRODUCTION AS A PERCENTAGE OF THE LATTER - 1970.

Enterprises	Design Staff	Percentage
WL	14	6.5
MLD	37	3.7
IE	20	6.3
ML	37	8.2
Average	29	5.5

1/ According to data provided by Leff (1968), mechanical, electrical, metallurgical, chemical and industrial engineering accounted for 47% of the engineers graduating from the Sao Paulo State Engineering schools, in 1962; comparing to 27% in 1934 (Leff, 1968, p. 58).

Our enterprises are located in the States of Sao Paulo (78%), Rio de Janeiro (including the former State of Guanabara) and Rio Grande do Sul. Circa 70% of the Brazilian engineers were concentrated in those States, in 1966 (Cummings, 1971).

2/ There seems to be a consensus in Brazil that the drastic expansion of the number of students of engineering has been accompanied by a decline in the quality of the education they get and by an excessive emphasis on text-book work and little experimental and practical experience (CNPG, 1974; Mascarenhas, 1975).

The interviews indicate that such staffs often have few engineers, especially among the WL enterprises, where the entrepreneurs are normally the main source of technical knowledge. In one of them, for instance, they had only one engineer in the whole firm and that "for legal reasons", The main exception among the WL enterprises is Case 4, discussed in Section 3, but where also the entrepreneurs played a critical technical role.

According to the interviews, the design staffs, in most enterprises, are only partially occupied with design, being often used for preparing proposals for biddings and other activities. In the enterprises which use licensing, especially those WL, their design activities consist to a large extent of detailed design, including adaptation of the licensed designs (see 4.5).

However if the firms where such skills should be developed through the experience of design use their engineers mainly for detailed design, the experience of basic design is never developed, justifying thus the allegation of the enterprises that such skills are not available.

This shortage probably applies much more to the knowledge required to design the products presently licensed, where basic design skills are not developed through experience nor taught through the licensing relationship, (see below) than for the products presently copied. For special skills, the firms which have attempted a self-reliant strategy in products relatively complex (especially Enterprises 3 and 5) have imported manpower from abroad (see Section 3).

Such import is, presumably, not cheap, as probably relatively high salaries and other incentives have to be offered to the experts who come to Brazil. Moreover, in comparison with licensing, those experts do not bring with them the security of technical success and of acceptance by the demand

- in fact, their main function is germinal: to educate a local staff for the design of specific products (something licensing provides for only partially, as we shall see). Indeed, the import of person-embodied knowledge makes sense only in terms of a long-term prospect, of a deliberate strategy of self-reliance, as the effect of its presence within the enterprise will probably take considerable time to be fully felt. It is significant that the only enterprises which have used this alternative are enterprises which are attempting to achieve self-reliance in the areas for which the experts were brought in.

The enterprises which have more possibilities of using this alternative are the enterprises which have licensing agreements, because of the contact with the technical staff of their licensors, from which they could hire the necessary experts and/or who could indicate to them candidates from other firms. It is indicative of the lack of interest of the enterprises which use licensing to develop an independent capacity, that only three of the twenty had exploited this possibility.

Therefore, we argue that although there is in Brazil a scarcity of experienced designers, especially for the more complex capital goods, this scarcity is partly the result of the strategy of copying-cum-licensing followed by the Brazilian enterprises, if our results apply to the industry's wider universe.

With the same qualifications, it can be said that one of the results of such strategy is that the Brazilian firms, individually, tend to benefit less from externalities in the form of receiving technical staff from other firms than tend to do their counterparts in the more advanced countries; the Brazilian firms having to train their own staff if they want to follow a strategy of self-reliance, often, as shown by our cases, with the additional cost of having to import the basic components of such staff.

(b) Suppliers

The enterprises interviewed often complained about the quality of the products of their suppliers of materials and components. The suppliers of materials (especially steel and plastics) perform limited technological activities in Brazil, mainly of adaptive character of imported technology (Biato et al., 1972; Reis and Redinger, 1975).'

