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Notes and explanation of symbols

The following symbols are used in tables in the *Review*:

Three dots (...) indicate that data are not available or are not separately reported.

A dash (—) indicates that the amount is nil or negligible.

A blank space in a table means that the item in question is not applicable.

A minus sign (-) indicates a deficit or decrease, unless otherwise specified.

A point (.) is used to indicate decimals.

A slash (/) indicates a crop year or fiscal year, e.g., 1970/1971.

Use of a hyphen (-) between years, e.g., 1971-1973, indicates reference to the complete number of calendar years involved, including the beginning and end years.

Reference to "tons" mean metric tons, and to "dollars", United States dollars, unless otherwise stated.

Unless otherwise stated, references to annual rates of growth or variation signify compound annual rates.

Individual figures and percentages in tables do not necessarily add up to corresponding totals, because of rounding.

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Industrial revolution, technological paradigm and regional alternatives

Hugo J. Nochteff*

An industrial revolution is taking place: its nucleus is the electronics complex, from which will emerge a new technological-economic paradigm and a new economic, social and cultural pattern which began to develop about 15 years ago and which will continue to unfold in the coming decades.

The appropriate use of the new technologies by the developing countries is made possible by the very trends of the diffusion of the new industrial technology model. In fact, the trends which have been called "intrinsic", trends towards the concentration of knowledge, control and economic and political power, strengthened by the technological protectionism of the big State and private organizations of the industrialized countries, are accompanied by the —equally necessary— diffusion trend of the new technologies, which is essential to the development of the new paradigm and the achievement of expanded reproduction. Technological knowledge is almost inevitably "liberated" in the course of the diffusion process.

However, given the characteristics of the new technologies, utilization of the possibilities offered by the "uncontrolled" diffusion process is more difficult than in the case of earlier technologies, and it depends increasingly on the scientific, technological and industrial capacity of the semi-industrialized countries. The development of this capacity and its direction are linked to the generation of "endogenous nuclei of technological dynamism" and, in general, of policies designed essentially for the creation of the capacity to adapt the use of the new technologies to the needs and potential of the semi-industrialized nations and their various social sectors.

This strategy can be described as "selective linking" and its central features are discussed in this article.

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I

Industrial revolution and technological paradigm

There is every indication that a new industrial revolution is taking place, with its nucleus or *key factor* located in the electronics complex, from which is emerging the now dominant economic-technological paradigm —an economic, social, cultural and technological pattern which began to be shaped about 15 years ago, is now rapidly consolidating itself, and will continue to unfold during the coming decades (Pérez, 1975; Forrester, 1980).

The industrial revolution has been defined in the recent literature as a profound transformation of the input-output matrix: not only are its internal ratios changing, but new lines and columns are being added as well. It has thus been defined as a radical and very long-term modification of the relative-price dynamics of all production inputs.

The nucleus of the structure of the new accumulation model is a technological-economic complex, in this case the electronics complex, which constitutes the *key factor* in the changes in the input-output matrix, in relative-cost dynamics, and in the determination of a new "best practice" frontier (Pérez, 1985 and 1986).

The development of the technological revolution is guided by a technological-economic paradigm (Dosi, 1982) which determines the main lines of the change in the new trajectories of invention, innovation and diffusion. This paradigm is consolidated in practice as a kind of "ideal type" —in normative rather than in methodological terms, for it should not be confused with Weber's ideal type— of economic organization, which spreads out until it forms the body of beliefs, values and techniques shared by technologists, investors, managers and political decision-makers.

This notion has been taken from the epistemology and history of science, specifically from the scientific paradigm of Thomas Kuhn (1985). Both in its content and in its development, the technological-economic paradigm shows a

marked resemblance to the one formulated by Kuhn. As in Kuhn, it emerges when the problems which come up in practice cannot be solved by means of further development of the application of the methods contained in the earlier paradigm and a very intense crisis results. This process includes the emergence of a new body of beliefs and practices and new key factors: the exemplars or models for problem-solving in the scientific paradigms (Borello, 1988). It promises success in the solution of the most important problems, achieved in what can be called the normal path, which takes the paradigm as matrix and trajectory of its development.

There is every indication that the phenomena described by these paradigms, and some of the trends predicted by their authors, have been empirically verified. In addition to analysing the theoretical validity of the concept of technological-economic paradigm, it is important to emphasize two of its features, owing to their significance for the peripheral countries.

