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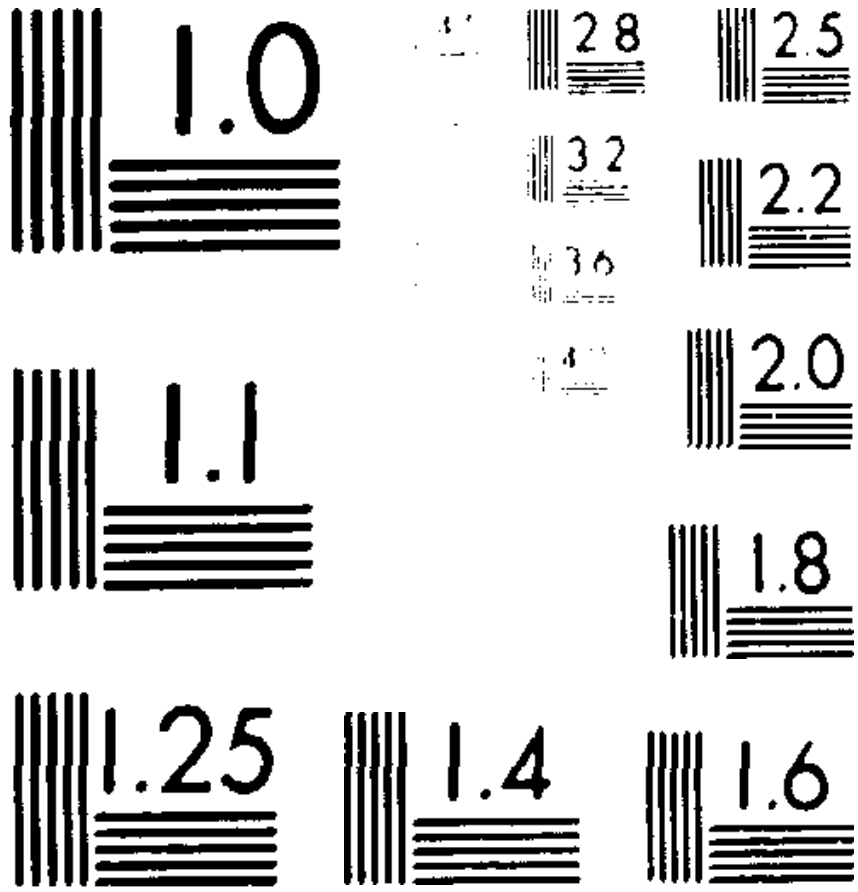

EXCHANGE OF VIEWS WITH EXPERTS ON THE IMPLICATIONS OF TECHNOLOGICAL ADVANCES IN MICROELECTRONICS FOR DEVELOPING COUNTRIES

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FROM THE SECOND TO THE THIRD INDUSTRIAL REVOLUTION *

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FROM THE SECOND TO THE THIRD INDUSTRIAL REVOLUTION

GERARD LAFAY

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FROM THE SECOND TO THE THIRD INDUSTRIAL REVOLUTION

par Gérard LAFAY (x)

The disorder of the world economy since the beginning of the year 1969 has been the result of various factors, apparently separate, which together form a veritable vicious circle: successive shocks affecting the petrol market, lack of balance in international trade , the exfoliation of the international monetary system, the brake on growth and the decline of the birthrate in the developed countries, etc...

In spite of the multiform character of this disorder, it would appear that numerous factors are connected - more or less directly - to the mode of growth of the world economy and to the nature of international relations which spring from it. One can then endeavour to analyse certain essential aspects of "the crisis" in the light of the processes of industrialisation which are still in progress after nearly two centuries.

In keeping this point of view, the actual period can then be regarded as a transitory phase, more or less long, which

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would mark the conclusion of the second industrial revolution at the same time as constituting the priming of the third.

1 - THE CONCLUSION OF THE SECOND INDUSTRIAL REVOLUTION

From the day after the Second World War a period of unprecedented economic stability and growth began, which lasted nearly thirty years. This period had been prepared by the unexpected changes between the two wars, and notably by the lessons of political economy drawn at the time of the great depression of the 1930s. Some long term structural tendencies thus reveal themselves, which will be analysed here in the manufacturing industries. Since the end of 1960s, however, an inflexion is perceptible, which has given way more recently to some phenomena of rupture.

1-1 - The structural tendencies of world demand

If one wants to reveal the great changes which concern the mass of countries, in making an abstraction of national peculiarities, it is necessary to do so at world level. The world demand of each product or group of products constitutes in effect an object worthy of analysis: equivalent to the world production - since the international exchanges compensate - it allows one at one and the same time, to characterize the world manner of

growth and to measure the natural strategies of specialization. This is the reason why, for several years, the C.E.P.I.I. has used this type of data in its studies (1), which it has then integrated in the CHELEM data bank (2) (3). The structural tendencies of the world demand can also be used as evidence at the level of big manufacturing sections as well as at different stages of the channels of production (4)

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(1) Cf G.E.P.I., "Croissance mondiale et stratégies de spécialisation" (Librairie du Commerce International, Paris, 1976).
C.E.P.I.I. succeeded to G.E.P.I. in April 1978.

(2) Michel FOUQUIN, " Une banque de données sur l'économie mondiale : CHELEM " (Economie et statistique, nº 104, octobre 1978).

(3) For the methodological and theoretical problems of this kind of analysis - cf Gérard LAFAY, "Dinamique de la spécialisation internationale" (Economica, Paris, 1979)

(4) For statistical reasons, the figures only concern market economies, and so it excludes eastern countries. As the exchanges of these with the rest of the world forme less than 5 per cent of world trade, the demand stays near the production by the whole group of countries with market economies.

1-1-2- - The relative growth of manufacturing sections

On a world scale, the growth in volume of the big manufacturing sections reflects the movements at bottom which transform the industrial tissues, as well as in the modes of consumption as in the modes of production. Beyond the conjunctural oscillations, one can then locate the longterm tendencies in calculating the relative growth of each section in comparison with the average of the manufacturing industries.

