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ELECTRONICS AND DEVELOPMENT IN VENEZUELA: A USER-ORIENTED STRATEGY AND ITS POLICY IMPLICATIONS

by

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RÉSUMÉ

Cet ouvrage cherche à déterminer un cadre conceptuel utile pour la diffusion de la microélectronique dans les pays en développement. Le Venezuela sert de base de référence à l'auteur. Il s'agit d'une économie latino-américaine de taille moyenne qui tente de s'affranchir de son extrême dépendance à l'égard des revenus d'exportations pétrolières et d'éliminer la surprotection de son industrie grâce à un effort de compétitivité internationale. Trois secteurs prioritaires sont au centre de sa politique d'industrialisation actuelle : la modernisation du complexe pétrochimique ; l'expansion et le renforcement du secteur minier et métallurgique (acier, aluminium) ; enfin, une stratégie agressive d'exportations pour des groupes agro-industriels sélectionnés (agriculture tropicale et pêcheries). Les exigences de ces trois secteurs prioritaires orientent la définition et la mise en place d'une stragégie microélectronique au service des ses utilisateurs.

Il faut considérer l'industrie électronique comme une partie du secteur des biens d'équipement. Les biens et les services qu'elle produit devraient consolider fortement, s'ils sont bien utilisés, la productivité et la compétitivité des secteurs essentiels de l'économie, d'où l'insistance sur les applications technologiques, en particulier au premier stade du développement industriel. Le développement d'une industrie électronique locale est essentiel pour l'acquisition de capacités et d'expérience technologiques au niveau national. D'où la nécessité, pour toute politique de développement de cette branche industrielle, de maintenir un juste équilibre entre les besoins des usagers et des producteurs, et d'essayer de ménager des interactions constructives entre les exigences requises par la conception, la fabrication et l'utilisation. Les nombreux et complexes échanges entre ces domaines sont ici envisagés dans le détail. On ne peut en abandonner l'organisation aux forces du marché ; mais "ils doivent faire l'objet d'une politique délibérée et d'actions concertées entre les secteurs public et privé". A la fois instrument d'orientation destiné à la définition d'une politique industrielle et traduction des principes en instruments d'action et de décision, cet ouvrage s'organise selon quatre axes : le développement des capacités et externalités critiques ; les modes de génération d'une demande de technologies nouvelles d'information ; la compétitivité et le protectionnisme ; enfin, le besoin d'une ossature institutionnelle viable capable de susciter un accord sur la stratégie.

SUMMARY

The purpose of this paper is to set out a conceptual framework for policies to promote the diffusion of microelectronics in the context of developing countries. The author bases her discussion on the experience of Venezuela, a medium-sized Latin American economy which is currently trying to overcome an extreme dependence on oil export revenues and eliminate the over-protection of its industry in an effort to upgrade its international competitiveness. Current industrialisation policies are centred on three priority sectors: the modernisation of the existing petro-chemical complex; an expansion and upgrading of the mining and metallurgical sector (steel and aluminium); and, finally, aggressive export strategies for a select group of agro-

industries, based on tropical agriculture and fisheries. Targeting the requirements of these three priority sectors should guide the formulation and implementation of a user-oriented microelectronics strategy.

The electronics industry needs to be viewed as part of the capital goods sector. It produces goods and services which, if adequately used, could drastically improve productivity and competitiveness in the main sectors of an economy -- hence a focus on technology application, particularly at an early stage of industrial development. Yet the development of a local electronics industry is essential for generating local technological capabilities and experience. Thus any policy to develop the electronics industry must balance the interests of users and producers and should try to strengthen the crucial interactions between design, manufacturing and user requirements. The numerous complex trade-offs involved are developed here in detail. These trade-offs cannot be left to be resolved by market forces but "should be the object of deliberate policies and concerted actions between the public and the private sectors." In this context, the paper develops guidelines for policy formulation and discusses how to translate them into effective policy instruments. Most of this analysis focuses on four topics: the development of critical externalities and capabilities; demand generation for new information technologies; competition policies and external protection; and, finally, the need to generate a viable institutional framework for strategic consensus planning.

PREFACE

This paper by Carlota Perez is a highly original and stimulating account of what developing countries need to do in order to reap the tremendous productivity-enhancing potential of new information technologies, without destroying their social fabric. It is a refreshingly unconventional contribution to the current debate on how industrial latecomers should go about improving their technological capabilities and their industrial competence in the context of radical technological and organisational change. We have thus chosen it to be the first of a number of Technical Papers based on reports commissioned for the Development Centre's project on "Technological Change and the Electronics Sector -- Perspectives and Policy Options for Newly Industrialising Economies".

One of the strengths of this paper is that it avoids falling into the trap of presenting the generation and the diffusion of technology as a simple dichotomy. Perez convincingly demonstrates that without a sound design and manufacturing foundation, no viable user-oriented strategy will be possible. Interactive learning, based on close user-producer links, is the basic prerequisite for establishing an electronics sector capable of providing essential support services for the leading growth sector of an economy. Strengthening such crucial interactions requires that "...a user-oriented strategy turns into a production development policy of a particular kind".

The author also reminds us that, particularly in the context of developing countries, a user-oriented strategy of technology diffusion would hardly be conceivable without very active involvement of the state. This relates specifically to four key areas: facilitating the development of technological capabilities and externalities (human resources, finance); demand generation and the creation of sophisticated users; sectoral targeting policies which, as a matter of fact, are applied nearly everywhere; and decisions related to the intellectual property rights regime and standardisation. Repairing the damage caused by over-protectionism and a rent-distributing state does not imply the return to "laisser-faire" economics. It requires, instead, a policy environment conducive to risk-taking and innovation, where sophisticated users would exert strong pressure to improve producers' capabilities.

Louis Emmerij
President of the OECD Development Centre
October 1990

I. INTRODUCTION*

When considering the development of the electronics industry in a developing country, it must be recognized that the microelectronics revolution is a twofold phenomenon. On the one hand, it has given the electronics industry itself such an unprecedented dynamism in terms of sales growth, product innovations and capacity to stimulate an ever increasing network of associated services, that it must be considered by any development policy. On the other hand, the revolution in equipment for offices, production and telecommunications is changing the technology of practically every other sector of the economy in a more or less radical manner. In this sense, the electronics industry cannot possibly be ignored by any country.

This means that although the consumer goods portion of the electronics sector could be seen as just another industry being transformed, the same cannot be said about producer or professional electronics. This segment, together with the development software, must be understood as a new and crucial part of the capital goods industry, playing an important role in the competitive restructuring of every economy.

Consequently, this situation must be taken into account by any development strategy for the microelectronics revolution. The selection of the most advantageous route for the establishment and growth of the electronics sector cannot ignore the short- and long-term impact upon the domestic user sectors. This poses the same old dilemma which makes the development of the capital goods sector so difficult. The protection of deficient equipment or intermediate input producers weighs on the quality and efficiency of the users, while the lack of local equipment producers restricts the creativity and the development prospects of the users (and of the country as a whole). The latter is true because the lack of domestic expertise in capital goods deprives a country of knowledge in some of the key supporting technologies.

Whether this dilemma, as it relates to capital goods in general, is left to market forces or is addressed in some form or another by government policy depends on the political and economic conditions of each country. However, we believe that the electronics industry is so important today for the development prospects of all countries that it should be the object of concerted policies by the public and private sectors, even where otherwise allocation by the market is preferable.

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The formulation of a specific policy to deal with the production and use of electronics becomes all the more important if one holds, as the author does, that there is a temporary window of opportunity for latecoming countries in information technology (PEREZ, SOETE).

Opportunities correspond to the twofold nature of the electronics revolution. On the one hand, within the electronics and software sectors, latecomers would have access to the technology of certain product areas while these are still in the early stages of their technological trajectories. On the other hand, countries and firms would be able to utilise the technical innovations provided by information technology, together with new organisational and managerial techniques, to rejuvenate and increase the competitiveness of other industries and services (PEREZ 1989).

What this means is that during this period developing countries would not necessarily have to look for mature products in order to obtain some comparative advantages, but that entry into relatively new product families in the early stages would also be possible and could lead to endogenous accumulation of technological capabilities.

The extent to which each country could profit from these conditions would vary greatly with the level of human and other resource endowments and the general level of development already reached. It would additionally depend upon institutional adaptability and the capacity to put into practice appropriate policies to take advantage of the opportunities identified.

This paper will discuss a user-oriented policy to face the challenges and the opportunities. It is based on the case of Venezuela where the author has been involved in analysis and policy making. We hope the general approach can be useful to other countries, but it must be kept in mind that the specific proposals have been designed for a country which is a rather typical second tier developing country, with some peculiar advantages and disadvantages derived mainly from being an oil-rich poor country.

The paper begins with a brief picture of the initial conditions. It then presents the criteria proposed for the development of a local electronics industry geared to maximising user advantages. The third section describes the existing industry in Venezuela, indicating how it has begun to fulfil these criteria and assessing its prospects. Then there is a brief discussion of the proposed policy instruments. Finally, there are some remarks on the relevance of this policy to other countries.

II. ELECTRONICS IN VENEZUELA: THE BACKGROUND SITUATION

The industrial structure that has evolved from the import substitution model in Venezuela appears, at first sight, a rather unfavourable candidate for the development of a modern electronics industry.

Until the mid-seventies the electronics industry consisted of a few dozen final assembly plants -- foreign affiliates or local firms under license -- for the production of consumer goods, such as black and white TV and audio equipment, and of some simple instruments with a market in the construction industry, such as fire alarms. There never was much more than "screwdriver assembly". Component production was limited to items such as small transformers or some simple capacitors, not even resistors or transistors were made. Production was strictly for the domestic market. In spite of idle capacity, the industry never produced for export, nor could it even consider it. The overvalued bolivar -- determined by oil exports rather than industry -- made labour costs very high, ruling out assembly-type exports in general. (According to the ILO, in 1976 average wages in Venezuela were almost 70 per cent higher than in Mexico and almost three and a half times the South Korean level.)

If those were the conditions of the traditional electronics industry, the situation was even bleaker in industrial electronics, which worldwide were in the process of becoming microelectronics-based. Only in telecommunications were there the beginnings of production of some peripheral equipment, however, under schemes that were quite unusual for the country and will be discussed below. In other areas there was practically nothing. Apart from one firm assembling telex machines, there was no office equipment production of any sort, that is, no typewriters, no cash registers, no calculators and, of course, no computers were produced. Furthermore, there was no machine-tool production. In fact, to this day, the bulk of the capital goods sector in Venezuela could be said to have avoided all "moving parts". It mainly produces products for the oil and construction industries and ovens, vessels, pipes and valves for the processing industries[1].

This lack of development of the engineering industries is both the result and the cause of a serious lack of skills and experience in precision mechanics. This constitutes a considerable handicap for the manufacture of almost all electronics consumer goods as well as for most types of computer peripherals.

It would have seemed that such conditions precluded developing a domestic electronics industry with a reasonable degree of competitiveness. Yet, even at that time, there were some indications of new possibilities: two firms, quite different from each other and quite different from the usual import substitution model, pointed towards a fruitful new direction.

One of them was MCM (today MICROTEL), set up in 1970 by two young electrical engineers. This firm marketed a Private Automatic Branch Exchange (PABX) of their own design; one of the first that was fully electronic in the world. The product succeeded in penetrating the domestic market, overcoming the traditional mistrust of local technology. It was later exported in small quantities to various countries and then manufactured under joint-venture arrangements in Ecuador, Argentina and Mexico. To design, export and license technology abroad was almost unheard of in Venezuelan industry at the time.

The other uncommon enterprise was MAPLATEX, a firm set up in 1974 for the production of telephone sets. It was founded by a local private group with engineering capacity, but they soon had to make a joint-venture agreement with the National Telephone company, to become, in fact, a "monopoly-monopsony" in telephone sets. Although at first sight it was a typical import substitution project under Ericsson license, MAPLATEX was determined to go beyond final assembly. It did, in fact, end up manufacturing the whole product: an electromechanical dialling set. Eventually, all metal and plastic parts were made in-house, including precision screws. Only a few parts, about 3 per cent, were either imported or obtained locally. This degree of integration stemmed from two factors: the lack of adequate local suppliers and a zero-defect requirement under which there was quality inspection of all parts. It was made possible by a deliberate increase in scale achieved by standardising down to a single-model, single-colour telephone set for the whole country. This still did not make the industry truly competitive for export (mainly because of the overvalued bolivar), but with subsidies the company did manage to place some of its excess production abroad at cost.

Ten years later, in 1986, in addition to MICROTEL and MAPLATEX, there were nearly 100 professional electronics firms, mainly in telecommunications and instruments, growing at a rate of 27 per cent a year, with over 100 products of their own design, 14 of which were being exported. They included a small number of foreign-based firms -- Siemens, Ericsson, Telenorma (Bosch), Telemecanique and Honeywell -- and some domestic ones working under license. But the great majority were young local ventures started by electronics engineers and manufacturing products of their own design.

In the same year, there were several hundred software firms, of which about 180 had more than five professional employees. Sales of locally developed programs and systems were estimated around $10 million and growing at more than 40 per cent a year.

At this point, we mainly want to indicate some of the factors that might explain the flourishing of small innovative firms in an apparently inhospitable environment. Besides the new microelectronics and information technology itself, with its applications, some of the favourable conditions in Venezuela have been:

(1) The existence of a significant pool of qualified human resources in the engineering design end. There were 10 000 persons with electrical, electronics, computer and systems engineering degrees in Venezuela in 1985 (that is, one out of every 1 500 inhabitants). Many of them had graduate or post-graduate degrees from some of the best universities abroad.

(2) The high exposure of the population to technological advances, from the mid-seventies to the early eighties. The very strong bolivar and the correspondingly high salaries allowed an unusually large proportion of the Venezuelan population to study, visit or shop abroad. Equally, the boom attracted many migrants having a wide spectrum of qualifications. They included technicians and highly trained professionals from Europe and Southern Latin America.

(3) At the same time, the availability of oil-derived resources, led to a wide use of information technology by both consumers and managers. In general, the professional elite is familiar with information technology and has equipment requiring services.

(4) After 1983, the drastic devaluation of the bolivar against the dollar (three times 100 per cent since then), has driven down all labour costs, including that of highly qualified personnel, as well as all other local costs[2].

These "environmental" conditions were enhanced by government incentives and tariff protection, but generally only after firms had already attained some significance or when foreign investors wanted to enter the market. One incentive that has helped a few products is the policy of giving preferred access to the public sector market, which includes the national telecommunications company, the oil industry, electricity, etc.

As will be discussed later, most of these firms are still small and fragile. How many will survive and grow will depend on many factors, of which an important one is government policy. The proposed criteria for such policies are the subject of the following section.

III. THE POLICY CRITERIA: USER-ORIENTED STRATEGY

Our basic assumption is that Venezuela lacks the potential for becoming a significant producer of electronics goods for the world market. It has little that could attract foreign investment in this sector and it has no previous experience to build upon to pursue a domestically led export drive in electronics. We consider that the country's most promising competitive potential lies in other industries, especially in making the most of its vast endowment of energy (petroleum, gas, hydro-electricity) and other natural resources. In fact, the industrial strategy now taking shape to overcome the extreme dependence on oil export revenue aims to eliminate the over-protection which prevented industry from seeking comparative advantages. The new policies are expected to promote the development of three sectors: petroleum-petrochemical, mining-metallurgy (steel and aluminium), and tropical agriculture and fisheries (CORDI-PLAN).

However, attaining an increase in competitiveness in these areas will require many different contributing elements. Firms will have to make an appropriate selection of products or product families, establish dynamic links with suppliers and clients, increase R&D efforts, etc. The public sector should provide the infrastructure, and adequate support services.

It is in the context of this last requirement that information technology is expected to play a strategic role. The development of a modern telecommunications network and of the local electronics sector are seen as a means of providing infrastructural and service support for that industrial strategy. In essence, the goal is to develop the electronics and software industries as a dynamic complement of the exporting sectors.

Consequently, the criteria for the development of the professional electronics and software sectors are to be derived from specific user needs.

This implies that user firms should have ample freedom to select the most adequate equipment and software, whether domestic or imported. Some would even argue that especially in view of past experience with import substitution and over-protection, that it would be better to import and not to produce at all. The question is whether the degrees of freedom for user firms are greater with or without a domestic electronics industry.

In our view, putting the accent on use as opposed to production looks like a valid option. But there is less of a choice than appears at first sight. The relationships between user ability and design capability as well as those between design capacity and manufacturing ability are very complex and warrant detailed study. It is our assessment, however, that without production, design capacity has no feedback and soon reaches limits and that something similar occurs to user ability without experience in design.

In contrast to the more traditional technology, electronics-based equipment is, by its very nature, adaptable and flexible as well as capable of being continuously improved. Thus a passive and rigid user, incapable of adapting, modifying, interconnecting or upgrading a system obtains few of the benefits of the technology.

Intelligent and efficient users of information technology thus need to have design capacity or to be able to count upon it as a service from accessible, that is, local expertise. At a minimum, this should include software, whether independent or associated with commercial representatives. But, a truly user-oriented strategy in information technology would have also to provide local capacity for custom and semi-custom design and manufacture of hardware elements.

A difficult question is how far upstream in the electronics industry it is necessary to go to achieve the minimum degree of autonomy and support to be a creative user.

Roughly speaking, one could say that in the electronics industry there are many iterations between design, production and use, in and between four basic levels: chips, products, systems and software. However, there are essentially two distinct stages of design: one for the manufacture of the core products and the other -- with many facets and perhaps many iterations -- which is design for the user (See Figure 1).

In our view, the ideal to pursue is the gradual coverage of almost the whole of the right hand loop in the figure. The order of the objects of adapted design -- software first and chips, Application-Specific Integrated Circuits (ASICs) last -- is what we consider the actual order to accessibility as well as the likely order in which experience is acquired. Covering the whole loop, though, requires reliable manufacturing capacity.

This generates a paradoxical situation, for user-oriented strategy requires producers capable of customising and fulfilling customer specifications. However, in order for firms to be available for customising, they must have a solid base in some profitable "bread-and-butter" products. It is the knowledge and experience gained in designing, producing and improving these "cash generators" that provides the capability of adapting and modifying those and similar products. It also helps increase the expertise for other services required by the users, such as maintenance or consultancy in equipment selection for import.

Thus a user-centered strategy turns into a production development policy of a particular kind. What follows offers guidelines for this strategy.

1. The Basic Policy Guideline: Maximise User Advantages and Flexibility

This basic guideline translates into criteria for government policy, for the type of firm to be fostered, the choice of areas of specialisation and the target markets.

Government policy which gives priority to the competitiveness of the user naturally rules out protecting structurally inefficient firms in electronic capital goods. There should also be no standardisation policies meant to facilitate economies of scale for the producer, but which only create inflexibilities for the user. In other words, the "make locally or import" decision is to be based on the resulting benefits for the users, defined as the major industries in the country, especially those with a clear export advantage. If some temporary compromises are to be made in favour of domestically produced electronics equipment as regards quality, technical excellence, price or any such variable, the trade-off should be made against specific advantages being created for the longer term interest of the user industries, and preferably with their consent.

Consequently, electronics firms must themselves be competitive in quality, cost and delivery, and at the same time be capable of meeting customer specifications by adapting, modifying or upgrading products.

2.The Necessary Complement: Conditions for Viable and Profitable User-Oriented Firms

It would be difficult for a firm meeting the above requirements to survive, thrive and grow without some basic "bread and butter" products to provide a permanent cushion for the more flexible front end. Even with such products, these firms would find it difficult to survive in isolation. They would need to be the front runners of a larger industrial structure. Paradoxically, we find that the efficient development of a key segment of industry seems to involve some degree of inefficiency elsewhere in the industry.

Thus the core of the proposed structure is a group of dynamic firms capable of hardware design and manufacture as well as of software and systems development in areas related to the country’s main export lines. These firms would be anchored, on the one hand, in the network of user firms and, on the other, in the electronics industry as a whole. The criteria for policies fostering the development of the latter would be maximisation of the advantages of the core firms.

