OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

17345-E

Distr. LIMITED
ID/WG.478/2(SPEC.)
5 September 1988
ENGLISH/FRENCH
Original: ENGLISH/FRENCH

United Nations Industrial Development Organization

Global Preparatory Meeting for the
First Consultation on the Electronics Industry
Grenoble (France), 28 November - 2 December 1988

GLOBAL STUDY ON WORLD ELECTRONICS*

prepared by

Marc Humbert**

* The views expressed in this paper a those of the author and do not necessarily reflect the views of the Secretariat of UNIDO. This document has been translated from an unedited original.

** GERDIC - Université de Rennes I, 7 place Hoche, 35000 Rennes (France).

V.88-27195 (EX)

FOREWORD

The object of this study is to present and to analyse the world electronics industry and its development prospects. According to the normal classifications this industry consists of industrial electronics, with in particular informatics and telecommunications, hardware and software, electronics components and the so-called measurement and regulation industries. Also included are Mass Consumer electronics, medical electronics and all activities which directly contribute towards forming the electronics "complex". The global nature of the study does not however make it possible to provide a detailed treatment of each of the very numerous sub-fields which are involved.

The study is to evaluate the impact of this electronics industry on all economic activities and, in order to attain its objective, which is to illuminate the choice of actions designed to promote electronics production in the Third World nations, will endeavour to specify what are, at the present moment, the absolute and relative achievements and strategies of not only the major industrialised countries and the principal firms in the world, together with the characteristics and trends of the principal world markets for products and services.

GLOBAL STUDY ON WORLD ELECTRONICS

GENERAL SUMMARY

CONTENTS

Chapter II THE IMPACT OF THE AGE OF ELECTRONICS ON ALL ECONOMIC ACTIVITIES

Chapter III AN EVALUATION OF THE STRATEGIES OF FIRMS AND OF NATIONAL PERFORMANCES

Chapter IV AN OVERVIEW OF PUBLIC AUTHORITY STRATEGIES IN THE INDUSTRIALISED COUNTRIES

Chapter V CHARACTERISTICS AND TRENDS OF THE PRINCIPAL WORLD MARKETS FOR PRODUCTS AND SERVICES

Chapter VI OBSTACLES AND POSSIBILITIES FOR PROMOTING ELECTRONICS PRODUCTION IN THE THIRD WORLD NATIONS

SUMMARY OF CHAPTER I

A DESCRIPTION OF WORLD TECHNICO-INDUSTRIAL EVOLUTION

1. A TECHNICO-INDUSTRIAL DEFINITION OF ELECTRONICS

1.1. The technique

1. The elementary technical object: the tool.
2. The technical complex: the combination of elementary techniques, contibuting towards a technical act.
3. The technique: a corner in nature: force, matter, physical or informational displacement, ENERGY, MATERIALS, COMMUNICATION.

1.2. From technique to industry

4. The industry: utilisation of the technique to produce. Technique and industry are indissociable.
5. A field of autonomy for the dynamism of technical creation.
6. Affiliations by predetermined technical lines: the genealogy of techniques.
7. The mother-technique, particularly prolific, organises an increasingly complex-technique with multiple contributory techniques.
8. The technical trajectory: a minimum of autonomy in technical evolution or a determinism linked to the accumulated past and the nature to be acted on.
9. The cluster of technical innovations.
10. The pervasiveness of a technique, a factor for homogenisation of all the technical complexes.

1.3. From technical progress to technological progress

11. Technical evolution proceeds by its interaction with industry. The homogenisation and progress of technical complexes advance through the resolution of tensions revealed between the industrial acts which permit the various complexes.
12. Examples. Strong industrial stimulants for technical creation. Procedures for the industrial selection of technical progress.
13. This justifies the concept of the technico-industrial system.
14. A transitory separation between technical know-how and scientific know-how. The chronological gap between the progress of one and the other.
15. Interaction between the two orders of knowledge which give rise to technology. Technical progress and technological progress thus merge within the technico-industrial system.

1.4. The three ages of the technico-industrial system

16. At the heart of a technico-industrial system founded on a homogeneous and viable assembly of technical complexes is found "the machine", the support around which the industry organises production.
17. A technique of very high pervasiveness constitutes a control point in the technico-industrial system since it is capable of provoking the recomposition of most of the technical complexes and their new homogenisation.
18. An energy as the control point of the first technico-industrial system: the age of steam.
19. From the age of steam to the age of steel, a material, the historical dynamic of the technico-industrial systems (Figure I-1: The historical dynamic of the technico-industrial systems).

1.5. The age of electronics

20. A new technical rupture with the microprocessor (1971) which gives birth to the age of electronics.
21. Electronics is "all those techniques which utilise variations in electrical parameters (electromagnetic fields, electrical charges) to sense, transmit and process information".

2. THE STRUCTURING OF THE AGE OF ELECTRONICS

22. Electronics forms a technico-industrial complex around a mother-technique.
23. Two technico-industrial sub-fields: the transmission of information and the processing of information which tend, because of the advances of the mother-technology, to become merged (Figure I-2: The electronics industry, 1904-1984).

2.1. The birth of the electron as the origin of a prolific mother-technique

24. The transmission of information: from the telegraph to transatlantic radio sustained by navies and armies.
25. The processing of information: the typewriter for offices and the punched card machine for censuses.
26. The electron, the diode and the triode.
27. The great potential extension of the telephone and radio-transmission.
28. The extended growth of firms in the electrical industry with the birth of electronics.
29. The development of the data processing firms, in particular IBM.

2.2. Advances in the transmission and electronic processing of the signal (1925-1955

30. The genesis of mass consumer electronics: television, cinema, record-players, tape-recorders.
31. Industrial, military and aerospace electronics.
32. Valved computers for ballistic computations: ENIAC

2.3. The mastery of an irradiating technique (1955-1985)

2.3.1. The micro-electronic basis

33. The perfect pervasiveness of electronics is acquired by the shift from vacuum valves to the solid semiconductor, first the discreet transistor then integrated into a circuit: the chip.
34. The density of integration doubles every year to reach very large scale integration (VLSI) by the end of the seventies, when circuits had become intelligent with the microprocessor, the real information processing machine. The chip becomes the basic brick in the service of the electronics construction industry (Table I-3: Electronics construction in 1985).

2.3.2. The development of the electronic processing of information

35. The physical construction, or hardware, is accompanied by the software, a non-physical service of design, architecture and operation, the two being indissociable within the electronic construction industries.
36. The generations of computers. The first were computers using valves, the second replaced these with transistors (from 1959 onwards) and was accompanied by the widespread use of the first universal programming languages and a first offshoot, the minis (PDP).
37. The third generation, with the IBM 360 in 1965, installed large data processing (informatics) for management purposes in large firms and in public administrations.
38. To achieve this required major R and D expenditure by IBM, which was integrated vertically and standardsed its operating systems throughout its range; it invented the EBCDIC code and the octet and developed a leasing system. Result: large-scale informatics grew in value by 20% a year.
39. The fourth generation ensured, during the seventies, the maturing of large centralised informatics and the explosion of other informatics concepts.
40. Mini-informatics developed at the same time as the CRAY super-computers.
41. Micro-informatics constitutes one of the direct applications of the pervasiveness of the mother-technique of data processing. In 1985 twenty million micro-computers were in operation throughout the world, scientists' work stations or secretarial workplaces. The concept of distributed informatics emerged.

2.3.3. The mutation in telecommunications

42. Unidirectional transmission is slowly transformed with cable TV networks in the United States, then the transatlantic transformation by satellites (1962) which combined TV and the telephone. After 1980 videotext gave the same combination, and the home computer combined this with informatics. Home informatics was approaching.
43. Bidirectional transmission progressed in switching systems, the speeds and modes of transmission and the nature of the possible communications.
44. Telephone exchanges became automated, then transistorised (1960) and finally became entirely electronic (1970), forming true data processing machines with their hardware and software problems.

45. The range of services offered by the telephone systems extends to data communication and advanced or value added services, all these being permitted by technical advances. Faced with the variability in costs, of needs and of payment capabilities, the public monopoly of telecommunications services, held by the "carriers" and their practice of a generalised balance between users and uses, gave way gradually to a deregulatory movement.

46. The satellites, the point of interaction between electronics and aerospace, become geostationary transponders. INTELSAT dominates intercontinental communications at very reduced costs for telephones, data transmission and television. Direct television satellites also appear with private global systems of advanced telecommunications.

47. Coaxial transatlantic cables (1956) evolve with the transistorisation of their repeaters (1964) but have to face a future with fibre optics (1972) which, thanks to lasers (1958), form tomorrow's economic alternative to satellite telecommunications and are already showing high performance in local informatics networks and for transmissions in an electrically hostile environment.

2.4. The inauguration of a new technico-industrial age

(Figure I-4 : The structuring of the age of electronics)

48. Around the components two sub-fields can be distinguished. Electronic computing as information processing has become, under the impact of the evolution of the mother-technique, communications-informatics extended to the processing of texts, images and sounds.

49. Telecommunications are turned upside down by digitisation which, in addition, extends the range of services by demanding real information processing within the old fields, which explains the cross-competition between IBM and ATT.

50. Telecommunications, the switching of major flowlines and informatics as the principle of the electronic manipulation of information retain their specific characteristics but interlock. Mechatronics today illustrates the cerebrofactive nature of the transforming activity in workshops and laboratories. Office informatics (bureautique) for administrative work in the office and home informatics (domotique) for household work in the home form, with mechatronics (mecatronique), the new complex need-product pairings which are born from the implementation of the new technico-industrial age.

51. Informatics itself evolves by the generalised recourse for its packaging and its manipulation to the new universal "alphabits" of communication which the basic bricks of electronics construction can process. The new technico-industrial age is thus also that of communication.

3. TECHNICAL PROSPECTS FOR THE EIGHTIES

52. Evolution will be in the hands of the dominant actors in the technico-industrial complex. Everything leads to the assumption of a future period of a deepening and enlarging of the scope of the technico-industrial complex around the same mother-technique, in increasing interaction with opto-electronics. The digitisation of information affects television and ISDN and all the machines will tend to process knowledge rather than information.

3.1. The deepening of the mother-technique: progress on the building bricks

53. The pursuit of integration along the same technical line?
54. The example of the DRAM memories show that the old integration factors: line widths, design features, filling levels and surfaces of circuits, will still play their role (Table I-5: The determinants of integration progress).
55. At the time of the mass production of 1 Mbit memories industrialists are already envisaging the mass production in the year 2000 of 64 Mbit memories. It is therefore necessary to count on the maintenance of the rate of evolution of their performance.
56. The design of integrated circuits will call on artificial intelligence. Optical lithography will continue to permit the production of 4 Mbit and 16 Mbit memories by using a system cf automatic alignment.
57. X-ray photorepeaters will make the lithography of 64 Mbit and larger memories possible. Direct writing with an electron beam will play a complementary role.
58. In addition to the classical etching techniques other competitive techniques, which are either already operational or under development, could ensure the quality of this stage at the coming levels of miniaturisation.
59. Microprocessors are likely to experience, in addition to considerable technical evolution, an extension of their utilisation as the basic modules for information processing. (Figure I-6: The evolution of integrated circuits and microprocessors)
60. One can however see an evolution in architecture (RISC) and the emergence of a new concept of operating systems (TRON). The coming years will above all see the specialisation necessary for what is, despite its very small size, a system which is sometimes very complex, as in the case of microprocessors.
61. Integrated circuits should be defined as a function of specific applications: Application Specific Integrated Circuits or ASICs.

3.2. Speed and facility in communications: opto-electronics and standardisation

62. Superconductivity remains a promising field without fundamental implications which can be forecast between now and the year 2000.
63. Gallium arsenide is likely to form the substrate for very rapid integrated circuits for specific applications.

3.2.1. The search for technical combinations.

64. The coming years should see the development of technical combinations and heterostructures. (Figure I-7: The relative performances of integrated circuits according to the techniques)
65. The qualificative subdivisions of the various types of integrated circuits - bipolar - MOS - seem to need redefining.
66. In power electronics it is necessary to await the appearance of true integrated circuits.
67. Three-dimensional (3D) integrated circuits should provide remarkable products in the nineties.
68. The logic of avoiding losing within the links the gains achieved inside each component by its miniaturisation will need to be studied in greater depth. It should lead to the development not only of ASICs (cf. 61) but also to customised hybrid circuits.

69. This type of circuit has developed a concept which has led in the case of printed circuits to the technique of surface mounted devices (SMD), a technique which should become dominant during the nineties.
70. Thin or thick film hybrid circuits should lead to the wider diffusion of electronics in innumerable potential industrial applications.
71. The search for technical combinations for these same reasons should ensure high rates of development for integrated circuits of the bi-MOS type.

3.2.2. Opto-electronics, a major contributory technique.

72. For point-to-point communications at a distance the nineties will be the decade of fibre optics.
73. However optical switching and the optical computer cannot be envisaged within this time-scale.
74. But opto-electronic components will undergo very considerable progress, in particular for compact discs, laser printers and all signalling fields (not so far electronised).

3.2.3. Standardisation: a constraint on communications.

75. For the potentialities of rapid communication to be reflected in economic advantages, and for these to be effective, it is necessary that the communicants should understand each other; this is the field of standardisation.
76. The OSI (Open Systems Interconnection) model with seven layers of the International Standards Organisation, is being used and has received the recent support of the major industrial firms.
77. The creation of a group of users, such as MAP (Manufacturing Automation Protocols), illustrates the progress being carried out towards increased possibilities of inter-functioning between the information processing machines necessary for any network.

3.3. Networks and knowledge

3.3.1. High-definition television.

78. The nineties will see the digitisation of mass consumer electronics and the extension of the electronics concept to domestic electrical appliances, prior to the subsequent maturing of home informatics.
79. One will also see expected but uncertain technical evolutions in already old types of products such as digital tape-recorders and compact discs, with the proliferation of minor technical innovations, guided by the opportunities of the market.
80. The major event in mass consumer electronics in the nineties will be the arrival of high-definition television, whilst the gradual extension of TV broadcasting should lead, towards the year 2000, to nearly half the planet participating quasi-simultaneously in cultural rites. Technically this matter is linked to advances in very many fields.
81. The technico-industrial character of this evolution is linked with an international regulatory decision of which the importance is already appreciated: the standardisation of high-definition TV where Japanese and European proposals are in competition.

3.3.2. Integrated Services Digital Networks.

82. The major project of the nineties is that of the installation of a communications network which carries not only speech but, more generally, every type of information.

83. Choices with a technical implication will be taken in the coming years, for example between a universal network like the existing telephone network and a group of specialised applications or users networks.
84. For some ISDN is partly a technical myth, meaning "I Still Don't kNow!".
85. The digitisation of transmission and switching remains embryonic in many countries where analogue switched speech networks co-exist with digital switched networks for data packets. The move from this situation to an ISDN is viewed differently by the leading countries.
86. However there is a kind of agreement on the installation of a so-called narrow band ISDN at 144 kbits/s which should, by the year 2000, form a basic characteristic and govern from that date onwards the technical development of components and equipment (Table I-8: Installation of a first-generation ISDN in the European countries).
87. It is only after the year 2000 that it is possible to envisage a network capable of carrying high-definition colour images through a wide band ISDN or IBCN (Integrated Broadband Communication Network).
88. This distant target poses problems for the discussion on the immediate standards for the narrow band ISDN.
89. For example the choice of real-time synchronous multiplexing for digitised speech, transmitted at 64 kbits/second seems very arguable at the present time: the evolution of switching will be affected and, with this, the coming generations of exchanges (Figure I-10: Necessary developments in switching techniques: amendment to the ISDN).

3.3.3. Software and artificial intelligence.

90. Any progress in the hardware must be accompanied by progress in the software, whether operating software - partly integrated into the hardware as "firmware" - or applications software or dedicated programs for specialised uses. Software becomes the critical point in the development of information processing machines.
91. More than 60% of working time in the production of electronics goods should be devoted to the software.
92. Software engineering should develop with analysis assisting and structured-design tools, together with automatic code generators.
93. The search for continuity in the utilisation of programs has led to an attempt by the major informatics manufacturers to draw up jointly their next operating system. It does not seem that this can be done without difficulties.
94. In the field of artificial intelligence one should expect the multiplication of expert systems, simplifications in the use of information processing machines and the development of their capabilities for visual and oral recognition (Figure I-11: Evolution in artificial intelligence according to MITI (Japan)).

4. EVOLUTION OF PRODUCTION CONDITIONS IN ELECTRONICS

4.1. The general characters of a multi-intensive dynamic

4.1.1. Highly dynamic conditions

95. The same type of evolution will be followed, irrespective of the product of electronics construction.

96. The rapid changes in the characteristics of the product means that information processing machines are constantly less expensive, smaller and more rapid (Figure I-12: Computers and information processing: cheaper, smaller and faster).
97. Falling absolute prices with improved performance in the case of mass consumer products such as the IBM-PC.
98. In the case of other products it is the absolute price of the unit service rendered which is falling. For example the price per MIPS (millions instructions per second) in informatics (Table I-13: Evolution of the MIPS cost for various IBM computers).
99. This is also the case with the cost of one channel on a communications satellite (Table I-14: Evolution of annual Intelsat costs).
100. This is linked in particular with evolution in the performance of components and should therefore continue with the developments forecast for these components. This is confirmed by the costs of satellite telecommunications circuits (Table I-15: Forecast evolution of annual costs for a half-circuit in a telecomminications satellite in 1983 US Dollars).
101. More generally a fall in the cost of telephone communications has been recorded. Technical progress such as fibre optics reduce the cost of services when they are advanced, that is to say for very high loadings (Figure I-16: Cost/performance comparisons between copper and fibre optics cables).
102. These very dynamic characteristics give apparent facility but mask the difficulties linked to the multi-intensive character of production.

4.1.2. But with difficulties linked to the multi-intensive character of production.

103. The intensity of technical progress gives advantages to producers near to the manufacturers of components (Table I-17).
104. This is impelling firms to vertical integration.
105. The convergence of formerly more distinct branches and their common and necessary proximity to the manufacturers of components imposes and cements an extended range of contacts to remain within the rhythm of developments and on highly disputed markets.
106. The high intensity of Research and Development requires many highly qualified personnel and very high and increasing expenditure with technical progress, to such a point that in certain sub-fields, such as that of telephone exchanges, it is necessary to expect a reduction in the number of manufacturers.
107. The high intensity of qualified personnel relates not only to R & D but also to software which it is necessary to develop and support at the same time as the hardware and the automation of the production process. Generally speaking non-skilled jobs are tending to be massively reduced in the electronics industry (Table I-18: Employment and its structure at Siemens (Germany)).
108. The profitability of such intangible investments demands sufficiently large markets for which the automated plant and the adequate production capacities generally lead to high investments which make this industry increasingly capital-intensive. Some exceptions remain, for example for products manufactured for a protected market or defined with original specifications, and which define a market segment (Table I-19: Technical and investment levels in some products of the electronics industry).

4.1.3. Copying to avoid the difficulties.

109. Escaping from the multi-intensive character of the dynamic by "swimming in the wake of a big fish".
110. The IBM compatibility "invented" in 1976 by AMIDHAL evaporated with the IBM-PC and the proliferation of its clones. It involved constructing an almost conforming copy of an information processing machine of which the majority of the components are available on the market.
111. This introduces a de facto standardisation and poses copyright problems. Many actions have been initiated, most national legislations trying to protect the market leaders.
112. Copying is however possible by agreement with the original producers, and is fairly frequently practised with OEM (Original Equipment Manufacturer) and second source systems.
113. These general conditions may be amended or supplemented here and there as may be seen in the two cases examined below.