TABLE 1 : RELATIVE GROWTH OF WORLD DEMAND BY SECTION (x)

(Annual rates % between the years)	38	58	71	78
Chemical products	+2,1	+2,8	+1,3	
Products from electromechanical industries	+1,7	+0,7	+0,5	
Construction materials	+0,3	-0,5	-0,3	
Iron and steel and metallurgical products	-0,1	-0,6	-1,1	
Wood, paper, various products	-0,6	-1,1	-1,2	
Food industry products	-1,4	-1,8	-0,4	
Textiles, clothes, leathers	-2,4	-2,2	-1,9	

Source: - O.N.U.: Yearbook of industrial statistics
- C.E.P.I.I.: CHELEM databank

(x) The growth in volume of each section is referred to that of the whole growth of manufacturing industries; the annual rates are calculated between the two years which demarcate each of the periods.

Table 1 gives the results obtained for more than forty years, in distinguishing three periods (save for 1978, the cutting out was done on the years of low conjuncture). The first two sections systematically have rates of growth higher that average: consequently they seem to play an encouraging role in the growth, but they suffer a different evolution in the course of time. Thus, the world demand for chemical products accelerated after 1958, at the same time as the general rythm of the manufacturing industries rose (5); though remaining at the head, its relative advance then falls a point and a half in the last period, while the manufacturing growth slows down. On the other hand, for the mass of electro-mechanical products, the relative advance becomes less more regularly: in annual rates, it goes from 1,7 % in the first period to 0,7% in the second, then 0,5 % in the third.

Among the three sections where the growth was near the average between 1938 and 1958, a certain degradation can be observed in the second period. While the relative position becomes stable after 1971 for two of them (the construction materials and the wood-paper-various products), on the contrary a deterioration can be noted in the iron and steel metallurgical products. For this section, characterised by strong conjunctural oscillations, the world demand seems to reproduce that of the electro-mechanical products, with a shift of a point and a half per year.

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(3) This is 4,5 % per year from 1938 to 1958, 6% from 1958 to 1971 3,9 % from 1971 to 1978.

The two last sections systematically have a rate of growth that is less than average. Their relative slowness was important between 1938 and 1958 : -1,4% for the food industry products, and -2,4% for the textiles-clothes-leathers. But wher this last section registers a slight improvement in the course of the two following periods, the evolution seems more abrupt for the food industry products : their relative position declines again between 1958 and 1971, but improves a lot after 1971. In reality, these relative variations are particularly related, for they hide a remarkable stability in the growth of that section over a lenght of time, the food industries showing a great autonomy in comparison with the movements affecting the other manufacturing sections.

1-1-2 - The division in two macro-channels

If one wants to understand the significance of these structural evolutions, it is necessary to do a more fine level of analysis. In the CHELEM databank, the manufacturing industries are broken up thus into 54 categories of products with free localisation (6), which can be situated in the successive stages of the different channels of production. In examining the principal relations of interdependence in the heart of the productive system, one can in particular bring about a division between two macro-channels which is due to distinct logics.

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(6) Four categories of manufactured products are excluded here: three are considered by fixed localization (BA:cement, lime and plaster, BB:ceramics, tiles and bricks, KC:flesh, fowl and fish, the fourth is special (FH:armaments)

Tables II and III, extracted from a recent study of the C.E.P.I.I. (7), also classify the products following the evolution of world demand during the 1960s (8), on the "agro-chemical channel" and the "metallic channel" respectively. The first of these complex channels starts from agriculture and non-metallic minerals; the end products are destined uniquely for consumption (semi-durable and fungible goods). The second starts from ferrous and non-ferrous minerals metals, and uses the metals as basic products by reason of their characteristics (hardness and/or electric conduction) ; it leads to equipement goods and durable consumer goods (9).

The agro-chemical channel (TableII) is characterised by two main traits. On the one hand, the relations are mixed up in intermediate stages, notably because of the possible substitutions among the natural raw materials produced by agriculture and the manufactured products sprung from the organic chemistry at base. On the other hand, the filiations are direct to the stage of the final products, where the elaboration is less forced than that of the products in the metallic channel.

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7) cf G. LAFAY et M. FOUQUIN (sous la direction de), "Specialisatic et adaptation face à la crise" (Economie Prospective Internationale, nº 1, la Documentation Française, Paris, janvier 1980).

8) Contrary to table I, where the figures are calculated between the extreme years of each period, the rates of growth in volume in tables II and III are determined by the method of peaks, relying in each category on the highest conjuncture of points.

9) These channels have been taken used as evidence by the C.E.P.I. in "Une économie à la recherche de la spécialisation optimale : Japon 1960-1980" (C.F.C.E., Paris, 1976).

In starting form non-metallic minerals, glass and other construction materials are obtained, which are mainly used in buildings and public works. The channel is basedequally on the basic mineral chemistry, which allows the making of the fertilizers used in agriculture. Finally, the carbon included in the energy products constitutes the raw material of the basic organic chemistry.

All these basic products are then used in the elaboration of those situated downstream in the channel, because either they are essentially or partially intermediaries, or almost exclusively finished. The food products also derive from agriculture and the finished chemical products from the chemistry at base; in return, some substitution processes have taken place between the natural and chemical products, mainly at the level of spinning weave, various manufactured articles and tyres.