In the area of components, for instance, the basic guideline is to increase the competitiveness and responsiveness of the professional electronics industry. Anything that would restrict the choice or augment the costs of this industry is to be avoided; anything that increases its flexibility is to be fostered. This means semiconductor production should be discouraged and certainly not protected but ASIC design capability would be encouraged (see HOBDAY 1989). It means facilitating semiconductor imports, while strongly supporting the development of local competent and competitive firms making all types of printed circuit boards, surface mounting and other design-dependent parts or services.

However, such parts-producing firms could hardly be cost efficient if they have to serve exclusively the highly diversified, low volume markets of a professional electronics industry, as proposed here. Consumer goods production, or some other mass manufacture would be required to provide a market of sufficient size for parts (including metal and plastic housings) and other common services. Besides this market generating role assigned to consumer electronics, it can also promote the acquisition of reliable assembly experience and mastery of some complementary technologies which will eventually be necessary for the professional electronics sector to obtain some significant niche positions for export.

This poses a complex problem. Given the small Venezuelan domestic market, production of electronic consumer goods could not become competitive without being able to export. Yet, as discussed above, there are no particular indications to expect that this industry can compete in international markets. Therefore, the strategy will require imagination, audacity of compromise. A solution might involve joining forces with neighbouring countries, or creating extremely favourable conditions for attracting some foreign investors or partners, or even designing a complex package for "import substitution" with efficiency and quality. Whatever the means, the objectives to be kept clearly in sight are that privileges or subsidies in this domain are to be understood as an investment in the competitiveness of the main export sectors, and that is how their results should be evaluated.

In the area of producer goods, it is clear that this policy would lead to a specialisation in medium to small batch products with custom and semi-customising possibilities. This would exclude most components, microcomputers and other mass-produced capital goods, which are the more visible segments of the industry and tend to be the target of other development strategies. This is intended to result in a relatively small, but competitive and dynamic, electronics industry, very responsive to the specific requirements of its clients. It would not necessarily be geared to the export market initially but export competitiveness in certain niche markets associated with the needs of the local user industries would be the natural outcome.

These guidelines suggest that the hardware industry to be developed in professional electronics should be an industrial service sector.

Obviously, similar considerations hold for the desired software industry, where the "service" character is more readily apparent. However, it is necessary to recognize that "software" is an indispensable part of any investment in computerised equipment and, as such, is a capital good. A failure to understand this fact can have practical consequences in the industrial credit policy of private and development banks and, in turn, a direct impact on user choice and the viability of a user-oriented local software industry.

3. Choose Product Range and Growth Path for Technology Accumulation

Imposing stringent requirements upon the core electronics and software firms means that the choice of product, target market, point of entry and growth path should be the object of careful analysis, far beyond what has been customary in import substitution policies.

A first rough selection of areas of specialisation is suggested by the definition of "user-oriented". It excludes, first of all, those product ranges which belong to the left hand loop in Figure 1, that is, it rules out "basic" chips, products, systems and software which are, by definition, mass produced for world markets and become the building blocks for the user-adapted stages of design. It favours products which are closer to the applications end of the product ranges, where the concrete requirements of specific users become important.

Clearly, the strategy being proposed is based on increasing the design capability, which has already been demonstrated in the country, both in software and hardware, and coupling it with manufacturing and marketing capacity. But the choice of product makes a big difference. A newcomer who designs a microcomputer in the 1990s is unlikely to achieve commercial success. That product is well past the early stages of evolution. It is mass produced, widely cloned, and competitiveness increasingly requires extensive manufacturing and marketing experience, while price is becoming a prime consideration in the market. Development costs could never be recovered. By contrast, designing a system to monitor and programme oil well maintenance could make more sense, especially it if could be developed and tested in collaboration with the user-industry experts. Practice in making such a product, first as a prototype and then in small numbers, allows time for acquiring knowledge and accumulating manufacturing and marketing experience. This approach is particularly important in Venezuela, where most of those who have ventured in this industry are young electronics and computer engineers with no business experience.

The problem is that there are an almost infinite number of user-adapted applications. The question is which criteria should be used to select, from the vast range of practically useful and technically possible products, those which are also cost effective and profitable to make.

In this respect, the producer is squarely confronted by the proposed strategy. The premise is that in these sectors of the industry there are two very important factors which can increase the chances of success: accumulation of technological capability inside the firm and accumulation of confidence and goodwill among the customers. This means consciously following a strategy of entrepreneurial learning (TEUBAL 1983), understanding that in this area learning and growth go hand in hand.

Translated into recommendations, this means starting with a solid footing on existing capacity as a base for a strategy of technology accumulation. At the market end, the firm should join forces with competent users. Let us discuss each of the these guidelines in turn.

a. Start from Existing Capacity and Accumulate Technological Capability

One of the main determinants of the choice of initial product range is, of course, the local ability to tackle design and/or production. Given the assessment of Venezuelan capabilities, three areas should be evaluated: relative complexity, scale of production and required complementary technologies. If these three domains were the dimensions of the product space, the recommendation would be to start with products located in the neighbourhood of the minima in all and move up each of them as learning proceeds (See Figure 2).

By relative complexity -- on the horizontal axis -- we refer to the electronics design proper. The simpler the design, the more likely it is that it can be tackled with existing local design and production capacity (by the nature of the technology, the difficulty of assembly is more or less directly proportional to design complexity). Although in Venezuela there are electronics engineers who can design relatively complex products, initial simplicity is generally recommended. It is estimated that design experience for fully "debugged" products is best acquired along a path of gradually increasing complexity. The same applies to manufacturing experience and how it leads capability for judging the sturdiness of design and guaranteeing reliability. Jumping the queue is better done in a joint venture with experienced partners. This is especially so when there is little expertise in the surrounding industrial environment to come to the aid of firms encountering production problems.

In respect to market volume -- the vertical axis in Figure 2 -- it has been implicit in the previous discussion that those goods which are normally mass produced in the world market are to be avoided as production targets and certainly as design targets. Medium- to small-scale products or product families are considered more likely to lead to competitive production.

In relation to complementary technologies we are in this case referring to requirements in other production technologies such as precision machining, optics, hydraulics, electrical machinery etc,. Most of these are mature fields with a considerable accumulation of tacit knowledge and "know-how". They thus tend to be dependent upon the existence of established firms, experienced personnel and a skilled workforce. As mentioned earlier, our general assessment is that in this respect Venezuela has very little to offer, which is quite a formidable limitation in certain fields.

Instrumentation is an area with possible opportunities, for instance, yet the above restriction reduces the field mainly to the areas of inspection, test, measurement, analysis and other data collecting and data processing applications. The production of direct control, closed loop systems, with "moving parts", will require a long and intense learning period, preferably with experienced partners.

However, avoidance of areas requiring complementary manufacturing technologies that are generally not available in the country should not be confused with the complementary technologies mastered by competent users, which are required for client-oriented products. The hybridisation between these technologies and software and hardware design capabilities is one of the pillars of the proposed strategy and is to be promoted by all available means.

In summary, local design-based firms should be encouraged to initiate their technology accumulation process with products involving only electronics, of minimal complexity, and produced in small to medium quantities. They can move forward from there, as permitted by the markets and their experience. Foreign investment should be invited to participate, alone or in partnership, in order to bring those technologies and skills which are lacking and unlikely to be developed locally. Meeting, hybridising, joint development and other forms of collaboration between foreign and local firms would be encouraged.

b. Target the Market as Close to the User as Possible

This general mapping out of the more approachable product space must now consider the market place. Given the user-oriented policy being proposed and the need to have "double duty" firms, it is important to identify the likely users of standard products and those at the more specialised end of the product range.

One of the few absolute advantages that a local producer can have is goodwill built up with powerful clients, based on the ease of face-to-face contact and the quality and reliability of service support. The more easily a product can be bought off the shelf and serviced by a standard maintenance technician, the less it matters where or by whom it was produced. The more customer-specific the product, the greater is the importance of being able to count on direct service from the manufacturers themselves. Thus the custom and semi-custom ends of the range, with their relevant services, are the safer markets in the longer term. Developing these markets requires the establishment of strong user-producer links (LUNDVALL) with technically competent clients, in reasonably large markets. That takes time and experience, and good client targeting and nurturing.

In essence, specialised products are expected to be the outcome of the technological convergence between the information technology expertise of the producer and the applications expertise of the user (VON HIPPEL). Good potential clients in markets for specialised products, tending towards strong user-producer links, including joint product development would be:

(1) The large state-owned companies such as those in telecommunications, electricity, metallurgy and the petroleum industry, capable of setting up active procurement policies and technically competent enough to collaborate in research and in the specification, evaluation and upgrading of products.

(2) Industries where the private sector has achieved enough technological capability to be able to specify the equipment it needs and evaluate it in use. These are mainly process industries in areas such as chemicals and agro-industry.

A coherent strategy would be to work with the technical personnel of these firms not only in custom or semi-custom specialities but also in identifying simple standard products that are the basic, lower-end versions of diversified product families, with a more complex front end. However, this is not always possible or convenient.

The other market segments that have some likelihood of being safe in the medium and long term, are those requiring some sort of adaptation to the characteristics of the country: climate, local peculiarities, legal requirements, and other specific conditions. These are more likely to lead to "bread-and-butter" products with a reasonable volume in the domestic market. Among them could be the following:

(1) Standard products fulfilling the needs and regulations of the construction or tourist industries (this includes intercom systems, security and alarm devices, PABX, etc.). Technical specifications and quality requirements for these can be -- and many have been -- determined and made official.

(2) Products which can be adapted to peculiarities -- or even disadvantages -- of the local infrastructure. Actual examples include voltage regulators with wider than standard tolerance ranges or UPS's with longer than standard operating time, to adapt to an inefficient electricity network. Another case is a modernising interface adapted to the old electro-mechanical exchanges, to allow IDD with automatic call-by-call subscriber billing.

(3) Products which need "tropicalisation" such as higher than average tolerance to heat or humidity. A domestic example of this is the power meter developed for the local electric company.

(4) Product interfaces which are adaptable or compatible with the great variety or imported electronic equipment.

In general, the more country-specific the required standards, the greater are the chances of capturing a good share of the market for medium volume products (and, eventually, for acquiring export markets in countries with similar conditions).

The same considerations and examples would apply to product family targeting in the area of software. In this case, however, the "bread-and-butter" income can come from the commercial representation of foreign equipment or software, or from wider ranging consultancy services and not necessarily from standard packages (which might in fact be a doubtful proposition).

In general, it is recommended that engineers wanting to set up design-based firms select simple products with some market demand, in areas and product ranges providing time and space for acquiring experience, and in fields where local characteristics are important or where local expertise (in the complementary knowledge related to the application) is associated with accessible domestic markets.

Other routes, such as starting with a joint venture or negotiating a license to manufacture a product of medium complexity are also to be encouraged as long as feasibility is not highly, or permanently, dependent on tariff protection. These firms would be expected also to guarantee installing, adapting, servicing, training, etc., in relation to their product. In practice, firms that have chosen this route have done all this as part of their marketing and have been very successful. One of them, FONOLAB, developed from the beginning as an assembler (and commercial representative) with parallel design and adaptation capacity; this firm has been one of the most effective in acquiring export markets.

At any event, it is likely that in the long run most local firms will establish collaborative arrangements with firms abroad, as they become stronger and better understand their needs and limitations.

In summary, the proposed development strategy for the electronics and software sectors is one of gradual accumulation of technology, geared to enhancing the flexibility and the competitiveness of the user industries, in particular those considered to have export potential. It is understood that this "service" role imposes such requirements that the electronics industry itself has to be a highly competitive, continuously improving sector.

We now turn to the existing electronics industry in Venezuela. The analysis will be carried out in the light of the preceding criteria and with the purpose of identifying the policies that would best serve the stated strategic goals.

IV. PRESENT AND POSSIBLE FUTURE OF THE ELECTRONICS INDUSTRY IN VENEZUELA

A good indicator of the validity of the general guidelines presented above is the fact that private industry has sprung up spontaneously with more or less the intended characteristics and has met with considerable success by Venezuelan standards. Let us describe the industry as it has grown within the past decade in order to assess its future prospects and the type of policy support that might be required.[3]

1. A Small Industry in a Dynamic Market

It must be clear from the outset that the weight of the electronics industry in Venezuela is very small indeed. The three sectors together -- consumer, components and professional electronics -- only have sales of about 500 million dollars. That figure constitutes 1.2 per cent of the value added by Venezuelan industry as a whole.

This should be understood in the context of the previously mentioned natural resource-based economy, with scant development of the capital goods industry. In fact, during the "oil boom" years (to others, the oil crisis) of 1974-79, Venezuelan industrial capacity developed a strong bias towards the processing industries, stemming from relative costs: very low cost energy (oil, gas and hydro-electric), vast mineral resources and relatively high labour costs. In that high growth period (12 per cent yearly average), intermediate products such as steel, aluminum, petrochemicals, cement and paper grew at over 16 per cent per annum, increasing their share from a third to almost half of industrial value added. During those same years the whole of machinery and electrical manufacturing, growing at 8 per cent per annum, saw its share of value added fall from 17 to 15 per cent. With the onset of the Venezuelan crisis since 1979, growth rates have diminished considerably (sometimes even becoming negative) but the relative trends remained.

Within the capital goods industry, itself only 6 per cent of total value added, professional electronics is relatively significant, constituting around one-tenth of the industry. Also, within the electronics industry as a whole, the capital goods portion represents 45 per cent of production and more than half of the establishments.

The domestic market of the professional electronics sector is growing very rapidly. Imports of electronic goods, in general, grew from 6 per cent of total imports into the country in 1980 to around 9 per cent in 1986, but the professional electronics grew much faster than consumer electronics, increasing its share from a half to 80 per cent of total electronics imports. This strong demand for information technology equipment allowed it to overcome the drastic reduction in imports following the 1983 devaluation, rebounding in two years to the 1982 peak of $442 million and surpassing it by 1986 ($453 million). In these same years, as will be seen later, sales of domestic production of professional electronics were growing at a 40 per cent pace.

Information technology has become widely used and there is a relatively high level of computer literacy and of new technological developments in computing (accompanied by a good measure of imitative consumption of the least sophisticated sort). In 1985, it was estimated that personal computers represented 15 per cent of the total computer market in terms of value. By then, about 50 000 micros had been sold, or about one per 200 persons of working age, while yearly sales were 15 000 units (PRODUCTO 30). Large firms, such as the petroleum company, are fully equipped with the latest in information technology.

2. The Professional Electronics Industry: An Overview

There are about 110 professional electronics firms (including component manufacturers) operating in Venezuela. However, as many as 40 or 50 of these companies actually belong to the so-called "informal sector". They have been set up by electronics engineers who design and manufacture applications products and either operate through a distributor or are themselves registered as commercial firms. This rather odd situation where high-tech products are manufactured under irregular conditions is considered to be a consequence of the cumbersome paperwork and costly requirements for setting up an industrial firm. This insight into bureaucratic obstacles to development also reveals something about the electronics applications industry. Initial capital can be rather small and, in certain products and segments, competitiveness is possible without protection and, at least for a time, without government help of any sort.

There are about ten firms in the industry which are considered large by Venezuelan standards (more than 100 employees). These include five foreign companies -- Siemens, Ericsson, Telenorma (Bosch), Telemecanique and Honeywell -- and five local firms -- Microtel, Maplatex, Fonolab, Avtek and Sovica. Together they represent about 70 per cent of sales and 50 per cent of employment. Maplatex alone had 800 employees in 1986 which was nearly 15 per cent of total employment estimated in the sector for that year.

With such a lopsided distribution, aggregate figures are not very meaningful. Nevertheless, Table 1 presents a profile of the sector with estimates of the main descriptive parameters.

Table 1

A PROFILE OF THE PROFESSIONAL ELECTRONICS INDUSTRY(*)
Venezuela 1986

Number of firms	110	
Sales	215	million
Value Added	83	million
Imports	55	million
Exports	1.4	million
R&D Investment	9.3	million
Number of different products	140	
Products being developed	136	
Personnel	5400	employees
Engineers and other professionals	960	
Professionals in R&D	360	

Source: Romero, Sanchez, Martinez

(*) Figures in dollars at the official 1986 industrial exchange rate of 7.50Bs. dollar.

Even in this doubtful aggregate, there are some points worthy of note:

(1) R&D expenditure represents nearly 5 per cent of total sales, an uncommon level in an industry whose main activity had been assembly under license.

(2) Professional employees, of whom more than a third are engaged in R&D represent 18 per cent of the personnel.

(3) Product diversity: 140 different products, considering that there are product markets where 6 or 7 firms compete, means the average number of products per firm is certainly more than one, and the same can be said about the number of products under development.

Thus this is a typical industry for Venezuela, with a capacity to innovate and with a certain degree of competitiveness. However, it produces mainly for the domestic market, for exports are less than 1 per cent of sales. In Venezuela in 1986 there were at least 180 software firms with more than five professional employees. From the survey, it was estimated that the total value of sales of locally developed software in that year was approximately Bs. 100 million ($14 million). Employment could be about 2 500, the great majority professionals, but this is an even more fluid and elusive group than that in hardware.

3. Evolution of Professional Electronics: Survey of 50 Firms [4]

Many of the firms in professional electronics are of recent origin, but unlike the great majority of new small firms in other industries, a smaller proportion were founded after Black Friday, the day of the first 100 per cent devaluation in March 1983. As shown in the first column of Table 2, more than half of the firms surveyed were established before 1983, together with many software firms.

However, the rate of growth of sales increased after Black Friday. Devaluation gave a boost to most domestic manufacturing against imports. Clients were forced to try the domestic alternative due to exchange controls and other import restrictions on final goods. This development helped dispel a widespread distrust of product engineering by local manufacturers of electronic products. Many domestically designed products gained market acceptance by getting this opportunity of being tested.

As shown in Table 2, after absorbing the shock of the first devaluation, sales increased in 1985-86 by more than 40 per cent, both measured in current bolivars (or in dollars at the official industrial rate).

Table 2

BIRTH, GROWTH OF SALES AND EMPLOYMENT IN 50 SURVEYED FIRMS
OF THE PROFESSIONAL ELECTRONICS SECTOR
Venezuela 1982-1986

FIRMS		SALES				EMPLOYMENT	
YEAR	No.	Million Bs.	Million $	Growth Rate Bs.	Growth Rate $	Number	Growth rate
1982	27	278	64.7			1 408	
1983	30	307	51.2	10.4%	-20.9%	1 289	-9%
1984	37	337	44.9	9.8%	-12.3%	1 568	22%
1985	43	502	66.9	49.0%	49.0%	1 863	19%
1986	50	714	95.2	42.2%	42.3%	2 590	39%

Source: Romero, Sanchez, Martinez.

If official deflators are applied, which is a very doubtful practice when referring to the electronics industry, growth rates in 1985 and 1986 are 34 per cent and 27 per cent. By contrast, the real industrial growth rate for 1985 was 1.2 per cent and in 1986 there was a decline of 4 per cent.

However, there are two other indicators of real growth: (a) the increase in the number of firms (seven new firms per year in the sample, which is a 40 per cent increase in three years); and (b) the growth in employment.

After the 1983 decline, growth in employment reached nearly 40 per cent in 1986. Since almost half the firms in that year were less than three years old and therefore likely to have only a few employees, much of the increase was probably accounted for by the relatively older firms.

By 1986, 32 per cent of the firms surveyed had less than 10 employees: 86 per cent had less than 60 and only 4 firms (8 per cent) had close to or more than 100 employees. In fact, these four firms had 57 per cent of all employed in the sample.

Obviously, a similar distribution applies to sales. In 1986, 38 of the 50 firms had less than 10 million Bs. ($1.3 million) in sales. Only 3 firms had sales of more than 50 million Bs (US $6.7 million).

Thus in the majority of cases these are small and fragile firms. There is a clearly positive correlation between value of sales and age of firm.