4.2. The case of the integrated circuits - memories

114. The production of semiconductors is partly captive, to the extent of a third of the total in the United States.
115. The directing group of the producers on the market are attempting to master an optimal trajectory for lowering prices with the renewal of products, as for example in the case of memories.
116. As evidence a curve of global apprenticeship can be adduced (Figure I-20: The curve of global apprenticeship per memory-bits).
117. This will have repercussions on all products of electronics construction (Figure I-21: Evolution of prices per memory-bits and of electronics products).
118. All categories of integrated circuits have a very brief renewal and life cycle during which the price forming process is itself modified (Figure I-22: Product cycles in integrated circuits).
119. Cycles from one generation to another depend on increasing volumes (Table I-23: Evolution in deliveries of DRAM generations).
120. In the same manner the Research and Development costs and the duration of development times are both rising. The mean R and D effort represents 10% of turnover and has risen to about US$ 100m for three years of work in respect of the latest generation of memories (1 Mbit) placed on the market.
121. Manufacturing costs are also rising, in particular for the lithography which is the largest item (40% to 45%).
122. The investments to be made are therefore considerable. On average they represented 10% of the turnover in 1975 and rose to 23% in 1984.
123. This very rapid path (Table I-24: Evolution in lithography plant) is made more delicate by a short-term evolution disrupted by phenomena of acceleration of the derived demand, giving it a cyclic character (Figure I-25: Half-yearly ratio of orders against invoice of DRAM integrated circuits).
124. Price evolutions are simultaneously subject to the effects of the product cycle, of fluctuations in the demand and the aggressive investment strategies of certain producers (Figure I-26: The abnormal fall in memory prices; Figure I-27: The Japanese path of investment in semiconductors).

4.3. The case of the television receivers industry

125. The television set, the origin of mass consumer electronics, still remains the pilot product.
126. The industry is highly concentrated, and today fewer than ten producers share the world market.
127. Evolutions in techniques and the weight of investments, even more than the potential expansion of the market, have made it essential to move on to long series production.
128. The consequence has been a trend towards national concentration in the sixties, then on a global scale in the seventies, mainly under the influence from Japanese firms.
129. The Japanese simultaneously exported their television sets by promoting their brands and by purchasing American plants and brands.
130. Their success is reflected in the almost complete dismantlement of the local American production apparatus.
131. As from the middle of the sixties new lines of development appeared: relocation, automation and joint firms, mainly in the industrialised countries.
132. European firms, protected until then by standards, reacted by a process of concentration around two firms, Philips and Thomson.
133. Thomson has imitated Japanese know-how in automating, relocating and, like Philips, reducing manpower levels.
134. Increasing the uniformity of production conditions locates the critical size at 2 million sets a year in order to take account of the magnitude of Research and Development expenditure and technical progress.
135. The first technological break-point was the introduction of colour in the sixties, which resulted in the disappearance of certain firms, such as those in Argentina.
136. Other progress should be noted: improvements in sound, reductions in energy consumption, the introduction of integrated circuits and improvements in image quality (Table I-28: Evolutions in television sets and the utilisation of integrated circuits in Japan).
137. In a television set the tube is a central component in the final price, and this provides an impulse towards vertical integration and the consideration that tube production protects the producers of television sets.
138. The Koreans have now entered this very competitive international oligopoly. They are turning towards the tubes market where they could generate over-production and may be tempted to lead a price war.
139. However the subsequent developments are not solely concerned with the existing tubes because of the very considerable Research and Development efforts.
140. Mass consumer goods will become, with digitisation, a high technology industry, and some new producers with associated capabilities will appear.
141. The principal challenge, however, remains the complete renewal which is expected with the move from digital television to high-definition television (cf 3.3.1.).

SUMMARY OF CHAPTER II

THE IMPACT OF THE AGE OF ELECTRONICS ON ALL ECONOMIC ACTIVITIES

1. The age of electronics has been installed, and the age of steel has to give way to it. An industrial mutation is taking place and activities are being modernised.

1. AN EVALUATION OF THE DEGREE OF DIFFUSION OF ELECTRONICS

2. The diffusion-insertion of electronics is principally that of the integrated circuits.
3. The mean annual rate of increase of sales of integrated circuits between 1982 and 1986 is above 27% (Table II-1: Destination, in percentages, of integrated circuits, 1982 and 1986).
4. The question of the diffusion of electronics and the industrial mutation must be distinguished from the rate of global growth.
5. The penetration of electronics into everyday life.
6. Its penetration into enterprises.
7. The significant diffusion of micro-electronics into industry in Great Britain, Germany and France according to the results of an in-depth survey.
8. Between 1970 and 1985 industrial jobs are influenced by the spread of micro-electronics (Table II-2: Extent of use of micro-electronics by industry; Table II-3: Stage of development in use of micro-electronics).
9. Users firstly utilise standard microprocessors in their products and equip themselves with programmable automatics.
10. According to the surveys electronics gives an advantage in mastery, but require for their diffusion a better general economic climate and more personnel with electronics know-how (Table II-4; Type of micro-electronics component used: product uses; Table II-5: Type of micro-electronics based equipment used: process uses; Figure II-6: Advantages, disadvantages and problems (for Great Britain only); Table II-7: Main disadvantages and problems in using micro-electronics).

2. ANOTHER MANNER OF PRODUCTION

2.1. Mechatronics

11. The move from mechanics to mechatronics leads to evolution in the product which becomes a complex-product composed of several elements.
12. To speak of robotics is a reduction of mechatronics to the point of caricature.
13. From flexible workshops to plants without workers (Figure II-8: A scheme for a flexible workshop).
14. More efficacy (Table II-9: The advantages of a flexible workshop (Yamazali, Japan, 1984).
15. The example of a flexible workshop engaged in the production of numerically controlled lathes.
16. Mechatronics has supported the rise of Japan within the international hierarchy of the economic powers.

2.2. Local industrial networks and logistics

17. Two problems of communication linked with mechatronics.
18. The birth of the MAP project.
19. MAP facilitates the development of local industrial networks.
20. Automation on islands.
21. Difficult production management.
22. Improvements involve a real-time communications network between the islands for centralised or decentralised processing and safe industrial control.
23. Logistics links internal management and the management of inputs and output to ensure overall optimisation.

3. A CRITICAL APPRECIATION OF THE EMPLOYMENT-PRODUCTIVITY DILEMMA

24. No irrefutable demonstration has been able to resolve opposing views.
25. The previously cited study shows an overall effect on two weakly negative axes (Table II-10: Changes in employment due to use of micro-electronics: all users).
26. The manner in which the employment-productivity dilemma is presented designates, a priori, the guilty party.
27. From a micro-economic point of view technical progress threatens employment.
28. But the wages which are not paid by the more productive enterprise return to the economic circuit and can serve, therefore, to provide other jobs. The problem of employment is also macro-economic.
29. In the long term agricultural employment and then industrial employment will fall to the profit of the service sector. It is not electronics which has caused or is causing unemployment; on the contrary it increases the employment potential (Figure II-11: Evolution of the sectorial structure of jobs).

4. AN INCOMPLETE LIST OF MODERNISED ACTVITIES

30-31. Steel
32. Chemicals
33. Petroleum
34. Automobiles
35. Textiles and clothing
36. Agriculture

SUMMARY OF CHAPTER III

AN EVALUATION OF THE STRATEGIES OF FIRMS AND OF NATIONAL PERFORMANCES

1. With technical evolution the industrial structures are undergoing in-depth changes. Enterprises are led to revise the strategic options which they had chosen up to the end of the seventies. From then on every horizon is planetary. Products and processes, particularly in the high-technology industries, can only be marketed (and conceived) as a major part of the world market. The change in the scale of production obliges firms to define industrial complexes by way of relocation/autochthonous and cooperative strategies.

2. Progressively, therefore, most of the branches structure themselves as oligopolies. The large dominant firms seem to have consolidated their domination. Their capabilities exceed the framework of their principal activities. However the segmentation of activities makes their position fragile in certain respects. This is why they have modified their strategies.

3. Relocation, often dictated by the search for cheap labour or the attempt to evade customs barriers, requires today an effort towards autochthonisation, that is to say of assimilation within the industrial fabric of their place of establishment. This operates more within the countries of the Big Three (Europe, the United States and Japan) than in the countries of the South, and all the major manufacturers are subject to it.

4. In addition to internal growth the growth of the markets and their segmentation requires recourse to the purchase of enterprises or to collaboration with competitors. Over the last four years the movement towards cooperation in electronics has taken on a hitherto unequalled magnitude, moving in the direction of the oligopolisation of the markets.

5. All sectors are subject to this movement, from informatics where IBM was only able to build its PC with the help of Microsoft or Tander, to semi-conductors where the division of work between the design firms and the actual producers is widening.

6. However these operations of firms result, at national level, in structural commercial imbalances. Whilst the markets are located in Europe, the United States and Japan, much of the production is in the hands of the Newly Industrialised Countries of Asia with Japan, Mexico and Ireland. The gap between markets and production has, as its corollary, very serious trading deficits in Europe and the United States.

7. These deficits have resulted in unequal protectionist tensions since the Second World War. The United States and Europe simultaneously broke the GATT rules in order to protect their electronics industries which were meeting "unfair" competition from the countries listed above.

SUMMARY OF CHAPTER IV

AN OVERVIEW OF PUBLIC AUTHORITY STRATEGIES IN THE INDUSTRIALISED COUNTRIES

The role of the strategies of the public authorities has been of fundamental importance in orientating the global technico-industrial evolution in electronics, and continues to be the same today. Obviously it is the authorities of the most industrialised economies which exert the greatest weight when determining this orientation. Thus it is the North American public authorities which can undoubtedly claim paternity for the advance of electronics. From the seventies they had to face up to a challenger which gradually became dominant in an increasing number of fields under the action of the firms but also, and mainly, because of the strategies of the public authorities. The older industrialised countries in Europe followed, with some delay, the American electronics evolution and, finding themselves somewhat outdistanced, saw that the timid and national measures which had been taken up until that time were insufficient. As a consequence, and within the framework of the European Community, they implemented the ESPRIT programme designed to put them back on course again. It is in effect in the electronics field that the real technological race between the industrialised countries was being run with their public authorities supporting them or even replacing them. Even in the case of the so-called deregulation of telecommunications one can observe the intensity of this global competition.

The traditional tools which were utilised, and which were found everywhere, included : public orders, the organisation of enterprises or associations, restructuring under the aegis of the public authorities, protective standardisation, direct subsidies and aid to industry and, more especially, the high level of participation of the public authorities in Research and Development expenditure.

1. The founders: the United States

2. The dominant challenger: Japan

3. Old Europe's somersault

3.1. A general overview of some interventions
3.2. The German policy
3.3. The British policy
3.4. The French policy
3.5. The ESPRIT programme

4. Technological competition between the nations

4.1. Mechatronics
4.2. Deregulation of telecommunications
4.3. Artificial intelligence.

SUMMARY OF CHAPTER V

CHARACTERISTICS AND TRENDS OF THE WORLD MARKETS FOR PRODUCTS AND SERVICES

1. The very unusual characteristic of the electronics industry is that it has founded its growth on simultaneously enlarging the existing markets and also extending the possible applications for this technology. Mass consumer electronics, dominant until the Second World War, occupies an increasingly limited part of world electronics production, giving place to industrial capital goods.

2. With its significant share in the GDP of the principal industrialised countries electronics has become a major industry. But the technical upsets, with the motive force of the diminishing size and price of the active components, have led to a very considerable segmentation of the major markets within which certain niches are appearing - whilst others are disappearing.

3. In electronic data processing, or "informatics", the producers of universal computers and mini-computers are seeing their positions threatened by the widespread introduction of micro-computers, in particular since the power of the latter has equalled or exceeded that of the classical mini-computers. At the same time the mini-computers are encroaching on the preserves of the larger or very high power computers.

4. As with informatics the software industry has been turned upside-down by modifications in the hardware. Using archaic production methods they do not offer any gains in productivity, in such a way that the software absorbs an increasing part of the operating costs of the systems. Furthermore, with the increasing power of the hardware the traditional operating systems become obsolete, incapable of controlling the new functions and the necessary central memory. In order to improve compatibility between generations of computers and to guarantee the transferability of the software the manufacturers are increasingly turning towards UNIX. The languages themselves are becoming obsolescent. FORTRAN, COBOL and BASIC have been abandonned for LISP or PROLOG, particularly in the field of expert systems.

5. In telecommunications the revolution consists of the implementation of ISDN (Integrated Service Digital Networks). These networks will make it possible to transmit speech, data and images at 144 kbits per second (kbps). The communication of data has thus required a redefining of the network. Simultaneously increasingly fast multiplexers are used to transmit data by the conventional networks at lower costs. But these standards are already upset by techniques of signal compression/decompression (CODEC) which make it possible to switch and transmit data at 64 kbps, reducing at a stroke the value of the ISDN standard or fibre optics.

6. In mechatronics the faltering market gained in strength when General Motors defined a communications protocol for use between the components of the flexible workshop. This MAP protocol should be accepted by all the manufacturers between now and 1995 and should stimulate the market for CAD/CAP, now totally integrated into the factory and where most of the systems utilise UNIX.

7. Frequently stagnating, and subject to the same economic conditions as the market for capital goods, mass consumer electronics gained its second wind towards the end of the eighties with the CD and the video recorder. The prospects are encouraging with home informatics ("domotique"), that is to say the integration within the intelligent home of all the domestic functions, collectively controlled by a central processing unit. In the short term the principal effects of the recovery will arise from the digitisation of TV, with the development of high-definition television (TVHD), but they will also come from the outlets offered to electronics by the domestic electrical appliances which have, until now, integrated little in the way of electronics.

8. The highly cyclical semiconductors industry is a considerable strategic challenge. The intense competition which operates on the standard markets leads manufacturers to try to fall back on the markets for customised semiconductors (ASIC) which is less competitive and where the growth is expected to be considerable. At the same time microprocessors will also undergo major modifications at hardware level (from 16-bit to 32-bit) and also in the software for their instruction set (RISC or CISC).

SUMMARY OF CHAPTER VI

OBSTACLES AND POSSIBILITIES FOR PROMOTING ELECTRONICS PROMOTION IN THE THIRD WORLD COUNTRIES

1. TOO RESTRICTED A PARTICIPATION IN WORLD ELECTRONICS PRODUCTION.

1. The countries of Latin America, Asia and North Africa are mostly producers, and some are exporters, of electronics goods, although this industry is still young and a similar situation took a hundred and fifty years to appear in the case of textiles. However the participation of the Third World nations in global electronics production seems to be too restricted.

1.1. The multinationals relocate to lower wages: jobs and foreign currency.

1.1.1. The New International Division of Work.

2. Analysts believe that they were able to perceive, in the seventies, a new international division of work, involving moving production to countries with low wage levels for its subsequent export to the industrialised countries.

1.1.2. The "offshore" installations of the multinationals.

3. Firms have relocated their productions by installing themselves "offshore" in the case of highly labour-intensive industries, which is particularly the case with semiconductor manufacture in the electronics industry.
4. In 1985, more than thirty years after Fairchild set up in Hong Kong (1962), a third of all jobs in American semiconductor firms were to be found "offshore".

1.1.3. Public encouragement: export free zones and special import tariffs.

5. A bonded ("duty-free") production zone on Mexican territory began in 1963 to house assembly firms, offering jobs and foreign currency to Mexico at wage rates very much lower than those in the United States, whilst at the same time facilitating frontier relationships. This zone has been subsequently utilised by the electronics industry and has operated on the basis of the special legislation for the zone and the American customs regime (tariff headings 806-807).
6. Tariffs 806-807 have been particularly used by the United States for their imports of semiconductors (about three-quarters of the total), and this has been at the root of electronics production in numerous Third World countries (Table VI-1: North American trading in semiconductors and tariffs 806.30 and 807.00 (1966-1983)).
7. The EEC has introduced a passive advantage system, but this is much less utilised than that of the United States, as may be seen from the examples of France and West Germany.
8. Taken overall it has, nevertheless, produced an international redeployment of activities which is one of the sources of the participation of the Third World countries in world electronics production (Figure VI-2: Evolution of imports into France from the developing countries after passive advantage; and Table VI-3:

Trading in electrical and electronic appliances in 1963 after passive advantage - France and the Federal Republic of Germany).

1.2. Intensification of the recourse to electronics products: to purchase or to manufacture?

1.2.1. The spontaneously increasing consumption of electronics eats into foreign currency.

9. Television receivers, telecommunications and computers are three areas of increasing consumption which inflate imports. Is it necessary to purchase or should one not, when the size of the domestic market is significant, produce them?
10. Television broadcasting systems are becoming more widespread and the rate of acquiring sets has been spectacular, in both the industrialised countries and also in the Third World, between 1965 and 1982. In South America a large proportion of the television sets have been at least assembled locally (Table VI-4: Evolution of the rate of equipment with television receivers).
11. Generally speaking there has been a frenzy of consumption where leisure electronics are concerned.
12. This is personal consumption, but in the case of television the public monopoly means that the governmental decision to install a television system opens up a process of the progressive purchasing of sets by the largest number of persons. The decision is partly linked with the idea of using television to reinforce public authority by way of its presumed power to convince.
13. It was also the public authorities, but for reasons of general interest, which decided to create a telecommunications infrastructure, forming a regional infrastructure and connected to the international network. The decision to equip generally leads to importing.
14. The development of the need to communicate by way of the telephone seems to be closely correlated with the per capital GNP. Economic growth therefore goes hand in hand with the rise in telecommunications, but the intensity of the need is increased and the telecommunications market is likely to develop much more rapidly as is shown by the very ambitious equipment plans of a large number of countries (Figure VI-5: Relationship between the level of telephone ownership and the per capita GNP for 1978).
15. States, everywhere, are adopting informatics. The international organisations are promoting this process and offering technical assistance in order to develop it (Table VI-6: The ASYCUDA system of UNCTAD).
16. Informatics projects rely today on micro-computers.
17. Micro-computers are proliferating not only within administrations but also in the private sector in most Third World countries.
18. Television, telephones and informatics are leading, in most countries, to severe haemorrhages of foreign currency when it is not possible to produce locally.
19. Is it therefore possible to be an efficient user without being a producer? The answer is not no in the case of mass consumer electronics, and perhaps the same with micro-computers; if imported components are available local maintenance is also possible.
20. By contrast in the case of the medium and large computer systems difficult problems are posed: under-utilisation, lengthy

breakdowns and, for the administration, real dependence on foreign producers. This encourages them to use micro-computers and to promote their local manufacture.

21. At the very least the decisions to purchase and use should be cleared by a unit consisting of a minimum number of nationals having the basic technico-industrial know-how.

22. In the case of telecommunications the procedure involves an international call for tenders, involving the most detailed consultations.

23. The infrastructures which are installed cannot dispense with an efficient maintenance service, for which it is neccesary to obtain training for the local personnel. A large market may make it possible on the occasion of drawing up an equipment programme to achieve the creation of an installation unit or even a unit for the production of components in order to facilitate maintenance.

1.2.2. An emerging wish to transform technology by way of electronics.

24. The public authorities may also have rasons to promote the utilisation of electronics.

25. Since the beginning of the seventies the idea has gradually grown that electronics constitutes an indispensable technique for any industrialisation strategy.

26. With the industrial world moving into the age of electronics analysts, initially reticent, have come to consider the necessity for technological pluralism within a perspective, for the countries of the South, of accepting technological change.

27. The countries concerned, the UNCTAD Group of 77, took up a clear position in 1986 where industrialisation seems to have to result from a process of technico-industrial transformation, finding its support in the advanced technologies and hence on electronics (Figure VI-7: Extract from "Preliminary outline of the strategy for the technological transformation of developing countries" (Document TD/B/C.6/L.73 of the UNCTAD Trade and Development Board)).

28. The employment of electronics should, from this point of view, therefore contribute towards the modernisation of productive activities. To the extent that all the activities are affected and run the risk of being downgraded this promotion of the employment of electronics introduces the risk of weighing heavly on the balance of payments.

29. It is possible to use electronics effectively but not to produce them; this seems quite illusory when it is a matter of a use intended to move the productive apparatus into the age of electronics.

30. The search for an efficient industrialisation strategy therefore demands the increased participation of Third World countries in world electronics production.

1.3. Comparative adventages in the laws of the World Industrial System

1.3.1. The objective limits to wage cost advantages

31. Whilst in a Third World country wage levels, in international currencies, are relatively low the fact remains that the other components in the production costs are, by contrast, much higher than in the industrialised countries.