Downstream, the products of the agro-chemical channel answer in general the most elementary needs, such as food and clothing. This is why, during the 1960s, the demand for the majority of these products grew slower that the median in the world plan, though it was more sustained in the developing countries.;

outside some chemical products (pharmacy and plastic articles), the only exception to this stage are carpets and foods for animals. On the other hand, these products above all

Table II Agro-chemical channel 1960-1970 (world demand, annual rates in volume)

Annual rate of growth	Basic products(a)	Essentially intermediate goods	Partially intermediate goods	Goods for consumption
+++ 9,3	G.C.Organy chemistry, 11,4	G.G.Plastics, fibres 11,4	G.H. Articles in plastic 12,5	D.D. (*) Carpets 11,0
9,2 ++ 7,8	IH(*)Derived from petrol 8,3	G.D. Paints 7,9		G.F. Pharmacy 9,0
7,7 + 6,8	B.C. Glass 7,7	G.I. Tyrs 7,2 G.B.Fertilizers 7,0	K.G.(*)Food for animals 7,3	
6,7 - 5,8	GA Mineral Chemistry 6,7	E.C(*) Paper 5,8		DC(*) knitted goods 6,3
5,7 -- 4,3		E.A(*)Articles in wood 4,3	F.B.(*)Furniture 5,5 ED(*)Printing 5,0	EE (*)Various articles 5,0 KH Beverages 4,8 KE(*) Fruit -vg. 4,4
4,2 ---		DA(*) Yarns and fabrics 3,3	KF Sugars, 3,6 DE(*)Leather, 2,8 KB Oils & fats 1,6	KI Manuf.Tobac. 4,0 GE Toilet. 3,9 KD Canned Meat 3,5 DB (*) clothing 2,6 KA Cereal products 2,2

(*) The contents of this category have been modified following study GEPI 76.

(a) raw materials situated upstream do not figure in this table.

Table III

Metallic channel 1960-1970 (world demand, annual rates in volume)

Annual growth rate	Basic products (a)	Intermediate goods	Equipment goods	Goods for consumption
+++ 9,3		F.L. electron.Comp. 12,5	F.O.Computer equipment 13,4 FF Equipment for construction 10,2 FG Specialised machines 9,3	F.K. Optical,photo 11,6 F.J Clockmaking 9,6
++ 9,2 – 7,8		F.C.Motors 3,5 FA Boiler making 8,2	FR Electrical Appliances 9,1 FE Machine tools 8,3	FM. Electronic goods for consumer market 8,4 FP Electric household appli. 8,2
+ 7,7 – 6,8			FN Telecom. material 7,6 FD Agricolar material 7,2 F.V. Ships 6,9 F.I Instruments of measure 6,8	
– 6,7 – 5,8	CA (*) Iron steel pro. 5,3	F.B Gl.Mechanics 6,6 FS (*) Vehicle Elem. 6,0	FQ Heavy electrical material 6,4 FU Utilit. vehicles (*) 6,1	FT(*) Cars 5,9
– – 5,7 – 4,3	CC(*) Non-ferrous metals 5,6	CB(*) Pipes, tubes 4,4		
– – – 4,2			FW Aeronautics 4,1	

(*) The contents of this category have been modified following the GEPI study (1976)

(a) The raw materials which are situated upstream do not figure in this table.

are found in strong growth in the stages situated more up-stream, thanks to the phenomena of substitution which favours the different categories of chemical products. The fundamental tendencies disclosed at the level of the great sections is consequently explained by the general structure of the channel.

The metallic channel (table III) is very different, because it is progressively diversified as the products are more elaborated. Il also starts with ferrous and non-ferrous minerals, which yield respectively iron and steel products and non-ferrous metals. In the following stage, the intermediary goods are more diversified but still attached to a main connexion; they are then combined at the stage of the production of finished goods, these being destined for consumption or for equipment.

The opposite of the agro-chemical channel, the world demand during the 1960s is sustained downstream for the greater part of the finished products of the metallic channel. Moreover, these tend to become more and more elaborated with time, so that the demand for categories situated more upstream grows less rapidly: the contents in metal of the electromechanic products gradually diminishes, and the rhythm of growth of the iron and steel products tends in consequence to become lower that the median.

1-2 - The rupture arising during the 1970s (10)

By following the analysis of different categories of manufactured products the length of two macro-channels, it is possible to understand better the changes since the 1960s. When the "agrochemical channel" suffers a contraction of the fan of growth rates, it is indeed perceptible that the tendencies observed for the mass of electromechanic industries conceal a veritable explosion of the "metallic channel".

1-2-1 - The contraction of the "agro-chemical channel"

In the agro-chemical channel, graph A shows the evolution of world demand in volume since 1970, in placing it in proportion with that observed during the 1960s (11). The reduction of growth in volume appear above all as a consequence of the crisis, to the degree that they become clear mainly after 1973 (only the construction materials have been affected since the mid-1960s) Moreover, the slowing down of economic activity provokes a contraction in the fan of growth rates.