Another difference is their innovative character, which is a source of dynamism and potential to adapt to market needs. Indicators of this are the level of investment in R&D, the employment profile and the use of time of professional personnel. In 1986, the 50 firms in the sample invested 70 million bolivars (about $2 million) in R&D, which represents on average 4.5 per cent of sales. This is reflected in the fact that more than 70 per cent of the products being marketed by these firms are in-house designs. It is also evident in the proportion of professional personnel, which is 34 per cent. Obviously, that is also a sign of immaturity. Many of the small firms are a sort of laboratory with three or four engineers engaged in design, a secretary and a couple of people in assembly. The larger the firm, the smaller is the proportion -- though not the absolute number -- of professional staff.

Another characteristic detail is the distribution of professional personnel by function. Nearly 40 per cent of professional staff (or of their time, because staff in young firms is often multi-function) is devoted to R&D. The other 60 per cent is divided roughly equally among production, administration and relationship with clients (including 12 per cent in sales and 7 per cent in service activities).

Finally, unlike other sectors with small firms in Venezuela some of the electronics firms have reached the export markets. In the sample there were 14 that had exported some product (line-conditioners, PABXs, protocol converters, etc.). Quantitatively, as noted before, exports are minute; they only approached $1.5 million for 1986. However, this points to some potential for the future.

a. A View Inside, a Bias in Specialisation

The existing professional electronics industry in Venezuela, as our proposed policy criteria would recommend, has by and large not entered the areas which might look like the most enticing: computers, office equipment and chips. Although there have been some attempts at highly protected "import substitution" type projects for computer assembly, and even one for producing integrated circuits under license, good competitive sense seems to have prevailed. The industry is basically oriented towards medium and small volume products in telecommunications, instruments and software.

In fact, telecommunications and instruments, represent 91 per cent of the total sales in the survey sample, 88 per cent of employment, 70 per cent of firms and 86 per cent of product families in the market.

A further analysis of the specialisation profile, as presented in Table 3, shows that telecommunications is the strongest element of the industry. The six firms in the sample (12 per cent) had 71 per cent of sales and 58 per cent of employment. The majority of the larger firms are therefore in this area; they produce mainly peripheral equipment and some interface systems for the telecom company. By contrast, the instruments producing segment appears highly diversified: 58 per cent of the firms manufactured 67 per cent of the product lines in the sample, and account for only 30 per cent of employment and 20 per cent of sales. This domain (together with data processing) is where most of the small new firms are to be found, although it also includes three of the largest and most successful firms: AVTEK in line conditioning and UPSs and SOVICA in alarm systems.

As a result of this specialisation, the coefficients of domestic supply vary widely according to products. For 1986, for instance, local production supplied around 50 per cent of domestic demand in telecommunications and instruments but only 7 per cent of demand in computers and other data processing equipment. There is also wide R&D expenditure. Telecommunications and instrument firms accounted for more than three-quarters of the total R&D of the sample.

Table 3

PROFILE OF THE PROFESSIONAL ELECTRONICS SECTOR BY SPECIALISATION
SURVEY OF 50 FIRMS
Venezuela 1986

Products	Proportion of firms	Sales	Employment	Product lines
Components	18%	6%	9%	8%
Data Processing and Office Equipment	12%	3%	3%	6%
Telecom. Equipment	12%	71%	58%	19%
Instruments[1]	58%	20%	30%	67%
Totals	50 firms	$ 95.2 million	2590 persons	130 product lines

1. Instruments groups together almost everything that cannot be clearly classified in the other three categories. It includes test and measurement equipment, monitoring and control instruments, industrial controls, alarm systems, etc.

Source: Romero, Sanchez, Martinez.

b. The Products and the Services

Table 4 presents the 121 products of the 42 surveyed firms that produce equipment (the other eight are component manufacturers) classified by relative complexity[5].

As shown in the table, there were no products warranting a "high" or "very high" rating in complexity of design and/or manufacture. Half or more of the product lines are at the "low" spectrum end of the complexity and only 13 products (11 per cent of the sample) were considered to be of "medium high" complexity.

There appears to be much less concentration among instrument manufacturers than among makers of telecommunications equipment. This could merely be the consequence of the wide spectrum of products included in the category "instruments". However, it does seem to indicate a group of firms still searching for areas of specialisation. The great majority of the low complexity products are instruments, but instruments also accounted for nine of the 13 products rated of medium high complexity. A weakness of the classification system is that it is not evident that about half of the more complex products are actually custom designs, whereas the same level products in telecommunications are medium volume export candidates (protocol converters, multiplexers, medium capacity PABXs, and the digital interfaces for modernising electromechanical central exchanges).

Table 4

NUMBER AND DISTRIBUTION OF 121 PRODUCTS
OF 42 SURVEYED FIRMS IN PROFESSIONAL ELECTRONICS*
CLASSIFIED BY RELATIVE COMPLEXITY AND SEGMENT OF SPEICALISATION
Venezuela 1986

Relative complexity by number of products							Percentages			
Products	Low	Med Low	Med High	High	Very High	TOTAL	Low	Med Low	Med High	TOTAL
DP & Office Eq.	1	8	0	0	0	9	11%	89%	---	100%
Telecommunciations	14	9	4	0	0	27	52%	33%	15%	100%
Instruments	47	29	9	0	0	85	55%	34%	11%	100%
Total	62	46	13	0	0	121	51%	38%	11%	100%

(*) Excludes the eight components producers in the survey.

Source: Romero, Sanchez, Martinez.

Another revealing form of product classification for our purposes is the relative degree of standardisation, which could be said to measure the distance of the manufacturer from the user, the greatest distance, at the more standard end of the range, to the smallest, at the custom end (as see in Table 5). Of the more than a hundred different products of the 42 equipment producing firms in the survey, just under 40 per cent are standard products, either manufactured under license or designed to standard specifications. These go from various measurement and control instruments (temperature, level, frequency, etc); through telephone sets and transmitters; to IBM compatible PCs, video distributing and switching systems, modems (low to medium speed) and multiplex equipment.

Nearly a third of the products have features that would define them as "country-adapted" and another third can be considered "user-adapted". The latter range from those that are basically standard products, but must be programmed and installed according to user requirements, such as a PABX, to products which must be engineered for each specific customer. An example of the latter would be a computerised scoreboard and information system for a sports stadium. Products custom designed for the client include those that are fully user specific and those where the custom user serves as a sort of experimental terrain for developing a good marketable product. A case of the first type is specific test equipment; examples of the latter are a portable data collector and a cash register with inventory control. In fact, many of the products that are classified (in 1986) as "country-adapted" were originally designed as custom or user-adapted products.

Table 5

NUMBER AND DISTRIBUTION OF THE PRODUCTS
OF 42 SURVEYED FIRMS IN PROFESSIONAL ELECTRONICS(*)
BY RELATIVE COMPLEXITY AND DEGREE OF STANDARDISATION
Venezuela 1986

	Relative Complexity							
	Number of Products				Percent Distribution			
Degree of standardisation	Low	Med L	Med H	Total	Low	Med L	Med H	Total
Standard (Worldwide)	28	16	1	45	45	35	8	37%
Country-adapted (Standard)	20	14	2	36	32	30	15	30%
Modified or adapted to user	5	6	5	16	8	13	38.5	13%
Designed for user (custom)	9	10	5	24	15	22	38.5	20%
Total	62	46	13	121	100	100	100	100%

(*) Excludes the eight components producers in the survey.

Source: Romero, Sanchez, Martinez.

It is interesting to note the close relation between complexity and closeness to user. Of the 13 products rated as "medium high" in complexity, 10 are user adapted; of the 62 considered of low complexity, almost half are standard and 20 are "country-adapted". Standard and semi-standard products represent 79 per cent of the simpler products.

In the survey, firms were asked which of a list of services they provided for customers. Three-fourths of the firms declared they provided adapting and modifying services and an equal number, maintenance and repair. Two-thirds performed installation and all but seven firms said they provided consultancy services. This high proportion might not mean too much, considering the breadth of the category: product selection, systems design, compatibility analysis, user training, etc. Nevertheless, the overall response indicates that the majority of the firms see services, during or after sales, as an integral parts of their business.

4. Evolution of Software Production - Survey of 23 Firms

Without counting the sometimes large in-house software development departments in user firms, such as the petroleum company, there are basically four types of software firms in the country:

(1) Commercial representatives of imported equipment who sell software as "value added" or use it as a marketing tool;

(2) The software services department of hardware firms;

(3) Consultancy firms which provide software as part of a solution for their clients; and

(4) Software producers.

The origin, behaviour and future prospects differ widely.

A large portion of the software firms belong to the first category. These range from a development department in a stable and powerful foreign affiliate such as IBM, UNISYS or EPSON to the small vulnerable shop run by young computer graduates. In this latter group both birth and death rates have been high. Some of the strongest survivors have moved on to categories 3 or 4.

The second category is generally at least as stable as the manufacturer it is associated with. Their classification as software firms is questionable and they in fact are doubly counted here. However, some of the equipment producers offer adapted software services for their own or similar equipment as a regular part of their business (and some have exported such services). Since this corresponds to the user-oriented strategy to be fostered, it justifies inclusion as a separate category.

The oldest firms are in the third group. It is mainly made up of firms that offered consultancy services to specific industries: petroleum, electric utilities, chemical manufacturers, construction, etc. They also offered audits and other administrative services. With the advent of information technology, they were suddenly forced to acquire expertise in software, systems and procurement or risk losing much of their business. The stability of these firms depends on the strength of their clients. Some have made software their main business and they perform selection, adaptation, development, installation, maintenance, upgrading and whatever else their customers require. Many of these are the relatively newer firms which grew from modest beginnings. Most of the more traditional companies, however, see software development as a service outside their area of expertise and sometimes subcontract it out.

The last category includes about ten firms facing high risks for high stakes. They develop applications packages for medium volume markets, usually for microcomputers. They generally test the product in the local market and then try to export. Some have had a certain degree of success (by 1989 one of them had affiliates in Spain, Ecuador and the United States). Their survival will depend on export success because the domestic market is too small. They count upon high quality, low cost professional personnel as a comparative advantage, but they compete on equal terms with other producers in the field. Their products can be considered standard and, except for the Spanish language, they are not particularly rooted in local characteristics or helped by local expertise. Like many other entrants in the software market, they base their hopes on finding a winning product.

The diversity of firms and the intangible nature of software makes it very difficult to obtain meaningful statistics on production and sales. For instance, the 23 firms in the survey declared total sales for 1986 of 300 million bolivars ($40 million) but, only a fifth of this was in locally developed software. The other 80 per cent includes everything from equipment to various services and imported software.

It is also difficult to classify their personnel, but it is known that the majority (61 per cent) of the 619 employees that the 23 firms had in 1986 have university degrees in computer sciences. The rest are other university professionals, 10 per cent; qualified technicians, 14 per cent; trained programmers, 5 per cent; and others (including secretarial support and other office services), 9 per cent.

R&D expenditures in 1986 represent 6 per cent of total sales or 30 per cent of sales of locally developed software. This high ratio is explained by the nature of software, for which the development process is the main cost of production (reproduction being trivial). Thus R&D manpower weighs heavily in the cost structure of producers of custom and small to medium volume products.

The Products and the Services

Given the mixed nature of the firms in question, the more typical situation is the multiproduct, multiservice firm. Apart from the products and services which are not strictly software related, most firms offer consultancy in information technology requirements, personnel training and software adaptation. Formerly, many offered data processing services. Some are in the data bank business.

There is a wide range of software products but it is confined to the applications area. Since there is practically no computer manufacturing, no one has attempted anything in system or utility software (outside of university research projects.) Within applications we can distinguish four main categories:

(1) Standard packages,

(2) Industry or country specific (medium volume) applications,

(3) Equipment specific software (for hardware manufacturers), and

(4) Custom made or custom modified solutions for clients.

Among the standard packages, the most common are the general administrative applications (personnel, orders, inventory management, accounting, etc). However, EPSON Venezuela developed a programme like LOTUS 1-2-3 for their machines that were not IBM-compatible, which helped sales to the point where they took strong roots in the local market (they hold 30 per cent of the microcomputer base). They have more recently developed a Spanish-language word processor which is marketed with EPSON micros throughout Latin America.

The custom made products are generally the province of small commercial firms or large consultancy companies. Big efforts are no longer so common, as standard or semi-standard packages become available and better known. In most cases, what is needed are adaptations and modifications. For some specific purposes some programmes might be custom developed but with a package such as D-Base.

The third category is made up of the type of software required by equipment such as real time programmes for industrial controls or telecommunications equipment, or the software required by, say, a SCADA system which must be adapted to the specific data acquisition and processing needs of the particular industry or activity.

The category which groups the products most directly at the local market is the country-specific, industry-specific area. These products include administrative packages adapted to the needs of various types of business (banks, petrol stations, hotels, fast food chains, schools, etc.); a monitoring system for the construction industry; computer aided courses; a customs control system, etc.

In general, the market is still very disparate and undefined so that, in software, as in the instruments segment of hardware, there is still considerable searching for profitable niches.

5. A Possible Future

The first question that has to be addressed at this point is how these firms will react to the new economic climate. In February 1989, preferential exchange rates for industry were eliminated and from mid-year a phased programme of tariff reduction began, with a planned ceiling of 20 per cent in 1992. The goal is to move all industry from sheltered import substitution to competitiveness.

Until 1988, professional electronics and software producers had been at least partially exposed to competition. Software firms developed in an open market, and many hardware producers, as already mentioned, operate in the "informal sector" without protection or incentives of any kind and some firms have gone to export markets. Even in the early 1980s, when the bolivar was grossly overvalued, small local electronics firms were able to win bids against imported products.

The stronger group in telecommunications, however, developed during the last few years in a highly protected environment, behind tariffs, with a virtual prohibition of imports of peripheral equipment (single sets and PABXs) and with a preferential exchange rate, which amounted to a subsidy. Yet domestic competition was very intense and, as seen above, this segment was not passive, but engaged in product engineering and explored export possibilities. The larger and "older" firms in the area of instruments enjoyed similar protection but also had to compete domestically (especially in alarm systems and standard products such as voltage regulators). Most of these also maintained an engineering effort and began to export. Some of the firms in both areas expanded upstream towards printed circuits, mechanical parts and other inputs in order to guarantee the quality of their final products and enhance their earnings.

Our assessment is that most of the larger firms, both foreign and local, have the internal resources to withstand the initial shock, which is a combination of reduced protection with drastically reduced demand, and that, gradually, they can find a path toward renewed growth.

The medium-sized firms might not all be able to survive. Some of them might have been planning to expand just as demand fell through the floor - a 60 per cent drop - and interest rates went through the ceiling to about 40 per cent. Worse still, they could have expanded recently and were caught indebted, laden with personnel and projects, while facing dwindling markets. Another reason that some will not survive is that Venezuela has no risk capital market which might come to the rescue.

By contrast, the more recently established, smaller firms could perhaps survive. For many, the very fact that they are small, agile and still highly flexible, could allow them to trim costs and go after the appropriate market. There already is a clear trend for growth in demand for maintenance service as well as for any other technical services or products that protect or upgrade old equipment and bring savings or allow postponement of new investment. Firms that are capable of responding to these sorts of requirements should be able to survive and even thrive.

If our assessment of the trends in the adjustment period is correct, it is possible that the existing professional electronics industry will consolidate - with some reshuffling of relative positions and some losses - and that the service bias will tend to be accentuated. Another possible scenario, however, is that the adjustment programme for the country fails and Venezuela enters an Argentina-type of inflationary chaos.

Similar considerations hold for software firms. The two groups that can certainly survive are the commercial representatives of healthy firms and the consultancy firms. Both would benefit from the fact that their clients must adapt to the new environment and will seek external help for modernisation and "reconversion". Those service departments associated with hardware producers are in an analogous situation and could actually increase the chances of survival of the manufacturing arm. More uncertain is the future of the software houses proper which are all searching for an anchor in the export market. Some will make it, some might not. In many cases, it is a question of whether they had an adequate product ready when the crunch came. The weakest group is the small computer shop which depended on the microcomputer boom. Yet these and the software group are comprised of firms whose main asset is human resources, both entrepreneurial and technical expertise, which could be reoriented to the new conditions if economic policy leads to growth.

Under optimistic macroeconomic assumptions, then, and supposing that a general consensus can be reached on a user-oriented strategy, after the readjustment period, the government policy task would be to guarantee the conditions for the growth and strengthening of the core firms in the professional electronics industry and in software and systems services.

With time we would expect the following trends to occur naturally (or to be fostered):

(1) A reduction in the product range of most firms, with greater specialisation in a particular range where they have accumulated expertise.

(2) A greater industry-specific specialisation in engineering-intensive and software firms towards the more dynamic sectors in the country.

(3) A loss of markets in the more standard products but a flourishing of markets where country-adapted features or "tropicalisation" is truly important.

(4) Growing exports in both country-adapted and industry-specific products and services.

(5) An increasingly intensive and creative relationship with foreign firms abroad, with diverse forms of collaboration: technology licensing, mutual services, joint ventures, technology agreements, product and service swaps, local representation providing technical client support, etc.

(6) Gradually growing foreign investment in two possible areas: the domestic market, where there is user-specific high demand such as the petroleum industry; and in export-oriented projects, where local engineering collaboration is important to better serve regional markets.

(7) Growing sophistication in professional electronics imports as users acquire expertise and as local consultancy, system design and software services obtain higher capability levels of support (up to now, excess money and limited knowledge have led to a high proportion of poor import choices, which lead to a dead end for both the buyer and the seller).

In general, although the proposed professional electronics and software industry is likely to be able to export enough to pay for its own imports, the sector as a whole would remain a deficit segment of the balance of payments. The positive contribution of the industry - and that of the imports it complements - would be measured in the better export performance of its clients in other industries or services.

The premises for the survival of this industry under the proposed conditions are the following:

(1) That the world electronics industry continues to be open to applications producers, in the sense of maintaining open trade in most semiconductor components, design aids, software development tools, etc., as well as in the general decoupling of the user end of software, ASIC design, interface, and other elements requiring open availability of information about the basic

product to be adapted.

(2) That domestic policy protected import substitution measures for manufacturing semiconductor components or professional electronics products.

Finally, it is important to note that this proposal is, in fact, a positive-sum game to be played with the international electronics industry and its home countries. We believe that when the United States, and other countries with balance of payments problems take a long-term view of the problem, they will realise that the higher the technological level of the developing countries, the greater their own electronics exports will be to those countries. The crushing game to defend a sale today is a losing situation for all in the medium and longer term.

We now turn to the specific policy instruments that are recommended for implementing the user-oriented strategy for the development of the professional electronics and software industry.

V. THE PROPOSED POLICY INSTRUMENTS

As Venezuela moves towards industrial competitiveness, we believe that the main change in government policy should be to move from a compensating to facilitating role. This means that government services should be highly efficient and that resources should be made available to firms under competitive conditions.

In that context, the development strategy for the professional electronics industry will be presented in terms of proposed policies, focusing on four areas: resources (financial, technical and human), stimulating demand, protection and competition, and the framework for strategic consensus planning.

1. Facilitating Resources

Among other things, endogenous accumulation of technological capability depends on having up-to-date information, a growing pool of qualified personnel abreast of current technology and, most important, the availability of the necessary capital, when it is needed and under appropriate conditions.

a. Human, Technical and Information Resources

As has been mentioned, Venezuela had profited from oil-derived income for obtaining information and training. Since 1983, however, travel and education abroad has been seriously restricted: libraries receive few scientific, engineering and trade publications; attendance at international seminars and congresses has become difficult; scientific laboratories have increasingly unmet equipment needs, and so on.

This situation, whose full impact is still to be felt, is harmful to the development potential of the electronics sector. There is less information about the most advance technology. There is a threat to the quality of university training, which no longer benefits from ample up-to-date literature and the influx of teachers with doctorates earned abroad. Finally, there is less support available from research laboratories, now insufficiently funded.