First, the importance of the problems, and therefore the central issues which the new paradigm promises to resolve, is not determined by the issues which can be called universal necessities. What counts for more is the perception of these problems by the leading social actors, in the light of the earlier paradigm and the social structure in which they exercise their leadership. Second, the normal path tends to disregard *a priori* any invention, innovation, production practice or modification of consumption and investment patterns which are not given priority by the paradigm, or—in other words—which are not relevant to the solution of the problems considered most important or central. The normal path follows the models of accepted trajectories, within which take place the processes of innovation and diffusion, and from which is disseminated and confirmed the new common outlook of managers, investors, technologists, policy-makers, scientific institutes, etc.

II

The new paradigm, the big organizations of the central countries, and the semi-industrialized countries

This industrial revolution, this new *key factor* and this new technological-economic paradigm constitute the basis of the response of the big State and private organizations of the most advanced countries to the crisis which began at the end of the 1960s. This crisis was caused to a large extent by the exhaustion of the capacity of the earlier technological-economic paradigm to ensure a dynamic process of capital accumulation and, therefore, of expanded reproduction of organization capitalism. In other words, the industrial technology model of the post-war period is no longer able to guarantee the economic and political growth of the big organizations of the most highly industrialized countries (Nochteff, 1987).

The new paradigm is therefore a "product" of the big organizations which have generated

and consolidated it, and its potential responds functionally to their requirements for economic and political growth.

The crisis which shook the post-war technological-economic paradigm, during which this new industrial revolution and its *key factor* came into being, seems to have stemmed from the inability of technology to overcome the constraints imposed, on one hand, by the diminishing supply and, on the other, by the increasing cost of raw materials, energy and labour as inputs in the accumulation process. In turn, the specific structure and dynamics of the demand for these inputs was largely determined by the production, consumption and investment patterns of the central economies, and by the specific characteristics of the prevailing processes of production, trade and economic

organization —determined to a large extent by those of the big organizations of the central countries.

The potential of the electronics complex, and basically of micro-electronics, which is making it the *key factor* of the new technological paradigm, is closely associated with its specific capacity to remove or offer a promise to remove such constraints, in the terms used in this article, in order to bring about a profound change in the relative-price dynamics of all the inputs of the production process and the organizational system.¹

This new industrial revolution causes an increase in society's freedom with respect to natural determinants. It invests the process of capital accumulation with greater independence with respect to the constraints imposed by nature in general and the labour force in particular. However, the new quantum of freedom which society is acquiring tends to be distributed unequally. Given the causes of this industrial revolution and the social actors which generate, lead and develop it, it is mainly the big organizations of the advanced countries which acquire this independence. In other words, the unequal distribution of the fruits of technological progress is directly associated with the fact that the social matrix, headed by the big organizations of the central countries, establishes the structure of the technological-economic paradigm and the normal path of its development. The capacity of the new paradigm to solve the problems of the societies and organizations which generated it does not mean that it has to solve the problems of other societies.

As suggested earlier, this trend is determined by what can be called the exclusion effect of the paradigm and its normal path. The normal path in its positive (or inclusive) effect, tends to accumulate knowledge and solutions, but only for handling the problems which the paradigm defines as such. The normal path creates a consensus as to what is the best production and organizational practice, what are the inputs whose prices should continue to fall, or

what is the desirable dynamics of the consumption and investment patterns. It tends to exclude, to the same extent but not rigidly, the exploration of technological, industrial and organizational trajectories which contradict or are secondary to the paradigm, or which have simply not been taken into account among the central problems and the solution options, given the objectives, the leading actors and the constraints on the accumulation model which caused the change of paradigm.

These trends, which can be called "intrinsic" in, although not essential to, the new industrial revolution, seem in fact to be harmful, at least in relative terms, to the peripheral societies and to semi-industrialized societies in general, this latter category including Latin America.