32. In order to participate more strongly in the fruits of world expansion it is necessary to raise wage levels in international currencies so that competitiveness is then achieved by improvements in the other components of the overall costs.
33. This takes us away from analyses in terms of comparative costs and leads us to the area of productivity: are there no specific productivity advantages held by the industrialised countries?
34. Under the generally unchanged conditions the countries with low wages remain attractive for the most labour-intensive industries.
35. Whilst the electronics industry is no longer ranked amongst these industries the countries which have not registered any changes in fields other than wage costs do not attract any electronics relocations.
36. This is because advantages in regard to wage costs do not promote any particular industry.
37. It is necessary to offer something else to attract foreign investments in electronics production, in particular specific productivity advantages.
38. Within the framework of conventional reasoning in terms of comparative advantages it is necessary to envisage a return to the industrialised countries by those previously relocated industries, with some rare exceptions, in particular in cases of products intended for the local domestic markets and where proximity constitutes a major specific commercial advantage.
39. In fact the relocation movements have been accompanied by the creation of dynamic effects, creating specific advantages for the receiving countries, in particular the improving of local industrial capabilities.
40. One can cite the example of the high wages in Singapore and the movement towards local automation, and the creation of Research and Development centres in the very heart of the Mexican assemblers, places in which specific advantages, which could not have been perceived by the analyses in terms of comparative advantages, have nevertheless been developed.
41. This leads to the necessity to analyse the functionning of an industry inserted into the world industrial system where the defined rules make it possible or not to participate in world production in an increasing manner.

1.3.2. Difficulties in mastering a high-technology global industry

42. The electronics industry has become a high-technology industry with increasingly large Research and Development activities.
43. It requires a highly qualified workforce, the use of automatic machines and the development of softwares.
44. The need for specific know-how of a highly evolved and cumulative nature constitutes a major barrier to entry.
45. The multiple technico-industrial interactions require the insertion of any electronics production into a well-developed industrial fabric, such as is not offered by many Third World nations.
46. The barrier to technico-financial entry is commercial and is also very high.
47. Finally the world electronics industry constitutes an internationally very convoluted field with highly competitive markets.
48. It may also be tempting to turn towards the few and rare facilities offered by this industry.

1.3.3. The facilities for dependent insertion by way of assembling or copying

49. It is possible, under certain conditions, to advance to local production after dissecting and then copying many electronics goods.
50. More complex assembling remains possible, for a sufficiently large domestic market, within the framework of agreements with the operator controlling the production.
51. International stadardisation or, on the other hand, national specifications, may also constitute facilities for an entry into electronics production.
52. However these facilities are dependent and cannot suffice to transform and to industrialise. It is therefore necessary to envisage a real strategy for entry into electronics.

2. TOWARDS AN INDUSTRIAL STRATEGY FOR ENTRY INTO ELECTRONICS

2.1. What point(s) of entry?

2.1.1. A critical examination of simplistic responses: softwares and ASICs

53. Third World countries could have a comparative advantage in software production.
54. Abundant qualified and skilled personnel would make it possible to develop software without producing the hardware.
55. In fact qualified and skilled manpower is not really abundant and only applications software could be considered outside the production of hardware, but with its use.
56. Even a country like India only has modest prospects, and the most remarkable of these are linked with the support of a foreign multi-national firm which produces the hardware.
57. In fact the barriers to entry are very significant.
58. This can be illustrated in the field of software for micro-computers.
59. The software option is therefore a difficult one and not really optimal for an industrial strategy.
60. Another option is that of designing ASICs, high-technology integrated circuits in a simplified version and without manufacturing them.
61. The capital investments needed are nevertheless considerable and the levels of training to be achieved are very high.
62. The idea of separating the software activity from the design activity seems to be totally illusory.
63. Softwares and ASICs therefore constitute responses which are too simplistic to give to a difficult question.

2.1.2. Focalisation-articulation requirements.

64. Reasoning of an engineering type would seem to require presence at all points because of the multiple interconnections within the electronics industry.
65. Going back to micro-electronics, or moving on to software, does not solve the problem which is posed.
66. It is necessary to seek a weak link for future mastery: this is the focalisation requirement.

67. At this point priority may be given to those articulations which relate to it.

2.1.3. Complexity level requirements

68. Entry into a high-technicity field involves three stages: the capability to implement the production technique, an overall understanding of the process to be utilised, and technological mastery.
69. The temptation to advance by vertical integration.
70. To devise a system which is linked to one constituent which is already achieved, with others of the same level, forms another route for progress.
71. All depends on the level of complexity. In addition to progressing by integration and by extension it is still possible to progress laterally.
72. The gradation of levels of complexity may be illustrated by that which the international hierarchy reveals on a fully global scale.
73. An example of this gradation is given by Korean difficulties in informatics or telecommunications systems.
74. This gradation applies equally to questions of maintenance (Table VI-8: Evaluation of the levels of complexity and of accessibility of electronics production according to the development levels of countries).

2.2. What tactics?

75. Do not re-invent the wheel.

2.2.1. Recourse to foreign technology

76. Technological dependence is very real in the face of enterprises desirous of retaining their specific advantages. But Third World nations are not alone in this: in 1982-83 Japan had an international trading deficit on licences of more than US$ 11 billion!
77. Recourse to foreign technology may borrow from either the logic of competition or that of cooperation.
78. The "technologies" are not only sold on the market; certain of the constituents are free products.
79. From old technology to the purchase of a licence is one method of rational acquisition.
80. Some examples of where this method of working has given interesting results.
81. International cooperation can develop with private firms.
82. Inter-state cooperation is also provided between the industrialised countries and the countries of the South.
83. and
84. South-South and regional cooperation, organised or not by international institutions, has so far only obtained modest results.

2.2.2. Seeking a level of global competitiveness.

85. In addition to the more technical elements it is necessary to consider the more industrial and commercial elements.
86. Even for a simple component there is value in seeking a level of global competitiveness.

87. This poses the problem of the choice of operators and possibly of their number.
88. This number is linked to the potential of the existing resources and the forecast market for the product to be produced.
89. The requirement to reach a level of global competitiveness is explained in particular by the multiple inter-relationships within the electronics industry which can, however, constitute an advantage.
90. In the case of exporting the requirement is obvious.
91. The search for global competitiveness can go as far as direct investment in the industrialised countries (Korea) (Table VI-9: Foreign investments by the Korean mass consumer electronics industry).

2.3. What tactics?

92. It is essential to define a problem, since the choices of a strategy cannot be made until this has been done.

2.3.1. Rejecting miserable dependence and sordid independence.

93. Escape from the traditional divisions.
94. Be open to the rest of the world.
95. This could lead to a situation of miserable dependence, but to take the opposite path runs the risk of leading to a sordid independence.
96. This would result from a desire to shut oneself off from the rest of the world.
97. A diagram demonstrates the orthogonality of the logics of the world industrial system and the national socio-economic systems (Figure VI-10: The orthogonality of the world industrial system and the national socio-economic systems).
98. It is therefore necessary to attempt to articulate these logics.

2.3.2. Linking a social dynamic to the World Industrial System.

99. Every successful strategy carries at the same time a national brand, that of its national socio-economic system, and a date, corresponding to the state of the world industrial system at that moment.
100. The important criterion is that of the elevation of the technico-industrial capacity of the largest number. The delicate point is that of triggering an endogenous social dynamic.
101. It is therefore necessary to try to organise a modulated and selective opening up to a judiciously chosen target in the world industry.
102. The process of technico-industrial catching up with a world electronics industry and, more generally, of a rapidly evolving world industrial system, together with the progressive elevation of the national capabilities, are the important forms of social transformation, the management of which is difficult and is the field of other disciplines than ours.

CHAPTER I

A DESCRIPTION OF WORLD TECHNICO-INDUSTRIAL EVOLUTION

1. A TECHNICO-INDUSTRIAL DEFINITION OF ELECTRONICS

1.1. The technique

1. What is the object of the component analysis of "technique"? On the evidence technique is materialised in the form of a concrete object and its modes of creation and utilisation: the elementary technical object is the tool. Since the stone age, the age of the knapped flint, evolution has been such that the reference to a given technique cannot, today, be reduced to the defining of a simple tool.

2. More particularly, and after the accelerated advance of technical creativity from the end of the 18th century onwards, any entity recognised and named as a technique in fact covers an assembly or a combination of elementary techniques. This multiplicity has a reality which is in fact very old. For example in the neolithic age the technique of coating with plaster was acquired, but this required the mastery and combination of many elementary techniques: finding the gypsum, breaking it down by fire, producing the correct mix with water so as to ensure that it would crystallise, applying it at the right time and in the right way, and so on. It is therefore preferable to consider the concept of a technical complex under the definition given by B. GILLE (1978, p.17): "contributory techniques of which the whole, that is to say the combination, combines to produce a well-defined technical act". The technical act is at the same time the creation of the technical complex and the utilisation or activation of this for the benefit of Man, the actor, and to the detriment of Nature, the environment on which it acts.

3. Technique is a kind of three-dimensional corner which Man digs into Nature. Its three dimensions correspond to the three lines which intelligent human action must follow in order to oblige Nature to serve Man: with a certain force, exercised on matter, and a physical displacement, more broadly informational, Man transforms Nature to his own benefit. Without always specifying what constitutes the unit these three dimensions are frequently invoked, in at least a separated manner, by calling them ENERGY, MATERIALS, and COMMUNICATION. History has seen these three dimensions contribute towards a mastery, a more extensive, deeper and more profound transformation of nature with its consequent effects of size, both gigantism and miniaturisation, and of manipulability, both targetting and speed of execution, the whole normally being reflected in a relative increase in power.

1.2. From technique to industry

4. Technical power thus constitutes a potential for the transformation of nature which, according to the more or less extensive usage of the technical complexes of which it is composed, is reflected in the industrial power of production. The technical act is only accomplished by making the production of an object intended to procure satisfaction a concrete reality. In this sense technique is indissociable from industry, the latter constituting the implementation of the technique in order to produce. This close relationship between technique and industry did not pose any problems in earliest times where the terms "industry" and "technique" were used indifferently to qualify this or that sub-period of the palaeolithic or neolithic periods.

5. By contrast , and for reasons linked to the context of more recent times (1), it is necessary to specify the content of this close relationship between technique and industry and, initially, to underline the existence of a field of autonomy for the dynamism of technical creation which is effective, although obviously delimited. This autonomy is principally served by a "gratuitous" and systematic curiosity, by the desire to find out more. Supported in this manner by the existing technical content of a complex, and also by that existing in other complexes, technical creativity is expressed in the improvement of existing techniques, by the superimpositions of new techniques or by the replacement of certain techniques by other techniques, newly invented or borrowed from different technical complexes. Without the need for precise solicitations external to a given technical complex, a deep trend towards the search for technical improvements underlies the dynamism of technical creation in each of them.

6. This dynamic, endogenous to the technique, is laid down on privileged lines of evolution which historians of techniques have been able to identify. As a result of the work by J.L. MAUNORY (1968) on the genesis of innovations the two principal French historians of techniques have, in the case of one of them, emphasized a mode of technical creation with "relationships by lines" (M. DAUMAS, 1979, p.xvi) and, in the case of the other, the fact that innovation "is located on a given technological line" (B. GILLE, 1978, p.40). From this point onwards the historian can reconstruct what it is possible to call a veritable genealogy of techniques.

7. However to go beyond the simple description of this genealogy which would appear, without a readers' guide, to be a superb example of entanglement, it is necessary to arm oneself with a number of concepts. The first is that of mother-techniques, those which are particularly prolific. One such example is the cylinder-piston assembly: from the water-pump to the steam-engine, passing through the air-pump and going on to the internal combustion engine, one finds a progressive progeny, all starting from the same technical principle. Around a mother-technique is organised an increasingly sophisticated technical complex, calling on multiple contributory techniques.

---

(1) This is explained below, in paragraph 14.

8. Secondly it is necessary to consider the concept of the technical trajectory; this can be found in much of the work of the SPRU (University of Sussex, UK), but it corresponds directly to the "technical line" found earlier in the work of the French historians (2). This concept underlines the existence of a certain autonomy or, to put it another way, of a minimum of determinism linked both to the structure, still poorly understood but pre-existent, of that Nature into which one wishes to excavate an "improved" corner, and to the present state of the corner. This determines at any given moment the privileged directions of evolution: indeterminism is not total, and totally external choices for determining technical evolution may prove to be aberrant (cf. Lysenko).

9. It is clear that the mother-techniques themselves develop along technical trajectories which may be multiple, linked to the technical complex which they organise, and giving rise, at successive and more or less distant historical moments, to veritable clusters of technical innovations, to follow the very early concept of J. SCHUMPETER (1912). So, looking again at the cylinder-piston example, it is possible to emphasize the multiplicity of the technical trajectories of internal combustion engines and the cluster of gas engines, petrol engines and Diesel engines, and those for cast iron, involving the open-hearth furnace and the acid and basic Bessemer converters.

10. Finally it is necessary to use the concept of the pervasiveness (3) of a technique. Certain technical trajectories may lead a mother-technique to give rise to techniques which are contributory towards a very wide variey of existing technical complexes. B. GILLE (op. cit.) speaks of technological transfer and diffusion, M. DAUMAS (op. cit.) of "the pervasiveness which makes them able to contribute towards all" the technical complexes. This pervasiveness constitutes a powerful factor for the homogenisation of the totality of the technical complexes, a totality which, if it were to be possessed of true evolutionary autonomy, could be erected into a technical system (4).

---

(2) B. GILLE has in fact spoken of a "filiere technique". This term has not been used for two reasons: 1) there is no accurate translation of it in English or in Spanish; 2) it is often confused with "filiere de production", or production route (or productive transformation route).

(3) [Author's own English translation of "fluidite"]

(4) This is what B. GILLE felt able to do, but without making reference to a definition of the concept of the system which was in conformity with systems analysis.

1.3. From technical progress to technological progress

11. In fact technical evolution necessarily passes through its interaction with industry since, as has already been pointed out, technique and industry are indissociable (cf. 4.). The technical complex clearly only exists when it is activated, and the activation of this technical complex is reflected in an act of production, an industrial act. The homogenisation of all the technical complexes and their progress certainly passes, in the case of a not negligible proportion, through a comparison of the levels of technical performance to which the transfer of new and contributory techniques gives rise. But this takes place even more by way of the resolution of the tensions revealed between the industrial acts which the various technical complexes permit.

12. These tensions may consist of quantitative or qualitative distortions. We may take an example of fairly contiguous industrial acts where the tensions and their stimulating character in regard to technical progress are obvious. At the beginning of the 19th century the British firm Horrocks, Miller and Company in Preston employed 700 cotton spinners in its four mills with 7000 weavers working in their homes: the distortion in terms of quantity or "productivity" showed the "backwardness" of the weaving technique as compared with that of spinning. Compensation for this was achieved by the multiplication of production sites; whilst the new organisation for implementing the spinning technique seemed to be of more interest to some the pressure of progress in the technique of weaving was much greater than that which would result from a situation of "autonomy". At the same period the bleaching of the fabrics also showed a backwardness, but this was difficult to compensate for since the technical act required for its implementation considerable quantities of milk with constantly increasing areas of the fields and of days in the sun. In the same way the distortions in terms of quality could not, in general, be compensated for. Still in this same economic field one should note the inadequacy of the techniques for printing the fabrics. So, here and there, strong industrial stimulants towards technical creation tended to focus the attempts. Without determining the technical evolution they therefore encouraged progress in one technical complex rather than another, or even encouraged the putting into use of one improvement rather than another, in this way moving towards a selection of techniques (A. MOUNIER, 1974).

13. In addition to this example it is necessary to accept that the interactions between industrial acts (5), and the tensions which may arise from them, nourish to a considerable extent the interactions between the technical complexes which underly them, thus constituting a fundamental factor for homogenisation. All the technical complexes

---

(5) It will be recalled (cf. 4) that the industrial act becomes a reality in the production of an object procuring satisfaction, for which a social value is recognised. This obviously plunges every industrial act into a larger social reality. We will not be examining this relationship here, as it has already been done elsewhere (cf. for example HUMBERT, 1988a).

are thus homogenised and evolve on the occasion of their being put into interactive use by industry; it is thus the existence of a technico-industrial system which has to be conceived. The totality of the coherences and liaisons which make a system viable are concerned with the techniques and their implementation, and what B. GILLE (op. cit. p.19) describes is clearly the rough sketch of a technico-industrial system.

14. Furthermore it should be noted that, since the end of the 19th century, a new trend has blended technique and industry into a single unity, the latter soon absorbing the former. In former times the act of technical creation simultaneously elaborated the industrial act of production. The advance of rational thought, in particular with the Greeks and then in Europe from the 13th century and certainly from the 17th century, entered into the field of technique. From philosophy to mathematics, the extension of the object of rational thought enabled us to pass, for example with A. de LAVOISIER (1743-1794), from alchemy to chemistry. One can therefore see, over several centuries and in a fairly independent manner, technical know-how, the technicians' art of production, cohabiting with scientific knowledge, the world of inventions and inventors. This separation between know-how and scientific knowledge was accompanied by a chronological time-lag between these two types of knowledge in progress towards identical concrete objectives. It has often been emphasized that the inventions or discoveries made by scientists (electricity, for example) had to wait for their practical application until technical conditions allowed it: conversely one can cite the introduction of innovations without scientific knowledge, as with the steam-engine which operated well before CARNOT set out the principles of thermodynamics.

15. The interaction between these two orders of knowledge then started up and became fertile. In the 19th century progress in the bleaching and dressing of fabrics was due to chemists and in particular to their discovery of chlorine, whilst the advances in the cast iron complex and of coal tar distillation at coke-works, provided the scientists in this discipline with the birth of organic chemistry. In the 19th century there was a progressive convergence between the fields of techniques and of science, a convergence in their utilisation in the service of man by way of industry. As an example relating to the premises of this convergence we may cite the fact that BERTHOLLET, the French chemist, was appointed in 1784 as the Director of Dyeing at the celebrated Manufacture des Gobelins and published in 1794 a book entitled "Elements de l'art de la teinture" (Elements of the Art of Dyeing). This was truly one of the first accounts of technology, that is to say a scientific examination and analysis of a series of techniques and their use in industrial acts. The know-how became intimately linked with science and science with doing, so technical progress became merged into technological progress. At the same time the magnitude of the organisation of industrial acts led to a search for mastery or, at least, the stimulation and selection of technological progress. For example "In the iron and steel industry it is known that it was the Holtzer company which, with Boussingault and Burstlein, organised in 1869 the first steelworks laboratory intended to create the first special steels" (op. cit., p.74). Thus technique is found to be almost absorbed by industry and so definitively justifies the concept of the technico-industrial system (6).

1.4. The three ages of the technico-industrial system

16. A stable technico-industrial system is thus based on a homogenised and viable grouping of technical complexes; viable here is to be understood in the sense that those tensions which may appear between the multiple industrial acts find their resolution within this grouping. At the heart of the technico-industrial system will be found, at least in a definitive manner after the 19th century, "the machine" rather than the simple tool, and it is with this that must be undertaken the essential operation of the transformation of nature with the three dimensions which have already been identified: energy, materials and communication. The industrial era is the era of the machine. The machine, the key-element in the transformation of nature by man, is thus seen as the target point of an accumulation to produce more objects in a more efficient manner and the technical support around which industry organises production. This machine must obviously be integrated within a stable technico-industrial system. Such a system corresponds to a homogenised assembly of technical complexes, achieved by the resolution of any tensions between the multiple industrial acts.

17. But it must also be noted that this assembly of technical complexes can be found to be awaiting a new homogenisation when a technique of very high pervasiveness appears at any point whatsoever of this assembly. In effect this is liable to provoke the efficacious recomposition of a very large number of technical complexes. Such a technique constitutes a control point in the technico-industrial system: as the factor making the grouping of technical complexes homogeneous and viable the time of its pre-eminence is also that of the stabilisation of the recomposed technico-industrial system.