One clear role for government policy is to seek ways to strengthen the research institutes related to microelectronics technology, to assure attendance at international conferences, to send trainees and post-graduate students to first rate institutions in other countries, to fund libraries and assure access to appropriate international data bases.

It must be clear that these international contacts are necessary to enhance the capacity to develop locally adapted technology. In this technology in particular, advance is very rapid as regards the tools and the inputs that make applications development more effective. Additionally, intelligent import choice -- including the selection of best value for money -- also depends on well informed access to what is available worldwide.

b. Timely, Sufficent Funds Adapted to Changing Needs

In many developed countries, a risk capital market has become available to innovating firms. In Venezuela, however, even the stock market is not a significant source of capital for business. It is the banks, either private or public, that supply most funds. Under these circumstances, and given that local private banks are far from ready to take risks with an unconventional firm, development banks should take the initiative.

Unfortunately, development banks have become very rigid, like other organisations oriented toward import substitution policies or compensating disadvantages in export promotion schemes. When a new type of firm appears with needs different from those traditionally handled, these banks find themselves at a loss: they are either restricted legally or lack technical competence or ideologically unprepared.

Service oriented, innovative, "organically" growing firms have different needs than the standard import substitution firm, set up to assemble a well known standard product under licence, in a standard plant with idle capacity, with known operating costs, known reference prices and a tested level of demand. Although this may oversimplify things, the fact is that development banks do not at present know how to cater to the specific requirements of innovative firms and their clients.

These requirements are, among others:

- seed money for design;
- venture capital;
- some form of medium-term money for financing projects of lengthy design and fabrication;
- amounts of working capital that are often much greater than fixed investment (which at first can be very small);
- long-term funding for intangible investment such as software packages;
- long-term funding for big R&D projects (in some cases with many participants, both users and producers);
- working capital for professional marketing costs;
- medium-term funding for the user firms (between up-front money on agreement and actual results from using the equipment); and
- funding for clients of consultancy services.

It is not necessarily a question of subsidising, as most developed countries have done, although this might be required for certain R&D projects. The main point is that funding should be adapted to the needs of firms (rather than the reverse, which is the situation today). In essence, the typical evolution of firms has to be analysed to identify the specific needs that appear at different phases of development.

Figure 3, presents a simplified image of the typical evolution of innovating firms. It is a "tropicalised" version of Noyce’s three stage evolution of entrepreneurial firms. Each phase of development involves a different type of firm with different needs in terms of resources. Each transition is a major learning process for the "engineer entrepreneur", but it also requires understanding on the part of the funding agency. An interesting scheme for helping cross some of those bridges was set up in Israel: it financed firms which could show they had already succeeded with one product and were ready to develop the next (TEUBAL). Much imagination will have to be brought to bear in designing the appropriate schemes. The object is to create a favourable environment for the growth in strengthening of these innovating firms; one where failure is attributable to the entrepreneurs own incapacity and not to lack of support in the environment.

2. Stimulating Demand

User confidence is crucial for the growth of service-oriented firms, but so is user capability. Demand for locally produced electronic goods or software can only grow with an increase in the sophistication and technical capability of potential customers. It is the mastery of its own specific technology and of its own business that makes the user firm truly capable of specifying, selecting and evaluating imported or locally made hardware and software.

In this sense, it is implicit in a user-oriented strategy that client industries are involved in a process of change. In any case, the decision to promote industrial reconversion has been made in parallel with that of fostering the growth of the information industry for this purpose. In this context, we believe that policy makers trying to foster an efficient user-oriented information technology sector should also be working to encourage modernisation of economic activity in general.

Nevertheless, the author considers that the major initial transformation required in most firms involves structure rather than equipment. This is especially in countries that followed the import substitution route. Inefficient plants, having idle capacity and a cumbersome organisation, are unlikely to become competitive simply by acquiring computers, automation and electronics-based equipment. The adoption of a more flexible system of management, developed most fully by the Japanese (See AOKI; BESSANT; HOFFMAN; KAPLINSKY; PEREZ 1989), is a precondition for the fruitful incorporation of information technology. In fact, it is possible to improve equipment and making more creative use of available human resources, before any fixed investment is necessary (BESSANT). In fact, the abandonment of an obsolete management style is one of the main recommendations made by the MIT Commission on Productivity for US industry for meeting the Japanese challenge (DERTOUZOS et al.). This recommendation is no less relevant for industry in Latin America and other developing countries.

Ironically, organisational modernisation would actually reduce imports of information technology equipment and stimulate local production in electronics. The erroneous belief that high technology, by itself, leads to competitiveness is responsible for many costly mistakes which weigh on the balance of payments. The prospects of domestic hardware and software producers will be improved by promoting an understanding of how organisational practices and human resources can contribute to competitiveness. This would be so, because one distinguishing feature of the new managment model is continuous learning and improvement, which means a conscious drive towards gradual mastery of product and process technologies. As client firms increase their technical capability, they will be better able to specify their needs and assess the quality of what is available locally, leading to better informed purchases both domestically and abroad.

For promoting economy-wide modernisation of management practices, it is recommended that funding for that purpose be made accessible, together with adequate information about the nature of organisational change, its relationship with information technology and potential benefits. The other policy tool is to make available knowledgeable consultants and/or to provide training for managers and engineers. Education of demand is likely to be a better way to foster the growth of good quality information technology production and services than protection or import substitution policies.

Active Market Policy: User-Producer Linkages

Another means of increasing demand and also moving towards more ambitious projects is to involve the large state owned firms and some of the more dynamic private sector firms or groups in the strengthening of their information technology suppliers.

Since 1982, there have been various efforts in Venezuela in the field of supplier development. Such firms as the petroleum holding company and government-sponsored organisations, in particular CONDIBIECA (the capital goods development council), have set up programmes whereby possible local suppliers to publicly owned firms are informed of market specifications and quality requirements for products they can manufacture. In the case of PDVSA, they went as far as evaluating each firm, technically and economically, and handing the consultancy report over to the applicant supplier, indicating the areas of change required to qualify.

A more recent development could be classed under what we have termed an "active market" procurement policy. Some public enterprises have begun negotiating product design and development with local firms. CADAFE, the national electric company, for instance, made a contract with FABELCA, one of the small instruments firms, to design and produce a tropicalised "universal power meter". It was basically a "futures" purchase, with an up-front payment. The specifications were jointly defined; there were technical contacts during development; the prototype was jointly tested and approved; and the field tests of the first production runs have been made and continue to be made by CADAFE personnel and there are regular information sharing meetings with FABELCA.

The meter has led to a 3 per cent saving in investment costs in each sub-station and a 70 per cent reduction in maintenance costs for the utility company. The electronics firm now has a tested product costing $500 to $600, with an assured domestic market in the hundreds of units per year and a good chance of exporting.

In another domain, the telecommunications company saved milions of dollars, and probably many headaches, by modernising the old electromechanical exchanges. These are now able to provide a service which "looks" like that of a modern exchange.

An active market policy is essentially a process of demand-pulled interactive technology development. It involves the user firm in identifying from among its needs those that it would be convenient to develop locally, then selecting one or more possible suppliers and providing technical collaboration before, during and after development. It can eventually involve support for export promotion. As the cases of interactive technology development between the electronics producer firms and competent user industries multiply, projects could increase in complexity, eventually incorporating systems design firms and research institutions.

The benefits accrue to both user and producer. The user gains because the local supplier will bend over backwards to satisfy every request. The producer benefits because user feedback improves the product and serves as a platform for market expansion, while following a well-anchored route to technology accumulation.

In the context of the proposed policy, this sort of occurrence would stop being an interesting exception and become a regular practice of all state owned firms as well as of many private firms or groups of firms. Already, two private industry associations are working with CONDIBIECA in supplier development programmes, which could easily incorporate an active market component. In any case, this would certainly be a very important aspect of the competitive restructuring process in the export-oriented sector.

3. Competition, Protection and Quality

For the government, one of the most delicate issues of the user-oriented policy is how to support and facilitate the development of this sector while fostering its competitiveness. This obviously entails not only what to do but also what not to do.

We have already mentioned one of the essential things not to be done, which is to offer protection to a company wanting to set up inefficient production of semiconductor components. This would not only risk the quality of the locally produced electronics goods, but would probably lead to restricting the choice of components, thereby reducing flexibility and jeopardising design capability.

However, as mentioned in Section 2, there are parts and components which , if made locally, could enhance the flexibility of the local service-oriented firms and some of them are quite indispensable. Among the latter are printed circuit boards. Without reliable local production of these, domestically designed small batch products would be impossible to produce competitively. Nevertheless, small diversified customers cannot guarantee sufficient demand for component producers. Consequently, larger markets are necessary for the survival of efficient and relaible component manufacturers.

This means, as discussed in Section 2, that an effective means has to be found to promote volume production of some electronics goods capable of supplying a "bread-and-butter" market for component producers. One way of achieving this could be through international negotiations towards some Original Equipment Manufacturer (OEM) or assembly commitments with firms in developed countries; another could be a market swapping agreement between Latin American countries. Our present proposal is to keep those options open but to apply a modified import substitution policy to the consumer goods firms already in the countries (perhaps adding such products as automatic bank tellers, computerised cash registers, etc.).

Two of the main negative consequences of import substitution policies stem from the thwarting of competition. Tariff protection can lead to productivity and the usual policy of obligatory use of local parts can lead to low quality. The question is whether measures can be taken to prevent such consequences.

With this intention in mind, a modified import substitution policy would make obligatory the use of locally produced printed circuits and other carefully selected components but with mandatory quality control of components (allowing imports if found defective). The tariff protection for volume assemblers electronic equipment should be accompanied by an agreed programme of productivity enhancement to keep protection low. In any case, multiproduct firms, rather than the traditional single product assemblers with large idle capacity, should be the basis for calculating the truly indispensable protection level.

Figure 4, shows the general interrelations which should serve as criteria for guiding policy. The core firms, which are the service-oriented producers, must count upon appropriate sources of components as well as sophisticated technical support from the research labs. The latter should also be required to lend their technical support to all the other firms in the sector.

In some cases, there may be areas of mutually beneficial collaboration with the volume producers: assembly services, production of high precision-engineered complementary devices, etc. Other possibilities may arise for technological co-operation with foreign investors interested in adapting products to regional characteristics, when using the country as an export base to neighbouring countries. In other cases, a locally developed product or interface could be exported together with the standard product. There are already some instances of this. One interesting development is a decision by Xerox to assemble photocopiers in the country, using locally designed electronic test equipment, because their standard Associated Testing Equipments (AIEs) were designed for much larger volumes.

These sort of agreements should be encouraged and, if necessary, financed, but it is probably better to let them occur as the true needs and possibilities arise.

The best safeguard for the service-oriented segments of the industry (as well as some of the medium volume producers of "tropicalised" goods) in the local market should be their better capability of adapting to local conditions and to user-needs. The same can be said for user-adapted software services. Experience shows that, if justified, a premium will be paid for that, even though sometimes a locally adapted product can be much simpler and less costly than a complex international version. If foreign investors want to come in and do the same sort of service, their competition should be welcomed.

However, there can be cases where temporary protection would be warranted to convince mistrustful customers, giving the producers a chance to prove themselves. This is slightly different from "infant industry" policies; it might be more an "adolescent industry" policy. If we are talking about innovating firms, it is probable that the need for support in penetrating the market would appear towards the end of Phase II (see Fig. 3), when volume and growth provide the platform for crossing over to Phase III. Some satisfied users should be called upon to support the claim to protection, which must be clearly understood as impermanent.

Being extremely clear and not making any exceptions is the only way to avoid a "production-oriented" strategy sneaking through the back door, which in this sector can have dire consequences. Employment and balance of payments problems should be confronted with other sectors. If interest groups are allowed to grow around inefficient production in electronics, all industry will suffer.

Finally, for the many capital goods which are not produced in the country and for imported software, some sort of legislation requiring after-sales service and guarantees from the commercial representative or importer is probably required to protect users from some of the most costly mistakes. Of course, most equipment representatives with a long-term view would naturally tend to set up services for client support. Furthermore, as mentioned in the discussion on software, some of the commercial subsidiaries can be considered an essential part of the user-oriented service infrastructure in this sector.

4. Consensus Planning

It is widely believed that a rational economic future will begin to evolve in a country where there has been protected import substitution if the state simply ends its intervention and subsidies, making the way for competition and market forces. In our view this is highly unrealistic. No domestic animal is expected to survive if suddenly let loose in the jungle, and it would not be the fault of the animal but of the domesticator.

Modernisation and competitive restructuring are certainly on the agenda and so is a radically reduced state involvement in the economy. However, modernisation requires resources for information, technical support and funding, to enable firms to restructure and become competitive. Reduced state involvement requires that the social framework be capable of providing direction for the restructuring process. If such resources and direction are wanting, the process could be more painful, prolonged and wasteful of existing potential than necessary, and it would be difficult to make the most of available opportunities in this technological transition for development (PEREZ 1988 and 1989).

The user-oriented strategy proposed here for the professional electronics industry in Venezuela is an integral part of a wider project of transformation of the country’s economy, including the democratisation of the decision making process as regards development choices.

The basic tool for guiding these changes is consensus planning. It is conceived as a "tropicalised" version of MITI, with concerted actions between the public and the private sector in each branch of industry. Some attempts have already been made with uneven results. The present government has pledged that its style of decision making will be "concertation".

Obviously, a user-oriented strategy would sit the core firms in electronics at two different consensus-building tables: one with all other participants in the electronics sector; another, with the main users of their possible services. The strategy presented here would be most successful if there were a national consensus on its contents and forms of implementation.

VI. APPLICABILITY TO OTHER DEVELOPING COUNTRIES

The preceding development strategy is based on what we consider to be intrinsic characteristics of microelectronics-based technology: its flexibility for serving an infinite variety of user needs and the crucial role of design capabilities. It is also based on the idea that during the present technological transition, there are windows of opportunity of a dynamic character for latecomers. These opportunities relate to the new technologies themselves and to their capacity to rejuvenate the more mature technologies.

In this sense, there is something universal in the idea that it is possible to undertake in this period a policy of endogenous technological accumulation, if a careful and intelligent selection is made of the areas and the means, and if adequate support is given to the effort.

The other generally applicable element, at least in developing countries, is the need to take on board the requirements of user industries, when formulating a development policy for the key supporting technology.

One last aspect, which paradoxically can be considered of general application, is that policies in this area should be country-specific. Thus implementing similar principles could be different for each country.

However, there are of course certain elements which relate to the particular characteristics of Venezuela, and the way it has developed, being an oil-rich, poor country.

There is a certain disjointed and unbalanced quality about Venezuela. It is a country of strong contrasts, which has not been able to assimilate fully the tremendous wealth that petroleum provided. Far more attention was given to spending the nation's wealth than learning how to enhance it, with the result that the foreign debt, accumulated during the decade of maximum oil income, is the fourth largest in Latin America.

However, if the oil money did not bring harmonious development, it did lead to the accumulation of certain tangible and intangible assets, which can serve as a foundation for economic development rather than mainly redistributing rent. It can also be said that the oil wealth somehow contributed to the maintenance of a democratic system for over 30 years in a Latin America where dictatorships had prevailed.

For our purposes, the three main characteristics inherited form the combination of democracy with oil money are: capital intensity of investment, a large number of university trained personnel and a "modernity" of consumption habits, at home and at work. Each of these creates specific advantages and disadvantages that shape the policy proposed here.

The average capital equipment in the country is very modern (usually the latest at the time of investment). This has educated the market for using and wanting "superior" equipment. However, much of the equipment is oversized, underutilised and poorly adapted to local conditions. As a competitive environment reveals these imbalances, the market for consultancy and adaptive services should grow. As capital availability dries up, the same should happen regarding maintenance services, which are on the whole sorely insufficient in the country.

The bias towards high fixed-investment process industries, already mentioned, has also had consequences for the training of skilled personnel. These happen to be areas where personnel supervises and tends the system rather than use the equipment, so the more dynamic industries have not created a good pool of middle level qualified workers and technicians. The other prevailing industry was of the "screwdriver-assembly" type, with generally low skill requirements. The result is the usual distorted distribution of qualifications common to many developing countries: university graduates at one end and not very qualified workers at the other. This bias in the skill profile was compounded when, during the "boom" years, more than 10,000 students received scholarships to go to universities abroad. Meanwhile, the required labour skills were imported from other countries, but the majority who came have left.

This particular human resource endowment naturally suggests an engineering-intensive rather than a skill-intensive strategy for developing microelectronics-based technology.

Furthermore, the combination of widespread travel abroad with massive import capacity, facilitated by the strong bolivar (which for a time made access to the United States so easy), established modern consumption habits and behaviour patterns among a significant portion of the population. As a consequence, young managers are very open to information technology and young engineers have been open to setting up their own innovative business. This is quite a social innovation in its own right, established values tended to consider knowledge and business as polar opposites.

Implementing new opportunities for development requires a conjunction of favourable circumstances. The higher the level of development already attained the easier it should be to profit from technological advances. However, this is not always true. Opportunities can be lost or wasted because existing institutions are too rigid or social actors are too blind to the new possibilities.

However, in developing countries there is certainly a minimum threshold of industrial development, human resources and infrastructural support, which must be reached before accumulation of advanced technology is possible, no matter how "wide" the window of opportunity.

Thus the user-oriented strategy outlined here would be applicable to most "middle-income" or second-tier countries, with appropriate modifications for specific local conditions. However, this does not mean that the strategy is the best for these countries. Some could follow an export-oriented strategy, alone, in partnership or as a location for foreign direct investment, in areas complementary with the front runners. Other countries could follow other paths.

Whatever the strategy, though, we would like to stress the general importance of a user-oriented component in the policies of all developing countries. This is true for the least developed, because they must train the users, and for the most developed because all strategic plans to penetrate world markets and hold market share will depend on having capabilities in advanced technology, notably information technology.

Actually, the "user-producer" partnership promotes exports in two ways. The competitiveness of the user’s process or product is improved and the producer’s specific capabilities are enhanced for niche markets.

We would like to emphasize again that greater productivity and quality depend on prior organisational change. In an electronics service-sector it is essential to understand that increased competitiveness does not come from the use of information technology as such, but from the organisational changes which create the conditions for profiting from the potential of the technology.

It is well known that if a user cannot specify the software and merely wants to automate the old cumbersome manual system, the computerisation could create more problems than it solves. This has been seen again and again in the automation of purchase and inventory management systems. In this sense, it is interesting to note that the model of organisation developed by the Japanese does not automate inventory, but rather tends to eliminate it (through "just-in-time" delivery and production).

The benefits of information technology will accrue to those that can create an organisation, with flexibility, adaptability, and a structural capacity to continuously improve the process and the products. Modern equipment alone, as the Venezuelan experience shows, does not insure high quality or high productivity. In this sense, all developing countries, especially the least developed, need to give priority to learning the new organisational model.

The following figures are not available due to technical reasons.

NOTES AND REFERENCES

1. The availability of oil-derived financial resources favoured and facilitated the import of capital goods for protected production of final consumer goods. Until the early 1980s there were no special incentives to manufacture capital goods in the country.

2. In order not to give this factor more than its proper weight, it is important to note that there were already about two dozen firms in professional electronics before the first devaluation in 1983.

4. All data come from the survey done in 1986-87 and relate to a reasonably representative sample of 50 firms. Qualitative information and available indicators suggest that the main characteristics of the industry have not changed.

5. The degree of complexity does not refer to an abstract measure of the product but to the complexity of the actual design and manufacturing tasks done by the firm in question. Final assembly of a complex product could be rated "low" but design and manufacture of the same product would be rated medium complex. Also, when a firm makes a range of products or many firms make the same product, the most complex of the lot gets the rating. This decision was taken because it marks the maximum level reached by the group of local producers, which was considered a better indicator of domestic potential.