The effects of the development of the new industrial technology complexes, especially electronics, on the semi-industrialized countries can be described in different ways —where it has already been possible to make evaluations— and they have dissimilar economic, social and political manifestations. Nevertheless, most of the studies of these effects emphasize:²

— The loss of the independent capacity to determine the patterns of production, consumption and income distribution;

— The transfer of the processes of gestation, acquisition and development of new knowledge overseas to the big organizations of central countries;

— The widening income gap between the most advanced and the semi-industrialized countries resulting from their different capacity for capital accumulation and economic development, which stems mainly from the importance of science and technology, concentrated in the most advanced countries, as inputs in the production process;

— The decline of the labour market, with the disappearance of the specialized and best-paid occupations (skilled workers and techni-

¹A discussion of the relationship between the constraints, the characteristics of organization capitalism and the potential of micro-electronics will be found in Nochteff (1987).

²This list is a summary and simplification of the effects discussed in the literature on this topic. Among this literature, reference may be made to such works as: Minian (1986), Ernst (1984), Antonelli (1981), Hoffman and Rush (1980), Leppan (1983), Kaplinsky (1985), Rada (1980a and 1980b), Seers (1984), UNCTC (1984) and Ernst (1980).

cians; and in some countries scientists and technologists as well);

— The concentration of economic power in transnational corporations;

— The exacerbation of the structural trends towards disequilibrium in the external sector of the economy;

— The trend towards the transformation of the industrial technology system into a set of "enclaves" whose activities bear little relationship to the needs and characteristics of the peripheral societies but are instead increasingly controlled by transnational corporations;

— The location of activities of declining value added in the semi-industrialized countries;

— Exogenous decision-making concerning the restructuring of activities, with respect both to technology and production and to the growth process;

— The increasing inequality of income distribution.

These phenomena are no strangers to the region's economies. On the contrary, they have been features of the Latin American societies at least since the end of the Second World War (Fajnzylber, 1985). The so-called intrinsic "trends" of this industrial revolution are therefore creating new problems for the region, but they are also, and more importantly, exacerbating the existing ones.

III

Conditions and proposals for an alternative strategy

However, these intrinsic trends should not be regarded as inevitable and necessary laws. The Latin American societies and the various social actors can jointly determine the way in which this industrial revolution will affect them, if indeed they actively influence the methods by which the new technologies are incorporated, adapting and developing them in the light of their own needs and their economic, social and political potential.

The appropriate use of the new technologies is made possible by the very characteristics of the diffusion of the new industrial technology models. In fact, the so-called "intrinsic" trends towards the concentration of knowledge, control and economic and political power, strengthened by the technological protectionism of the big State and private organizations of the advanced countries, are accompanied by —equally necessary— trends towards the development of a new paradigm and attainment of expanded reproduction and towards the diffusion of the new technologies. Technological knowledge is almost inevitably "liberated" during this diffusion process. This phenomenon takes place in various ways which do not need to be listed and

discussed in detail here. The sale of micro-electronic components not installed in equipment results from the need to achieve increasing economies of scale and absorb the cost of research and development and of capital, the proliferation of "silicon chips", the speed with which "clones" are developed and forced and accelerated obsolescence are some of the manifestations of this process of "uncontrolled" diffusion.

However, given the characteristics of the new technologies, it is more difficult to take advantage of the opportunities offered by the process of "uncontrolled" diffusion than in the case of the earlier technologies, and this depends increasingly on the scientific, technological and industrial capacity of the semi-industrialized countries.

In terms of the normal path of the new paradigm, this capacity is essential to the utilization of radical innovations and the adoption of innovation, dissemination and development policies which can solve problems different from the ones given priority by the central countries. The generation of scientific and technological know-how in Latin America is therefore neces-

sary for two reasons: first, to take proper advantage of the products of the normal path of the new paradigm; second, to offset what we have called here the exclusion effect of the normal path. This latter task implies to some extent the creation of a partial alternative paradigm, for it will require the identification of central problems different from the ones defined as such in the dominant technological-economic paradigm.