18. Since the advent of the industrial era at the start of the 19th century we can distinguish three ages of the technico-industrial system (cf HUMBERT, 1984, pp. 74 et seq.). The first age is that of steam, the introduction of an artificial form of energy to drive the steam-engine which could then actuate machines; the technical principle of this is still found in petrol engines. The amount of horse-power available to any nation is the yard-stick by which its place in the industrial hierarchy of nations is measured. Steam-engines penetrated into all industrial activities, so that steam is incontestably the control point of the first technico-industrial system. Its construction dates from the end of the 18th century, the date of the major inventions (1787). It is the epoch of emerging industry with a machine which is the product of a truly autonomous industry, the engineering industry. Until then machines linked with industry were built in a specific manner at the "factory" or "mill" of production, the two words being synonymous in English.

---

(6) However the autonomy of technique in relation to industry, as defined in paragraph 5, evidently still exists; this is shown by frequent criticisms made by executives in industrial companies that research workers in their laboratories are often felt to be too little concerned with industrial problems.

19. Steam continued to be used for a long time, up to the start of the 20th century; however a technical leap, in a new field which was to be revealed as of very high per[illegible]eness, took place in the middle of the second half of the 19th century. It was at this moment that steel, a material which had been known for a long while and the production of which had been the object of numerous improvements, showed its true importance. The inventions of Bessemer (the acid converter of 1856), of Thomas (the basic converter of 1879) and Martin (the open-hearth furnace of 1865) led to processes which were exclusively used up to the middle of the 20th century and which allowed the rise in the power and quality of the iron and steel industry. This quality was to be reinforced by the advance in special steels containing chromium (1877), manganese (1882), nickel (1888), etc. In fact from the last quarter of the 19th century and practically up to the fifties industrial power was now measured in terms of steel production. This rise in power is also reflected in the phenomena of concentration and the increasing size of firms. It was the epoch of heavy and concentrated industry and of the management of large works where efforts were made to coordinate the activities of the machines. It was at the moment when production line working appeared and developed that the technician was replaced by the engineer. On the demand side the auto-consumption of the age of steam was replaced by the development of the open market, but external markets had constituted an essential factor for the developing industries, particularly for English cotton textiles. In the age of steel heavy production experienced a remarkable rate of growth, but the demand of the populations remained that of consumer goods. Within the national industrial spaces there was established an effective national regulation which returned an important place to the domestic demand which was gradually saturated in terms of food products and then developed its consumption of semi-durable and durable goods. The following diagram summarises the principal characteristics of the different ages of the technico-industrial system and, in particular, that age in which we live today.

Figure I-1 : THE HISTORICAL DYNAMIC OF THE TECHNICO-INDUSTRIAL SYSTEMS

		L'âge de la vapeur	L'âge de l'acier	L'âge de l'électronique	
Période Approximative Année centrale	Avant 1750 ?	1740-1840 1790	1830-1930 1880	1920-2020 1970	2010 et après ?
Organisation industrielle	La préindustrie La machine construite sur place (le moulin).	L'Industrie naissante La machine-produit moteur à énergie artificielle	La Grande Industrie Industrie lourde concentrée diversifiée L'atelier de machines coordonnées La chaîne construite sur place	L'Industrie Totale Industrie intelligente managériale Les machines miniaturisées et les machines ateliers-produits	L'Industrie Maîtrisée L'Industrie flexible des Biens et Services Le Travail au foyer
	L'artisan	Le technicien	L'ingénieur	Le concepteur	
Energie	Naturelle animale eau, vent	VAPEUR (gaz) artificielle (naturel transformé)	Electricité (naturel scientifique) (micro-nature utilisée)	Nucléaire (micro-nature transformée)	Solaire (naturel)
Dimensions techniques Matériau	Naturel bois, pierre	Charbon Fer (mélange naturel)	ACIER Aciers spéciaux Pétrole Carbochimie	Composites et synthétiques (artificiels) → pétrochimie	Biochimiques (micro-organismes domptés)
Communication physique	Cheval	Canaux Ballons Bateaux à vapeur Chemin de fer →	automobiles → dirigeables → avions →	Fusées Satellites	Stations orbitales permanentes
Information	Plume	Sémaphore Vitesse → 20 km/h	Télégraphe MORSE TSF-Téléphone Radar → Télévision → Machine à écrire → Linotype Vitesse → >100 km/h	ELECTRONIQUE Manipulation de signes Traitement et Transmission instantanés → Stylo-bille, feutre Vitesse → max.	?
Demande adressée aux appareils industriels nationaux	Autoconsommation de survie Ruralité dominante	Consommations extérieures Biens de consommation alimentaires et textiles Alphabétisation → Urbanisation →	Consommations intérieures nationales Biens de consommation semi-durables durables → Enseignement secondaire →	Demande mondiale Investissements en logements Services → Santé-Culture Loisirs Enseignement supérieur → Mégalopoles	? ?

Source : M. HUMBERT, GERDIC, 1983, p. 77.

1.5. The age of electronics

20. A new technical break, orchestrated by a technique which was again characterised by its very high degree of pervasiveness, was to be produced in about 1971, the date of the invention of the microprocessor by the INTEL company (USA). It was no longer the mastery of an energy or of a material which constituted the control point of the technico-industrial system but mastery of a means of communicating information, the manipulation of a signal or of a code. This is the age of electronics, the structure of which will be shown later (cf Table I-2). M. DAUMAS locates "the technological turning-point of the century" round about "1920-1940" (1981, p. 111) and B. GILLE wrote in 1978 "An already new world. Everyone is conscious of the extraordinary transformation provoked by the new techniques.... In many fields electronics is really one of the fundamental elements in the new technical system."

21. The electron was discovered in the closing years of the 19th century; however it was necessary to wait until 1920-1930 for its real value to be recognised by industrialists and engineers, and even until the sixties to receive the homage of the mass public. According to the Encyclopaedia Unversalis electronics is "all those techniques which utilise variations in electrical parameters (electromagnetic fields, electrical charges) to sense, transmit and process information" (Vol 6, p. 57, 1970). This definition is the most pertinent of those which can be found since, if it is neither perfectly technical not exclusively industrial, it is technico-industrial. Electronics, the electronic technique, is made available in the service of the processing of information, of a signal, and of its manipulation: storage, combination and transmission. And the "total pervasiveness of electronics" (cf. M. DAUMAS, 1981, p. 125) does not relate exclusively to the electron. It relates to the fact that our sophisticated technico-industrial system has an imperious need for information, for all that the management and execution of the industrial tasks demands, in all the technical complexes and between them, in regard to the transmission, storage and processing of information, whether data or messages. The electronic technique will, by virtue of its progress, revivify all the activities by extending to them an extraordinarily increased efficacy and power. On the evidence this clearly leads to a situation which has broken away completely from that of the age of steel; a new control point on the technico-industrial system has been created: electronics. The new tool is obviously the electronic component which arrived at is maturity around 1970, homogenising the entire field of information processing and leading, through the perfect pervasiveness of this technique, towards a new stability in the technico-industrial system which, for the time being, is recomposed into the age of electronics.

2. THE STRUCTURING OF THE AGE OF ELECTRONICS

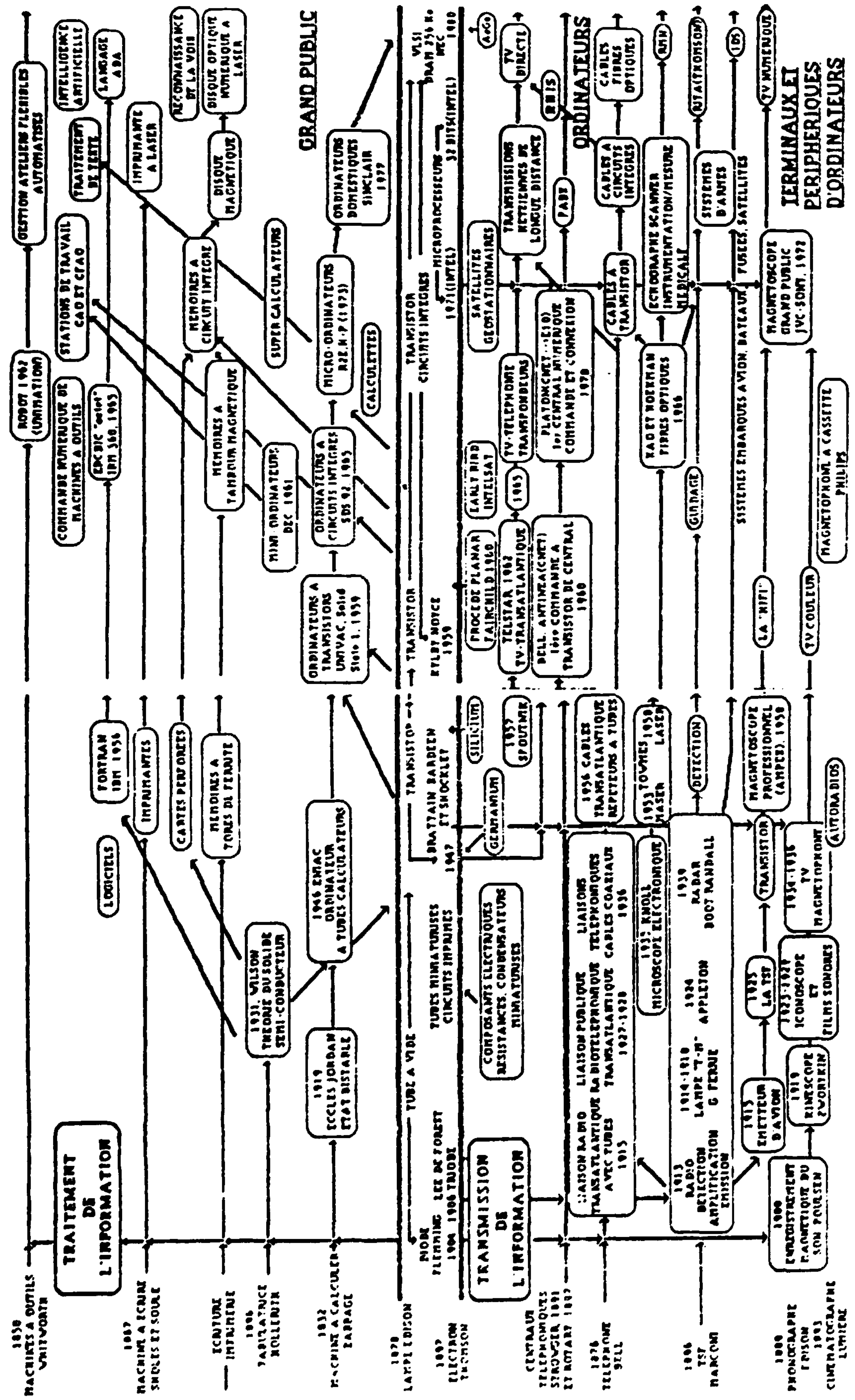
22. Electronics forms a technico-industrial complex which is gradually constituted around a mother-technology. The interactions between the industrial acts to which it contributes and the supports provided by the contributory techniques to lead to new fields of production are articulated around this mother-technology. To transmit or amplify or, in a word, to manipulate a signal, "an element of information" which consists, potentially, of any complex form of information, whether a written or spoken message, a fixed or moving image, with sound or colour or in relief, pose technical problems which electronics solved with vacuum tubes and then with increasingly miniaturised and sensitive transistors: today it is possible to produce in the laboratory a transistor which reacts to the passage of one single electron in less than a millionth of a millionth of a second! (7)

23. At least some of these problems had already been faced, using mechanical and then electromechanical techniques, giving rise to concrete solutions, linked with clearly distinct industrial acts. From the beginning of the 20th century it is possible to distinguish between two technico-industrial sub-fields: on the one hand the transmission of information and on the other the processing of information. These both have in common the fact that they have been able to find, using the same mother-technology of electronics, part of the solution to the identical problems which they face and then to call increasingly on identical contributory techniques, such as magnetic storage, and to cover the same new technical complexes of space, instrumentation, etc. The advance of the mother-technology has led gradually to the unification of these two sub-fields which are now very difficult to distinguish one from the other. So, in order to define which of these constitute Value Added Networks (VAN) it is necessary to specify that the latter consist of information transmission networks which carry out, simultaneously, the processing of this information in such a way as to add value to it. The following diagram provides a historical panorama of the technico-industrial evolution which is described in the following paragraphs and which will demonstrate a process of structuring in four phases.

---

(7) An elementary circuit consisting of two submicronic layers of aluminium deposited on each side of a layer of aluminium oxide with a thickness of a few tenths of an Angstrom (engraved at 0.05 micrometres). The circuit at the ATT Laboratories operates in less than one pico-second at the temperature of liquid helium (CPE Flash, 16/5/1988).

Figure I-2 : ELECTRONICS, 1904-1984



2.1. The birth of the electron as the origin of a prolific mother-technique

24. In the transmission of information a first major advance making it possible to go beyond visual signals or the mail was the electric telegraph of MORSE in 1843. It may be seen that, from this first step, information is linked with elecricity. Networks were installed throughout the industrialised world with their great servants, the corps of telegraph engineers, followed by the telephone of G. BELL and E. GRAY (1876). The networks became international with a first submarine cable linking Dover to Calais in 1851 followed by a transatlantic cable in 1866 so that Europe and America could communicate without any delays. The techniques of sending and receiving were progressively improved together with the cables, due to the work of the French Emile BAUDOT (1874). His five-unit code is still used in the transmission of written messages by telex, where the code is translated into electrical pulses. At the same time the theoretical work of MAXWELL (in particular his 1873 treatise on electricity and magnetism, supplemented by the work of HERTZ and in particular his verification in 1888 of the existence of electromagnetic waves which moved without the need for any conducting material (through the "ether", as it was believed at the time) was to open the way, with the aid of a series of inventions, to an innovation which would rapidly be seen to be fundamental. After Edouard BRANLY had developed his coherer, or wave detector, in 1890, there were few problems to be solved (such as antennas) in order to develop wire-less telegraphy or wireless. In 1895 MARCONI succeeded at Bologna in transmitting a message on a Morse tape over a distance of 2.4 kilometres; after a whole series of improvements he achieved the first transatlantic transmission in 1901 over 3400 kilometres between Cornwall and Newfoundland. The forces, and in particular the navies, stimulated and supported technico-industrial progress in this field.

25. The processing of information involved initially the writing of messages, the technique of which was greatly improved with the birth of the typewriter, the first industrial model of which was produced by REMINGTON (1876). This was one of the first office machines which were very soon to become indispensable. It took a long while to develop accounting machines to process information consisting of data, since the machines of PASCAL (1642) or LEIBNITZ (1671) were not operational. The machine invented by BABBAGE (1834), which solved many problems, would have used the perforated cards developed by JACQUART (1801) and to have had a memory, but it was never really built. It is true to say that at that time the needs for accounting calculations were relatively modest, and even scientific calculations were of reasonable dimensions. Research was not therefore really stimulated by industry and BABBAGE's invention remained under wraps for a long while. By contrast when a field appeared where the mass of data to be handled encouraged technical progress the latter was soon achieved. This took place in a field where the public authorities were involved. On the occasion of the 1890 Census in the United States the Bureau of Censuses launched a call for tenders and the electromechanical system for tabulating perforated cards developed by H. HOLLERITH made it possible to complete this census in three years instead of seven. The way was open for the electrical processing of information.

26. This situation, which prevailed in the various fields of information where electricity played a role which was already essential, was to find itself greatly disrupted and undergoing a first phase of structuring with the birth of the electron. The name is due to the English physicist STONEY (1874), but the demonstration of its existence had to wait for J.J. THOMSON in 1879 and J. PERRIN. The work of J.J. THOMSON was to explain a phenomenon observed by EDISON in 1883 in the incandescent lamp which he had invented in 1897; this was the bluish light between the electrodes (anode and cathode) of his lamp, and the electric current which was detected, later termed the thermo-ionic or thermionic phenomenon. FLEMING, who worked with EDISON and also with MARCONI, developed the first vacuum tube, the diode, in 1904 which could be used as a detector. Lee DE FOREST in 1906 added a grid and obtained the triode which, apart from being a better detector, could also be used as an amplifier and could, for example replace, with the flexibility of total variability, the electromechanical relays which had until then been the only known means of controlling the action of more powerful machines. The sub-field of information, and particularly its transmission, were to benefit very rapidly from this remarkable progress.

27. From 1915 onwards the triode was to serve, under the influence of ATT, as an amplifier, a relay and as a rectifier on telephone lines and then, as a result of the possibility of using it to construct sustained wave emitters and the development of methods for the modulation of these waves by amplitude modulation in 1915 (and frequency modulation in 1933) and also for their reception (by the heterodyne technique in 1917), it became the origin of mass broadcasting, regular transmissions of which began in 1924. There was no comparable effect, during the first decade of the century, on calculating or tabulating machines. However in 1919 with ECCLES and JORDAN the technique was offered a scheme for a twin-state memory. This, associated with the binary system introduced by the French Louis COUFFIGNAL (1936) in his projected machines (electromagnetic, with the Logabax company), formed an essential element in future computers.

28. This first phase at the start of the century was, at the same time, the birth of the various fields of information handling using electricity, the birth of electronics which was to fundamentally alter the possibilities for its transmission and, potentially, its processing, and finally the great support given by the public authorities, in particular the forces, in developing techniques and in industrial production. However it must not be imagined that private firms were absent from the scene: on the contrary it was at this very time that firms were established which, on a global scale, became rivals and collaborators and which are, for the most part, the origins of the existing major firms, sometimes as a result of detours but mostly in a direct line. Mention has already been made of the names of EDISON, BELL, REMINGTON and MARCONI (EMI) who were both inventors and industrialists, and American Telephone and Telegraph (ATT) are all well known. One may also cite the leading enterprises in the electrical industry which rapidly developed in the United States. Capitalist inventor-industrialists were at the origin of these: Thomas EDISON, Elihu THOMSON, Edwin HOUSTON and George WESTINGHOUSE: Thomson-Houston came into bitter competition with the other two but finally merged with Edison in 1892 to form the General Electric Company which then found itself facing Westinghouse with which it signed agreements. It was General Electric which formed the Radio Broadcasting Corporation of America (RCA) in 1919 to market radio receivers manufactured using its patents. ITT was formed in 1925 when ATT and its production subsidiary Western Electric had to relinquish their international operations.

In Europe the company of the SIEMENS brothers , together with Philips Gloeilampen NV (in which GE held 17% of the capital in 1935), like practically all companies apart from the Swiss Brown Boveri company, signed cross-licences with the American companies to share out the world market. The latter also have fairly large investments in Europe. The Deutsche Edison Gesellschaft (German Edison Company) was the precursor of AEG in Germany, and around 1910 the General Electric Company in Great Britain became independent of GE which had founded it; in 1892, the year in which GE was formed, the Thomson-Houston International Company (created around 1888), after having established British Thomson-Houston, signed an agreement with the French company to operate the Thomson-Houston processes in France, leading to the creation of the French Thomson company, the only company left today to perpetuate the name of the American inventor.

29. In the field of data processing with tabulators there appeared at the start of the century the principal participants in a global oligopoly which still continues today. The company founded by HOLLERITH in 1896 had to merge with others to meet the competition. It became IBM in 1917 after being headed by F.N. KONDOLF who was subsequently to become President of Remington Typewriter (a subsidiary of Remington-Rand) and then by G.W. FAIRCHILD, who founded and gave his name to a celebrated semiconductors firm: under his chairmanship the director in 1914 was T.J. WATSON who came from NCR (originally manufacturers of cash registers), and so on. The principal rival company when the Hollerith patents (1909) came into the public domain was Powers, also to be bought by Remington-Rand (which became the mechanographic division of Sperry-Rand). At the end of the twenties it held 25% of the world market compared with 75% by IBM, which already had production subsidiaries in 54 countries(!) The directly competitive companies (such as the British Tabulating Corporation in Great Britain and Machines Bull in France) are small and few in number, and the existing firms in related fields - such as NCR in cash registers or Burroughs in accounting machines - do not now attempt to penetrate this market. In total therefore one may consider that there is a real technico-industrial complex with its mother-technology and its industrial actors who are responsible for utilising and developing it in liaison with the extension and development of both the contributory techniques and also the fields of application.