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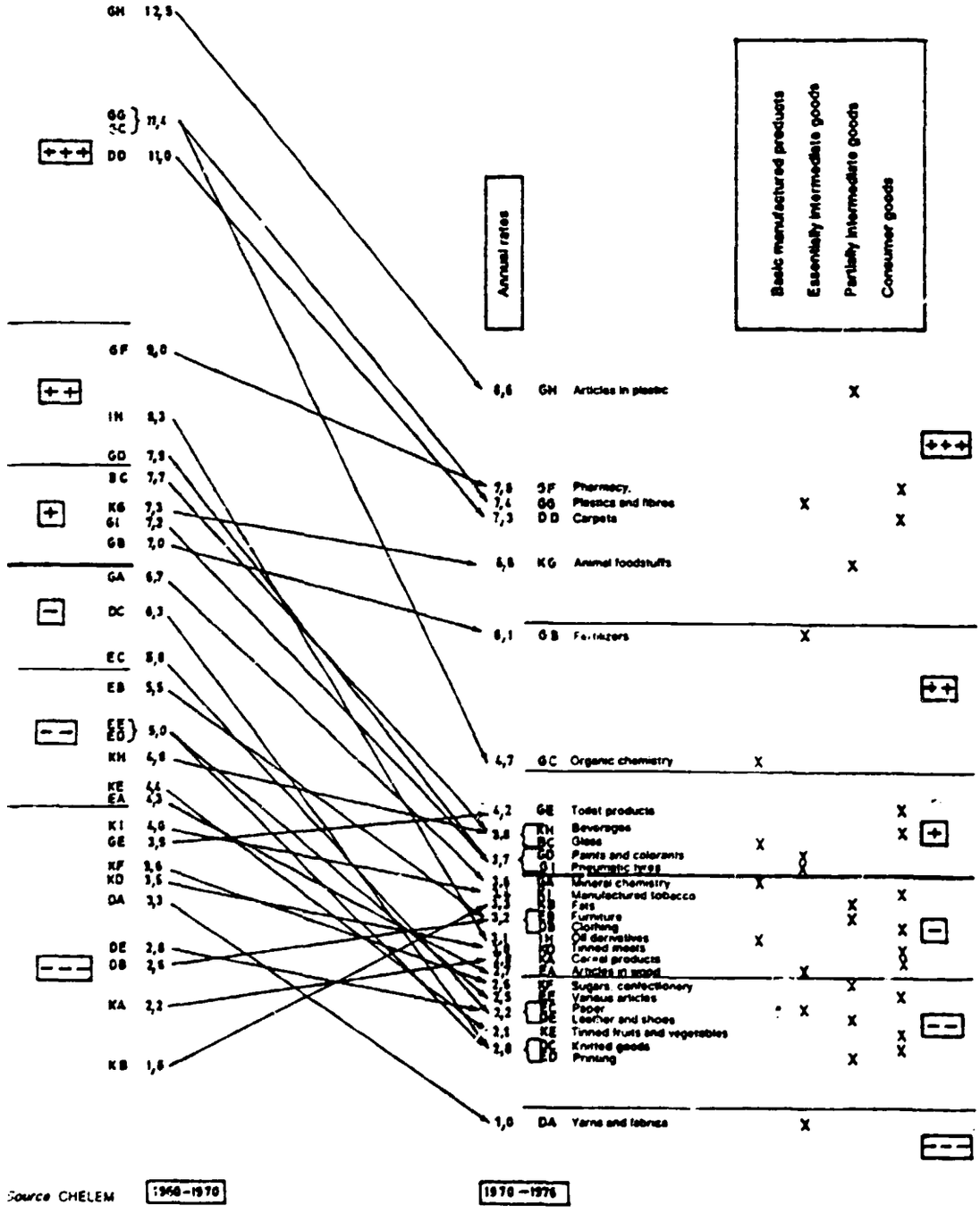
10) This paragraph resumes a section of chapter one of the study cited - as in text reference (7)

11) In the period 1970-1976, the method of peaks is no longer significant because of the amplitude of the fluctuations, and the rates of the two channels are generally calculated by a regression on the logarithms of indices: somme corrections are always brought, either when the conjunctural variations are more strong, or when a reversal of the tendency appears and continues after 1976. (Case of naval construction and clothing).

GRAPH A : AGRO-CHEMICAL CHANNEL

(World demand in volume)



The deviation among the extreme categories goes in effect from nearly 11 points in 60-70 to less than 8 points in 70-76. Out of 29 categories of products, 20 have from now on an annual rate of growth between 2% and 3,8%. However, the hierarchy of products is not sensibly modified, because the big tendencies observed during the 1960s are maintained.

The downstream of the channel, mainly made up of food products and textiles, most often keeps a modest rhythm of growth of the world demand; upstream, the chemical products go on restructuring the channel and benefiting from a more sustained demand.

Some notable changes however appear in some categories. Some of those which figure among the least dynamic in the 1960s see their rate of growth slightly rise. Such is the case of fat stuffs, cereals and toilet products, where one can see the demand gathering in countries of the Third World. With clothes, on the other hand, the growth seems principally due to a substitution vis-a-vis knitted goods, which acts in the inverse sense in the two successive periods.

The most accentuated inflexions appear above all in chemistry and connected products. Organic chemistry, the derivatives of petrol and plastic fibres suffer very definite falls in the world

demand, more than 4 points. To the exhaustion of phenomena of substitution which have acted in the preceding period are added, in the circumstances, the effects of the rise in the price of petrol. On the other hand, pharmacy and fertilisers are barely touched by the crisis, in the same way as foodstuffs for animals; if these categories of products are those nearer biology, it is again too soon to be able to discern here the emergence of biochemistry, but without doubt this is called upon to transform profoundly this channel in the future.

1-2-2 - The explosion of the "metallic channel"

When one analyses world demand at the level of the detailed nomenclature of CHELEM, the usual classifications are revealed as insufficient. The vast section of electromechanic industries - which represents nearly 40 % of the manufacturing production in the group of countries with market economies - conceal evolutions more and more disparate. Some more recent classifications, which incorporate consumer goods and equipment goods in two distinct groups, do not appear more pertinent for perceiving the importance of mutations in progress, and they risk being led to the same errors of any analysis.