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RÉSUMÉ

Cet ouvrage cherche à déterminer un cadre conceptuel utile pour la diffusion de la microélectronique dans les pays en développement. Le Venezuela sert de base de référence à l'auteur. Il s'agit d'une économie latino-américaine de taille moyenne qui tente de s'affranchir de son extrême dépendance à l'égard des revenues d'exportations pérolières et d'éliminer la surprotection de son industrie grâce à un effort de compétitivité internationale. Trois secteurs prioritaires sont au centre de sa politique d'industrialisation actuelle : la modernisation du complex pétrochimique ; l'expansion et le renforcement du secteur minier et métallurgique (acier, aluminium) ; enfin, une stratégie agressive d'exportations pour des groupes agro-industriels sélectionnés (agriculture tropicale et pêcheries). Les exigences de ces trois secteurs prioritaires orientent la définition et la mise en place d'une stragégie microélectronique au service des ses utilisateurs.

Il faut considérer l'industrie électronique comme une partie du secteur des biens d'équipement. Les biens et les services qu'elle produit devrait consolider fortement, s'ils sont bien utilisés, la productivité et la compétitivité des secteurs essentiels de l'économie, d'où l'insistance sur les applications technologiques; en particulier au premier stade du développement industriel. Le développement d'une industrie électronique locale est essentiel pour l'acquisition de capacités et d'expérience technologiques au niveau national. D'où la nécessité, pour toute politique de développement de cette branche industrielle, de maintenir un juste équilibre entre les besoins des usagers et des producteurs, et d'essayer de ménager des interactions constructeurs entre les exigences requise par la conception ; la fabrication et l'utilisation. Les nombreux et complexes échanges entre ces domaines sont ici envisagés dans le détail. On ne peut en abandonner l'organisation aux forces du marché ; mais "ils doivent faire l'objet d'une politique délibérée et d'action concertées entre les secteurs public et privé". A la la fois instrument d'orientation destiné à la définition d'une politique industrielle et traduction des principes en instruments d'action et de décision ; cet ouvrage s'organise selon quatre axes : le développement des capacités et externalités critiques ; les modes de génération d'une demande de technologies nouvelles d'information ; la compétitivité et le protectionnisme ; enfin, le besoin d'une ossature institutionnelle viable capable de susciter un accord sur la stratégie.

SUMMARY

The purpose of this paper is to set out a conceptual framework for policies to promote the diffusion of microelectronics in the context of developing countries. The author bases her discussion on the experience of Venezuela, a medium-sized Latin American economy which is currently trying to overcome an extreme dependence on oil export revenues and eliminate the over-protection of its industry in an effort to upgrade its international competitiveness. Current industrialisation policies are centred on three priority sectors: the modernisation of existing petro-chemical complex; an expansion and upgrading of the mining and metallurgical sector (steel and aluminium); and, finally, aggressive export strategies for a select group of agro-industries, based

on tropical agriculture and fisheries. Targeting the requirements of these three priority sectors should guide the formulation and implementation of a user-oriented microelectronics strategy.

The electronics industry needs to be viewed as part of the capital goods sector. It produces goods and services which, if adequately used, could drastically improve productivity and competitiveness in the main sectors of an economy -- hence a focus on technology application, particularly at an early stage of industrial development. Yet the development of a local electronics industry is essential for generating local technological capabilities and experience. Thus any policy to develop the electronics industry must balance the interests of users and producers and should try to strengthen the crucial interactions between design, manufacturing and user requirements. The numerous complex trade-offs involved are developed here in detail. These trade-offs cannot be left to be resolved by market forces but "should be the object of deliberate policies and concerted actions between the public and the private sectors." In this context, the paper develops guidelines for policy formulation and discusses how to translate them into effective policy instruments. Most of this analysis focuses on four topics: the development of critical externalities and capabilities; demand generation for new information technologies; competition policies and external protection; and, finally, the need to generate a viable institutional framework for strategic consensus planning.

PREFACE

This paper by Carlotta Perez is a highly original and stimulating account of what developing countries need to do in order to reap the tremendous productivity-enhancing potential of new information technologies, without destroying their social fabric. It is a refreshingly unconventional contribution to the current debate on how industrial latecomers should go about improving their technological capabilities and their industrial competence in the context of radical technological and organisation change. We have thus chosen it to be the first of a number of Technical Papers based on reports commissioned for the Development Centre's project on "Technological Change and the Electronics Sector -- Perspectives and Policy Options for Newly Industrialising Economies".

One of the strengths of this paper is that it avoids falling into the trap of presenting the generation and the diffusion of technology as a simple dichotomy. Perez convincingly demonstrates that without a sound design and manufacturing foundation, no viable user-oriented strategy will be possible. Interactive learning, based on close user-producer links is the basic prerequisite for establishing an electronics sector capable of providing essential support services for the leading growth sector of an economy. Strengthening such crucial interactions requires that "...a user-oriented strategy turns into a production development policy of a particular kind".

The author also reminds us that, particularly in the context of developing countries, a user-oriented strategy of technology diffusion would hardly be conceivable with very active involvement of the state. This relates specifically to four key areas: facilitating the development of technological capabilities and externalities (human resources; finance); demand generation and the creation of sophisticated users; sectoral targeting policies which, as a matter of fact, are applied nearly everywhere; and decisions related to the intellectual property rights regime and standardisation. Repairing the damage caused by over-protectionism and a rent-distributing state does not imply the return to "laisser-faire" economics. It requires, instead, a policy environment conducive to risk-taking and innovation, where sophisticated users would exert strong pressure to improve producers' capabilities.

Louis Emmerij
President of the OECD Development Centre
September 1990

I. INTRODUCTION*

When considering the development of the electronics industry in a developing country, it must be recognized that the microelectronics revolution is a two-fold phenomenon. On the one hand, it has given the electronics industry itself such an unprecedented dynamism in terms of sales growth, product innovations and capacity to stimulate an ever increasing network of associated services, that it must be considered by any development policy. On the other hand, the revolution in equipment for offices, production and telecommunications is changing the technology of practically every other sector of the economy in a more or less radical manner. In this sense, the electronics industry cannot possibly be ignored by any country.

This means that although the consumer goods portion of the electronics sector could be seen as just another industry being transformed, the same cannot be said about producer or professional electronics. This segment, together with the development software, must be understood as a new and crucial part of the capital goods industry, playing an important role in the competitive restructuring of every economy.

Consequently, this situation must be taken into account by any development strategy for the microelectronics revolution. The selection of the most advantageous route for the establishment and growth of the electronics sector cannot ignore the short-and long-term impact upon the domestic user sectors. This poses the same old dilemma which makes the development of the capital goods sector so difficult. The protection of deficient equipment or intermediate input producers weighs on the quality and efficiency of the users, while the lack of local equipment producers restricts the creativity and the development prospects of the users (and of the country as a whole). The latter is true because the lack of domestic expertise in capital goods deprives a country of knowledge in some of the key supporting technologies.

Whether this dilemma, as it relates to capital goods in general, is left to market forces or is addressed in some form or another by government policy depends on the political and economic conditions of each country. However, we believe that the electronics industry is so important today for the development prospects of all countries that it should be object of concerted policies by the public and private sectors, even where otherwise allocation by the market is preferable.

The formulation of a specific policy to deal with the production and use of electronics becomes all the more important if one holds, as the authors does, that there is a temporary window of opportunity for latecoming countries in information technology (PEREZ, SOETE).

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Opportunities correspond to the twofold nature of the electronics revolution. On the one hand, within the electronics and software sectors, latecomers would have access to the technology of certain product areas while these are still in the early stages of their technological trajectories. On the other hand, countries and firms would be able to utilise the technical innovations provided by information technology, together with new organisational and managerial techniques, to rejuvenate and increase the competitiveness of other industries and services (PEREZ 1989).

What this means is that during this period developing countries would not necessarily have to look for mature products in order to obtain some comparative advantages, but that entry into relatively new product families in the early stages would also be possible and could lead to endogenous accumulation of technological capabilities.

The extent to which each country could profit from these conditions would vary greatly with the level of human and other resource endowments and the general level of development already reached. It would additionally depend upon institutional adaptability and the capacity to put into practice appropriate policies to take advantage of the opportunities identified.

This paper will discuss a user-oriented policy to face the challenges and the opportunities. It is based on the case of Venezuela where the author has been involved in analysis and policy making. We hope the general approach can be useful to other countries, but it must be kept in mind that the specific proposals have been designed for a country which is a rather typical second tier developing country, with some peculiar advantages and disadvantages derived mainly from being an oil-rich poor country.

The paper begins with a brief picture of the initial conditions. It then presents the criteria proposed for the development of a local electronics industry geared to maximising user advantages. The third section describes the existing industry in Venezuela, indicating how it has begun to fulfil these criteria and assessing its prospects. Then there is a brief discussion of the proposed policy instruments. Finally, there are some remarks on the relevance of this policy to other countries.

II. ELECTRONICS IN VENEZUELA: THE BACKGROUND SITUATION

The industrial structure that has evolved from the import substitution model in Venezuela appears, at first sight, a rather unfavourable candidate, for the development of a modern electronics industry.

Until the mid-seventies the electronics industry consisted of a few dozen final assembly plants -- foreign affiliates or local firms under license -- for the production of consumer goods, such as black and white TV and audio equipment, and of some simple instruments with a market in the construction industry, such as fire alarms. There never was much more than "screwdriver assembly". Component production was limited to items such as small transformers or some simple capacitors, not even resistors or transistors were made. Production was strictly for the domestic market. In spite of idle capacity, the industry never produced for exports, nor could it even consider it. The overvalued bolivar -- determined by oil exports rather than industry -- made labour costs very high, ruling out assembly-type exports in general (According to the ILO, in 1976 average wages in Venezuela were almost 70 per cent higher than in Mexico and almost three and a half times the South Korean level).

If those were the conditions of the traditional electronics industry, the situation was even bleaker in the industrial electronics, which worldwide were in the process of becoming microelectronics-based. Only in telecommunications were there the beginnings of production of some peripheral equipment, however, under schemes that were quite unusual for the country and will be discussed below. In other areas there was practically nothing. Apart from one firm assembling telex machines, there was no office equipment production of any sort, that is, no typewriters, no cash registers, no calculators and, of course, no computers were produced. Furthermore, there was no machine-tool production. In fact, to this day, the bulk of the capital goods sector in Venezuela could be said to have avoided all "moving parts". It mainly produces products for the oil and construction industries and ovens, vessels, pipes and valves for the processing industries[1].

This lack of development of the engineering industries is both the result and the cause of a serious lack of skills and experience in precision mechanics. This constitutes a considerable handicap for the manufacture of almost all electronics consumer goods as well as for most types of computer peripherals.

It would have seemed that such conditions precluded developing a domestic electronics industry with a reasonable degree of competitiveness. Yet, even at that time, there were some indications of new possibilities: two firms, quite different from each other and quite different from the usual import substitution model, pointed towards a fruitful new direction.

One of them was MCM (today MICROTEL), set up in 1970 by two young electrical engineers. This firm marketed a Private Automatic Branch Exchange (PABX) of their own design; one of the first that was fully electronic in the world. The product succeeded in penetrating the domestic market, overcoming the traditional mistrust of local technology. It was later exported in small quantities to various countries and then manufactured under joint-venture arrangements in Ecuador, Argentina and Mexico. To design, export and license technology abroad was almost unheard of in Venezuelan industry at the time.

The other uncommon enterprise was MAPLATEX, a firm set up in 1974 for the production of telephone sets. It was founded by a local private group with engineering capacity, but they soon had to make a joint-venture agreement with the National Telephone company, to become, in fact, a "monopoly-monopsony" in telephone sets. Although at first sight it was a typical import substitution project under Ericsson license, MAPLATEX was determined to go beyond final assembly. It did, in fact, end up manufacturing the whole product: an electromechanical dialling set. Eventually, all metal and plastic parts were made in-house, including precision screws. Only a few parts, about 3 per cent, were either imported or obtained locally. This degree of integration stemmed from two factors: the lack of adequate local suppliers and a zero-defect requirement under which there was quality inspection of all parts. It was made possible by a deliberate increase in scale achieved by standardising down to a single-model, single-colour telephone set for the whole country. This still did not make the industry truly competitive for export (mainly because of the overvalued bolivar), but with subsidies the company did manage to place some of its excess production abroad at cost.

Ten years later, in 1986, in addition to MICROTEL and MAPLATEX, there were nearly 100 professional electronics firms, mainly in telecommunications and instruments, growing at a rate of 27 per cent a year, with over 100 products of their own design, 14 of which were being exported. They included a small number of foreign-based firms -- Siemens, Ericsson, Telenorma (Bosch), Telemecanique and Honeywell -- and some domestic ones working under license. But the great majority were young local ventures started by electronics engineers and manufacturing products of their own design.

In the same year, there were several hundred software firms, of which about 180 had more than five professional employees. Sales of locally developed programmes and systems were estimated around $10 million and growing at more than 40 per cent a year.

At this point, we mainly want to indicate some of the factors that might explain the flourishing of small innovative firms in an apparently inhospitable environment. Besides the new microelectronics and information technology itself, with its applications, some of the favourable conditions in Venezuela have been:

(1) The existence of a significant pool of qualified human resources in the engineering design end. There were 10000 persons with electrical, electronics, computer and systems engineering degrees in Venezuela in 1985 (that is, one out of every 1500 inhabitants). Many of them had

graduate or post-graduate degrees from some of the best universities abroad.

(2) The high exposure of the population to technological advances, from the mid-seventies to the early eighties. The very strong bolivar and the correspondingly high salaries allowed an unusually large proportion of the Venezuelan population to study, visit or shop abroad. Equally, the boom attracted many migrants having a wide spectrum of qualifications. They included technicians and highly trained professionals from Europe and Southern Latin America.

(3) At the same time, the availability of oil-derived resources, led to a wide use of information technology by both consumers and managers. In general, the professional elite is familiar with information technology and has equipment requiring services.

(4) After 1983, the drastic devaluation of the bolivar against the dollar (three times 100 per cent since then), has driven down all labour costs, including that of highly qualified personnel, as well as all other local costs [1].

These "environmental" conditions were enhanced by government incentives and tariff protection, but generally only after firms had already attained some significance or when foreign investors wanted to enter the market. One incentive that has helped a few products is the policy of giving preferred access to the public sector market, which includes the national telecommunications company, the oil industry, electricity, etc.

As will be discussed later, most of these firms are still small and fragile. How many will survive and grow will depend on many factors, of which an important one is government policy. The proposed criteria for such policies are the subject of the following section.

III. THE POLICY CRITERIA: USER-ORIENTED STRATEGY

Our basic assumption is that Venezuela lacks the potential for becoming a significant producer of electronics goods for the world market. It has little that could attract foreign investment in this sector and it has no previous experience to build upon to pursue a domestically led export drive in electronics. We consider that the country's most promising competitive potential lies in other industries, especially in making the most of its vast endowment of energy (petroleum, gas, hydro-electricity) and other natural resources. In fact, the industrial strategy now taking shape to overcome the extreme dependence on oil export revenue aims to eliminate the over-protection which prevented industry from seeking comparative advantages. The new policies are expected to promote the development of three sectors: petroleum-petrochemical, mining-metallurgy (steel and aluminium), and tropical agriculture and fisheries (CORDI-PLAN).

However, attaining and increasing in competitiveness in these areas will require many different contributing elements. Firms will have to make an appropriate selection of products or product families, establish dynamic links with suppliers and clients, increase R&D efforts, etc. The public sector should provide the infrastructure, and adequate support services.

It is in the context of this last requirement that information technology is expected to play a strategic role. The development of a modern telecommunications network and of the local electronics sector are seen as a means of providing infrastructural and service support for that industrial strategy. In essence, the goal is to develop the electronics and software industries as a dynamic complement of the exporting sectors.

Consequently, the criteria for the development of the professional electronics and software sectors are to be derived from specific user needs.

This implies that user firms should have ample freedom to select the most adequate equipment and software, whether domestic or imported. Some would even argue that especially in view of past experience with import substitution and over-protection, that it would be better to import and not to produce at all. The question is whether the degrees of freedom for user firms are greater with or without a domestic electronics industry.

In our view, putting the accent on use as opposed to production looks like a valid option. But there is less of a choice than appears at first sight. The relationships between user ability and design capability as well as those between design capacity and manufacturing ability are very complex and warrant detailed study. It is our assessment, however, that without production, design capacity has no feedback and soon reaches limits and that something similar occurs to user ability without experience in design.

In contrast to the more traditional technology, electronics-based equipment is, by its very nature, adaptable and flexible as well as capable of being continuously improved. Thus a passive and rigid user, incapable of adapting, modifying, interconnecting or upgrading a system obtains few of the benefits of the technology.

Intelligent and efficient users of information technology thus need to have design capacity or to be able to count upon it as a service from accessible, that is local expertise. At a minimum, this should include software, whether independent or associated with commercial representatives. But, a truly user-oriented strategy in information technology would have to also provide local capacity for custom and semi-custom design and manufacture of hardware elements.

A difficult question is how far upstream in the electronics industry it is necessary to go to achieve the minimum degree of autonomy and support to be a creative user.

Roughly speaking, one could say that in the electronics industry there are many iterations between design, production and use, in and between four basic level: chips, products, systems and software. However, there are essentially two distinct stages of design: one for the manufacture of the core products and the other -- with many facets and perhaps many iterations -- which is design for the user (See Figure 1).

In our view, the ideal to pursue is the gradual coverage of almost the whole of the right hand loop in the figure. The order of the objects of adapted design -- software first and chips, Application-Specific Integrated Circuits (ASICs) last -- is what we consider the actual order to accessibility as well as the likely order in which experience is acquired. Covering the whole loop, though, requires reliable manufacturing capacity.

This generates a paradoxical situation, for user-oriented strategy requires producers capable of customising and fulfilling customer specifications. However, in order for firms to be available for customising, they must have a solid base in some profitable "bread and butter" products. It is the knowledge and experience gained in designing, producing and improving these "cash generators" that provides the capability of adapting and modifying those and similar products. It also helps increase the expertise for other services required by the users, such as maintenance or consultancy in equipment selection for import.

Thus a user-centered strategy turns into a production development policy of a particular kind. What follows offers guidelines for this strategy.

1. The Basic Policy Guideline: Maximise User Advantages and Flexibility

This basic guideline translates into criteria for government policy, for the type of firm to be fostered, the choice of areas of specialisation and the target markets.

Government policy which gives priority to the competitiveness of the user naturally rules out protecting structurally inefficient firms in electronic capital goods. There should also be no standardisation policies meant to facilitate economies of scale for the producer, but which only create inflexibilities for the user. In other words, the "make locally or import" decision is to be based on the resulting benefits for the users, defined as the major industries in the country, especially those with a clear export advantage. If some temporary compromises are to be made in favour of domestically produced electronics equipment as regards quality, technical excellence, price or any such variable, the trade-off should be made against specific advantages being created for the longer term interest of the user industries, and preferably with their consent.

Consequently, electronics firms must themselves be competitive in quality, cost and delivery, and at the same time be capable of meeting customer specifications by adapting, modifying or upgrading products.

2. The necessary complement: conditions for viable and profitable user oriented firms

It would be difficult for a firm meeting the above requirements to survive, thrive and grow without some basic "bread and butter" products to provide a permanent cushion for the more flexible front end. Even with such products, these firms would find it difficult to survive in isolation. They would need to be the front runners of a larger industrial structure. Paradoxically, we find that the efficient development of a key segment of industry seems to involve some degree of inefficiency elsewhere in the industry.

Thus the core of the proposed structure is a group of dynamic firms capable of hardware design and manufacture as well as of software and systems development in areas related to the country’s main export lines. These firms would be anchored, on the one hand, in the network of user firms and, on the other, in the electronics industry as a whole. The criteria for policies fostering the development of the latter would be maximisation of the advantages of the core firms.