2.2. Advances in the transmission and electronic processing of the signal (1925-1955)

30. The first point to be noted during the second phase of structuring is the birth, at the beginning of this phase, of what will subsequently be termed mass consumer electronics (MCE). From the time of his work in 1897 J.J. THOMSON had used a device which consisted of a cathode tube which projected electrons onto a phosphor-coated screen; considerably improved this became the receiver tube of television sets, but the emission posed the inverse and unresolved problem: the transmission of images. The French scientist BELIN was a precursor in the transmission of images by line (the Belinographe, 1907) and his system for transmitting photographs using lamp amplifiers became universal during the thirties. The wire-less transmission of images involved the iconoscope which the Russian emigre ZWORYKIN developed in 1928, and the first experimental television programmes were broadcast in England in 1929, with the first permanent transmitter being used from London in 1936. The recording and reproduction of sound, and not only of images, had made important advances from the position at the beginning of the century, mainly due to the techniques of amplification. EDISON developed his wax cylinder phonograph in 1889; Louis LUMIERE and he produced their first cinematographic

films between 1893 and 1895. These obviously borrowed from the long photographic tradition but mainly called on the process of a photographic film on a roll of G. EASTMAN (1884) who produced the first "KODAK" in 1888. By 1930 the electrophone (the name patented by Thomson) and the electromagnetically cut disc were widely used, and the sound cinema supplanted the silent cinema, in part due to Lee DE FOREST. In fact the magnetic recording of sound was also to advance; the considerable improvements in the process which POULSEN had presented in 1900 were slightly held back by the dynamism of the phonograph, but after MARCONI tried to buy the STILLE process, which used a steel strip instead of a wire, the collaboration in Germany between a chemical company (I G FARBEN) and an electronics firm (AEG) resulted in the development of a system using a substrate of a synthetic material coated with a magnetic track, and by 1934 the tape-recorder was functional.

31. Other progress in respect of the valve (or "tube") was to reinforce the so-called industrial electronics and, in particular, that intended for military equipment. Worthy of note are the velocity modulation and resonance valves which were to result by 1939 in the Magnetron of H.H. BOOT and J.T. RANDALL which was the direct origin of Radio Detection and Ranging or RADAR. The world conflict clearly encouraged much progress in this field for land, sea and air detection. A first interaction with space, which will be amplified during the third phase, should be noted here. Aviation was to make considerable progress as a result of the conflict. The V1 of 1941 was a jet-reactor and the Germans had, by 1945, the first operational turbo-reactor aircraft whilst the first rocket was the first ground-to-ground missile, the V2. These developments provided great industrial support to the techniques of information transmission, which were themselves advanced by the impressive efforts made during the war.

32. It was also space, but above all the war and the huge computing needs of the United States Army, which made it possible to take a major step forward in the processing of information and to make a real entry into the electronic era. W.J. ECKERT developed the IBM tabulators, mainly from 1934 onwards, at Columbia University; at Harvard University H. AIKEN worked in the same direction and, with the aid of IBM, built the MARK calculators; Mark I, which was operational in 1944, operated up to 1959 and was first of all used to carry out secret calculations for the US Navy. H. AIKEN and IBM then followed separate paths. The latter, with help from ECKERT, built the SSEC (Selective Sequence Electronic Calculator) which was not entirely electronic. For reasons of reliability classical electromagnetic relays were preferred for this machine which was completed in 1948. All this research work, including the previous work of the German Konrad ZUSE, who produced the first calculator with a recorded program in 1941, or that of BELL who tried to assist in firing computations with a programmed calculator in 1946 (his 1943 calculator was used by the Navy up to 1961), demonstrates the intense pressure exerted by the calculations which were needed for studying the profiles of aircraft or ballistics firing tables. It was the efforts made by the US Army which was to permit the passage from mechanography or electromechanics to the fully electronic machine, the computer. At the Moore School of Electrical Engineering in the University of Pennsylvania, and in conjunction with the Ballistics Research Laboratory of the US Army, John MAUCHLY and J.P. ECKERT proposed in 1942 and again in April 1943 to build a digital electronic calculator. The object was to solve numerically the differential equations of the type encountered in ballistics problems, and amongst the techniques envisaged are the use of bistable circuits of the Eccles and Jordan type as memories. With considerable reticence the US Army financed this project which was very expensive at that time (US$ 400,000). By June 1944 a first adding machine had been produced, capable of adding 5000 10-digit numbers a

second, a thousand times faster than anything which was possible up to that time. A first complete computer, known under the project name ENIAC (Electronic Numerical Integrator and Computer), was constructed at the end of 1945 and commissioned in 1946 (with improvements it was used up to 1955) by the US Army. Its defect lay in the time needed to pose the problem to be solved since programming required the manual shifting of a large number of plugs. The ENIAC group, in which von NEUMAN particpated from the end of 1944 onwards, invented the modern method of recorded programming. ECKERT and MAUCHLY left the University to found the Electronic Control Company: its first product (the BINAC for the Northrop Aircraft Company) was not a success, but the second, UNIVAC 1, which was delivered to the US Administration in 1951 for census purposes, merits attention for two reasons. Firstly there was the fact that, lacking finance to build it, the inventors offered to sell it to three firms: IBM found it uninteresing, National Cash Register hesitated for too long, and it was Remington-Univac which purchased it, so ensuring that this company retained 100% of the world computers market up to 1954. Secondly there is the fact that UNIVAC 1 had no really superior successor until we arrive at the third stage of structuring of the age of electronics.

2.3 The mastery of an irradiating technique (1955-1985)

2.3.1. The micro-electronic basis

33. A third phase of structuring occupies about thirty years which may be centred around 1970. It allowed the electronics technique to achieve perfect pervasiveness which first of all led to the complete electronisation of information handling and thence to its processing and transmission under extraordinarily improved conditions. This pervasiveness was acquired principally by the miniaturisation and densification of signal processing: using increasingly reduced volumes it was possible to obtain processing capacities which were multiplied to a considerable extent. The vacuum valve in effect gave way to a triode on a solid semiconductor (germanium): the transistor (BARDEEN, BRATTAIN and SHOCKLEY) appeared in 1948 and resulted in a fundamental evolution in the nature of the component. However it was necessary to wait until 1959 for the first entirely transistorised computer. (8) In this same year R. NOYCE at FAIRCHILD (subsequently he founded INTEL) and J. KILBY at TEXAS INSTRUMENTS developed the first integrated circuit, the manufacture of which was to be facilitated by Fairchild's Planar process (1961). What was involved here? The principle of the transistor remained much more reliable than the valve; very much less voluminous it gradually became microscopic. On a semiconducting substrate (of silicon from 1954 onwards), a few square millimetres in size, are integrated several transistors between which a circuit is etched, linking them together to produce a connectable logic unit: this is a component which is no longer single, which is "discrete" but complex, equivalent to a printed circuit board. Its presentation, embedded in a kind of black resin domino from which emerge the connecting lugs, explains its name of "chip". First of all this method was used to produce the "memories" which retain information given to them in the form of a string of "bits" (binary digits), that is to say a succession of numbers which are either 0 or 1 according to a base of 2, each of these strings having its own "address" in the memory.

---

(8) However "transistor" radios appeared at the beginning of the fifties, ten years later "Hi-Fi" and colour TV had arrived; by 1972 we had the mass consumer tape-recorder, with the increasing utilisation of electronic components in these.

34. The frst integrated circuits contained only a few transistors and the term SSI (Small Scale Integration) was therefore used to describe them. By the end of the sixties integration had become medium (MSI) and by 1970 memories were available for storing 1000 bits, or 1k memories (9). At the beginning of the seventies integration was spoken of as being large-scale (LSI), the chips containing tens of thousands of transistors, and integration would seem to be doubling every year, as was predicted by G. MOORE (of INTEL) in 1964. Memories were holding considerable amounts of information: 4k in 1973, 16k in 1976 and 64k in 1978. The end of the seventies saw Very Large Scale Integration (VLSI) with nearly a hundred thousand transistors on one chip. The component is no longer just a component when the unit of definition consists of several tens of thousands of simple elements, so why not interconnect them into a complex circuit? The American INTEL firm decided to do this in 1971 and produced the first microprocessor. This was a real miniature machine for processing information: it can store data, be programmed, call for inputs, effect outputs and, obviously, execute the programmes using a central processing unit of the type used in computers. Continuing progress on this mother-technology gave us, in 1985, microprocessors operating on 32-bit words with 256 kbit memories. One can therefore produce micro-computers which, with several chips, can be carried in an attache case but are hundreds of times more powerful than the IBM 650 which came out in 1955 and which was, in current Dollar terms, a hundred times more expensive! The chip may therefore be regarded as one of the basic bricks of an electronics construction industry. It involves the building of machines to process information, and the following diagram summarises this situation which results from interactions between fundamental research in university laboratories and firms, but also between the military-aerospace programmes of the public authorities, mainly those in the US, and the competition which exists between the firms.

---

(9) 1 kbit = 2^{10} bits or 1024 bits, read as "one kilobit".

Figure I-3 : ELECTRONICS CONSTRUCTION IN 1985

"HARDWARE" — "SOFTWARE"

Source :

M. HUMBERT, 1988, p. 26.

LA PUCE : Brique de base du traitement de l'information

Au coeur d'une microplaquette de silicium (1 cm²) sont générés par dopage microscopique d'impuretés des dizaines, voire des centaines de milliers de transistors, reliés par des chemins gravés par faisceau d'électron et dont la largeur est de l'ordre du micron (1/1000e de mm)

. Les briques simples et standards : Les mémoires RAM, DRAM et SRAM, ROM, EPROM...

. Les briques sur mesure "ASIC's"
  - à la finition "GATE ARRAYS"
  - à l'assemblage "STANDARD CELLS"
  - à la conception "FULL CUSTOM"

. Le module de base (véritable sous-système de traitement de l'information) : LE MICROPROCESSEUR

<-- CONCEPTION

des chemins pour une application du système organisant entre elles les briques de base

<-- SYSTEME D'EXPLOITATION

(Operating System, ex. MS DOS, UNIX...) pour utiliser un système de traitement de l'information, une "machine".

LES MACHINES : Des systèmes à traiter de l'information

. Les ordinateurs ("computers", "Electronic Data processing machines"...)
  Ils sont en premier lieu des calculateurs, comme les super-ordinateurs (CRAY) ou les "Mini" scientifiques et industriels.
  Ils sont devenus "universels" (Main-frames)

. Les micro-ordinateurs sont construits autour d'un seul micro-processeur et quelques composants

. Les machines à traitement de texte

. La station de travail (Working Station) dans un atelier pour commander un ensemble d'usinages

. Le scanner ou le matériel DAO

. Les centraux de commutation téléphoniques numériques grands centraux publics et petits centraux privés (PABX) via un réseau

. Un terminal

<-- PROGRAMMES D'APPLICATION

Pour réaliser des traitements spécifiques de l'information, grâce à un système d'exploitation, sur une "machine"

Ces programmes sont des LOGICIELS écrits dans différents langages (FORTRAN, PROLOG, BASICS, PASCAL...).

Sur le marché, quand ils sont vendus comme des produits, on les appelles PROGICIELS

La transmission, et réception sur un TERMINAL, plus ou moins "intelligent" (système plus ou moins complexe), constitue une TELECOMMUNICATION qui peut se faire de manière plus ou moins interactive. Elle peut avoir lieu :

- entre deux composants sur une puce
- entre une unité centrale de calcul et une mémoire de stockage
- entre deux "ordinateurs" dans une entreprise
- entre deux postes téléphoniques via un central "PABX" d'entreprise
- entre deux ordinateurs, l'un à Paris, l'autre à San Francisco, entre un émetteur de télévision à Mexico et un récepteur à Bruxelles
- entre un centre de pilotage à Kourou et Ariane ou Giotto

<-- Des machines et des logiciels aident à construire d'autres logiciels, d'autres machines, d'autres puces, à produire :

- CAO Conception Assistée par Ordinateur (CAD Computer Aided Design)
- FAO Fabrication Assistée par Ordinateur (CAM Computer Aided Manufacturing)

2.3.2. The development of the electronic processing of information

35. The constructional activity consists of assembling the basic bricks of different types during one physical operation. However it is clear that success depends on the architect who draws up the plans, on which he conceives the whole before beginning to construct it. This non-physical activity becomes all the more necessary as the number and the variety of the bricks to be used becomes larger and when their assembly is to result in a more complex assembly. This analogy enables us to appreciate the difference between the HARDWARE, which is physical, being the chips and the machines which they serve to build, and the SOFTWARE, which is non-physical, being the mental activity needed to design the chips themselves, the machines, their general mode of operation - the operating systems - and the methods of use: information processing machines are mostly open to a wide variety of uses, for each of which it is necessary to consider the necessary piloting. The applications programs, and also those needed for design including designing the chips, are now written using information processing machines. This illustrates the indissociable character of hardware and software in the electronic construction industries.

36. During this period the typical machine built to this scheme was the computer which was firstly an accounting machine, then a computing machine and one which could handle strings of characters and to process texts and finally a machine to process information of any kind, provided that it could be digitised, that is to say translated into bits, hence the importance of coding. Progress was closely linked to that of the mother-technology, and the generations of computers are distinguished according to the use made in their construction of the new generations of components. The first generation of valved computers, started with the ENIAC (cf paragraph 32) gave way to the second generation of 1959 using solely transistors. The UNIVersal Automatic Computer from the fathers of the ENIAC used magnetic tapes as external memories in 1951, but still relied exclusively on valves whereas the SEAC of the same period used only 750 valves and 10,000 diodes instead of the 5000 valves of the UNIVAC. In 1958 Seymour CRAY of Control Data put forward the CDC 1604 with 25,000 transistors and a ferrite core memory, the system invented by Jay FORRESTER at MIT in 1951 and used in his machine the Whirlwind, with its 30,000 words and 48 bits, in 1953. In the following years the UNIVAC Solid State 1 was entirely transistorised (J.L. PERRAULT, 1981). At that time these computers were gigantic machines which occupied very considerable space, necessitating large rooms equipped with air conditioning, and a very large number of operators and technicians. At the beginning of the sixties DIGITAL EQUIPMENT changed this concept with its series of PDP (Programmed Data Processor) mini-computers, designed by K. OLSEN. Machines which could be used in a research laboratory (or which the US Navy installed in its submarines) made electronic computing directly available to practically all scientists. The information processing machine is no longer an immense workroom; it can now be effectively a machine operated by a very small number of operators. This new concept was born with the second generation which generalised the first universal programming languages, principally FORTRAN (FORmula TRANslation), launched in 1956 with a 25,000-line compiler program for translating into machine code.

37. This concept was not really confirmed until the launching of the third generation in 1965 with the IBM 360. In effect the third generation involves the general utilisation of large-scale centralised information processing ("informatics") in large companies (rather than the specific equipment in their laboratories or design offices) and then in public administrations. In this way informatics passed from the major university, military computing

centres, or large networks such as airline and other transport reservation systems, to large enterprises and administrations, in particular for the management of their personnel and their accounting. Certainly small systems had become numerous and were rapidly increasing in number (23,000 in 1965 to 49,000 in 1970) but they were still mainly installed in the United States (90% in 1965, 80% in 1970) and could not be compared in terms of value with the large systems which were more widely distributed outside the United States with a not inconsiderable production in Europe, and subsequently in Japan. The American total, with 3700 general computers, still however accounted for 45% of the world total in 1965 and 52% in 1970 with 14,000 machines.

38. IBM, with its 360 series, was the king-pin of this growth, and this was not solely due to the progress in hardware, which had benefitted from a Research and Development expenditure of no less than US$ 5 billion! This machine did not use the integrated circuits which FAIRCHILD had been selling from their catalogue since 1962, but only hybrid circuits or micro-modules. However it is from this date that vertical integration dates with IBM, producing its own micro-modules and subsequently its integrated circuits. Technical progress was more in the software with a first standardisation of the operating systems which made it possible to use a program written for one machine on any other computer in the series, at a time when clients were beginning to see programming costs represent major costs which they did not want to have to meet again when changing to a more modern and more powerful machine. This meant an advantage for the client, but only if a new IBM machine was purchased, so keeping the clientele faithful. There was further progress on the software by the development of a new standardised EBCDIC code (Extended Binary Coded Decimal Interchange Code) with eight binary digits, making it possible to code 256 characters instead of the usual 6-digit codes which could only handle 64 characters or signs whereas an accounting department customarily uses 120 signs, consisting of the upper and lower case alphabets, accents, punctuation marks, operational signs and commercial symbols such as @, &, $, £, %, etc. Corresponding to this the smallest unit accessible in the memory was no longer the word defined by several characters but the character defined by an 8-bit octet. IBM's R & D expenditure was also directed towards the problems of distribution and, in particular, of maintenance. IBM had instituted a major commercial innovation: the leasing of its large systems. Since clients only had to pay one forty-eighth of the total cost each month they found this a major encouragement to installing the systems, and thence obviously remained totally faithful to IBM. By 1965 the total number of computers of all sizes was of the order of 30,000: in 1967 IBM was producing 20,000 annually, or 50% of the world total. Although the end of the sixties could be seen as a period of damping-down of economic activities in the industrialised countries the large computer market saw its turnover increase by 20% per year.

39. The fourth generation was progressively installed during the middle of the seventies and simultaneously confirmed the arrival at maturity of the centralised large computer systems and the explosion of other concepts of electronic data processing (EDP or informatics) through the use of circuits with increased densities of integration and of microprocessors. The universal computers or mainframes also utilised this progress, replacing ferrite cores with integrated circuits; the perforated cards, which were the last vestiges of the 19th century tabulators, disappeared in their turn as a result of the time-sharing system which, from 1971 onwards with the IBM 370 series, made it possible to enter programs or data from a keyboard or terminal which was linked, possibly at some distance, from the central processing unit (CPU) and which also allowed some degree of interactivity, which did not necessarily involve a high level of batch working, by means of a team of

operators. Operating systems became very complete, using computers with large internal memories, several programming languages and high-performance storage peripherals such as tape readers and then magnetic disks with access times of a small fraction of a second for considerable quantities of information: one billion bits per disk, or the equivalent of seventy thousand normal pages of text.

40. This time mini-informatics was able to develop very considerably as a result of the progress in the integration of circuits and the reduction of costs, whilst for the largest military, meteorological or scientific computations these technical possibilities resulted in the birth of the super-computers. The first of these was ILLIAC IV, launched in the United States as a result of credits granted by the Pentagon through ARPA, the Advanced Research Project Agency, by the University of Illinois and Burroughs. Developed in 1970 with an architecture allowing it to carry out calculations in parallel it was capable of carrying out 50 million floating decimal point operations per second whereas the IBM 370, which came out in 1971, could execute less than one million instructions per second. CRAY, at Control Data from 1972 onwards and then with the company he founded, began the race to greater power with the CRAY 1 in 1976: today CRAY can offer a billion floating decimal point operations per second. On the one side there are now the gigantic machines (but with only 150 machines in the world in 1985), on the other the increasingly smaller and less expensive machines with powers that are very far from being laughable. In 1987 the most powerful IBM general computers are equivalent in power to the ILLIAC IV, whilst office micro-computers have the same power as a 1971 IBM 370.

41. Micro-informatics, that is to say the construction of a computer around a microprocessor, was born just after the invention of the latter: the then independent French producers R2E seems to have been the first to build and sell a machine of this kind in 1973. The direct result of the miniaturisation of components it constitutes one of the direct applications of the pervasiveness of the mother-technique to the processing of information. To build a computer around a single microprocessor involves adding to it some components, an operating system, a keyboard, a screen, a cassette reader and, subsequently, a floppy disk drive (invented in 1973 by D. AHL at DEC) or even a hard disk, and peripherals such as a printer or even a laser printer. This makes the micro-computer not just a more complex computing tool than the small calculators which have proliferated since the beginning of the seventies but also a working station for a design engineer or for a secretary-typist who needs to organise her office and to process texts, etc. In fact it was the personal micro-computer which was the origin of the widespread explosion of informatics: in 1985 the world total of these micro-computers was about twenty million (costing less than US$ 10,000) as compared with fifteen thousand large systems (costing over US$ 1m), two hundred thousand medium-sized systems (averaging US$ 300,000) and two million small systems with fewer than sixteen operators (at an average of US$ 10,000). This growth has seen tha advance of other firms, in particular APPLE (1976) which was to dominate the office micro-computers segment of the market until the late arrival of IBM with its PC in 1981. Linked to others by means of local networks, connected if necessary to one or more more powerful central computers, also accessible from the consoles, this gave rise to a new concept of distributed informatics. The expansion of the mother-technique has not only overturned the processing of information but has also influenced the transmission of information.