With respect to components and sub-components, there is little local technological development. Local production of electric and electronic components such as controls, switchbaards and instrumentation is largely dominated by foreign subsidiaries, which use the technology of their parent companies. Where there are Brazilian firms operating (cutting tools, for instance) they tend to use technology from abroad. The use of local components is in fact limited: for machine tools they are largely imported (IPEA, 1974) and for heavy-engineering products imports cover circa 70% of the demand (Pupo, 1975).

That such conditions represent an obstacle to the local technological development of capital goods products, as argued in Chapter II (especially Section 2.5) is undeniable. However, it is important to stress that the strategy of copying-cum-licensing followed by the Brazilian capital goods manufacturers is, in good measure, responsible for this situation as the reliance on foreign designs and/or products leads to specification of components as abroad, blunting the incentives to local design by the producers of components. In fact, one finds the producers of components replicating the complaints of the capital goods producers about engineering firms - that the use of foreign specifications leads them to use foreign technology (Bello , 1075).

(c) Research institutes [1/]

The Brazilian research institutes, especially Sao Paulo's IPT (Instituto de Pesquisas Tecnologicas - Technological Research Institute) played an important role in the beginning of the capital goods industry in Brazil. It is worth quoting Leff, in this respect, to some length:

> "... the Technological Research Institute of the Sao Paulo Polytechnical School played an important role in promoting the early technical development of this and other Sao Paulo industries. Especially during the 1930's and 1940's the Institute functioned as a central laboratory for all Sao Paulo industry. In order to carry on these efforts the Institute was of a respectable size. ... The Institute did most of the materials testing required for the use of local raw materials. It also functioned as a technological pioneer introducing unknown practices and processes from abroad." (Leff, 1968, pp. 19/20, my emphasis).

In the beginning of the 1970's, as shown by several studies (Carneiro Jr. et al., 1971; Biato et al., 1972, Erber et al., 1974b), there was relatively little use of the research institutes by the Brazilian industry [2/] including the capital goods industry, especially as a channel of communication of new products and processes.

At the time of the interviews the situation of the research institutes had come under close examination by the State apparatus in charge of science and technology, especially by the Planning Ministry, and several measures had been taken or were in the process of elaboration in order to

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1/ Under the heading "research institutes" are subsumed not only independent research institutes, but also those linked to universities.

2/ The decay of some institutes, such as the IPT, and the lack of development of the majority of them is, to a considerable extent, the result of the dearth of funds from the State, who is responsible for them in Brazil, aggravated by administrative procedures which prevented the technical staff of the institutes receiving competitive salaries, and compounded by the lack of interest of the private enterprises in funding and even using the institutes, partially a result of the increased reliance on licensing throughout Brazilian industry (see op. cit. for a full discussion).

give them better operational conditions, including the increase in their resources and the removal of the administrative limitations above-mentioned. However, such measures would take a substantial time to be effective and the enterprises interviewed did not seem to be aware of them.

Among our 27 enterprises, over half of them (16) used the research institutes. However, practically always this use was for rather modest purposes - mainly for routine tests and quality control. We found only one case in which the collaboration had gone further, with the research institute cooperating with the development of the machine and another (Case 5 mentioned above) where a similar collaboration was envisaged, with the same institute.

Several of the enterprises which did use the research institutes complained about their services - slowness of operation, excessive bureaucracy, poor quality and excessive prices, often attributed by the enterprises to the need of the research institutes to compensate for their lack of funds from the State.

It is interesting to note that the use of the research institutes is stronger among the enterprises WL (see Table IV-15), which can be attributed to their more modest technological requirements, stemming from their simpler lines of production. The larger enterprises tend also to have their own quality control systems, prescinding from the research institutes for such services.

TABLE IV-15: ENTERPRISES WHICH USE THE SERVICES OF THE RESEARCH INSTITUEES

Enterprise	Number
WL	7
MLD	5
ML	2
IE	2
Total	16

Neverthsless, it is important to stress that the enterprises often acknowledged that they had not tried to explore the full possibilities of the research institutes and that relationships with the latter were established mainly on the basis of geographical proximity and/or personal contacts. In fact, despite the general decline or stagnation of the research institutes, some of them (or parts of them) have maintained a good technical standard, as shown for instance, by the development of NC machine-tools by the IPT or by the work of the Agronomical Institute of Campinas in agricultural machines.