The development of this capacity and its direction are connected with the generation of so-called "endogenous nuclei of technological dynamism" (ECLAC-UNIDO, 1985) and, in general, with the design of policies whose main goal is the creation of the capacity to use the new technologies to satisfy the needs and potential of the semi-industrialized nations and their various social sectors. This is the meaning of the word "endogenous" and, at the same time, the basis of its importance. In short, it is a question of generating capacities which cater to the needs which each society and each social sector regards as pertinent and urgent, and of taking advantage of the dissemination of the new paradigm to utilize these capacities and satisfy these needs. This means that the application of the concepts of efficacy —defined as the means of achieving ends— and of efficiency —defined as the means of achieving the ends with the lowest expenditure of resources— is linked to those ends, which can be determined only by the social actors themselves. This means therefore that the goals of the introduction of new technology and the development of the economy and industry, and the most efficacious and efficient means of achieving these goals, cannot be determined by the big organizations or by reference to the "state of the art" as defined by the most advanced countries. In other words, if it is held that the modernization of the production apparatus and technological development consist of something distinct from "window-dressing modernization" and the mere transmission of exogenous stimuli, then this modernization must be closely associated with the democratization of scientific, technological and production decision-making.

Political and social issues, and indeed the distribution of freedom and power among social actors, are therefore inseparable from the technological-economic models. If the incorporation of these models takes place without prior

democratic debate or without regard to the goals of the social actors, this will in fact confirm the technological determinism which characterizes, with varying degrees of explicitness, much of the recent literature on these topics. It is therefore vitally important to stress that this determinism is merely an ideological expression of the actual determination, by the big organizations of the most advanced countries, both of the social ends and of the means of achieving them.

The identification of priority problems for Latin America and the satisfaction of the needs of the majority of its population, the creation of scientific capacities for an alternative paradigm and normal path, and the creation of endogenous nuclei of technological dynamism also imply alternative types of engagement with the centres. In general terms, it implies a strategy of selective linking to the world market and the big organizations of the central countries, for the dominant paradigm is disseminated and consolidated through consumption and investment patterns, foreign trade, new notions of best practice and the common outlook of investors, technologists, managers and political decision-makers. To the extent that exogenous factors and the exogenously determined incorporation of the dominant paradigm produce negative effects and lead to the reproduction of an unsuitable, imitative, truncated and socially exclusive accumulation model, selectivity in the linking of the Latin American economies to the central countries becomes a decisive factor in the economic and social development strategy.

Some of the main lines of a strategy of selective linking are listed in the following paragraphs:³

— Development of technological and production capacities which facilitate the increasing use of new technologies and the selection of technologies, goods and production options most suited to the economic, social and political

³The background of the concept of selective linking may be found in the works on *Selective Disengagement* by Ward Morehouse, especially (1979); and on *Decoupling Policy* by Juan Rada, especially (1982). For a discussion of the problems of the exogenously determined incorporation of technology in Latin America, see the works by Eugenio Lahera and Hugo Nochteff which take up the notion of "selective endogenization", especially (1982).

development of each society, it being understood that "suitable" means those which respond most efficiently to the needs of the various social actors, but primarily to the priority needs of the majority of the population;

— Where demand is concerned, definition of the most efficient consumption pattern in terms of the needs, and therefore of the democratically determined social goals, rather than by reference to the dominant pattern in other societies or in the international market or to the standard patterns explicit or implicit in the models produced in the big organizations, including the scientific organizations, of the advanced countries;

— Where supply is concerned, determination of the most efficient industrial technology pattern with respect to the demand pattern referred to above, the potential of each society, and the preferences of the majority of the economically active population as to working conditions, types of job qualification and the control and characteristics of the work process in general;

— Identification, in the light of the above, of the most suitable technologies available in the international market with a view to copying, adapting or developing them, and determination of the forms of incorporation and engagement in the international market in the light of the concepts of suitability and efficiency described earlier;

— At the same time, introduction of a policy of co-operation and complementarity with respect to technology, production and foreign trade between societies which have similar or complementary needs and potentials and which are endeavouring to develop strategies of the same kind and with similar goals. It must be stressed that in the form in which it is usually presented and in which it has been experienced by some countries of the region, the model of external openness is an ideological one. A strategy of selective linking is not a "pass key"; the degree of an economy's liberalization in foreign trade —understood strictly as the foreign-trade coefficient— can be smaller or much larger than the level produced by the liberalization model. But the content of the trade flows is different, just as the societies of the trading partners are

different. A selective linking model, based on increasing technological and industrial integration, can also generate export flows of increasing added value. In view of the effect of the control of the consumption pattern and the integration of the production network, together with the kind of exports mentioned above, the model will have a positive effect on the external sector;