In the area of components, for instance, the basic guideline is to increase the competitiveness and responsiveness of the professional electronics industry. Anything that would restrict the choice or augment the costs of this industry is to be avoided; anything that increases its flexibility is to be fostered. This means semiconductor production should be discouraged and certainly not protected but ASIC design capability would be encouraged (see HOBDAY 1989). It means facilitating semiconductor imports, while strongly supporting the development of local competent and competitive firms making all types of printed circuit boards, surface mounting and other design-dependent parts or services.

However, such parts-producing firms could hardly be cost efficient if they have to serve exclusively the highly diversified, low volume markets of a professional electronics industry, as proposed here. Consumer goods production, or some other mass manufacture would be required to provide a market of sufficient size for parts (including metal and plastic housings) and other common services. Besides this market generating role assigned to consumer electronics, it can also promote the acquisition of reliable assembly experience and mastery of some complementary technologies which will eventually be necessary for the professional electronics sector to obtain some significant niche positions for export.

This poses a complex problem. Given the small Venezuelan domestic market, production of electronic consumer goods could not become competitive without being able to export. Yet, as discussed above, there are no particular indications to expect that this industry can compete in international markets. Therefore, the strategy will require imagination, audacity of compromise. A solution might involve joining forces with neighbouring countries, or creating extremely favourable conditions for attracting some foreign investors or partners, or even designing a complex package for "import substitution" with efficiency and quality. Whatever the means, the objectives to be kept clearly in sight are the privileges or subsidies in this domain are to be understood as an investment in the competitiveness of the main export sectors, and that is how their results should be evaluated.

In the area of producer goods, it is clear that this policy would lead to a specialisation in medium to small batch products with custom and semi-customising possibilities. This would exclude most components, microcomputers and other mass-produced capital goods, which are the more visible segments of the industry and tend to be the target of other development strategies. This is intended to result in a relatively small, but competitive and dynamic, electronics industry, very responsive to the specific requirements of its clients. It would not necessarily be geared to the export market initially but export competitiveness in certain niche markets associated with the needs of the local user industries would be the natural outcome.

These guidelines suggest that the hardware industry to be developed in professional electronics should be an industrial service sector.

Obviously, similar considerations hold for the desired software industry, where the "service" character is more readily apparent. However, it is necessary to recognize that "software" is an indispensable part of any investment in computerised equipment and, as such, is a capital good. A failure to understand this fact have practical consequences in the industrial credit policy of private and development banks and, in turn, a direct impact on user choice and the viability of a user-oriented local software industry.

3. Choose Product Range and Growth Path for Technology Accumulation

Imposing stringent requirements upon the core electronics and software firms means that the choice of product, target market, point of entry and growth path should be the object of careful analysis, far beyond what has been customary in import substitution policies.

A first rough selection of areas of specialisation is suggested by the definition of "user-oriented". It excludes, first of all, those product ranges which belong to the left hand loop in Figure 1, that is, it rules out "basic" chips, products, systems and software which are, by definition, mass produced for world markets and become the building blocks for the user-adapted stages of design. It favours products which are closer to the applications end of the product ranges, where the concrete requirements of specific users become important.

Clearly, the strategy being proposed is based on increasing the design capability, which has already been demonstrated in the country, both in software and hardware, and coupling it with manufacturing and marketing capacity. But the choice of product makes a big difference. A newcomer who designs a microcomputer in the 1990s is unlikely to achieve commercial success. That product is well past the early stages of evolution. It is mass produced, cloned, and competitiveness increasingly requires extensive manufacturing and marketing experience, while price is becoming a prime consideration in the market. Development costs could never be recovered. By contrast, designing a system to monitor and programme oil well maintenance could make more sense, especially it if could be developed and tested in collaboration with the user-industry experts. Practice in making such a product, first as a prototype and then in small numbers, allows time for acquiring knowledge and accumulating manufacturing and marketing experience. This approach is particularly important in Venezuela, where most of those who have ventured in this industry are young electronics and computer engineers with no business experience.

The problem is that there are an almost infinite number of user-adapted applications. the question is which criteria should be used to select, from the vast range of practically useful and technically possible products, those which are also cost effective and profitable to make.

In this respect, the producer is squarely confronted by the proposed strategy. The premise is that in these sectors of the industry there are two very important factors which can increase the chances of success: accumulation of technological capability inside the firm and accumulation of confidence and goodwill among the customers. This means consciously following a strategy of entrepreneurial learning (TEUBAL 1983), understanding that in this area learning and growth go hand in hand.

Translated into recommendations, this means starting with a solid footing on existing capacity as a base for a strategy of technology accumulation. At the market end, the firm should join forces with competent users. Let us discuss each of the these guidelines in turn.

a) Start from Existing Capacity and Accumulate Technological Capability

One of the main determinants of the choice of initial product range is, of course, the local ability to tackle design and/or production. Given the assessment of Venezuelan capabilities, three areas should be evaluated: relative complexity, scale of production and required complementary technologies. If these three domains were the dimensions of the product space, the recommendation would be to start with products located in the neighbourhood of the minima in all and move up each of them as learning proceeds (See Figure 2).

By relative complexity -- on the horizontal axis -- we refer to the electronics design proper. The simpler the design, the more likely it is that it can be tackled with existing local design and production capacity (by the nature of the technology, the difficulty of assembly is more or less directly proportional to design complexity). Although in Venezuela there are electronics engineers who can design relatively complex products, initial simplicity is generally recommended. It is estimated that design experience for full "debugged" products is best acquired along a path of gradually increasing complexity. The same applies to manufacturing experience and how it leads capability for judging the sturdiness of design and guaranteeing reliability. Jumping the queue is better done in a joint venture with experienced partners. This is especially so when there is little expertise in the surrounding industrial environment to come to the aid of firms encountering production problems.

In respect to market volume -- the vertical axis in Figure 2 -- it has been implicit in the previous discussion that those goods which are normally mass produced are to be avoided as production targets and certainly as design targets. Medium to small scale products or product families are considered more likely to lead to competitive production.

In relation to complementary technologies we are in this case referring to requirements in other production technologies such as precision machining, optics, hydraulics, electrical machinery, accumulation to tacit knowledge and "know-how". They thus tend to be dependent upon the existence of established firms, experienced personnel and a skilled workforce. As mentioned earlier, our general assessment is that in this respect Venezuela has very little to offer, which is quite a formidable limitation in certain fields.

Instrumentation is an area with possible opportunities, for instance, yet the above restriction reduces the field mainly to the areas of inspection, test, measurement, analysis and other data collecting and data processing applications. The production of direct control, closed loop systems, with "moving parts", will require a long and intense learning period, preferably with experienced partners.

However, avoidance of areas requiring complementary manufacturing technologies that are generally not available in the country should not be confused with the complementary technologies mastered by competent users, which are required for client-oriented products. The hybridisation between these technologies and software and hardware design capabilities is one of the pillars of the proposed strategy and is to be promoted by all available means.

In summary, local design-based firms should be encouraged to initiate their technology accumulation process with products involving only electronics, of minimal complexity, and produced in small to medium quantities. They can move forward from there, as permitted by the markets and their experience. Foreign investment should be invited to participate, alone or in partnership in order to bring those technologies and skills which are lacking and unlikely to be developed locally. Meeting, hybridising, joint development and other forms of collaboration between foreign and local firms would be encouraged.

b) Target the Market as Close to the User as Possible

This general mapping out of the more approachable product space must now consider the market place. Given the user-oriented policy being proposed and the need to have "double duty" firms, it is important to identify the likely users of standard products and those at the more specialised end of the product range.

One of the few absolute advantages that a local producer can have is goodwill built up with powerful clients, based on the ease of face to face contact and the quality and reliability of service support. The more easily a product can be bought off the shelf and serviced by a standard maintenance technician, the less it matters where or by whom it was produced. The more customer-specific the product, the greater is the importance of being able to count on direct service from the manufacturers themselves. Thus the custom and semi-custom ends of the range, with their relevant services, are the safer markets in the longer term. Developing these markets requires the establishment of strong user-producer links (LUNDCALL) with technically competent clients, in reasonably large markets. That takes time and experience, and good client targeting and nurturing.

In essence, specialised products are expected to be the outcome of the technological convergence between the information technology expertise of the producer and the applications expertise of the user (VON HIPPEL). Good potential clients in markets for specialised products, tending towards strong user-producer links, including joint product development would be:

(1) The large state owned companies such as those in telecommunications, electricity, metallurgy and the petroleum industry, capable of setting up active procurement policies and technically competent enough to collaborate in research and in the specification, evaluation and upgrading of products.

(2) Industries where the private sector has achieved enough technological capability to be able to specify the equipment it needs and evaluate it in use. These are mainly process industries in areas such as chemicals and agro-industry.

A coherent strategy would be to work in the technical personnel of these firms not only in custom or semi-custom specialities but also in identifying simple standard products that are the basic, lower-end versions of diversified product families, with a more complex front end. However, this is not always possible or convenient.

The other market segments that have some likelihood of being safe in the medium and long term, are those requiring some sort of adaptation to the characteristics of the country: climate, local peculiarities, legal requirements, and other specific conditions. These are more likely to lead to "bread-and butter" products with a reasonable volume in the domestic market. Among them could be the following:

(1) Standard products fulfilling the needs and regulations of the construction or tourist industries (this includes intercomsystems, security and alarm devices, PABX's, etc.). Technical specifications and quality requirements for these can be -- and many have been -- determined and made official.

(2) Products which can be adapted to peculiarities -- or even disadvantages -- of the local infrastructure. Actual examples include voltage regulators with wider than standard tolerance ranges or UPS's with longer than standard operating time, to adapt to an inefficient electricity network. Another case is a modernising interface adapted to the old electro-mechanical exchanges, to allow IDD with automatic call-by-call subscriber billing.

(3) Products which need "tropicalisation" such as higher than average tolerance to heat or humidity. A domestic example of this is the power meter developed for the local electric company.

(4) Product interfaces which are adaptable or compatible with the great variety or imported electronic equipment.

In general, the more country-specific the required standards, the greater are the chances of capturing a good share of the market for medium volume products (and, eventually, for acquiring export markets in countries with similar conditions).

The same considerations and examples would apply to product family targeting in the area of software. In this case, however, the "bread and butter" income can come from the commercial representation of foreign equipment or software or from wider ranging consultancy services and not necessarily from standard packages (which might in fact be a doubtful proposition).

In general, it is recommended that engineers wanting to set up design-based firms select simple products with some market demand, in areas and product ranges providing time and space for acquiring experience, and in fields where local characteristics are important or where local expertise (in the complementary knowledge related to the application) is associated with accessible domestic markets.

Other routes, such as starting with a joint venture or negotiating a license to manufacture a product of medium complexity are also to be encouraged as long as feasibility is not highly, or permanently, dependent on tariff protection. These firms would be expected also to guarantee installing, adapting, servicing, training, etc. in relation to their product. In practice, firms that have chosen this route have done all this as part of their marketing and have been very successful. One of them, FONOLAB, developed from the beginning as an assembler (and commercial representative) with parallel design and adaptation capacity; this firm has been one of the most effective in acquiring export markets.

At any event, it is likely that in the long run most local firms will establish collaborative arrangements with firms abroad, as they become stronger and better understand their needs and limitations.

In summary, the proposed development strategy for the electronics and software sectors is one of gradual accumulation of technology, geared to enhancing the flexibility and the competitiveness of the user industries, in particular those considered to have export potential. It is understood that this "service" rise imposes such requirements that the electronics industry itself has to be a highly competitive, continuously improving sector.

We now turn to the existing electronics industry in Venezuela. The analysis will be carried out in light of the preceding criteria and with the purpose of identifying the policies that would best serve the stated strategic goals.

III. PRESENT AND POSSIBLE FUTURE OF THE ELECTRONICS INDUSTRY IN VENEZUELA

A good indicator of the validity of the general guidelines presented above is the fact that private industry has sprung up spontaneously with more or less the intended characteristics and has met with considerable success by Venezuelan standards. Let us describe the industry as it has grown within the past decade in order to assess its future prospects and the type of policy support that might be required.[3]

1. A Small Industry in a Dynamic Market

It must be clear from the outset that the weight of the electronics industry in Venezuela is very small indeed. The three sectors together -- consumer, components and professional electronics -- only have sales of about 500 million dollars. That figure constitutes 1.2 per cent of the value added by Venezuelan industry as a whole.

This should be understood in the context of the previously mentioned natural resource-based economy, with scant development of the capital goods industry. In fact, during the "oil boom" years (to others, the oil crisis) of 1974-79, Venezuelan industrial capacity developed a strong bias towards the processing industries, stemming from relative costs: very low cost energy (oil, gas and hydro-electric), vast mineral resources and relatively high labour costs. In that high growth period (12 per cent yearly average), intermediate products such as steel, aluminum, petrochemicals, cement and paper grew at over 16 per cent per annum, increasing their share from a third to almost half of industrial value added. During those same years the whole of machinery and electrical manufacturing, growing at 8 per cent per annum, its share of value added fell from 17 to 15 per cent. With the onset of the Venezuelan crisis since 1979, growth rates have diminished considerably (sometimes even negative) but the relative trends remained.

Within the capital goods industry, itself only 6 per cent of total value added, professional electronics is relatively significant, constituting around one tenth of the industry. Also, within the electronics industry as a whole, the capital goods portion represents 45 per cent of production and more than half of the establishments.

The domestic market of the professional electronics sector is growing very rapidly. Imports of electronic goods, in general, grew from 6 per cent of total imports into the country in 1980 to around 9 per cent in 1986, but the professional electronics grew much faster than consumer electronics, increasing its share from a half to 80 per cent of total electronics imports. This strong demand for information technology equipment allowed it to overcome the drastic reduction in imports following the 1983 devaluation, rebounding in two years to the 1982 peak of $442 million and surpassing it by 1986 ($453 million). In these same years, as will be seen later, sales of domestic production of professional electronics were growing at a 40 per cent pace.

Information technology has become widely used and there is a relatively high level of computer literacy and of new technological developments in computing (accompanied by a good measure of imitative consumption of the least sophisticated sort). In 1985, it was estimated that personal computers represented 15 per cent of the total computer market in terms of value. By then, about 50000 micros had been sold, or about one per 200 persons of working age, while yearly sales were 15000 units (PRODUCTO 30). Large firms, such as the petroleum company, are fully equipped with the latest in information technology.

2. The Professional Electronics Industry: An Overview

There are about 110 professional electronics firms (including component manufacturers) operating in Venezuela. However, as many as 40 or 50 of these companies actually belong to the so-called "informal sector". They have been set up by electronics engineers who design and manufacture applications products and either operate through a distributor or are themselves registered as commercial firms. This rather odd situation where high-tech products are manufactured under irregular conditions is considered to be a consequence of the cumbersome paperwork and costly requirements for setting up an industrial firm. This insight into bureaucratic obstacles to development also reveals something about the electronics applications industry. Initial capital can be rather small and, in certain products and segments, competitiveness is possible without protection and, at least for a time, without government help of any sort.

There are about ten firms in the industry which are considered large by Venezuelan standards (more than 100 employees). These include five foreign companies -- Siemens, Ericsson, Telenorma (Bosch), Telemecanique and Honeywell -- and five local firms -- Microtel, Maplatex, Fonolab, Avtek and Sovica. Together they represent about 70 per cent of sales and 50 per cent of employment. Maplatex alone had 800 employees in 1986 which was nearly 15 per cent of total employment estimated in the sector for that year.

With such a lopsided distribution, aggregate figures are not very meaningful. Nevertheless, Table 1 presents a profile of the sector with estimates of the main descriptive parameters.

Table 1

A PROFILE OF THE PROFESSIONAL ELECTRONICS INDUSTRY(*)
Venezuela 1986

Number of firms	110	
Sales	215	million
Value Added	83	million
Imports	55	million
Exports	1.4	million
R&D Investment	9.3	million
Number of different products	140	
Products being developed	136	
Personnel	5400	employees
Engineers and other professionals	960	
Professionals in R&D	360	

Source: Romero, Sanchez, Martinez

(*) Figures in dollars at the official 1986 industrial exchange rate of 7.50Bs. dollar.

Even in this doubtful aggregate, there are some points worthy of note:

(1) R&D expenditure represents nearly 5 per cent of total sales, an uncommon level in an industry whose main activity had been assembly under license.

(2) Professional employees, of whom more than a third are engaged in R&D represent 18 per cent of the personnel.

(3) Product diversity: 140 different products, considering that there are product markets where 6 or 7 firms compete, means the average number of products per firm is certainly more than one, and the same can be said about the number of products under development.

Thus this is a typical industry for Venezuela, with a capacity to innovate and with a certain degree of competitiveness. However, it produces mainly for the domestic market, for exports are less than 1 per cent of sales. In Venezuela in 1986 there were at least 180 software firms with more than five professional employees. From the survey, it was estimated that the total value of sales of locally developed software in that year was approximately Bs. 100 million ($14 million). Employment could be about 2500, the great majority of professionals, but this is an even more fluid and elusive group than that in hardware.

3. Evolution of Professional Electronics: Survey of 50 Firms [4]

Many of the firms in professional electronics are of recent origin, but unlike the great majority of new small firms in other industries, a smaller proportion were founded after Black Friday, the day of the first 100 per cent devaluation in March 1983. As shown in the first column of Table 2, more than half of the firms surveyed were established before 1983, together with many software firms.

However, the rate of growth of sales increased after Black Friday. Devaluation gave a boost to most domestic manufacturing against imports. Clients were forced to try the domestic alternative due to exchange controls and other import restrictions on final goods. This development helped dispel a widespread distrust of product engineering by local manufacturers of electronic products. Many domestically designed products gained market acceptance by getting this opportunity of being tested.

As shown in Table 2, after absorbing the shock of the first devaluation, sales increased in 1985-86 by more than 40 per cent, both measured in current bolivars (or in dollars at the official industrial rate).

Table 2

BIRTH, GROWTH OF SALES AND EMPLOYMENT IN 50 SURVEYED FIRMS
OF THE PROFESSIONAL ELECTRONICS SECTOR
Venezuela 1982-1986

FIRMS		SALES				EMPLOYMENT	
YEAR	No.	Million Bs.	Million Bs.	Growth Rate Bs.	$	Number	Growth rate
1982	27	278	64.7	...		1 408	...
1983	30	307	51.2	10.4%	-20.9%	1 289	-9%
1984	37	337	44.9	9.8%	-12.3%	1 568	22%
1985	43	502	66.9	49.0%	49.0%	1 863	19%
1986	50	714	95.2	42.2%	42.3%	2 590	39%

Source: Romero, Sanchez, Martinez.

If official deflators are applied, which is a very doubtful practice when referring to the electronics industry, growth rates in 1985 and 1986 are 34 per cent and 27 per cent. By contrast, the real industrial growth rate for 1985 was 1.2 per cent and in 1986 there was a decline of 4 per cent.

However, there are two other indicators of real growth: (a) the increase in the number of firms (seven new firms per year in the sample, which is a 40 per cent increase in three years); and (b) the growth in employment.

After the 1983 decline, growth in employment reached nearly 40 per cent in 1986. Since almost half the firms in that year were less than three years old and therefore likely to have only a few employees, much of the increase was probably accounted for by the relatively older firms.

By 1986, 32 per cent of the firms surveyed had less than 10 employees: 86 per cent had less than 60 and only 4 firms (8 per cent) had close to or more than 100 employees. In fact, these four firms had 57 per cent of all employed in the sample. Obviously, a similar distribution applies to sales. In 1986, 38 of the 50 firms had less than 10 Mill. Bs. ($1.3 million) in sales. Only 3 firms had sales of more than 50 million Bs (US $6.7 million).

Thus in the majority of cases these are small and fragile firms. There is a clearly positive correlation between value of sales and age of firm.

Another difference is their innovative character, which is a source of dynamism and potential to adapt to market needs. Indicators of this are the level of investment in R&D, the employment profile and the use of time of professional personnel. In 1986, the 50 firms in the sample invested 70 million bolivars (about $2 million) in R&D, which represents on average 4.5 per cent of sales. This is reflected in the fact that more than 70 per cent of the products being marketed by these firms are in-house designs. It is also evident in the proportion of professional personnel, which is 34 per cent. Obviously, that is also a sign of immaturity. Many of the small firms are a sort of laboratory with three or four engineers engaged in design, a secretary and a couple of people in assembly. The larger the firm, the smaller is the proportion -- though not the absolute number -- of professional staff.