In this sense, there is, again, a vicious circle operating: as the enterprises demand from the research institutes only relatively simple services, the latter do not progress further, which leads the enterprises to again demand only such type of services..... Breaking up this vicious circle has been one of the main concerns of the Brazilian Science and Technology policy and we return to this in the following Chapter.

(d) Engineering firms

Especially for process industries it may be said that the usual pattern is for the Brazilian engineering firms to be used mainly for detail work, while the main specifications of the equipment remain the responsibility of the main contractor who is usually a foreign firm.

At the time of the interviews there was a growing awareness of the limitations to local technological development implicit in such division of labour, among the capital goods producers, the engineering firms and parts of the State apparatus, especially FINEP [1/], and, in the interviews, we asked

1/ From 1965, year of its creation, until 1971, when it became the Secretary of the National Fund for Scientific,and Technological Development (see Chapter V) FINEP had dealt mainly with financing feasibility and engineering studies.

the capital goods firms if they "had considered the possibility of participating in the creation of an engineering firm or of establishing a link withthose already existant".

Of the 27 firms interviewed, one had set up a separate engineering firm and another was planning to do so, both in association with foreign groups. Both are leading producers of custom-built equipment and belong to the ML group. Another enterprise, a producer of railway equipment and metallic structures had established a close relationship with three engineering firms, especially one composed largely of members of its disbanded technical and dosign department and which acted largely as a replacement of such department. Two producers of process plant equipment were planning to establish agreements with existing engineering firms. Finally, one firm had tried unsuccessfully to set up a link with engineering firms in the cement sector.

The firms interviewed expressed fears that, if they established a special link with one engineering firm, they might jeopardise their chances of sales when different engineering firms were commissioned. Their behaviour is also probably linked to their own lack of specialisation and the lack of specialisation of the engineering firms in Brazil, which tend to operate in wide ranges of sectors. Also, their behaviour as regards the engineering firms is consistent with their strategy of reliance on copying and licensing, where the main concern is with market shares in the short run and not with long-term autonomous technological development.

(d) Industrial standards

In Chapter I we stressed the importance of what may loosely be termed "information systems" as a support of local efforts of technological development and we emphasised the importance of national standards among such systems as, when used by the purchasers of capital goods or by engineering

firms in their specifications, they help to orient purchases towards goods locally designed and, when used by the producers of capital goods, they contribute to reduce design and production costs by reference to a codified specification. They are also an important instrument against foreign competition.

In Brazil there are relatively few standards - in the early seventies there were circa 2,000, compared with 15,000 in India and circa 40,000 in the U.S. (Gazinelli, 1975). Such standards which do exist are mainly the result of the work of the ABNT (Associacao Brasileira de Normas Tecnicas- Brazilian Association of Technical Standards), which is a civil society with a small technical staff and therefore largely dependent on the cooperation of producers and consumers.[1/]

Given the potential importance of local standards we asked the enterprises interviewed whether there were any Brazilian standards for their lines of production and how they affected their technological activities. Only six of the enterprises (four of them in the WL and MLD groups) showed a significant interest in Brazilian standards. The majority used foreign standards, mainly American or German, or specifications given by their clients, which in turn refer to those foreign standards.

Moreover, the enterprises often acknowledged their passivity as regards the development of Brazilian standards either by not sending representatives

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1/ At the time of the interviews, studies were being conducted at the Ministry of Trade and Industry to set up a system of industrial information, which would include standards, as well as certification of quality of products, weights and measures and general information for the Brazilian industry, projects which are presently in the process of implementation, included in the Plan for Science and Technology (see Chapter V).

to the ABNT commissions or by sending junior people with not enough experience of the problems involved - they often felt that the opportunity cost of the time of senior personnel was too high as the results would come only in the long run.

Also, especially those enterprises which relied mainly on licensing, feared that such Brazilian standards could entail increased costs for them, as they or their licensors would have to adopt the designs to conform to those standards. Again, this behaviour is consistent with a strategy of reliance on copying and licensing and with a relative indifference towards technological self-sufficiency.