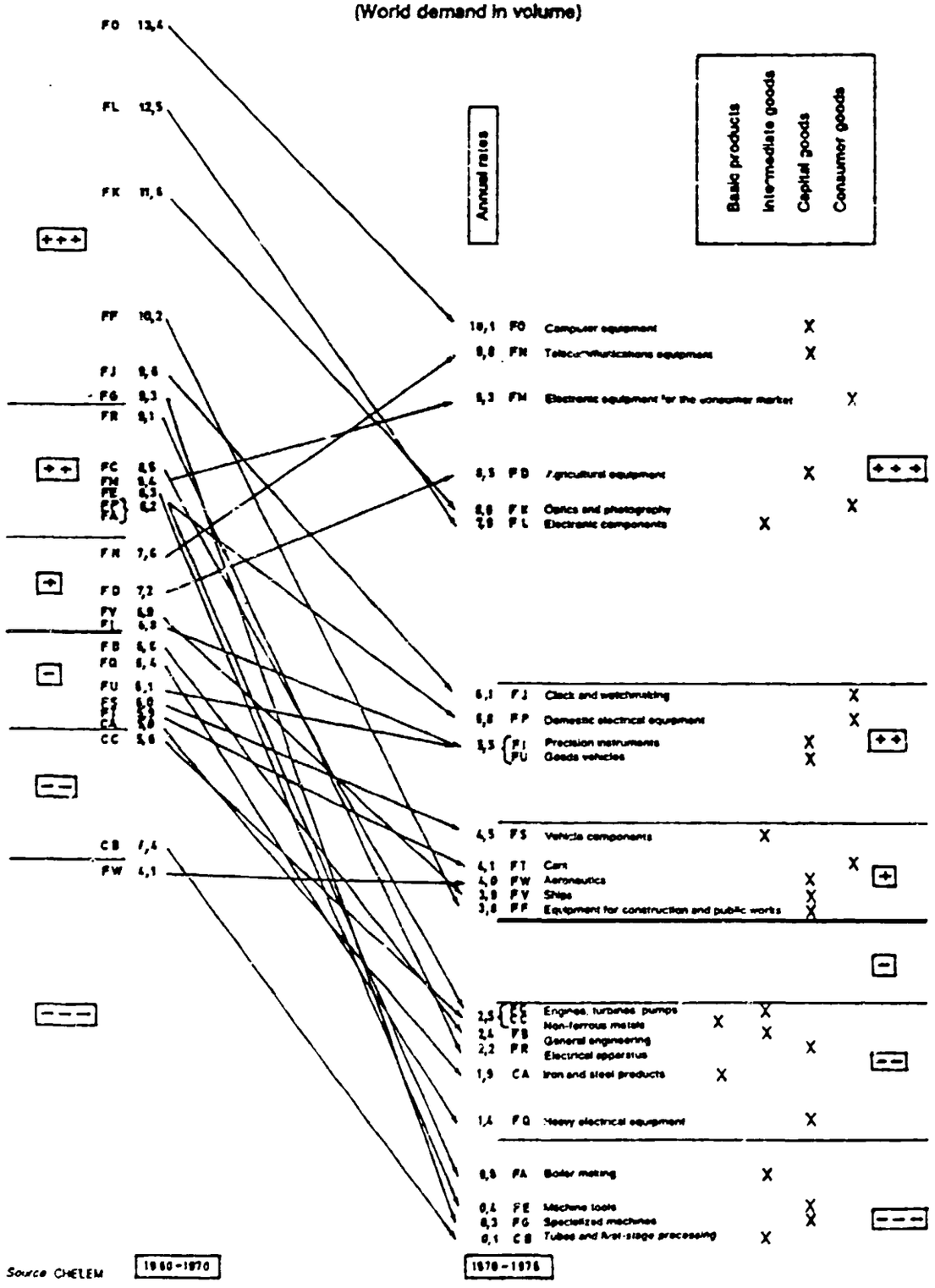
Graph 3 describes the evolution of world demand in volume since 1970, placed to afford a comparison with that observed during the 1960s in the four main stages of the metallic

channel. Between the two periods 1960-1970 and 1970-1976, the heirarchy of products is radically modified among the equipment goods. There can also be observed a veritable depression in heavy machinery, which figures in a very good position in the 1960s: the drops in growth rates of volume of the world demand exceed 6 points in material for building and public works, 7 points for machine-tools, and it reaches 9 points in the machines for specialised industries, agricolar material being the only category of this group where the demand drops instead of rises. Electrical construction is scarely better divided: world demand falls from 5 points in the heavy electrical material and nearly 7 points in the electrical apparatus and supplies.

This depression is passed on upstream, in the traditional metallic channel. Some very noticeable falls may be observed in the intermediary goods (going from 4 to 7 points per year), and they have a repercussion on the iron and steel metallurgic products which form the base of the channel. Now it has to be remembered that the demand for these products already grows less quickly than the average in the 1960s, because of the fall of the metal contents of products. Thus the crisis of iron and steel and metallurgy would seem linked essentially to to fall in world demand, which was itself linked to the moment when new methods of production were taking place in different countries.

GRAPH B : METALLIC CHANNEL

(World demand in volume)



Source CHELEM

In the material of transport, the developments are very different. At the end of the 1960s, transport had been the first to suffer a slackening of growth, affecting as well as the categories of the car industry the whole of aeronautical construction. The impact of first petrol crisis is finally less perceptible than had been anticipated: the world demand figures from now on are among those whose rate of growth is above average. The case of naval construction is more singular: The growth of world demand accelerates quickly at the beginning of the 1970s, but the giving way of international trade (and in particular the exhange of crude petroleum) provokes a complete return to the tendency as from 1976. The rate of growth which figures in graph B is then only halfway between a very high rate at the beginning of the period (nearly 10 % per year) and a collapse at the end of the period.

With regard to these evolutions, certain categories of products only suffered a moderate drop in world demand. Such is at first the case of the whole of consumer goods of the metallic channel, the electronic products for the consumer market benefiting from a slight gain between the two periods studied. Among the equipment goods, the gain is again more distinct with telecommunication equipment (2 points), meanwhile computer equipment stays strongly progressive and measuring instruments keep a relatively high rate of growth. Upstream, the electronic components stay

among the most dynamic compartments of world demand.

With the exception of agricultural material, the goods which appeared at the head of the different stages from now on are, essentially, producted by the electronics industry (electronic components, computer equipment, electronic goods for the consumer market, telecommunication material). They trail in their wake those which tend to incorporate a more and more elevated dose of electronics : precision material (measuring instruments, clockmaking, opticians - photography) is thus distinguished, more and more, from the classical machine.

While the heavy metal channel collapses, there is then a veritable electronic channel which tends to stand out. This double movement appeared before the petrol shock of 1973, and consequently it can be examined for its profound significance: does it not reflect the achievement of a certain form of growth - already announced in certain foregoing symptons - at the same time that is shows the first sign of a new industrial revolution ?

x x

x

2 - THE PRIMING OF THE THIRD INDUSTRIAL REVOLUTION

Two different interpretations could be given to explain

the mutation of world demand since the end of the 1960s. It could first of all be analysed as a simple consequence of the crisis: at a time of slowing down, the acceleration of investment works inversely and evidently knocks the whole equipment goods sector. This phenomenon explains without doubt, for one part, the depression of the traditional metallic channel after 1973; it doesn't help to understand how the giving way could have appeared before that date, and still less why the electronics industry remained largely sheltered from the crisis.

Without contradicting the preceding, the second interpretation attributes an active role, in the actual releasing of the crisis, to the stunting of world demand, the mechanism of the accelerator coming afterwards to amplify a movement previously primed. Taking the shift of the traditional electro-mechanics, the electronic appeared from that time as a decisive factor in the transformation of economic structures, which could be the base of a new form of growth in the next decades.