2.3.3. The mutation in telecommunications

42. The unidirectional transmission of information did not undergo any major transformations before those which emerged at the beginning of the eighties. Up until then land-based radio links broadcast radio and television. However during the sixties cable television networks were installed in the United States and Telstar inaugurated in 1962 the transmission of television images by satellite between Europe and the United States. Whereas the conventional radio land relays linked together the independent broadcasting networks the use of satellites was to combine unidirectional and bidirectional transmissions: telephony and television were to share the utilisation of the satellites. From the point of view of the general public receiving and storing the transmissions we have already pointed out (paragraph 33, note (1)) the change to colour television and the video-recorder. Another combination with telephony appeared with the emergence of videotex (teletex): information of a new type, in particular data series transmitted over the telephone lines and visualisable on the screen of a television set or a dedicated terminal, such as MINITEL in France. We are already at the end of the period: the electronic directory was launched in France with Minitel in 1983 and was a success whereas the British PRESTEL, which started later in 1979, was not. The television set has also been able to serve as a domestic computer (launched in 1977 by SINCLAIR in Great Britain) even if the fall in the cost of micro-computers was also showing in 1985 a tendency towards the independence of these machines and hence towards a multiplication of domestic screens. The house was becoming equipped and home informatics(*) was coming into sight.

43. The bidirectional transmission of information constitues what may be termed a communication, and when this is carried out over a large distance, a telecommunication. Up to the middle of the sixties it was almost exclusively by telephone, with an essential place for person-to-person speech communication, even if the advance of the telex was impressive when transmitting texts which needed to remain short because of the time needed for transmission: ten seconds for one page over the normal telephone networks. The managers of these networks were thus real information carriers, causing the information to circulate in analog fashion in the form of variations in the electric current along a twin line which had to be established in space to link the two correspondents. Considerable progress was to take place in regard to putting the two communicants in contact with each other by way of switching systems, in respect of the speeds and modes of transmission and, correspondingly, on the nature of the communications which were possible.

44. Telephone switching was initially carried out manually using plugs invented by the American JACK, establishing communication by joining together two lines on a square switchboard. Research work rapidly established a system of automatic switching, each client having an identifying number. The first system to be widely adopted was that proposed by STROWGER in 1891 and which, improved on many occasions, has now more or less completely disappeared. By contrast the so-called ROTARY system, developed in 1897 by Western Electric (ATT) is still being used to some extent throughout the world.

(*) The word used in the original French text is "domotique".

These systems have not however been further improved but have been replaced (in France in the sixties) by automatic systems with centralised control. In 1960 the first telephone exchanges under entirely transistorised control appeared (ATT in the United States, Antinea from CNET in France). These are termed semi-electronic space-division systems since electronic control continues to establish a conventional spatial connection between the subscribers through which the messages are transmitted in real time and in an analog manner along a physically established line. Extended usage of the electronic technique will lead to time-switching, so called because it does not place the two subscribers in continuous contact but provides them, for example with 4 microseconds of conversation every 125 microseconds; this means that it is possible to chop up and then reconstitute thirty simultaneous conversations on a single channel of communication. The time-switching does not alter the message, but to achieve this requires very accurate equipment and to carry it out in such a way that the selected portions of the message do not suffer from any interference or distortion. To arrive at this it is necessary to digitise the messages: the subscribers are thus not in a direct relationship; the relationship is in real time but is effected by a digital binary coding (into bits). The exchange becomes effectively an information processing machine with analog inputs and outputs, but primarily a point of "digital" processing and so is a true computer. The CNET was the originator, in 1970, of PLATON, the first time-switched subscriber exchange (for 2000 lines) which was commissioned in 1970 at Perros-Guirec in France. This exchange went into production by the CGE under the name E10 in the following year, and since that time the major world firms have proposed their own all-electronic exchanges, the performances of which have been improved by the use of integrated circuits. It is possible to see quite clearly here the convergence, by the diffusion of progress in the mother-technique, of the two fields of the processing of information and the transmission of information. It is entering enterprises with the appearance, at the beginning of the eighties, of electronic private automatic branch exchanges (PABX). Switching therefore involves developing an information processing machine with its hardware, software and servicing problems.

45. In the case of telecommunications lines on the networks those services which remained, until the sixties, exclusively carrier services have always represented a turnover which was many times larger than that of sales of switching or transmission equipment. The carrier service has remained linked essentially to management and invoicing. The range of services offered will be extended from speech communication to the communication of data, firstly on the existing channels and then on others because of the needs of enterprises: they want to exchange between themselves the data which they utilise on their computers so that they can gradually manage all their activities and all their multiple installations dispersed over the same country, even if this is vast like the United States, and even sometimes over the entire planet. In the same way the creation here or there of a vast data bank has the value of being able to extend the facilities for consulting it beyond its normal users or visitors (those entering the actual building) who can consult it by means of consoles linked to the central computer: why not sell remote consultation? To go even further it is possible, when the processing capacity of a large computer is not all being used, to consider selling its part remote usage to a few clients... Faced with such needs the carriers are often public bodies (such as the DGT in France) or exclusive concessionaires (like ATT in the USA) in order to cover the whole of the national territory. They have to install a network of more or less evenly distributed density and to offer a tariff structure allowing access to the telephone to homes and

isolated areas without taking the relative surcharges on costs into account; that is to say they have to practise a generalised costing which means over-charging long distance communications and under-charging urban communications. The technical progress linked with electronics can only accentuate the differences to be compensated for whilst encouraging the carriers to offer a service - advanced or value added - which will go beyond speech transmission: the transport of digital data with addresses, temporary storage, the establishment of special higher speed radio or other links, electronic mail, new terminals, answering machines, radiotelephony, teleconferencing and telefaxing. The extreme diversification of the possible services, the ways of implementing them and the high level of variability in the real costs, of the needs and the payment capabilities of the users make it necessary to consider not only the question of whether the telecommunications services can remain the province of a public monopoly, whether approved of or not, but also the fact that the nature of the terminals to be used may also evolve to a considerable extent. This evolution has given rise to a movement towards deregulation which resulted in the United States in 1984 in the dismemberment of ATT, whilst at the same time authorising it to propose value added services and to launch out into informatics. A movement of the same type is making itself felt in most of the industrialised countries, linked very closely to technico-industrial evolution.

46. The recent digitisation of switching has been a complementary stimulant to that which the deregulatory movement had previously found in the evolutions in modes of transmission: by the use of microwave relay stations and more especially of satellites in order to effect specialised point-to-point links for users who were not important in terms of numbers but who each had very high levels of consumption. The satellites constitute one of the points of industrial and technical interaction between two differentiated complexes: electronics and space. The rockets, born in the Second World War, only made it possible to put satellites into orbit after the first "Sputnik" in 1957. The catching-up programmes of NASA and the armed forces in the United States largely encouraged the development of the mother-technique towards micro-electronics and have continued to promote the development of telecommunications techniques using rockets placed in terrestrial orbits, catapulted to the moon or even sent to the very edge of the universe. Other nations apart from the United States and the USSR have started up the ladder (Europe with the Ariane space programme since 1984) to offer a satellite launching service, particularly for telecommunications (10). From 1965 onwards, with sufficiently powerful rockets, it was possible to place satellites carrying electronics in an equatorial orbit, at a height of nearly 36,000 kilometres, acting as "transponders", that is to say receiving, amplifying and retransmitting signals. With such an orbit they appear fixed in one place in the sky: they are geostationary. The first of these, Early Bird in 1965, made it possible to offer 240 circuits to five ground stations which could then organise global telephony using radio waves via satellites. An international organisation INTELSAT, with an American majority holding, reigned for twenty years in this field whilst operating it, up to 1984, as a public service. Other organisations exist: INMARSAT for maritime navigation and, in telecommunications, EUTELSAT for Europe, ARABSAT for the Arab countries and INTERSPUTNIK for the communist countries (although theoretically open to all).

---

(10) Japan, China, India and Brazil are at the very least potential candidates.

In 1983 Intelsat had more than 100 members, used 680 land-based stations (owned by the member states) and offered 300,000 telephone circuits with more than 1000 international routings and five television channels; it also leased transponders to more than twenty countries for their domestic communications requirements. The monthly cost of leasing a telephone circuit, which was nearly US$ 3000 in 1965, fell to almost US$ 300 in 1983. Retransmission techniques are evolving with the move to Multiple Access by Frequency-Sharing and Multiple Access by Time-Sharing with on-board wave switching, which will further multiply their capacity. These satellites transmit not only telephone conversations and television broadcasts but also data transfers at very high speed, compatible with the working speeds of the computers to which they are connected in this way. There are also national or multinational satellites to organise internal telephonic or informatics communications, or again for the Direct Broadcasting by Satellite (DBS) of television. As a result of the increasing power of the satellites placed in orbit it is now possible to operate in such a way that anyone with a personal antenna (which electronics progress is making constantly smaller) can receive the broadcasts from the satellite. In the Franco-German project the antennas needed will be less than 80 centimetres in diameter. Finally private companies, mainly in the United States, are starting to use satellites to transmit their television broadcasts to their cable network centres or to establish long-distance communications which,under US legislation, has been permitted on US territory since 1973 and for international communications since 1979. Amongst other activities this makes it possible to establish and to sell the services of private global networks for advanced or value added telecommunications, such as those of General Electric.

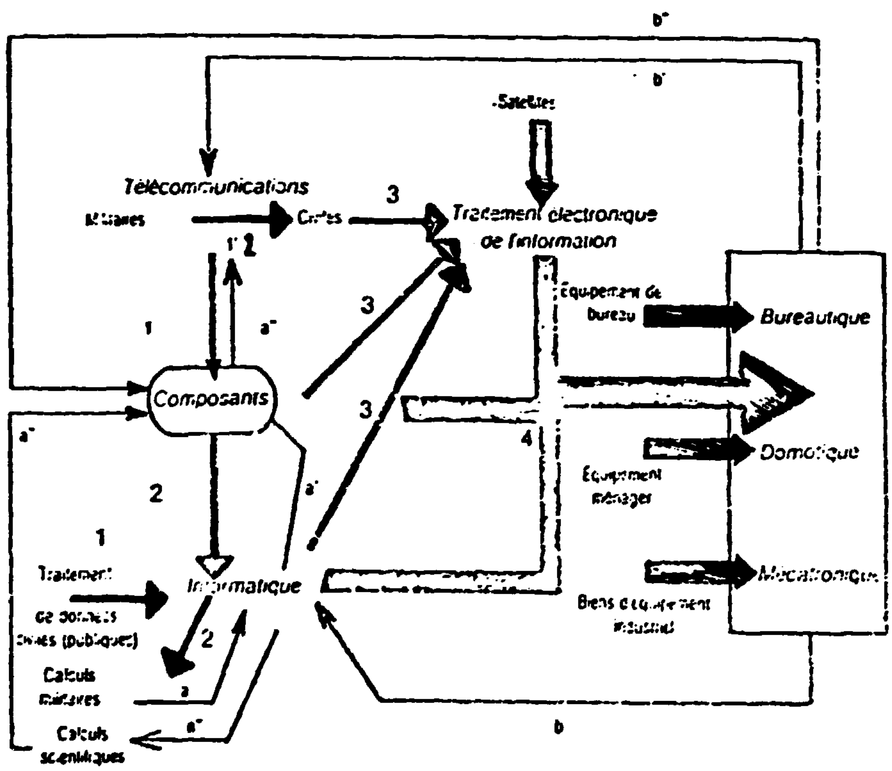
47. Transmissions by cable have certainly suffered to some extent from this competition from non-terrestrial radio links, despite not inconsiderable progress. The first cables transmitted telegraphy but obviously were not efficient enough for telephony which had to use the radio system, for example to cross the Atlantic. On land the use of amplifying relays obviously did not pose the same installation problems. The first transatlantic coaxial cable, the TAT-1, with submerged valve repeaters, was laid in 1956 and was used until 1978: it could carry 36 conversations simultaneously. The use of transistors from 1964 onwards meant that it was now possible for this type of transmission to carry up to 3500 communications. No new major improvements were made on copper cables, but on the other hand an important change came with the development of the LASER (Light Amplification by Stimulated Emission of Radiation). This was invented by TOWNES in 1958 on the basis of the MASER (Microwave Amplification by Stimulated Emission of Radiation), of which he was the co-inventor (he also shared the 1964 Nobel Prize for physics), and uses the principle of optical pumping. Lasers are used as a means of analysis, to carry energy (as in cutting sheet metal or textiles, or human tissues in surgery) or as information substrates. The laser makes it possible to obtain a coherent beam of light which can be modulated to transmit information. This idea had been patented by BELL himself in 1880, but it was necessary to wait for the laser to have such a form of light. However it needed an efficient guide: glass fibres seemed to be indicated, but unfortunately their attenuation is very high. With an ordinary glass fibre only 10^{-100} of the energy introduced is left at the end of one kilometre, or in other words nothing. The progress obtained with silica fibres has been considerable. In 1972 the American Corning Glass company succeeded in retaining 40% of the energy, or a calculated attenuation of 4 deciBels per kilometre; today the attenuation would seem to be of the order of 1 dB/km.

Fibre optics are therefore already operational, and furthermore offer very wide pass bands. They do not seem able, however, to compete in the immediate future with the existing applications for transmissions from satellites, but they are particularly well suited to very high transmission rates over short distances (local informatics networks) or in hostile electromagnetic or electrostatic environments (military communications). It is however proposed to put into service in 1988 a fibre optics cable, TAT-8, 6600 km long between the United States and Europe, capable of carrying 40,000 simultaneous telephone conversations at a high speed (280 million bits/second) and at a cost level of between 25% and 60% of that for the previous copper coaxial cable TAT-7.

2.4. The inauguration of a new technico-industrial age

Figure I-4 : THE STRUCTURING OF THE AGE OF ELECTRONICS

Its pole : the components
Its vector : office informatics, home informatics, mechatronics



Actions are shown by heavy lines with the chronology of the impulses in figures: amplifying retroactions are shown by thinner lines and identified by letters.

Source : "Mecatronique et modernisation industrielie", Marc HUMBERT, Les Enjeux, N°52, November 1984.

48. The above diagram shows how two technico-industrial fields, born in the 19th century and remaining quite distinct up to the start of the fifties, are positioned around the components. These two fields are firstly what is termed in this report "informatics", that is to say the processing of information, or rather of data, and to begin with solely by computation, and secondly what is termed "telecommunications", that is to say the transmission of information, or more precisely on the majority of cases interpersonal speech communication (telephony) or the unidirectional broadcasting of sounds and images. Under the main impact of evolutions in the mother-technique, which became what is commonly called micro-electronics and which spread into both fields, there was a prodigious expansion of informatics from the sixties onwards which began to be a communicating-informatics: with distributed, divided-up and portable operating systems between machines and local networks and the communication of data over a distance between computers, a movement towards the inter-operability of information processing machines capable of working not only as calculators using numbers but of processing texts, images and sounds.

49. Under the influence of these same causes telecommunications were profoundly altered, passing from a moderate usage of the mother-technique and of analog modes of transmission to digital switching and transmission. This change is nearing completion in the case of telephony, it may be forecast (cf. I.3) in the case of television broadcasting but has yet to come, and is even moving towards a marriage between optics and the optronics-electronics of lasers and fibre optics. This introduction of micro-electronics is also extending to those services which it is possible to offer when a telecommunication link is established: this now demands the extensive processing of information in order to digitise it, to form it into packets, to multiplex and switch it and then to reconstitute it. The new proximity of these old techniques is principally illustrated by the two American giants in each of the formerly distinct sub-fields: ATT and IBM, each of whom are attempting to establish a footing in those activities which would until now have seemed to be reserved for the other company. ATT has entered the field of informatics, offering its UNIX operating system as the future standard for telecommunicating informatics, whilst IBM has entered the private automatic branch exchange (PABX) field with telecommunications via satellites and major value added networks, videotexts, etc.

50. Everywhere, in factory workshops or laboratories, in the offices of enterprises, in large and small administrations and even in the homes of private persons, the electronics technique makes it possible to solve problems of the electronic handling of information which, in general, links together local processing and transmission. Whilst communications involving long distances and the communication of major quantities of information remain the specific field of telecommunications, and whilst the principles of the electronic manipulation of information continue to constitute what we term informatics in this report, they are becoming increasingly interlocked in this area: a switching exchange forms part of informatics. Furthermore specialists in either of these fields are able to meet the specific and differentiated needs of workshops, offices and private homes when existing equipment is being renewed. Mechatronics ("mecatronique") should thus lead to a new concept of the machine and of the process of transformation, and should today join together mechanical engineering and electronics, the hardware and the software, leading to an activity which could be termed cerebrofactive.

Office informatics ("bureautique") brings with it the in-depth transformation of all office activities: filing, classifying, the productions of original documents or copies of them, even internal printing and distribution in organisations not involved in such activities, have all become possible and have made it possible to go beyond the "informatised" management of personnel and accounts. Finally domestic equipment is itself in the process of transformation which demands certain specific developments. This is not just a matter of converting the telephone into an intelligent terminal, of associating with it the television receiver and the tape recorder, or of making the compact disc evolve towards a peripheral for a micro-computer, but also of "cabling" the house so as to make it intelligent, to ensure its security and air conditioning and to operate, if necessary by remote control, the various appliances for household service and production: home informatics ("domotique") also constitutes a kind of new product-complex in the same way as mechatronics or office informatics and calling on the same technico-industrial electronics complex.

51. Finally the level of maturity attained by the technico-industrial complex has led to an extremely important evolution in regard to not only the manipulation of the information but in the information itself. Information has no existence unless it is communicated (or is at least communicable), and this requires "the 'formatting' of a material substrate" (L. GILLE, 1987, p. 30) to constitute an original which will then be delivered in that form or after duplication. With the exception of that which is experienced without any intermediary - face-to-face, by direct action or as a living spectacle - the formatting or delivering of any information, that is to say its "packaging" (L. GILLE, ibid) and its manipulation, which constitutes an information or communication service, is increasingly being carried out with recourse to electronics which increase the performance of the service. From creation to reception, through writing, production, printing, programming, distribution and dissemination, all types of information, whether through the press and printing, audio-visual means or the cinema, and not just those previously cited (inter-personal communication, informatics and office informatics) have come to involve the employment of electronics and digitisation in a period of transition and of convergence. This is the result of what one may term the new universal 'alphabit' of communication (HUMBERT, 1987, p. 43), the alphabits which constitute the elements which are processed by the basic bricks of electronics construction. The new technico-industrial age which is being instituted is clearly also that of communication.

3. TECHNICAL PROSPECTS FOR THE EIGHTIES

52. The technical evolution of the coming years will be principally in the hands of those actors who are at the preset time dominant in the technico-industrial complex. The prospects which are set out below therefore conform to those of these actors, for example to the prospects set out by J.S. MAYO. Vice-President for Networks Systems at the BELL LABORATORIES of ATT (1985, p. 132) or, again, to the survey carried out by the Japanese journal NIKKEI ELECTRONIC in 1988 of the heads of research in public laboratories and electronics enterprises in Japan (F. GROUT, 1988). This forms a summary of a considerable quantity of information extracted from professional journals which have not been systematically quoted elsewhere. This summary confirms the pertinence of the approach which we have adopted in the previous sections, and so allows us to set out the prospects for the eighties as being those of a period of the deepening and extension of the coverage of the technico-industrial complex, the contours of which have already been well defined, and

not as new ruptures in the complex. Evolution will be pursued around the same mother-technique but also by way of increasing interactions with certain contributory techniques, especially opto-electronics. The advance of the digitisation of information will principally affect the field of television (and more especially audio-video tecnhiques) and the field of networks, particularly the important matter of the ISDN, the "Integrated Service Digital Neworks". These extensions of capacity, coupled with increasing powers of processing, will draw all the information processing machines increasingly towards the processing of knowledge with on the further horizon, extended ISDN services, the Artificial Intelligence of the fifth generation computers, the intelligent house of home informatics and the factory without men of mechatronics which will give a stimulus to and provide the final objectives for the efforts made in the coming years and up to the year 2000.