In short then, to conclude this brief overview, we can say that if, on one hand, it seems true that the defficiencies in the Brazilian supply of design inputs represents obstacles to the development of local design and increased costs, also, on the other hand, the Brazilian capital goods enterprises themselves have done less than they could do to overcome such obstacles, making little efforts to develop an independent technological capacity, either within their own organisations or by mobilising the available resources in the Brazilian economy or abroad.

This last point is reinforced if we consider the opportunities of reducing the costs of self-reliance to the enterprises which have not been utilised (see (f) below).

(e) Risks of legal action against copying

In Chapter II we argued that a firm which copied a product of another was liable to legal action from the original producer which, if successful, could oblige it to cease production of the copied equipment as well as paying fines and other legal costs.

In the Brazilian case, among the enterprises interviewed, this threat seems to be of very little importance. We found only one instance of legal action against copying and this sole occurrence happened in 1913. Moreover, although it almost brought the copying firm to its closure, it did not seem to have had great educational effect: the firm changed its main line of production, but still based on copying.

There are several, combined reasons for this impunity of copying. First, fnr many of the copied products the technology is of public domain (e.g. the universal lathes produced by two of the WL enterprises).

Second, patent obstacles may be circumvented by the adaptation which often accompanies the copying. 1/

Finally, there is the slowness and general inefficiency of the Brazilian patent system. In 1970 it was reported that there was a backlog of circa 400,000 patents to be examined in Brazil (Vaitsos, 1973a). This inefficiency is also illustrated by the attitudes of the entrepreneurs interviewed towards patenting.

In the questionnaire we enquired whether they had patented any product. Twelve out of the 27 replied affirmatively but then qualified this answer. Only one of them saw any real usefulness in patenting and then only as a defensive mechanism. The most general attitude was expressed, perhaps in its bluntest form, by the entrepreneur who replied, "why bother? Everyone copies from everybody else!".

1/ A more recent study on machine-tools in Brazil, confirmed that the Brazilian producers use mainly copying and explained that, in order to avoid legal problems, such producers often used a technique of "blending" i.e. combining features of machines of different producers (Versiani and Pastore, 1978).

(f) Risk-bearing by the enterprises - financial resources for the costs of design and related activities.

(i) the importance of the costs for the enterprises:

As suggested by the interviews the main advantage of copying-and-adaptation is in terms of costs. Because of the characteristics of the products and the experience of the enterprises, such process can often be done with relatively small design staffs, with few engineers, often working part-time; expecially in the case of the WL enterprises, where the entrepreneurs themselves were often the main source of technical knowledge. Table IV-16 shows the percentages of the employees of the enterprises represented by the design staffs, comparing the enterprises which rely mainly on licensing with those that rely totally or mainly on copying (WL and MLD). For the latter the design staff represents circa 3.3% of their total manpower and for the former almost 6%. We know (MIC, 1967) that labour costs represent circa 30% of the value of production in the capital goods industry. Even assuming that the costs of the design staff were the double of the average labour costs in the industry (an unlikely assumption 1/), this would make the costs of copying equivalent to circa 2% of the value of production.

TABLE IV-16:- DESIGN STAFF AS PERCENTAGE OF TOTAL MANPOWER FOR ENTERPRISES WHICH RELY MAINLY ON COPYING (WL AND MLD) AND FOR ENTERPRISES WHICH RELY MAINLY ON LICENSING (ML).

Enterprises	Percentage
WL & MLD	3.3
ML	5.7

1/ Manufacturing activities in capital-goods production employ a large number of skilled workers (see Chapter II), besides engineers. The latter are also widely used in sales activities. According to a study on salary levels in Sao Paulo (where the majority of the enterprises are located) a mechanic earned as much as a designer (non-graduate), on average (Pastore, 1972).

Moreover, the cost of the acquisition of the machine to be copied is, in the majority of cases we found, reduced by the fact that the machine copied is not wasted - it is re-assembled and used or sold. Furthermore, we found several instances, especially in standard, simple equipment, such as equipment for processing agricultural products (mills, etc.) where the machine to be copied was supplied by the customer, who wanted "another of those".