2-1 - Electronics, decisive factor of transformation

The growth maintained by the electronic industries, in spite of slowing down and jolts which have characterised the world economy in the course of the last few years, isn't due

to chance. It is due to technological progress which permits a growth of applications, thereby prefiguring a general restructuring of the metallic channel.

2-1-1 - The consequences of technological progress (12)

The technological revolution that has appeared in electronics tends to the miniaturisation of components and to the considerable fall in their fabrication costs. According to certain experts (13), all the five years they are divided by ten. The development of integrated circuits - and especially of micro-processors - opens the way to a profound transformation of the structures of production and consumption, because it permits the general application of electronics.

A first form of application is constituted by data processing.

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12) See in this field:
- M. MAC LEAN, "Science and Technology in the New Economic context" Report of the Electronics Sector Survey (Science Policy Research Unit, February 1978).
- INTERFUTURS, "Electronique industrielle: Evolution structurelle et perspectives mondiales" (Résultats du projet de recherche octobre 1979).

13) Cf G. FRIEDRICHS, "Micro-Electronics, a new dimension of technological change and innovation" (papier présenté au Club de Rome).

Developing rapidly for more than fifteen years, this has at first permitted the amelioration of the internal management of enterprises; from now on it is able to permit the transformation in depth of the conditions of trading of tertiary activities which play a "cybernetic" role in the economic system (14). So, for example, the procedures of "scanning" allow - by the optical reading of the labels - one to know immediately the reactions of consumers and to know systematically the movement of merchandises, which is able to confer considerable power on commercial enterprises. Likewise the informatisation of banks has overtaken their internal activity to apply it to the whole of their relations, as mutual as their environnement, thanks notably to the development of the "electronic money" (15). The connection of the information network to telecommunications leads henceforth to the "telematique" (16).

In a parallel way, the conditions of production in the manufacturing industries offer a vast new field of application for electronics, which is only beginning to be outlined. The diffusion of micro-processors allows the move to an extensive formof automatisation, in which the classic machines can be

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14) See the role of commercial and bank intermediaries in A. BRENDER "Socialisme et cybernétique" (Calmann Levy, 1977).

15) The stakes of these transformations are already perceptibles in the American Economy:cf study of the C.E.P.I.I. on the USA - (Economie Prospective Internationale, nº 2, 2e trimestre 1980).

16) Cf P. NORA et A. MINC, "L'informatisation de la société" (La Documentation Française, Paris, 1978).

regulated and utilised in a more supple way, more performing and better integrated. It is even possible, by controlling "magnetic rollers", to eliminate the phenomena of friction. Such a revolution has to have the consequence of prolonging the progress of the mechanization of the sector, notable in industries where the feebleness of series and the diversity of products had not permitted it until the present substantial gains in productivity. As for the information, that is in effect the productivity which should be the main beneficiary of that evolution, after a more or less long period of apprenticeship.

At the level of the final consumption, the virtualities are again more considerable since, up to the present, electronic goods have remained limited to radio-TV receivers and to sound reproducers. Not only will the very nature of health and education services be profoundly transformed in the future, but it is possible to think that the massive production of new durable goods will permit a reply to the growing cultural needs of families. It is not a matter here of simple gadgets (such as electronic games), but a veritable change in the way of life that will be affected in the next decades : the production in the home of multiple information services, documentation, formation and leisure will also be assured, the diffusion and treatment of knowledge making calls to the network of the "telematique" like the most decentralised utilisation of the "privatique" (17).

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17) Cf J. BOUNINE et B. LUSSATO "Télématique ou privatique" (Editions d'informatique, Paris, 1979).

The amplitude of the transformations that are thus beginning to take shape is such that it puts back the actual methods of the national accounts. The instruments of the measurement of the growth have been essentially conceived by the material goods, the physical characteristics of which only evolve slowly. Now these instruments have never really been adapted to the nature of the services, and they appear more and more overtaken for seizing the technological transformation which are unfolding at the present moment.

In the industrial sector, the accountancy of the flows in volume pose a problem for all the activities where the technological mutation is very rapid: on the one hand the costs of production diminish vertiginously, and on the other the products become less and less material, so that the frontier between goods and services blurs more and more. The measure of the production and of the demand in volume becomes very delicate then, as it is practically impossible to reason with constant prices : at the cost of an old year, the flows in volume of numerous electronic products would represent a considerable part of the industry, when this part lives modestly in the flows in value (at current prices).

Before this new difficulty, the statistical institutes adopt a prudent attitude, which consists in deflating the flows in volume by more or less conventional price indexes. So it turns out

that the rates of growth in volume of electronic products — that have been presented as such in the first part - will not give the real breakthrough of that industry; this is without doubt much stronger than the figures calculated hint at. One can equally deduce that the longterm forecast of the rates of growth in volume will remain without object in so far as an appropriated methodology will not be adjusted to measure validly a new form of growth.

2-1-2 - Towards a general restructuring of the metallic channel

One might be tempted to forecast a veritable split between the 'electronic channel' and the rest of the 'metallic macrochannel'; historically, the electronic at first appeared as one of the sub-sections of the electric construction, but its extension gives it more and more specific characteristics so that they have only a distant relation to the section of origin. Moreover, the disparity of rhythms of growth after the start of the 1970s would confirm such a split.

In reality, the electronic channel remains intimately linked to the whole of the metallic channel, since its products are susceptible to incorporate more and more massively in the classic electro-mechanic. Thus, a growing number of measuring and precision instruments, watchmaking, numerous optical and

photocopying aids use possibilities offered by electronics, so that that group of precision mechanics benefits from training which has allowed it to conserve an elevated growth in the course of recent years. The electronic pays equally a very important role in aerial navigation and in railway transport, as much for the regulation of traffic as for the reservations or the tarification of services rendered, and it begins to penetrate the car and household electrical appliances. In the future the development of micro-processors is going to be applied to an always numerous growth of machines, that is to say it is going to concern itself with the greater part of equipment goods. In replacing manual procedures, the electronic allows at the same time the development of the 'robotisation' and the increase of the performances in considerable proportions.