3.1. The deepening of the mother-technique: progress on the building bricks

53. Developments in the density of integration of the basic bricks, of the chips and more particularly the memories, has constituted an essential element in passing to the age of electronics, making it possible to incorporate information processing machines into most activities (see Chapter II). Requirements in respect of density of integration, that is to say for processing even larger quantities of information, remain potentially very considerable and open up the possibilities of operating in all these activities with improved performance. Is it possible to envisage the continuance of the very rapid rate of progress in the intensification of integration of the past whilst still remaining on the same technical lines?

54. Taking the example of the Dynamic Randon Access Memories (DRAM) we may look at the analysis set out by C. PARE within the framework of a prospective study for the French Plan (de ROBIEN, 1986, pp.52-53) and in which we participated. Several factors intervene in increasing the level of integration :

(i) Line widths (L). As the definition becomes finer so there is an obvious increase in the number of elements which can be created on the substrate. The elementary criterion is defined by the surface which defines the intersection of two lines, the pixel. The techniques for drawing on the substrate are obviously important.

(ii) Design features Designers endeavour to store one bit of information using the least possible number of pixels, where N is this minimum number. It has already been found possible to advance from a group of three to a single transistor, and it is now necessary to reduce the size of the latter.

(iii) The surface area S and its filling level R (%). A part of the area is used not to store bits but for the inputs and outputs. One seeks therefore to maximise R and to increase S. However S will remain limited for at least two reasons: the first is that efficiency falls very rapidly with the surface area and secondly because the power which is dissipated increases rapidly (even if it decreases with the width of the line). The following table summarises probable developments between now and the year 2000 and what is today regarded as the domain of the possible.

Table I-5 : THE DETERMINANTS OF INTEGRATION PROGRESS

	1960	1984	2000	Potential
L (microns)	60	2.4	2.25	0.15*
Pixel (micron²)	3600	5.76	0.0625	0.0225
N (pixels/bit)	100	12	6	2.8
R (%)	36	52	60	75
S (mm²)	1	35	100	200
Bits/circuit	1	256 kbit	18 Mbit	over 1 Gbit

(*) Line widths well below 1 micron are beginning to be explored, but at these dimensions one has to ignore all the electronics effects, production costs, efficiencies, etc.

Source : De ROBIEN (1986, p. 53)

55. At the present time 1 Mbit memories (1 Mbit = 1 million bits) are being sold which contain two million components. Samples of 4 Mbit memories, with a line width of between 0.8 and 1 micron, have already been produced by the major manufacturers who promise samples of 16 Mbit memories in 1990. Their laboratories already envisage the production of 64 Mbit memories which could thus be in mass production towards the year 2000. In the following paragraphs we give some information to highlight the certainty of these prospects, the importance of which is considerable. In particular it implies that production of the basic bricks will follow the same trends as those of the last fifteen years, and that all electronics construction will also follow, at the same rate, these improvements in performance, at least up to the year 2000. Furthermore, and even if the technical development of the basic bricks then falls off the time-lag in their utilisation in electronics construction will ensure that the latter enjoys some supplementary years of rapid evolution. It is obviously impossible to forecast with the same certainty what electronics construction will achieve with these future basic bricks. However one must count not on a halt or a slowing down but the maintenance of the rate of evolution of the performance of integrated circuits between now and the year 2000.

56. During the manufacture of integrated circuits there are three particularly delicate stages when integration is greatly increased. The first is that of designing the circuit, on which it will be necessary, by the end of the century, to place and coordinate up to 100 million components. The problems will have to be resolved by using the tools which the electronics construction industry will be developing for itself, and which will tend towards artificial intelligence: we will return to this under point 3.3. The second concerns lithography: this is used to reproduce the drawing of the circuit on the disc of silicon, and three such techniques are available at the present time. Optical lithography, almost exclusively utilised up to the present time, is claimed to be unusable below a width of 2 microns. After having produced a mask this is reduced optically using the lens of a reducing appliance, and this drawing is then repeated over the entire surface of the disc of silicon, or wafer: in this way some n copies of the same circuit are produced. This is photolithography, which encounters an obvious limit: the degree of precision of the structures cannot exceed the wavelength used for the exposure (the drawing is projected onto a photo-sensitive resin).

Today the producers of equipment, such as ASM Lithography, offer optical photo-repeaters capable of production writing of 0.6 microns and fitted with lenses operating at a wavelength of 0.365 microns. Such equipment will permit the production of 4 Mbit memories. They are also preparing for photo-repeaters working with light (in the ultraviolet section of the mercury spectrum) with a wavelength of 0.248 microns and which will allow minimum drawing widths of 0.3 microns. The difficulties which still have to be resolved when producing 4 Mbit and 16 Mbit memories from the side of the lithography equipment relate to the accuracy of positioning and the respective movement of the marks and the substrates, and this will certainly be obtained by integrating automatic alignment systems.

57. The second technique available today is that of X-ray photo-repeaters. The equipment available today is satisfactory down to design criteria of 0.5 microns; the new equipment, using synchrotron sources, will allow drawing to a minimum width of 0.2 microns, that is to say it will make 64 Mbit memories possible. It should also be recalled that the NTT laboratory announced in 1987 X-ray drawing down to 0.01 microns... Clearly lithography is not a limiting factor. There is in addition a third technique, that of direct drawing with an electron beam. This technique has not been widely developed since although it does not need any masks, which could make it attractive for short runs, the cost of the equipment is extremely high and the exposure times are very long. In practice this is still a laboratory technique, but one with potentially very high precisions of very much less than one micron. It offers potential for the pursuit of the miniaturisation of circuits, perhaps more in the case of specific circuits (see paragraph 60) than in the case of standard circuits.

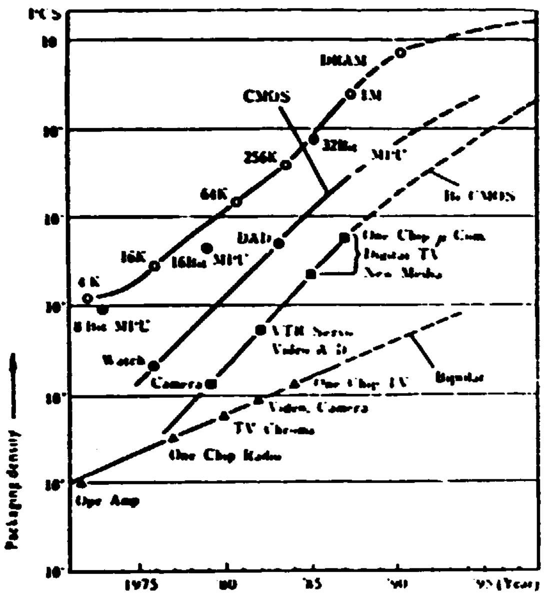
58. A last and particularly delicate stage, once the design of the structures has been delineated on the wafer, is obviously that of the so-called etching stage. In addition to the classical RIE technique (Reactive Ion Etching) there are now competitive techniques which utilise a reduced energy of ion bombardment whilst allowing greater selectivity. These techniques such as MIE (Microwave Ion Etching) and ECR (Electron Cyclotron Resonance) are already operational whilst others are still being developed such as etching by focussed ion beams. These facts convince us that there will certainly be a continuing miniaturisation of memories and, more broadly, of the basic bricks.

59. The other basic modules, the microprocessors, do not go out of fashion at the same diabolical rate as the simple memories, even if their integration density follows. The reason for this is obvious: they are already extremely complex systems. Certainly they have their own levels of complexity: since INTEL's first 4004 microprocessor of 1971, working on 4-bit words, there have been the INTEL 8008 of 1974 working on 8 bits, then the 8086 of 1978 on 16 bits; the first microprocessor with a true internal architecture was the 32-bit NS 32016 of National Semiconductor in 1982. However if the use of less integrated circuits is tending to disappear use still continues to be made of microprocessors using shorter words. A survey carried out in 1986 at the Japan Electronic Industry Development Association showed that they only used 32-bit microprocessors for systems priced between 40,000 FF and 400,000 FF, and 70% of these applications were concerned with CAD, robots, advanced telecommunications or military electronics, and only 30% were used in office and micro-informatics. By contrast these applications will be in the lead (84%) by 1990. For the moment no interest is seen in 64-bit microprocessors: many applications are still happy with 8-bit microprocessors. In 1984 more than 85% of the microprocessors sold throughout the world (585 million units) were 8-bit microprocessors, their value being half that of the global sales of microprocessors. All forecasts are agreed in considering that the annual rates of growth of sales will remain very high (of the order of 25% in volume

and 18% in value), even if the rates of growth for 16-bit and 32-bit microprocessors will be higher than these figures. The technical evolution is that of the massive diffusion of these basic modules for information processing and by the middle of the nineties the annual production is likely to be in excess of one billion microprocessors. The following figure provides two diagrams illustrating the evolution of integrated circuits and of microprocessors.

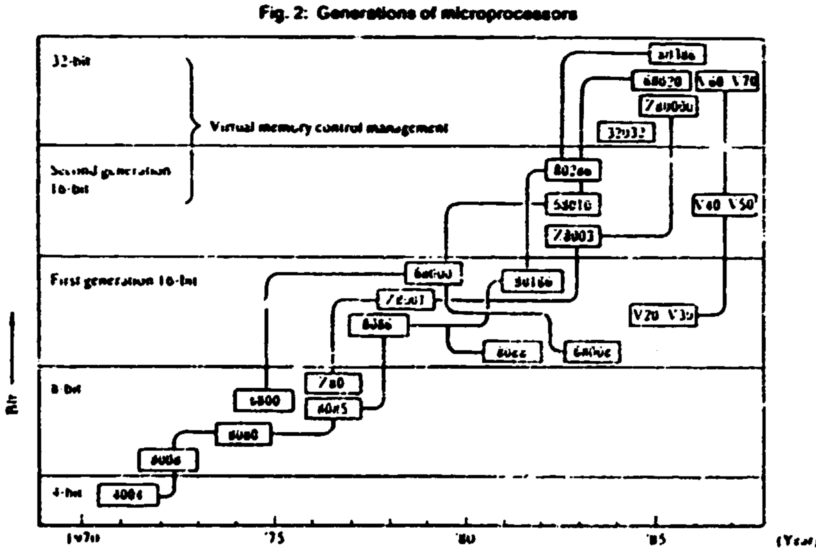
Figure I-6 : THE EVOLUTION OF INTEGRATED CIRCUITS AND MICROPROCESSORS

Fig. 1: IC packaging density and technology trend



Source EIAJ

Fig. 2: Generations of microprocessors



Source EIAJ

NOTES :

PCS number of components per circuit
MPU microprocessor unit
Bi-CMOS Bipolar : type of integrated circuit
VTR video tape recorder

Series :	8xxx	INTEL family
	Zxxx	ZILOG family
	68xx	MOTOROLA family
	Vx	NEC family

60. The evolution of microprocessors could however be marked by some happenings. In each category of microprocessors there are several generations, and in 1988 there appeared not only new generations from the usual manufacturers but also a new concept with the TRON microprocessors from the Japanese manufacturers. TRON provides a new concept of the operating system at the same time as the American manufacturers seem to be moving ahead by abandoning the conventional CISC (Complex Instruction Set Computer) architecture to move towards an RISC (Reduced Instruction Set Computer) architecture which makes it possible to obtain more from the same material potential. Furthermore many applications do not use microprocessors directly but rather micro-controllers which consist of a microprocessor, input-output devices, peripheral memories, clocks and counters, all on the same chip. Sales of these in 1984 were more than four times greater than microprocessors alone. These are micro-systems for information processing, more specialised than microprocessors, some being intended for video recorders of telephone exchanges (with 4-bit microprocessors), others (with 16 bits) for control functions in automobiles, etc. Most of the microprocessors are themselves intended directly and almost exclusively for use in micro-computers, such as INTEL's 80286 for IBM's PC-AT and for all its "clones".

61. It can be clearly seen how the unitary component, because of its extreme density of integration, more than ever - and apart from the memory circuits - constitutes a system which has to be found very near to its application. With the exception of systems offering major outlets in relatively standardised products such as micro-informatics, automobiles, mass consumer electronics goods, ISDN and perhaps its terminals of tomorrow, integrated circuits have to be defined as a function of specific applications and be produced on a relatively small scale which does not make it possible to achieve the same productivity as the large-scale products when the equivalent techniques are employed. The development of the so-called ASIC's or Application Specific Integrated Circuits, or customised, made-to-measure or personalised circuits, will therefore continue to be seen. Fully made-to-measure or "full custom" circuits will, because of their high cost, remain restricted to very limited fields (military applications), whilst the prediffused netwoks or "gate arrays" where the connections are made as a function of the application, or the "standard cells" produced from a library of precharacterised cells, should continue to develop. With the cloning of IBM's PC's or its new PS's a number of firms are offering ASIC's in addition to their microprocessors. Texas Instruments is itself offering, through its Japanese subsidiary, an assembly of five integrated circuits for use in a PC-AT.....

3.2. Speed and facility in communications: opto-electronics and standardisation

62. Apart from the fineness of the writing and etching of circuits, which allows their miniaturisation, there is also the problem of the concentration of very many components on a very small space; on the one hand this makes a greater speed of reaction possible whilst on the other it leads, because of the concentrated consumption of electricity, to too high a level of dissipated heat. In this latter field the possibilities of superconductivity and its properties discovered at temperatures which are moving steadly away from absolute zero in a number of ceramics, together with the announcement in April 1987 by IBM Zurich of "a simple working micro-electric device with sprayed-on ceramic superconductor", have led to the idea of a technical break-through in the near future. In reality what is involved here is still laboratory work, and major effective implications in electronics cannot be predicted over the next dozen years. Many other promising fields have been the subject of

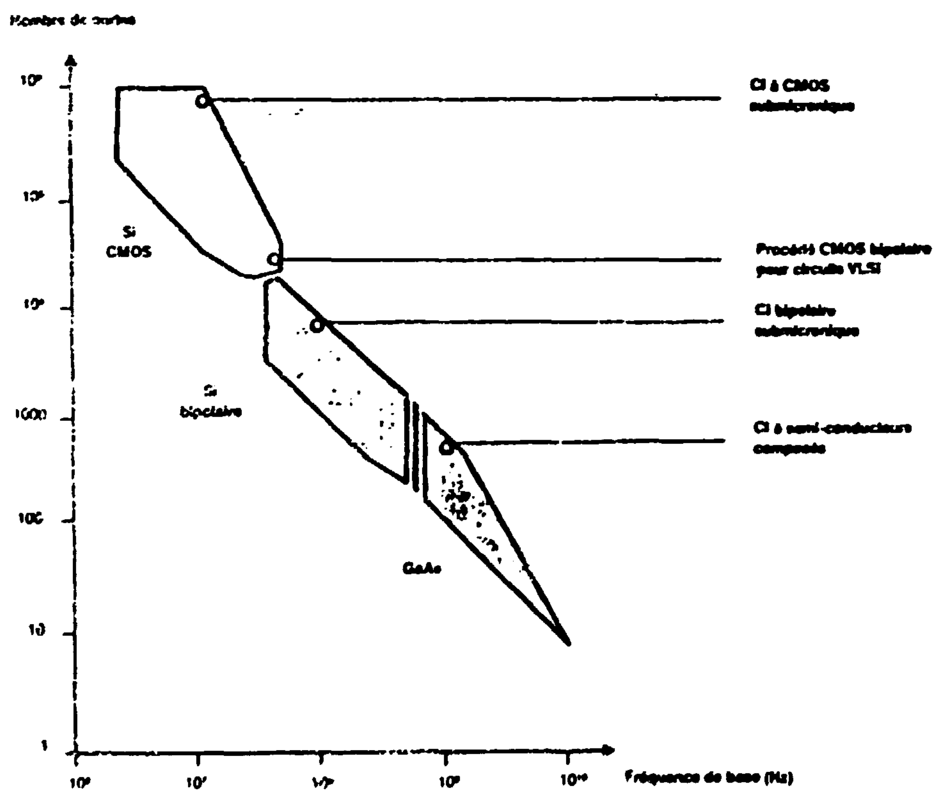
laboratory work over the last twenty years, such for example as the Josephson functions: for the time being superconductors remain one of these fields.

63. The search for rapidity will therefore follow either the classical route or routes other than superconductivity. For several years research on the III-V compounds in the atomic table have predicted a wonderful future for Gallium arsenide, GaAs, as a replacement for silicon. The fact is that this material allows greater rapidity (see Table I-7) but with a much lower density of inegration. It would seem that this time GaAs will leave the field of discrete components (of opto-electronics and high frequencies) to enter that of digitised integrated circuits (in France Thomson Hybride et Micro-ondes has opened a foundry department).

3.2.1. The search for technical combinations

64. It would seem in fact that there has been a further and more extensive questioning of the distribution of relative performances according to the categories of integrated circuits, and that the coming years will certainly belong to the heterostructures.

Figure I-7 : THE RELATIVE PERFORMANCES OF INTEGRATED CIRCUITS, ACCORDING TO THE TECHNIQUE



Source : ESPRIT Document (EEC), 30.6.1986

65. Until recently the integrated circuits, almost entirely built on a silicon substrate, were subdivided into two main technical categories. The bipolar circuits, the more rapid circuits which are controlled by an electric current, use more electricity and hence dissipate more heat than the MOS

circuits (Metal Oxide Semiconductors) which are controlled by a voltage applied to the gates (FET's or Field Effect Transistors) which are therefore unipolar. Amongst the bipolar circuits the type most widely used is the TTL (Transistor-Transistor Logic), whereas the ECL (Emitter Coupled Logic) and I2L (Integrated Injection Logic) types are more integrated. In the MOS group there are the N-MOS and P-MOS types (according to whether the movements of electrons or holes are utilised) but it is now the CMOS (Complementary Metal Oxide Semiconductors) which are by far the most widely used; special applications have led to the production of SOS (Silicon On Sapphire) and CCD (Charge-Coupled Device) circuits. More generally it has been found that the CMOS are easier to produce, more suited to processing digital signals and they have gradually gained in rapidity, approaching in this respect the performance levels of the bipolar circuits whilst retaining their initial advantages; the silicon bipolar circuits have been overtaken in terms of rapidity by the GaAs circuits.

66. The MOS were utilised not only in the integrated circuits for information processing but also gradually in power electronics where the transistors are, in particular, used as rectifiers (thyristors and silicon rectifier diodes) at high powers. On the other hand one can now see the arrival of very rapid bipolar transistors (such as Thomson's ETD) which should replace the MOS in a number of situations. At the same time an increase in the power of the MOS is forecast; models are announced for very high powers of several Megawatts and, in particular, real integrated power circuits (bipolar or MOS) with logic zones for the true sophisticated processing of information associated with the application of power.

67. Another way of gaining in speed involves, as has gradually been done in the case of integrated circuits in the past, not limiting the circuit to a single layer but producong a multilayer or 3D integrated circuit in three dimensions. These circuits make it possible to increase the effects of miniaturisation by allowing miniaturised interconnections between two superimposed sub-assemblies, so facilitating processing in parallel. The first of these circuits came from the Japanese laboratories, for example an image processing circuit from Mitsubishi in three layers interconnected by way of vertical holes 1-2 microns in diameter and with connecting lengths of the same size. On the upper layer is the image sensor, below that an analog-digital converter associated with each point image and, in the lower layer, the arithmetic and logic processing circuits. The existing circuit has a 5x5 pixels sensor with 11,000 active elements which sense, digitise and process the image in parallel. This forms the prototype of a sub-assembly of a 500x500 pixels sensor which is under development. Amongst the technical problems to be resolved before industrial production that of the superimposition of the layers must obviously be emphasized. Mitsubishi form above the usual layer, covered by an insulator, a 0.5-micron coat of monocrystalline silicon obtained by the layer recrystallisation of polycrystalline silicon. Toshiba use an electron beam sysem. From the evidence the Japanese 3D programme, launched in 1983, should end in 1990 with the expected success; this will certainly be less spectacular that that of the VLSI programme but, associated with the plane integration densities of the period, it should produce remarkable products in the nineties.