Among the enterprises interviewed, the problem of costs of local development of designs seems to be especially important as expected, in the cases of complex, custom-built equipment, where the design costs are substantial and where the Brazilian market is relatively restricted, especially when this market absorbs only a small part of the models, which the original producer develops using the same (or very similar) basic designs, diluting thus the design costs (e.g., travelling cranes for steel mills, bits and drills for oil exploration).

The importance of the costs of self-reliance as a deterrent of such strategy can be further inferred from the policy suggestions of the entrepreneurs, asked for at the end of the interviews, "in order to do or increase their technological research". The majority of those suggestions [1/] were concerned with credit, especially for the development of prototypes, and, to a lesser extent, with fiscal incentives (tax exemptions) - measures which would reduce and spread over time such costs; bearing in mind that the credit being asked for was "development credit", i.e. credit which, in the Brazilian context, is traditionally cheap (often subsidised at

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1/ It is worth commenting a difference observed in the suggestions of policies between the ML enterprises and the others; not in the content of such policies in general terms, but in their precision - the suggestions of the latter were much more precise, often backed up by specific problems and indicating previous concern with the question than those of the former, which were very often of a very imprecise nature.

negative rates because of the inflation) and at long term, especially in comparison with the commercial credit the firms of the sector use for their working capital (Suzigan et al., 1972). (See Table IV-17 for a discrimination of the main policy measures suggested - there, measures numbers 1 to 3 can be considered as being mainly cost-related and the rest mainly uncertainty-related.)

TABLE IV-17:- SUGGESTION OF POLICY MEASURES NEEDED TO INCREASE OR TO BEGIN ACTIVITIES OF TECHNOLOGICAL R & D.

Policy Measures	Number of [1] Enterprises
1) Credit	
(a) For design activities and prototype development within the enterprise	7
(b) For equipment for R&D	3
(c) For manpower	4
(d) For purchase of designs	2
(e) Credit "in general"	3
2) Fiscal incentives (tax rebates)	3
3) Improvement of the Research Institutes	2
4) Guarantee of Brazilian market	5
5) Association of State with Brazilian enterprises	2

NOTE: [1] Enterprises often suggested more than one policy measure, so sum exceeds total number of enterprises.

It is possible that ex post the cost designing locally some of the licensed products would not be much superior to the full (see 4.5) expenditures for licensing them, even for some custom-built equipment (e.g. some types of cranes, boilers), where the Brazilian enterprises have an experience of copying. Ex ante, however, as their experience of design is limited the uncertainty about such SR costs is probably much greater (see (g) below).

Moreover, as the interviews indicate, while in licensing the main payments are contingent to sale (see 4.5), in a strategy of SR the costs

precede the sales - and sometimes for a long period, as shown by the case of Enterprise 3. That is, in comparison with licensing the costs of SR are nearer in time (i.e. greater in terms of present value, assuming a positive time-preference, which the firms interviewed positively indicated they had) and also that SR implies a longer immobilisation of resources, as a longer period lies between costs and sales. As we shall see below, although the use of public funds could have reduced the amount of the firms' resources invested, nevertheless the latter would have had to bear the main part of the risks.

(ii) public credit for design and related activities:

As mentioned above, the main request from entrepreneurs interviewed in terms of policy measures, was for credit - especially for the development of prototypes. Indeed, based on such requests and, more specifically, using as a starting point one of the cases found during the interviews, FINEP, as mentioned in the Introduction, started operating a line of credit, with resources of the National Fund for Science and Technology, for such purposes. (See next Chapter for a discussion of its use.)

However, more important for the present discussion is the fact that the BNDE, the main Brazilian agency for development credit had, since the end of 1964, a fund (FUNTEC: Fundo Tecnico e Cientifico - Technical and Scientific Fund) which had as one of its main purposes the financing of research and development done by Brazilian enterprises, either intra-muros or by commission to some research institute.

According to the rules prevailing at the time of the interviews (BNDE, 1971) the Fund could provide resources for funding personnel expenditures (mainly for university graduates) at an interest rate of 1% per year, "for a long period" (Art. 8 § 1); i.e. at a highly negative rate, considering that in the period 1968/1972 the General Prices Index had risen at a yearly