Another characteristic detail is the distribution of professional personnel by function. Nearly 40 per cent of professional staff (or of their time, because staff in young firms is often multi-function) is devoted to R&D. The other 60 per cent is divided roughly equally among production, administration and relationship with clients (including 12 per cent in sales and 7 per cent in service activities).

Finally, unlike other sectors with small firms in Venezuela some of the electronics firms have reached the export markets. In the sample there were 14 that had exported some product (line-conditioners, PABX's, protocol converters, etc.). Quantitatively, as noted before, exports are minute; they only approached $1.5 million for 1986. However, this points to some potential for the future.

a. A View Inside, a Bias in Specialisation

The existing professional electronics industry in Venezuela, as our proposed policy criteria would recommend, has by and large not entered the areas which might look like the most enticing: computers, office equipment and chips. Although there have been some attempts at highly protected "import substitution" type projects for computer assembly, and, even one for producing integrated circuits under license, good competitive sense seems to have prevailed. The industry is basically oriented towards medium and small volume products in telecommunications, instruments and software.

In fact, telecommunications and instruments, represent 91 per cent of the total sales in the survey sample, 88 per cent of employment, 70 per cent of firms and 86 per cent of product families in the market.

A further analysis of the specialisation profile, as presented in Table 3, shows that telecommunications is the strongest element of the industry. The six firms in the sample (12 per cent) had 71 per cent of sales and 58 per cent of employment. The majority of the larger firms are therefore in this area; they produce mainly peripheral equipment and some interface systems for the telecom company. By contrast, the instruments producing segment appears highly diversified: 58 per cent of the firms manufactured 67 per cent of the product lines in the sample, and account for only 30 per cent of employment and 20 per cent of sales. This domain (together with data processing) is where most of the small new firms are to be found, although it also includes three of the largest and most successful firms: AVTEK inline conditioning and UPS's and SOVICA in alarm systems.

As a result of this specialisation, the coefficients of domestic supply vary widely according to products. For 1986, for instance, local production supplied around 50 per cent of domestic demand in telecommunications and instruments but only 7 per cent of demand in computers and other data processing equipment. There is also wide R&D expenditures. Telecommunications and instrument firms accounted for more than three quarters of the total R&D of the sample.

Table 3

PROFILE OF THE PROFESSIONAL ELECTRONICS SECTOR BY SPECIALISATION
SURVEY OF 50 FIRMS
Venezuela 1986

Products	Proportion of firms	Sales	Employment	Product lines
Components	18%	6%	9%	8%
Data Processing and Office Equipment	12%	3%	3%	6%
Telecom. Equipment	12%	71%	58%	19%
Instruments[1]	58%	20%	30%	67%
Totals	50 firms	$ 95.2 million	2590 persons	130 product lines

1. Instruments groups together almost everything that cannot be clearly classified in the other three categories. It includes test and measurement equipment, monitoring and control instruments, industrial controls, alarm systems, etc.

Source: Romero, Sanchez, Martinez.

b. The Products and the Services

Table 4 presents the 121 products of the 42 surveyed firms that produce equipment (the other eight are component manufacturers) classified by relative complexity[4].

As shown in the table, there were no products warranting a "high" or "very high" rating in complexity of design and/or manufacture. Half or more of the product lines are at the "low" spectrum end of the complexity and only 13 products (11 per cent of the sample) were considered to be of "medium high" complexity.

There appears to be much less concentration among instrument manufacturers than among makers of telecommunications equipment. This could merely be the consequence of the wide spectrum of products included in the category "instruments'. However, it does seem to indicate a group of firms still searching for areas of specialisation. The great majority of the low complexity products are instruments, but instruments also accounted for nine of the 13 products rated of medium high complexity. A weakness of the classification system is that it is not evident that about half of the more complex products are actually custom designs, whereas the same level products in telecommunications are medium volume export candidates (protocol converters, multiplexers, medium capacity PABX's, and the digital interfaces for modernising electromechanical central exchanges).

Table 4

NUMBER AND DISTRIBUTION OF 121 PRODUCTS
OF 42 SURVEYED FIRMS IN PROFESSIONAL ELECTRONICS
CLASSIFIED BY RELATIVE COMPLEXITY AND SEGMENT OF SPEICALISATION
Venezuela 1986

Relative Complexity:	Number of Products						Percentages			
Products	Med-Low	Med-low	high	Very High	High	TOTAL	Med-Low	Med-low	high	TOTAL
DP & Office Equip.	1	8	0	0	0	9	11%	89%	---	100%
Telecommunications	14	9	4	0	0	27	52%	33%	15%	100%
Instruments	47	29	9	0	0	85	55%	34%	11%	100%
Total	62	46	13	0	0	121	51%	38%	11%	100%

(*) Excludes the eight components producers in the survey.

Source: Romero, Sanchez, Martinez.

Another revealing form of product classification for our purposes is the relative degree of standardisation, which could be said to measure the distance of the manufacturer from the user, the greatest distance, at the more standard end of the range, to the smallest, at the custom end (as see in Table 5). Of the more than a hundred different products of the 42 equipment producing firms in the survey, just under 40 per cent are standard products, either manufactured under license or designed to standard specifications. These go from various measurement and control instruments (temperature, level, frequency, etc); through telephone sets and transmitters; to IBM compatible PCs, video distributing and switching systems, modems (low to medium speed) and multiplex equipment.

Nearly a third of the products have features that would define them as "country-adapted" and another third can be considered "user adapted". The latter range from those that are basically standard products, but must be programmed and installed according to user requirements, such as a PABX, to products which must be engineered for each specific customer. An example of the latter would be a computerised scoreboard and information system for a sports stadium. Products custom designed for the client include those that are fully user specific and those where the custom user serves as a sort of experimental terrain for developing a good marketable product. A case of the first type is specific test equipment; examples of the latter are a portable data collector and a cash register with inventory control. In fact, many of the products that are classified (in 1986) as "country-adapted" were originally designed as custom or user-adapted products.

Table 5

NUMBER AND DISTRIBUTION OF THE PRODUCTS
OF 42 SURVEYED FIRMS IN PROFESSIONAL ELECTRONICS(*)
BY RELATIVE COMPLEXITY AND DEGREE OF STANDARDISATION
Venezuela 1986

	Relative Complexity							
	Number of Products				Percent Distribution			
Degree of standardisation	Low	Med L	Med H	Total	Low	Med L	Med H	Total
Standard (Worldwide)	28	16	1	45	45	35	8	37%
Country-adapted (Standard)	20	14	2	36	32	30	15	30%
Modified or adapted to user	5	6	5	16	8	13	38.5	13%
Designed for user (custom)	9	10	5	24	15	22	38.5	20%
Total	62	46	13	121	100	100	100	100%

(*) Excludes the eight components producers in the survey.

Source: Romero, Sanchez, Martinez.

It is interesting to note the close relation between complexity and closeness to user. Of the 13 products rated as "medium high" in complexity, 10 are user adapted; of the 62 considered of low complexity, almost half are standard and 20 are "country-adapted". Standard and semi-standard products represent 79 per cent of the simpler products.

In the survey, firms were asked which of a list of services they provided for customers. Three fourths of the firms declared they provided adapting and modifying services and an equal number, maintenance and repair. Two thirds performed installation and all but seven firms said they provided consultancy services. This high proportion might not mean too much, considering the breadth of the category: product selection, systems design, compatibility analysis, user training, etc. Nevertheless, the overall response indicates that the majority of the firms see services, during or after sales, as an integral parts of their business.

4. Evolution of Software Production - Survey of 23 Firms

Without counting the sometimes large in-house software development departments in user firms, such as the petroleum company, there are basically four types of software firms in the country:

(1) Commercial representatives of imported equipment who sell software as "value added" or use it as a marketing tool;

(2) The software services department of hardware firms;

(3) Consultancy firms which provide software as part of a solution for their clients; and

(4) Software producers.

The origin, behaviour and future prospects differ widely.

A large portion of the software firms belong to the first category. These range from a development department in a stable and powerful foreign affiliate such as IBM, UNISYS or EPSON to the small vulnerable shop run by young computer graduates. In this latter group both birth and death rates have been high. Some of the strongest survivors have moved on to categories 3 or 4.

The second category is generally at least as stable as the manufacturer it is associated with. Their classification as software firms is questionable and they in fact are doubly countered here. However, some of the equipment producers offer adapted software services for their own or similar equipment as a regular part of their business (and some have exported such services). Since this corresponds to the user-oriented strategy to be fostered, it justifies inclusion as a separate category.

The oldest firms are in the third group. It is mainly made up of firms that offered consultancy services to specific industries: petroleum, electric utilities, chemical manufacturers, construction, etc. They also offered audits and other administrative services. With the advent of expertise in software, systems and procurement or risk losing much of their business. The stability of these firms depends on the business and they perform selection, adaptation, development, installation, maintenance, upgrading and whatever else their customers require. Many of these are the relatively newer firms which grew from modest beginnings. Most of the more traditional companies, however, see software development as a service outside their area of expertise and sometime subcontract it out.

The last category includes about ten firms facing high risks for high stakes. They develop applications packages for medium volume market, usually for microcomputers. They generally test the product in the local market and then try to export. Some have had a certain degree of success (by 1989 one of them had affiliates in Spain, Ecuador and the United States). Their survival will depend on export success because the domestic market is too small. They count upon high quality, low cost professional personnel as a comparative advantage, but they compete on equal terms with other producers in the field. Their products can be considered standard and, except for the Spanish language, they are not particularly rooted in local characteristics or helped by local expertise. Like many other entrants in the software market, they base their hopes on finding a winning product.

The diversity of firms and the intangible nature of software makes it very difficult to obtain meaningful statistics on production and sales. For instance, the 23 firms in the survey declared total sales for 1986 of 300 million ($40 million) but, only a fifth of this was in locally developed software. The other 80 per cent includes everything from equipment to various services and imported software.

It is also difficult to classify their personnel, but it is known that the majority (61 per cent) of the 619 employees that the 23 firms had in 1986 have university degrees in computer sciences. The rest are other university professionals, 10 per cent; qualified technicians, 14 per cent; trained programmers, 5 per cent; and others (including secretarial support and other office services), 9 per cent.

R&D expenditures in 1986 represent 6 per cent of total sales or 30 per cent of sales of locally developed software. This high ratio is explained by the nature of software, for which the development process is the main cost of production (reproduction being trivial). Thus R&D manpower weighs heavily in the cost structure of producers of custom and small to medium volume products.

a. The Products and the Services

Given the mixed nature of the firms in question, the more typical situation is the multiproduct, multiservice firm. Apart from the products and services which are not strictly software related, most firms offer consultancy in information technology requirements, personnel training and software adaptation. Formerly, many offered data processing services. Some are in the data bank business.

There is a wide range of software products but it is confined to the applications area. Since there is practically no computer manufacturing, no one has attempted anything in system or utility software outside of university research projects. Within applications we can distinguish four main categories:

(1) Standard packages,

(2) Industry or country specific (medium volume) applications,

(3) Equipment specific software (for hardware manufacturers), and

(4) Custom made or custom modified solutions for clients.

Among the standard packages, the most common are the general administrative applications (personnel, orders, inventory management, accounting, etc). However, EPSON Venezuela developed a programme like LOTUS 1-2-3 for their machines that were not IBM-compatible, which helped sales to the point where they took strong roots in the local market (they hold 30 per cent of the microcomputer base). They have more recently developed a Spanish-language word processor which is marketed with EPSON micros throughout Latin America.

The custom made products are generally the province of small commercial firms or large consultancy companies. Big efforts are no longer so common, as standard or semi-standard packages become available and better known. In most cases, what is needed are adaptations and modifications. For some specific purposes some programmes might be custom developed but with a package such as D-Base.

The third category is made up of the type of software required by equipment such as real time programmes for industrial controls or telecommunications equipment, or the software required by, say, a SCADA system which must be adapted to the specific data acquisition and processing needs of the particular industry or activity.

The category which groups the products most directly at the local market is the country-specific, industry-specific area. These products include administrative packages adapted to the needs of various types of business (banks, petrol stations, hotels, fast food chains, schools, etc.); a monitoring system for the construction industry; computer aided courses; a customs control system, etc.

In general, the market is still very disparate and undefined so that, in software, as in the instruments segment of hardware, there is still considerable searching for profitable niches.

5. A Possible Future

The first question that has to be addressed at this point is how these firms will react to the new economic climate. In February 1989, preferential exchange rates for industry were eliminated and from mid-year a phased programme of tariff reduction began, with a planned ceiling of 20 per cent in 1992. The goal is to move all industry from sheltered import substitution to competitiveness.

Until 1988, professional electronics and software producers had been at least partially exposed to competition. Software firms developed in an open market, and many hardware producers, as already mentioned, operate in the "informal sector" without protection or incentives of any kind and some firms have gone to export markets. Even in the early 1980s, when the bolivar was grossly overvalued, small local electronics firms were able to win bids against imported products.

The stronger group in telecommunications, however, developed during the last few years in a highly protected environment, behind tariffs, with a virtual prohibition of imports of peripheral equipment (single sets and PABXs) and with a preferential exchange rate, which amounted to a subsidy. Yet domestic competition was very intense and, as seen above, this segment was not passive, but engaged in product engineering and explored export possibilities. The larger and "older" firms in the area of instruments enjoyed similar protection but also had to compete domestically (especially in alarm systems and standard products such as voltage regulators). Most of these also maintained an engineering effort and began to export. Some of the firms in both areas expanded upstream towards printed circuits, mechanical parts and other inputs in order to guarantee the quality of their final products and enhance their earnings.

Our assessment is that most of the larger firms, both foreign and local, have the internal resources to withstand the initial shock, which is a combination of reduced protection with drastically reduced demand, and that, gradually, they can find a path toward renewed growth.

The medium sized firms might not all be able to survive. Some of them might have been planning to expand just as demand fell through the floor - a 60 per cent drop - and interest rates went through the ceiling to about 40 per cent. Worse still, they could have expanded just recently and were caught indebted, laden with personnel and projects, while facing dwindling markets. Another reason that some will not survive is that Venezuela has no risk capital market which might come to the rescue.

By contrast, the more recently established, smaller firms could perhaps survive. For many, the very fact that they are small, agile and still highly flexible, could allow them to trim costs and go after the appropriate market. There already is a clear trend for growth in demand for maintenance service as well as for any other technical services or products that protect or upgrade old equipment and bring savings or allow postponement of new investment. Firms that are capable of responding to these sort of requirements should be able to survive and even thrive.

If our assessment of the trends in the adjustment period is correct, it is possible that the existing professional electronics industry will consolidate with - some reshuffling of relative positions and some losses - and that the service bias will tend to be accentuated. Another possible scenario, however, is that the adjustment programme for the country fails and Venezuela enters an Argentina-type of inflationary chaos.

Similar considerations hold for software firms. The two groups that can certainly survive are the commercial representatives of healthy firms and the consultancy firms. Both would benefit from the fact that their clients must adapt to the new environment and will seek external help for modernisation and "reconversion". Those service departments associated with hardware producers are in an analogous situation and could actually increase the chances of survival of the manufacturing arm. More uncertain is the future of the software houses proper which are all searching for an anchor in the export market. Some will make it, some might not. In many cases, it is a question of whether they had an adequate product ready when the crunch came. The weakest group is the small computer shop which depended on the microcomputer boom. Yet these and the software group are comprised of firms whose main asset is human resources, both entrepreneurial and technical expertise, which could be reoriented to the new conditions if economic policy leads to growth.

Under macroeconomic assumption, then, and supposing that a general consensus can be reached on a user-oriented strategy, after the readjustment period, the government policy task would be to guarantee the conditions for the growth and strengthening of the core firms in the professional electronics industry and in software and systems services.

With time we would expect the following trends to occur naturally (or to be fostered):

(1) A reduction in the product range of most firms, with greater specialisation in a particular range where they have accumulated expertise.

(2) A greater industry-specific specialisation in engineering-intensive and software firms towards the more dynamic sectors in the country.

(3) A loss of markets in the more standard products but a flourishing of markets where country-adapted features of "tropicalisation' is truly important.

(4) Growing exports in both country-adapted and industry-specific products and services.

(5) An increasingly intensive and creative relationship with foreign firms abroad, with diverse forms of collaboration: technology licensing, mutual services, joint ventures, technology agreements, product and service swaps, local representation providing technical client support, etc.

(6) Gradually growing foreign investment in two possible areas: the domestic market, where there is user-specific high demand such as the petroleum industry; and in export-oriented projects, where local engineering collaboration is important to better serve regional markets.

(7) Growing sophistication in professional electronics imports as users acquire expertise and as local consultancy, system design and software services obtain higher capability levels of support (up to now, excess money and limited knowledge have led to a high proportion of poor import choices, which lead to a dead end for both the buyer and the seller).

In general, although the proposed professional electronics and software industry is likely to be able to export enough to pay for its own imports, the sector as a whole would remain a deficit segment of the balance of payments. The positive contribution of the industry - and that of the imports it complements - would be measured in the better export performance of its clients in other industries or services.

The premises for the survival of this industry under the proposed conditions are the following:

(1) That the world electronics industry continues to be open to applications producers, in the sense of maintaining open trade in most semiconductor components, design aids, software development tools, etc., as well as in the general decoupling of the user end of software, ASIC design, interface, and other elements requiring open availability of information about the basic product to be adapted.

(2) That domestic policy protected import substitution measures for manufacturing semiconductor components or professional electronics products.

Finally, it is important to note that this proposal is, in fact, a positive-sum game to be played with the international electronics industry and its home countries. We believe that when the United States, and other countries with balance of payments problems take a long-term view of the problem, they will realise that the higher the technological level of the developing countries, the greater their own electronics exports will be to those countries. The crushing game to defend a sale today is a losing situation for all in the medium and longer term.

We now turn to the specific policy instruments that are recommended for implementing the user-oriented strategy for the development of the professional electronics and software industry.

V. THE PROPOSED POLICY INSTRUMENTS

As Venezuela moves towards industrial competitiveness, we believe that the main change in government policy should be to move from a compensating to facilitating role. This means that government services should be highly efficient and that resources should be made available to firms under competitive conditions.

In that context, the development strategy for the professional electronics industry will be presented in terms of proposed policies, focusing on four areas: resources (fiancial technical and human), stimulating demand, protection and competition, and the framework for strategic consensus planning.

1. Facilitating Resources

Among other things, endogenous accumulation of technological capability depends on having up-to-date information, a growing pool of qualified personnel abreast of current technology and, most important, the availability of the necessary capital, when it is needed and under appropriate conditions.

a. Human, Technical and Information Resources

As has been mentioned, Venezuela had profitted from oil-derived income for obtaining information and training. Since 1983, however, travel and education abroad has been seriously restricted: libraries receive few scientific, engineering and trade publications; attendance at international seminars and congresses has become difficult; scientific laboratories have increasingly unmet equipment needs, and so on.

This situation, whose full impact is still to be felt, is harmful to the development potential of the electronics sector. There is less information about the most advance technology. There is a threat to the quality of university training, which no longer benefits from ample up to date literature an influx of teachers with doctorates earned abroad. Finally, there is less support available from research laboratories, now insufficiently funded.

One clear role for government policy is to seek ways to strengthen the research institutes related to microelectronics technology, to assure attendance at international conferences, to send tranees and post-graduate students to first rate institutions in other countries, to fund libraries and assure access to appropriate international data bases.