In these conditions, the cleavage between the classic machines in decline and the 'electronised' machines in expansion will pass more and more to the interior of each category of products. In the same way that, in the past, the chemical products have contributed to the transformation of the whole of the agro-chemical channel in substituting it for natural products (notably in textiles), similarly the electronic is going to engineer a general restructurisation of the metallic channel. It is in this sense that it is useful to analyse the rivalry,

between the main industrial countries (18)

Since the start of the 1960s, American Enterprises have begun to acquire a distinct advance in the field of information, to the point that certain authors consider with fear the 'American challenge'. By the multinationalisation of their activities, these enterprises extend their supremacy over the whole economic world and seem irresistible. In the same way, the rapid progress registered in the technology of electronic components have been due, in a large part, to American efforts. However, the economic machine of the United States is a bit shrunken so that this advance hasn't up to the present allowed the clinching of the new dynamic of growth.

The strategy of Japan is very different. Following a proven method, Japanese firms concentrate their efforts on a limited number of "competivity poles", which diffuse the effects of training and contribute to structure the whole body of industrial tissue. Thus, to fill the technological delay with regard to the United States, the Japanese attack has successfully followed two axes in the electronics industry. In a direct way, the offensive was at first carried out in the consumer goods, beginning with the selling of colour television receivers, then in following these lines of high-fidelity and magnetoscopes. The Japanese industry has succeeded in acquiring

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18) Cf G. LAFAY, "La nouvelle spécialisation des grands pays industriels" (chapter II of the cited study of the C.E.P.I.I., Economie prospective internationale, n21, La Documentation Française, Paris, janvier 1980.)

dominant positions in these markets, while opposing American industry in electrical components.

It is true that the American position remains stronger than the statistics of international trade would suggest, because of the exterior implantations of transnational corporations. But the pole of competivity acquired by the Japanese begins to yield its fruits, for since 1977 nearly 40% of it relative surplus on the electronic channel was obtained outside products destined for consumption. In comparison, the position of the main European countries manifest a great weakness, save in the materials of information services and telecomunications.

More recently, Japanese strategy has been engaged in a second axis, which allows a indirect attack on the electronics field. The pole of competivity constructed in the car industry risking being menaced by the concurrence of developing countries, the restructuration set to work responds here to a double objective: not only the competivity of Japanese enterprises is consolidated by the automation of that industry, but the intensive utilisation of micro-processors authorises the putting into practice of new technologies applicable in other fields. In pivoting around the automobile pole, the

utilisation of electronics in the whole group of capital goods are going to be able to be developed (19).

2-2 - Industrial Revolution and mode of growth

The mastery of the electronics industry constitues the key to the future, save in the hypothesis of a cataclysm, progress will not be definitively stopped over the whole planet. Thus, the actual phase of the crisis doesn't mark the end of industrial growth, it only marks the difficult passage between two forms of growth. For the next few decades, a new approach of long-period cycles from now on lets in a glimpse of the possibility of a renewed growth, where from now onwards it is possible to attempt to disclose the stakes.

2-2- 1 - A new approach to longterm cycles

The existence of longterm cycles has been formerly taken as evidence by KONDRATIEFF (20), whose works have been prologued by SCHUMPETER (21). In the actual context, the "Kondratieff cycles" have not much more significance, but it is possible to locate a logic even more profound that longterm cycles, which combines at one and the same time technological factors, the strategy of actors and the mechanisms of interdependence on the on the world ladder. The concept of "industrial revolution" expresses this general articulation and allows the schematization

(19) Cf A. BRENDER, "Capitalisme et organisation industrielle, quelques remarques à propos du cas japonais" (Annales des Mines, janvier 1980).

(20) Cf N.D. KONDRATIEFF "The long waves in economic life" (The review of Economic Statistics, 1935).

(21) Cf J. SCHUMPETER, "Business cycles" (1939).

of the structural mutations which unfold under our eyes.

From this angle, it is advisable to put in their proper place the disturbances coming out of developing countries. Their weight in the whole of manufacturing industry (12 % of world production outside eastern countries) doesn't allow the imputation to their competition a notable responsability for the crisis. As for petrol shocks emanating from the O.P.E.C., it is possible to think that they wouldn't have been reproduced with the same amplitude if the developed world hadn't been avowedly incapable of replying to the challenge made in 1973. It is in the inside of the industrial countries that it is necessary to search for the long-term movements which are susceptible of explaining certain essential springs of the crisis.

At the heart of the functioning of the world economy the structural deformation of the demand is thus found: on the one hand this flows from the evolution of needs and of the macro-economic context, on the other hand it reflects the conditions in which the producers are in a position to create or use scientific progress. From a technological point of view, the existence of long-term cycles doesn't seem unavoidable, because the innovations can be relatively continuous. On the other hand discontinuity characterises the game of economic actors since the onset of the industrial era, in the dawn of the nineteeth century.

During two successive periods, the world economy was each time developed under the impulse of a motor country, which had acquired for its technological advance a superior productivity and the highest standard of living. Such was the case of England until the start of the twentieth century, then of the United States until the start of the 1970s. According to the logic that appeared successively in the two cases, the most advanced economy contributes to the setting up of a coherent system on a world scale, permitting the establishment of stable rules for financial and commercial plans, and the issuing of a money whose international purchasing power is lastingly the most high.

England had thus been the motor agent of the first industrial revolution (table IV). The primary energy depended then essentially on coal, and the steam engine - in allowing the mechanization of equipments - constituted the principal factor of transformation. The railway (in the field of communications) and textiles offered to these equipments their privileged field of application. After a period of instability and transition, a second industrial revolution is then drawn, under the impetus of the United States. While petrol gradually took the place of coal and the classic electro-mechanic replaced the steam engine, mechanization extended to certain durable consumer

goods. The American mode of consumption thus massively diffused such products as the car and electric household goods while chemistry was affirmed as another field.