— Design of a science and technology policy in which the concepts of technological gaps and obsolescence refer primarily to the needs of each individual society, to its capacities and to its democratically established social goals, and not to the technologies and areas of research prevailing in the most advanced countries or in the international market;

— Tendency, with respect to the technologies and goods regarded as of greatest importance from the social standpoint and from the standpoint of the country's technological and industrial development, for the domestic product cycle to adjust to the needs and possibilities of the national economy rather than to the logic of the domestic markets of advanced countries or to the logic of the trade between those countries;

— Adoption of product-quality criteria which, in addition to upgrading quality requirements, give priority to the products' useful life and ease of maintenance, and to the suitability of the benefits they deliver (or their technical specifications) in terms of the country's resources, rather than to the quantity and novelty of the products or their similarity to the products offered in the most advanced countries;

— Introduction and development of new technologies, primarily in order to satisfy the people's basic needs and to bring consumption and investment patterns into line with the requirements and potential of the Latin American countries. This control of patterns must be accompanied by improved productivity and competitiveness, in order to prevent the continuation of the structural bias towards deficits in the external sector.

The reconciliation of objectives requires the introduction of new technologies to satisfy basic needs through increasing productivity. This must also be achieved in the sectors of "non-tradeable" goods and services in order indirectly to reduce the costs of the sectors of "tradeable"

goods and services. This reconciliation also requires an increment, by means of technological and organizational change, in the productivity of the sectors which, in each case, are less engaged in the international market and therefore less exposed to external competition, and an increment in the competitiveness of the sectors, product lines or market sectors which are less engaged in foreign trade, especially those in which the aim is to achieve a higher export coefficient.⁴ All this implies, of course, the development of the capacity for creation and efficient use of technology. The Latin American experience indicates that the massive and indiscriminate incorporation of new "pioneering" technologies and plants has led to reduced efficiency in many cases, especially in services, to the detriment of the competitiveness of "tradeable" goods.

— Diffusion, from the endogenous nuclei of technological dynamism, of the most efficient and suitable methods of incorporating new technologies. The internationalization of technological know-how makes it possible to keep down the cost of new plant, use it in the most efficient manner and incorporate it within a framework of suitable organizational changes. The efficient incorporation of new technologies depends directly on technological capacity and independence. This fact, together with increased efficiency in the incorporation of new plant within a framework of simultaneous, or even prior, organizational changes is demonstrated both at the microeconomic level and throughout the whole economy, not only in the region but also in more advanced countries.

The foregoing considerations are some of the elements of a selective strategy which seeks to ensure that the determination of the patterns of consumption, supply and technological and industrial development is consistent not only

with exogenously generated trends but also, and to the greatest extent possible, with endogenous needs and goals.

Of course, it is an essential requirement for the design and introduction of a strategy of this kind that the design and introduction of the scientific, technological and industrial policies should be determined and controlled in a democratic manner by means of the directest possible participation by all the social actors, but especially by the majority of the population, in the decision-making and control machinery.

One of the necessary conditions of the viability of this democratization process is a public debate, in the widest sense of the term, about the matters which have been discussed in this article. A fundamental element in this debate, on which the degree of freedom of the social actors depends to a large extent, is the adoption of a critical attitude towards the issues raised by this new industrial revolution and by science and technology in general. In other words, criticism must be a central element of education, especially in technological subjects. It appears increasingly necessary to "unlearn" what is taught through the innumerable media, not only the mass media, which range from direct sales brochures and advertisements to the fairly complicated literature of diffusion concerning the intrinsic virtues of the new technologies.

Latin America's historical neglect of scientific and technological issues, and of the information, or rather, disinformation which is disseminated on a mass scale, tends to create an uncritical attitude to matters of technological change. This is reflected at very different levels, ranging from State decisions on matters involving technological change to the continuing lack of interest on the part of most of the population in discussion of scientific and technological decisions and in demanding participation in them.

⁴Industrial efficiency and international competitiveness are not perfect synonyms. In addition to issues of market conformation, it must be remembered that in the case of most manufactured goods competitiveness entails not only industrial efficiency but also requirements of design, delivery, packaging, etc., associated with the differentiation of products. On the other hand, lack of

competitiveness in the international market does not necessarily imply low productivity. In other words, it is possible to produce goods and services which are uncompetitive internationally (in terms of design, performance, etc.) but which are nevertheless very efficient.

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