It must be clear that these international contacts are necessary to enhance the capacity to develop locally adapted technology. In this technology in particular, advance is very rapid as regards the tools and the inputs that make applications development more effective. Additionally, intelligent import choice -- including the selection of best value for money -- also depends on well informed access to what is available worldwide.

b. Timely, Sufficent Funds Adapted to Changing Needs

In many developed countries, a risk capital market has become available to innovating firms. In Venezuela, however, even the stock market is not a significant source of capital for business. It is the banks, either private or public, that supply most funds. Under these circumstances, and given that local private banks are far from ready to take risks with an unconventional firm, development banks should take the initiative.

Unfortunately, development banks have become very rigid, like other organisations oriented toward import substitution policies or compensating disadvantages in export promotion schemes. When a new type of firm appears with needs different from those traditionally handled, these banks find themselves at a loss: they are either restricted legally or lack technical competence or ideologically unprepared.

Service oriented, innovative, "organically" growing firms have different needs than the standard import substitution firm, set up to assemble a well known standard product under licence, in a standard plant with idle capacity, with known operating costs, known reference prices and a tested level of demand. Although this may oversimplify things, the fact is that development banks do not at present know how to cater to the specific requirements of innovative firms and their clients.

These requirements are, among others:

- seed money for design;
- venture capital;
- some form of medium-term money for financing projects of lengthy design and fabrication;
- amounts of working capital that are often much greater than fixed investment (which at first can be very small);
- long-term funding for intangible investment such as software packages;
- long-term funding for big R&D projects (in some cases with many participants, both users and producers);

- working capital for professional marketing costs;
- medium-term funding for the user firms (between up-front money on agreement and actual results from using the equipment); and
- funding for clients of consultancy services.

It is not necessarily a question of subsidising, although this might be required for certain R&D projects, as most developed countries have done. The main point is that funding should be adapted to the needs of firms (rather than the reverse, which is the situation today). In essence, the typical evolution of firms has to be analysed to identify the specific needs that appear at different phases of development.

Figure 3, presents a simplified image of the typical evolution of innovating firms. It is a "tropicalised" version of Noyce’s three stage evolution of entrepreneurial firms. Each phase of development involves a different type of firm with different needs in terms of resources. Each transition is a major learning process for the "engineer entrepreneur", but it also requires understanding on the part of the funding agency. An interesting scheme for helping cross some of those bridges as set up in Israel: it financed firms which could show they had already succeeded with one product and were ready to develop the next (TEUBAL). Much imagination will have to be brought to bear in designing the appropriate schemes. The object is to create a favourable environment for the growth in strengthening of these innovating firms; one where failure is attributable to the entrepreneurs own incapacity and not to lack of support in the environment.

2. Stimulating Demand

User confidence is crucial for the growth of service-orietned firms, but so is user capability. Demand for locally produced electronic goods or software can only grow with an increase in the sophistication and technical capability of potential customers. It is the mastery of its own specific technology and of its own business that makes the user firm truly capable of specifying, selecting and evaluating imported or locally made hardware and software.

In this sense, it is implicit in a user-oriented strategy that client industries are involved in a process of change. In any case, the decision to promote industrial reconversion has been made in parallel with that of fostering the growth of the information industry for this prupose. In this context, we believe that policy makers trying to foster an efficient user-oriented information technology sector should also be working to encourage modernisation of economic activity in general.

Nevertheless, the author considers that the major initial transformation required in most firms involves structure rather than equipment. This is especially in countries that followed the import substitution route. Inefficient plants, having idle capacity and a cumbersome organisation, are unlikely to become competitive simply by acquiring computers, automation and electronics-based equipment. The adoption of a more flexible system of management, developed most fully by the Japanese (See AOKI; BESSANT; HOFFMAN; KAPLINSKY; PEREZ 1989), is a precondition for the fruitful incorporation of information technology. In fact, it is possible to improve equipment and making more creative use of available human resources, before any fixed investment is necessary (BESSANT). In fact, the abandonment of an obsolete management style is one of the main recommendations made by the MIT Commission on Productivity for US industry for meeting the Japanese challenge (DERTOUZOS et al.). This recommendation is no less relevant for industry in Latin America and other developing countries.

Ironically, organisation modernisation would actually reduce imports of information technology equipment and stimulate local production in electronics. The erroneous belief that high technology, by itself, leads to competitiveness is responsible for many costly mistakes which weigh on the balance of payments. The Prospects of domestic hardware and software producers will be improved by promoting an understanding of how organisation practices and human resources can contribute to competitiveness. This would be so, because one distinguishing feature of the new managment model is continuous learning and improvement, which means a conscious drive towards gradual mastery of product and process technologies. As client firms increase their technical capability, they will be better able to specify their needs and assess the quality of what is available locally, leading to better informed pruchases both domestically and abroad.

For promoting economy-wide modernisation of management practices, it is recommended that funding for that purpose be made accessible, together with adequate information about the nature of organisational change, its relationship with information technology and potential benefits. The other policy tool is to make available knowledgeable consultants and/or to provide training for managers and engineers. Education of demand is likely to be a better way to foster the growth of good quality information technolgoy production and services than protection or import substitution policies.

a. Active Market Policy: User-producer Linkages

Another means of increasing demand and also moving towards more ambitious projects is to involve the large state owned firms and some of the more dynamic private sector firms or groups in the strengthening of their information technology suppliers.

Since 1982, there have been various efforts in Venezuela in the field of supplier development. Such firms as the petroleum holding company and government-sponsored organisations, in particular CONDIBIECA (the capital goods development council), have set up programmes whereby possible local suppliers to publicly owned firms are informed of market specifications and quality requirements for proudcts they can manufacture. In the case of PDVSA, they went as far as evaluating each firm, technically and economically, and handing the consultancy report over to the applicant supplier, indicating the areas of change required to qualify.

A more recent development, could be classed under what we have termed an "active market" procurement policy. Some public enterprises have begun negotiating product design and development with local firms. CADAFE, the national electric company, for instance, made a contract with FABELCA, one of the small instruments firms, to design and produce a tropicalised "universal power meter". It was basically a "futures" purchase, with an up-front payment. The specifications were jointly defined; there were technical contacts during development; the prototype was jointly tested and approved; and the field tests of the first production runs have been made and continue to be made by CADAFE personnel and there are regular information sharing meetings with FABELCA.

The meter has led to a 3 per cent investment costs in each sub-station and a 70 per cent reduction in maintenance costs for the utility company. The electronics firm now has a tested product costing $500 to $600, with an assured domestic market in the hundreds of units per year and a good chance of exporting.

In another domain, the telecommunications company saved milions of dollars, and probably many headaches, by modernising the old electromechanical exchanges. These are now able to provide a service which "looks" like that of a modern exchange.

An active market policy is essentially a process of demand-pulled interactive technology development. It involves the user firm in identifying from among its needs those that it would be convenient to develop locally, then selecting one or more possible suppliers and providing technical collaboration before, during and after development. It can eventually involve support for export promotion. As the cases of interactive technology development between the electronics producer firms and competent user industries multiply, projects could increase in complexity, eventually incorporating systems design firms and research institutions.

The benefits accrue to both user and producer. The user gains because the local supplier will bend over backwards to satisfy every request. The producer benefits because user feedback improves the product and serves as a platform for market expansion, while following a well-anchored route to technology accumulation.

In the context of the proposed policy, this sort of occurrence would stop being an interesting exception and become a regular practice of all state owned firms as well as of many private firms or groups of firms. Already, two private industry associations are working with CONDIBIECA in supplier development programmes, which could easily incorporate an active market component. In any case, this would certainly be a very important aspect of the competitive restructuring process in the export-oriented sector.

3. Competition, Protection and Quality

For the government, one of the most delicate issues of the user-oriented policy is how to support and facilitate the development of this sector while fostering its competitiveness. This obviously entails not ony what to do but also what not to do.

We have already mentioned one of the essential things not to be done, which is to offer protection to a company wanting to set up inefficient production of semiconductor components. This would not only risk the quality of the locally produced electronics goods, but would probably lead to restricting the choice of components, thereby reducing flexibility and jeopardising design capability.

However, as mentioned in Section 2, there are parts and components which , if made locally, could enhance the flexibility of the local service-oriented firms and some of them are quite indispensable. Among the latter are printed circuit boards. Without reliable local production of these, domesticaly designed small batch products would be impossible to produce competitively. Nevertheless, small diversified customers cannot guarantee sufficient demand for component producers. Consequently, larger markets are necessary for the survival of efficient and relaible component manufacturers.

This means, as discussed in Section 2, that an effective means has to be found to promote volume production of some electronics goods capable of supplying a "bread and butter" market for component producers. One way of achieving this could be through international negotiations towards some Original Equipment Manufacturer (OEM) or assembly commitments with firms in developed countries; another could be a market swapping agreement between Latin American countries. Our present proposal is to keep those options open but to apply a modified import substitution policy to the consumer goods firms already in the countries (perhaps adding such products as automatic bank tellers, computerised cash registers, etc.).

Two of the main negative consequences of import substitution policies stem from the thwarting of competition. Tariff protection can lead to productivity and the usual policy of obligatory use of local parts can lead to low quality. The question is whether measures can be taken to prevent such consequences.

With this intention in mind, a modified import substitution policy would make obligatory the use of locally produced printed circuits and other carefully selected components but with mandatory quality control of components (allowing imports if found defective). The tariff protection for volume assemblers electronic equipment should be accompanied by an agreed programme of productivity enhancement to keep protection low. In any case, multiproduct firms, rather than the traditional single product assemblers with large idle capacity, should be the basis for calculating the truly indispensable protection level.

Figure 4, shows the general interrelations which should serve as criteria for guiding policy. The core firms, which are the service-oriented producers, must count upon appropriate sources of components as well as sophisticated technical support from the research labs. The latter should also be required to lend their technical support to all the other firms in the sector.

In some cases, there may be areas of mutually beneficial collaboration with the volume producers: assembly services, production of high precision-engineered complementary devices, etc. Other possibilities may arise for technological cooperation with foreign investors interested in adapting products to regional characteristics, when using the country as export base to neighbouring countries. In other cases, a locally developed product or interface could be exported together with the standard product. There are already some instance of this. One interesting development is a decision by Xerox to assemble photocopiers in the country, using locally designed electronic test equipment, because their standard Associated Testing Equipments (AIE’s) were designed for much larger volumes.

These sort of agreements should be encouraged and, if necessary, financed, but it is probably better to let them occur as the true needs and possibilities arise.

The best safeguard for the service-oriented segments of the industry (as well as some of the medium volume producers of "tropicalised" goods) in the local market should be their better capability of adapting to local conditions and to user-needs. The same can be said for user-adapted software services. Experience shows that, if justified, a premium will be paid for that, even though sometimes a locally adapted product can be much simpler and less costly than a complex international version. If foreign investors want to come in and do the same sort of service, their competition should be welcomed.

However, there can be cases where temporary protection would be warranted to convince mistrustful customers, giving the producers a chance to prove themselves. This is slightly different from "infant industry" policies; it might be more an "adolescent industry" policy. If we are talking about innovating firms, it is probable that the need for support in penetrating the market would appear towards the end of Phase II (see Fig. 3), to Phase III. Some satisfied users should be called upon to support the claim to protection, which must be clearly understood as impermanent.

Being extremely clear and not making any exceptions is the only way to avoid a "production-oriented" strategy sneaking through the back door, which in this sector can have dire consequences. Employment and balance of payments problems should be confronted with other sectors. If interest groups are allowed to grow around inefficient production in electronics, all industry will suffer.

Finally, for the many capital goods which are not produced in the country and for imported software, some sort of legislation requiring after-sales service and guarantees from the commercial representative or importer is probably required to protect users from some of most costly mistakes. Of course, most equipment representatives with a long-term view would naturally tend to set up services for client support. Furthermore, as mentioned in the discussion on software, some of the commercial subsidiaries can be considered an essential part of the user-oriented service infrastructure in this sector.

4. Consensus Planning

It isFwidely believed that a rational economic future will begin to evolve in a country where there has been protected import substitution if the state simply ends its intervention and subsidies, making the way for competition and market forces. In our view this is highly unrealistic. No domestic animal is expected to survive if suddenly let loose in the jungle, and it would not be the fault of the animal but of the domesticator.

Modernisation and competitive restructuring are certainly on the agenda and so is a radically reduced state involvement in the economy. However, modernisation requires resources for information, technical support and funding, to enable firms to restructure and become competitive. Reduced state involvement requires that the social framework be capable of providing direction for the restructuring process. If such resources and direction are wanting, the process could be more painful, prolonged and wasteful of existing potential than necessary, and it would be difficult to make the most of available opportunities in this technological transition for development (PEREZ 1988 and 1989).

The user-oriented strategy proposed here for the professional electronics industry in Venezuela is an integral part of a wider project of transformation of the country's economy, including the democratisation of the decision making process as regards development choices.

The basic tool for guiding these changes is consensus planning. It is conceived as a "tropicalised" version of MITI, with concerted actions between the public and the private sector in each branch of industry. Some attempts have already been made with uneven results. The present government has pledged that its style of decision making will be "concertation".

Obviously, a user-oriented strategy would sit the core firms in electronics at two different consensus-building tables: one with all other participants in the electronics sector; another, with the main users of their possible services. The strategy presented here would be most successful if there were a national consensus on its contents and forms of implementation.

VI. APPLICABILITY TO OTHER DEVELOPING COUNTRIES

The preceding development strategy is based on what we consider to be intrinsic characteristics of microelectronics-based technology: its flexibility for serving an infinite variety of user needs and the crucial role of design capabilities. It is also based on the idea that during the present technological transition, there are windows of opportunity of a dynamic character for latecomers. These opportunities relate to the new technologies themselves and to their capacity to rejuvenate the more mature technologies.

In this sense, there is something universal in the idea that it is possible to undertake in this period a policy of endogenous technological accumulation, if a careful and intelligent selection is made of the areas and the means, and if adequate support is given to the effort.

The other generally applicable element, at least in developing countries, is the need to take on board the requirements of user industries, when formulation a development policy for the key supporting technology.

One last aspect, which paradoxically can be considered of general application, is that policies in this area should be country-specific. Thus implementing similar principles could be different for each country.

However, there are of course certain elements which relate to the particular characteristics of Venezuela, and the way it has developed, being an oil-rich, poor country.

There is a certain disjointed and unbalanced quality about Venezuela. It is a country of strong contrasts, which has not been able to assimilate fully the tremendous wealth that petroleum provided. Far more attention was given to spending the nation’s wealth than learning how to enhance it, with the result that the foreign debt, accumulated during the decade of maximum oil income, is the fourth largest in Latin America.

However, if the oil money did not bring harmonious development, it did lead to the accumulation of certain tangible and intangible assets, which can serve as a foundation for economic development rather than mainly redistributing rent. It can also be said that the oil wealth somehow contributed to the maintenance of a democratic system for over 30 years in a Latin America where dictatorships had prevailed.

For our purposes, the three main characteristics inherited form the combination of democracy with oil money are: capital intensity of investment, a large number of university trained personnel and a "modernity" of consumption habits, at home and at work. Each of these creates specific advantages and disadvantages that shape the policy proposed here.

The average capital equipment in the country is very modern (usually the latest at the time of investment). This has educated the market for using and wanting "superior" equipment. However, much of the equipment is oversized, underutilised and poorly adapted to local conditions. As a competitive environment reveals these imbalances, the market for consultancy and adaptive services should grow. As capital availability dries up, the same should happen, regarding maintenance services, which are on the whole sorely insufficient in the country.

The bias towards highfixed-investment process industries, already mentioned, has also had skill formation. These happen to be areas where personnel supervises and tends the system rather than use the equipment, so, the more dynamic industries have not created a good pool of middle level qualified workers and technicians. The other prevailing industry was of the "screwdriver-assembly" type, with generally low skill requirements. The result is the usual distorted distribution of qualifications common to many in developing countries: university graduates at one end and not very qualified workers at the other. This bias in the skill profile was compounded when, during the "boom" years, more than 10,000 students received scholarships to go to universities abroad. Meanwhile, the required labour skills were imported from other countries, but the majority who came have left.

This particular human resource endowment naturally suggests an engineering-intensive rather than a skill-intensive strategy for developing microelectronics-based technology.

Furthermore, the combination of widespread travel abroad with massive import capacity, facilitated by the strong bolivar (which for a time made access to the United States so easy), established modern consumption habits and behaviour patterns among a significant portion of the population. As a consequence, young managers are very open to information technology and young engineers have been open to setting up their own innovative business. This is quite a social innovation in its own right, established values tended to consider knowledge and business as polar opposites.

Implementing new opportunities for development requires a conjunction of favourable circumstances. The higher the level of development already attained the easier it should be to profit from technological advances. However, this is not always true. Opportunities can be lost or wasted because existing institutions are too rigid or social actors are too blind to the new possibilities.

However, in developing countries there is certainly a minimum threshold of industrial development, human resources and infrastructural support, which must be reached before accumulation of advanced technology is possible, no matter how "wide" the window of opportunity.

Thus the user oriented strategy outlined here would be applicable to most "middle-income" or second-tier countries, with appropriate modifications for specific local conditions. However, this does not mean that the strategy is the best for these countries. Some could follow an export oriented strategy, alone, in partnership or as a location for foreign direct investment, in areas complementary with the front runners. Other countries could follow other paths.

Whatever the strategy, though, we would like to stress the general importance of a user-oriented component in the policies of all developing countries. This is true for the least developed, because they must train the users, and for the most developed because all strategic plans to penetrate world markets and hold market share will depend on having capabilities in advanced technological, notably information technology.

Actually, the "user-producer" partnership promotes exports in two ways. The competitiveness of the user's process or product is improved and the producer's specific capabilities are enhanced for niche markets.

We would like to emphasize again that greater productivity and quality depend on prior organisational change. In an electronics service-sector it is essential to understand that increased competitiveness does not come from the use of information technology as such, but from the organisational changes which create the conditions for profiting from the potential of the technology.

It is well known that if a user cannot specify the software and merely wants to automate the old cumbersome manual system, the computerisation could create more problems than it solves. This has been seen again and again in the automation of purchase and inventory management systems. In this sense, it is interesting to note that the model of organisation developed by the Japanese does not automate inventory, but rather tends to eliminate it (through "just-in-time" delivery and production).

The benefits of information technology will accrue to those that can create an organisation, with flexibility, adaptability, and a structural capacity to continuously improve Venezuelan experience shows, does not insure high quality or high productivity. In this sense, all developing countries, especially the least developed, need to give priority to learning the new organisational model.

The following figures do not appear due to technical reasons:

Figure 1: Two Different Stages of Design in Microelectronics Technology

Figure 2: Preliminary Identification of Products Approachable with Local Capacity According to Technological Characteristics

Figure 3: Phases and Transitions in the Typical Evolution of Innovative Firms in Electronics Applications

Figure 4: Interrelationships among Firms in a User-Oriented Development Strategy for Professional Electronics

NOTES AND REFERENCES

1. The availability of oil-derived financial resources favoured and facilitated the import of capital goods for protected production of final consumer goods. Until the early 1980s there were no special incentives to manufacture capital goods in the country.

2. In order not to give this factor more than its proper weight, it is important to note that there were already about two dozen firms in professional electronics before the first devaluation in 1983.

3. Information for this is based on two surveys conducted between 1989 and 1987 by the Ministry of Development in the context of a UNIDO-UNDP sponsored project, where the author acted as consultant. In professional electronics (ROMERO, SANCHEZ, MARTINEZ) the sample was 50 out of 110 firms known to operate; in software (ORTEGA, MILLAN, MARTINEZ) 23 out of 180 firms with five or more professional employees were surveyed.

4. All data come from the survey done in 1986-87 and relate to a reasonably representative sample of 50 firms. Qualitative information and available indicators suggest that the main characteristics of the industry have not changed.

5. The degree of complexity does not refer to an abstract measure of the product but to the complexity of the actual design and manufacturing tasks done by the firm in question. Final assembly of a complex product could be rated "low" but design and manufacture of the same product would be rated medium complex. Also, when a firm makes a range of products or many firms make the same product, the most complex of the lot gets the rating. This decision was taken because it marks the maximum level reached by the group of local producers, which was considered a better indicator domestic potential.

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