In the two cases the achievement of a certain mode of growth goes hand in glove with the decline of the advance economy which had contributed to its promotion. In fact, this logically led to use its resources to diffuse abroad its own mode of growth (especially by international investment), and didn't succeed anymore in creating in its breast the structural transformations which would be necessary to receive new types of production and consumption, stemming from technological innovations. At the end of each period, the potentialities for a new industrial revolution exist, but they cannot be put into concrete form with a fullness and in sufficient delays to avoid the discontinuity.

TABLE IV: SIMPLIFIED SCHEME OF THE THREE INDUSTRIAL REVOLUTIONS

Motor Agent	Basic Energy	Transformation factor	Form of communication	Another branch
England	coal	steam engine	Railway	Textiles
U.S.A.	petrol	classic electromechanic	Car	chemistry
?	nuclear, solar and geothermic	electronic	telecommunications	biochemistry

At the present moment, it can be seen from now on and for already what will be the components of the third industrial revolution (table IV). The new energies (nuclear, then geothermic and solar) will gradually take the place of petrol; electronics already permit the stretching of the field of mechanization, since it is susceptible to being applied to tertiary sector as to private consumption; there will be especially found an immense field of application for the transmission of knowledge and telecommunication ; subsequently biochemistry will offer another field of action with multiple possibilities. Then it is possible to demand how these components can combine in the bosom of a new mode of growth.

2-2-2 - Possibility of and stakes in a renewed growth

The mode of growth which developed during the second industrial revolution strikes in the future numerous limits, which have been analysed at length (notably by the Club de Rome) Thus of natural resources on a world scale: whether for physical reasons (foreseeably exhausted some actually known layers), for economic reasons (rise in extraction costs on new sites), or for geopolitical reasons (monopoly exercised by groups of countries such as those of O.P.E.C.), it isn't conceivable that the rhythm of exploitation of these resources continues in an exponential way. In the same way the internal plan, the growth of nuisances (pollution, degradation of industrial tasks) and the saturation

of the biggest part of necessary materials in the developed countries oppose themselves to the prolongation of past tendencies.

However, if the second industrial revolution's term draws near, that would not mean that the world is hopelessly condemned to the "stationary stage", according to a vision that returns periodically in economic literature. Present and future technological progress is such that no physical global constraint can halt the growth of the world economic whole, as the work of the INTERFUTURS has shown (22). In the third industrial revolution, the electronics industry is in particular susceptible of exercising a "structuring" role, again more extended than that played sucessively by the steam engine and the classic electro-mechanic.

It is clear, nevertheless, that if the diffusion of electronics was restricted to increase the general efficiency of the productive apparatus without permitting the satisfying of new forms of final demand, it would only produce unemployment without creating a new growth.

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22) Cf INTERFUTURS, "Face aux futurs: pour une maîtrise du vraisemblable et une gestion de l'imprevisible" (OCDE, juin 1979)

That will clutch at in a lasting way when the final demand - private and associative - will offer new outlets. Now the cultural needs open precisely a huge field to new mass consumptions, since the diffusion and the treatment of knowledge suffers a mutation as important as that which resulted - in its time - from the invention of printing; and the new forms of consumption reply to the occurrence of "change in the systems of values" and to the emergence of a "postmaterialist culture" that has been much in evidence.

To a horizon more or less near, a logic of renewed growth would then appear possible. Incorporating more of "grey matter" than raw materials, it will allow at first to face squarely the perspectives of the provision of natural resources on the planet. Contrary to the "zero growth", which would lead to the distribution of the stoppage in default of halting the progress, a renewed growth would be susceptible to reestablish full employment and in authorising a gradual and moderate decline in the working hours, the extension of spare time going with it. Only such a perspective could eventually ensure in the most equilibrated from North-South relations: the permanent progress of developed countries is the condition of one part of the opening of new outlets to growing industries in developing countrie (notably in biochemistry), permitting the most acute needs of the Third World to be faced.

Save if one keeps a scenario of catastrophe, one can think that the taking place of a new mode of growth will happen sooner or later. On the other hand it is difficult actually to foresee if the transition phase between the second and third industrial revolution will be confined to a few years, or whether on the contrary it will be prolonged over several decades. The reply to such a question depends on the way in which the countries susceptible of playing a motor role in the future (United States, European nations, Japan) will succeed in eliminating the actual brakes.

These brakes are at first psychological. The neo-Malthusian ideas propagated by the Club de Rome have without doubt exceeded the original objective, because they have reinforced the change of attitude vis-a-vis progress which was beginning to appear at the end of the 1960s. Whereas, after the first industrial revolution, progress was judged capable of resolving all the problems stemming from the processus of industrialisation, a feeling of defiance has been widely spread. The "fear of future" shows itself at first in the Malthusian demography, which exercises its ravages in all the industrialised countries, Federal Germany being the country most affected. Without being too serious, Malthusian economics are equally at the root of certain blockages : the dispute over nuclear energy helps to aggravate the energy crisis instead of braking the efforts at self-sufficiency

of the good name of a country.

The mo t important brakes, however,are the organisation of the whole of each national economy. The mastery of the electronics industry - key to the third industrial revolution – isn't only the function of the capacity of enterprises to put into technologies which give the best performance at the least cost; it also depends on the whole capacity of the economic system to open a coherent group of openings, as much in the equipment of different sectors as in the final consumption in its different forms.

This implies deep changes, on the one hand in the relations between the sectors - the "cybernetic" role of banking and commercial intermediaries is crucial here - on the other hand the satisfaction of the needs of health and education. The diffusion of a new mode of production and of consumption will go in the future with the formation of men and the adaptation of structures on the spot; it has equally to preserve individual freedom in favouring the expansion and the diversity of cultures. That is to say that the third industrial revolution has little chance of developing in some rapid delays if it is study oup only to the spontaneous mechanisms of the market.

For throwing into gear a new dynamic of growth in the

years to come - and accordingly to thwart the factors of disorder which are multiplying at an international level - it remains to invent a "New deal" capable of dealing with the problems posed. The stake is considerable: the nations which succeed in forging the instruments of the future during this transitional phase, in spite of the foreseeable upsets to the world economy, will play a principal role in the decades to come.

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