68. One of the logics providing an impulse towards the development of these 3D circuits is the desire not to lose in the connections between various very highly integrated components the advantages acquired through this very high level of integration. It is this which calls for the circuits to be piled one on another when side-by-side integration is not possible, and this will continue: what is one to do when one has to build an architecture using

highly diverse components? The optimal, but costly, solution is to manufacture on demand a specific integrated circuit, an ASIC (cf paragraph 61); apart from the cost it is possible that the magnitude of the application does not allow it to be done at the level of integration achieved, either in two dimensions or in three dimensions. The feasible solution is then the hybrid circuit which is half-way between an integrated circuit and a printed circuit. There are certainly standard hybrid circuits (amplifiers and converters), but within the logic of its development this circuit is one which should correspond to one application and so should be made-to-measure. With an extremely reduced format and with a reliability comparable to that of the integrated circuits they make it possible to fulfil a function which is in general fulfilled by at least an entire assembly of components arranged on a printed circuit board.

69. It is the concept of hybrid circuits which is at the origin of the SMD or Surface Mounted Device which can be used in all printed circuit operations and facilitates the techniques of automatic insertion: this technique is likely to become more widely used in the coming years. Connecting the components in circuits, in particular printed ones, poses the problem of the size of the pins which are enormous when compared with the component itself, such as a chip. These pins are inserted into holes, and it is then necessary to solder connections which are as short as possible to the points of contact established at the time of bonding. Most types of components are available today and can be inserted concurrently on a same classical epoxide resin printed circuit board. Because of the elasticity of the solder this will hold, apart from extreme conditions, despite differing coefficients of expansion of the components and the substrate. The complete technique uses silk-screen processes for depositing the soldering paste, automatic machine positioning of SMD components and their soldering by remelting. This technique is likely to become largely dominant during the nineties.

70. Hybrid circuits operate at a much finer scale than printed circuits. It is on the lines of this same logic that it is desired to fixed the chip itself to the substrate, without its case, and making the necessary connections. Conducting tracks and resistive tracks, with their values adjustable by laser, are created on this substrate, in very thin films in the case of metallic films formed by cathodic spraying or thick films with processes involving the automated silk-screen printing of inks. The very extensive diffusion of electronics into innumerable potential industrial applications should take place by way of a very considerable extension of the hybrid circuits technique which makes it possible, by a relatively inexpensive specific miniaturisaton, to make this diffusion attractive and operational.

71. To complete the survey of these technical prospects linked with the search for technical combinations one can emphasize the foreseeable progress in the technique of the BiCMOS integrated circuits, that is to day the development on the same substrate of integrated circuits calling on these two techniques which, up until now, have been quite distinct. Figure I-7 indicates the performance which can be achieved using this combination; it may be added that the first family of circuits, launched by Texas Instrument in 1988 and using this technique. was the occasion on which this firm underlined its interest in regard to interface integrated circuits and hence of connections between, for example, a microprocessor and its applications: the whole could if necessary be on a single surface mounted printed circuit board - or, perhaps tomorrow, a hybrid circuit. These biCMOS circuits combine rapidity with the low consumption of electricity and dissipation of heat but using many design features which can only refine them and ensure their increasing importance in the nineties.

3.2.2. Opto-electronics, a major contributory technique.

72. The search for rapid and easy links between systems which are more complex than the components and relatively more distant, of such a kind that one can use the term communication, is a search which, by its nature, follows on from that described in the previous paragraph (3.2.1.), but it finds its solution in recourse to a contributory technique, that of opto-electronics. Whether the communication takes place over one metre or thousands of kilometres, and if it is still a point-to-point communication, the technical solution will, in a gradually dominant manner, be the use of fibre optics. Local networks, intelligent professional premises (long before private houses) are likely to be an industrial reality in the nineties, developing very greatly as a result of the use of the opto-electronic technique of fibre optics since this technique is the only one which will permit the transfer of information at speeds greater than 100 Mbits per second. In telecommunications the satellite still remains of interest for communications involving multiple points of arrival, such as television, teleconferencing and private networks. By contrast in basic networks, such as the telephone or the future ISDN, fibre optics have a not unimportant advantage. In 1985 the BELL Laboratories demonstrated the possibility of transmitting ten multiplexed signals, each of 2 Gbits (2 billion bits) per second over seventy kilometres. This level of performance will continue to rise in a spectacular manner to make the nineties the decade of fibre optics in respect of point-to-point communication over a distance.

73. The particular problem which is posed in telecommunications is that of optical switching. Whilst switching units have been the subject of experiments in laboratories they can only handle a very limited number of channels and one can hardly envisage an operational optical switching system before the year 2000. The same comment also applies to optical computers which could, theoretically, be from a hundred to a thousand times faster than the highest performance machines now available. However whilst optical switching seems to be on the direct technological trajectory optical computers seem, by contrast, to be less on the direct line even if potentially more strategic from the industrial point of view.

74. If therefore certain developments are to be considered only in terms of a distant future it is still the case that many opto-electronic components (photons <--> electrons) were developed some time ago. Light-emitting diodes (LED's) were developed by Texas Instruments in 1964 and continue to be used extensively in display units but are also used, with lights of different wavelengths, in systems for communication by fibre optics. The advanced devices in the coming years will be integrated emission and reception components. Japanese laboratories have succeeded in integrating a microlaser and its control circuit on a surface area of 5x90 microns; these Japanese developments are stimulated by their industrial position in compact discs or laser printers which use semiconductor lasers (with a wavelength of 0.78 microns). This stimulation continues to be felt and the results for certain types of components will, in their turn, stimulate the need to obtain results for other components, and since this new research work does not seem to be meeting any blockage it seems very likely that there will be major advances in the performance and miniaturisation of opto-electronic components during the nineties. In particular it should be noted that it is probable that all fields of signalling, from automobile lights to publicity panels, and including portable screens, will involve considerable development in the techniques of these components.

3.2.3. Standardisation: a constraint on communications

75. The gains which can be obtained from the age of electronics, as compared with the situation in the age of steel, are linked to the rapidity and efficacy of communications. This requires that the components control their internal communications rapidly, that communication between the components in a system is rapid and that communication between systems at more or less of a distance are also rapid: at the same time it is necessary that this communication is efficient, which means that the various communicating points speak the same language and possibly also operate in the same manner. This is the field of standardisation.

76. The International Standardisation Organisation (ISO) is the international body responsible for standards: it has developed the Open Systems Interconnection (OSI) model, which has seven layers, to facilitate the interconnection of systems which thus become open. Since the beginning of the eighties this model has met with considerable goodwill from the major electronics construction firms in Europe, the United States and Japan who wish to see information processing machines evolve in this direction, that is to say to permit not only "interconnection" but also "interworking".

77. In most of the specialised fields of communication the defining of standards is in hand and this clearly marks out, to some extent, the specific technical trajectories in these fields and thus facilitates travelling along them. Technical progress, so very important in regard to the development of all kinds of networks, and for which it will be necessary to wait until the coming decade, is very closely linked to this advance in standardisation. We will of necessity be returning to it in subsequent paragraphs, looking here solely at an illustration of the communicability between machines in a company. General Motors required its suppliers of information processing equipment to make inter-functioning and communication possible and convinced other major users of the need to associate themselves with this objective. In this way the Manufacturing Automation Protocols (MAP) were set up by a first group of users; other groups were gradually established and provided pressure on standardisation. It would seem likely that the nineties will lead to major progress in regard to standardisation and hence to the possibilities of inter-functioning between information processing machines.

3.3. Networks and knowledge

3.3.1. High-definition television

78. The nineties will see the culmination of the digitisation of mass consumer electronics. This does not make it possible to predict the appearance of entirely new appliances but rather superior performance and new functionalities. The portability and handiness of living-room appliances, the increased intelligence of all the existing appliances and the extension of the electronics concept to all domestic electrical appliances ("white goods"), an indispensable prelude to the effective appearance, after the year 2000, of the intelligent home and the coming-of-age of home informatics ("domotique") providing for the generalised control of all the domestic functions.

79. Amongst all the products which have appeared in recent years we can note certain expected but uncertain technical evolutions, for example the competition between re-writable optical discs on the one hand and video recorders and digital tape recorders on the other. Furthermore it is probable that personal office tools will make their entry into the home in an appropriate form: micro-computers and laser printers, telephone terminals linked to the development of the ISDN and more complete in their functions than existing answering machines and the French Minitel. In this field one may expect a proliferation of technically minor innovations which are guided by newly created market opportunities where marketing strategies will be determinant. Amongst such examples are digital photography to be produced on paper by a printer.

80. However the main event in mass consumer electronics in the nineties will be the arrival of high-definition television. This stands in the front rank of installations of the age of electronics: there will be certain television broadcasts able to reach nearly half of the inhabitants of the planet by the year 2000, almost simultaneously (apart from some time-zone lags). The Olympic Games at Seoul will be only a pale reflection of what is likely be seen in the year 2000 as planetary cultural rites. Such broadcasting at global level, will make increasing calls on the satellites which will continue their technical development, whilst at the same time it will be integrated in various national networks, either ISDN (see below) or specific networks. Technically it will be associated with numerous other advances: major progress in integrated circuits, the development of specific circuits for image processing (see paragrapg 67 on 3D circuits), for the coding-decoding and compression of signals and also in the technical development of cameras and the transmission and receiving systems, particularly antennas and screens. Furthermore many other domestic appliances will need to be connectable to the domestic television set which will receive the high-definition broadcasts which could, for example, offer a number of sound channels in various languages to go with the same vision channel. Such aspects underline the considerable magnitude of the challenges linked with this technical evolution which will take place during the nineties.

81. Again one of the major problems to be resolved here is standardisation: it is this which will ensure the global character of this technical evolution and which will specify the technical trajectory along which it will, as a consequence, be able to travel most rapidly. The CCIR (International Consultative Committee on Radiocommunications) proposed standards for digital television in 1982 in its Resolution 601, but must now lay down the details on the concrete solutions put to it. At Dubrovnik in 1986 the Japanese presented an already advanced solution called MUSE (Multiple Sub-Nyquist Sampling Encoding) for "Hi-Vision", the commercial beginnings of which could take place in 1990. In fact the CCIR has deferred its decision to the Plenary Meeting in May 1990 because of the existence of the competitive European standard MAC (analog component multiplexing). The Japanese system marks a complete break with existing television systems and leads immediately to a high-definition television which is already almost operational. The European system operates through increasing compatibility: digitisation with improved definition, firstly with images that traditional receivers could receive (from the end of 1988) by using an adaptor, then extension of the quality of the image up to the high-definition standard which should be the equivalent of 35mm films and then, in the case of the Europeans, the move from D2-MAC to HD-MAC. The Americans, at first ready to support the Japanese project, have now come round to the European project, paricularly after the purchase of RCA/GE by

the French Thomson company. Their transitory phase would be their own, using the ACTV (Advanced Compatible Television) system, making it possible to advance from the existing American NTSC standard (which is also used in Japan). The technico-industrial character of this evolution, the important character of which has been pointed out above, is closely linked with an international legislatory decision and to its effective adoption by the nations which will open profitable markets for the products developed according to these technical standards.

3.3.2. Integrated Services Digital Networks (ISDN)

82. Technological advances in recent years in telecommunications have been linked to their digitisation and based on the fact that the different types of equipment used have become information processing machines, certainly directed towards specific applications and for which improvements in performance depends on that of the integrated circuits, so allowing more rapid and easier communication (cf 3.2. and 3.2.1.). This is obviously the result of the fact that the electronics industry is an industry building complex systems from contantly improved basic bricks. The major project of the nineties is that of the installation of a network which carries not just speech, like the existing telephone network, but also to carry data at high speed - to be processed by computers - and generally all information, written texts, images and sounds and even animated images with sound in the longer term.

83. Technical evolution, which is certain to take place in the nineties, will be strictly configured by the directions indicated to it by industrialists and the public authorities which will continue, despite movements towards deregulation, to exercise considerable power over standardisation and the defining of networks. Choices which will have implications on the technical trajectory followed will be made in the coming years: In Europe, within the framework of the RACE programme, and in the United States between the various operators, principally ATT, and the FCC, the Federal legislatory body. A main choice involves the adoption or not of a project for a universal network for the interactive circulation of information, analogous to the project for a telephone network and to which any body, enterprise or household, established or circulating in any part of the planet, could be connected. The alternative would be the development by the side of an improved universal telephone network of more advanced networks dedicated to certain applications and which, not having a public service function, could be reserved for certain actors either by means of specific locations or modes of access in real costs, with the abandoning of the normal telecommunications requirements concerning generalised tariff procedures (cf paragraph 45).

84. On the one side this major project, as a gigantic future market for the manufacturers of equipment such as large exchanges, private exchanges or terminals, or the basic bricks for them, still constitutes a technical myth. The most pragmatic of the industrialists have translated the acronym ISDN (Integrated Service Digital Network) into "I Still Don't kNow" what its all about!

85. Firstly it should be noted that there is practically no existing installation of a switched digitised network, and that the coming years will, for most countries, be occupied with the progressive digitisation of the existing telephone networks: the digitisation of transmission and the digitisation of switching, essential conditions for the development of existing networks, services and equipment. Certain countries, such as France, will continue to link the classical telephone network to a digital network for the transmission of data in packets, using concentrators. This

means the co-existence of two technical concepts: a universal analog network for circuit switching and a digital network for packet switching. The European idea is to make these two concepts converge, users having only limited access to the new potentialities as long as they remain analog connected and/or analog switched to the digital network. The Japanese approach, under the name Information Network System (INS), seems to be very ambitious, but perhaps in the longer term apparently universal, but in fact more enterprise orientated. The more pragmatic North-American approach seems to be clearly directed towards the implementation of non-universal networks which are dedicated to specific applications (the Wide Area Networks) or intended for specific users with competition between numerous operators for these VAN or Value Added Networks. In both cases enterprise users are privileged.

86. In all cases telecommunications services with a wider band than those of the existing telephone networks will be offered, during the nineties, in a gradually extended manner. The services offered will be initially of the first generation ISDN type, for which initial international standardisation is in hand. One still speaks of narrow band ISDN with channels handling 64 kbits/second. This network, with relatively wide access, should be established fairly rapidly in Europe; nevertheless by the year 2000 it will constitute a basic characteristic and will therefore govern technical developments in components and equipment.

Table I-8 : INSTALLATION OF A FIRST-GENERATION ISDN IN THE EUROPEAN COUNTRIES

Country	40% digitised transmission	40% digitised switching	Year of launch of ISDN	50% availability for professional usage
Belgium	1995	1995	1985	1996
Denmark	1990	1990	1989	-
France	1986	1990	1986	1988
Great Britain	1990	1992	1985	1988
Greece	1995	1995	1995	-
Ireland	1990	1990	1988	-
Italy	1990	1990	1985	1995
Netherlands	1987	1995	1986	1995
Portugal	?	?	1995	-
Spain	?	?	1987	1993
West Germany	1986	1990	1986	1989

Source : S. GRASSET "L'Europe du RNIS dans les annees 90", IDATE Bulletin No.25, November 1986.
C. HAMELINK "Dealing with global networks, a descriptive study", Tilburg, 30/31 October 1986

After FAST II, Dossier No.5, "Les reseaux numeriques a integration de service", August 1987.

87. This narrow band digital network does however constitute a considerable development when compared with the existing possibilities. However it is not 144 kbits/second which is needed for the transmission of high-definition colour television images but 144 Mbits/second, a thousand times greater than this. It will certainly not be until after the year 2000 that it will be possible to install the future wide band digital network which is beginning to be called in Europe the Integrated Broadband Communication Network or IBCN within the framework of the European RACE project.

Figure I-9 : EVOLUTION OF INTEGRATED SERVICES DIGITAL NETWORKS

	Type de transmission	Situation actuelle	Situation future moyen terme	long terme
1) Communication de documents	Point à point diffusion	poste presse	ISDN	IBCN
2) Audio-communication	point à point diffusion	téléphone radio		
3) Vidéo-communication	point à point diffusion	- télévision	transmission d'image	

Dans le cas du RNIS, les services offerts regrouperaient la téléphonie usuelle, la télécopie, le télétex, le vidéotexte, la communication entre ordinateurs, la connexion de terminaux, la transmission d'images, l'audio-conférence, le traitement de message, la téléaction, la vidéo-téléphonie (première génération) plus une série de services supplémentaires. Par ailleurs, le GAP a identifié 3 types de services qui pouraient justifier le développement de réseaux à large bande : - les services vidéo-interactifs (vidéo-conférence, vidéo-réunion, vidéo-téléphonie), - les services combinant de la pure distribution à l'accès à des banques de données (audio ou vidéo-librairies), - et les services de transmission de données à grande vitesse.

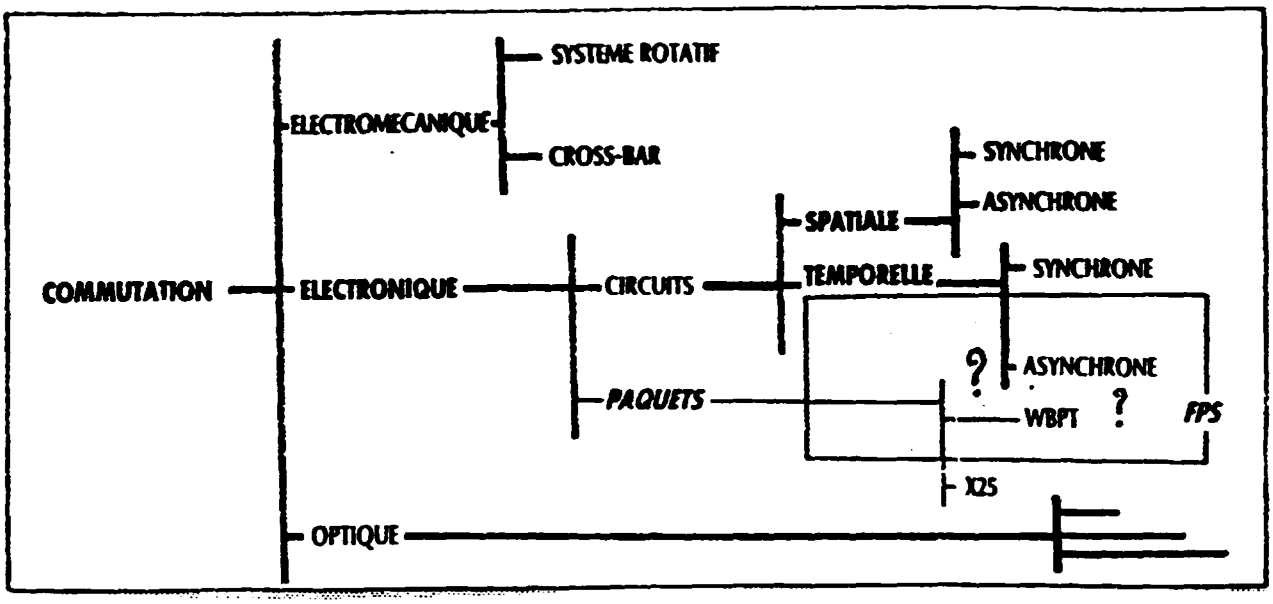
Source : J. SEETZEN et alii, *Vermittelte breitbandkommunikation - Technik, nutzung, wirtschaftlichkeit*, Heinrich-Hertz-Institut für Nachrichtentechnik, Berlin, 1986 ; propositions du "Groupe d'Analyse et de Prévision", (GAP) pour l'introduction coordonnée du Réseau Numérique à Intégration des Services dans la communauté ; Bruxelles, 5 juin 1985 ; Proposals by the "Analysis and Forecasting Group (GAP) for the coordinated introduction of Broadband Services in the community ; Brussels ; october 16, 1986.

Source : FAST II, *Synthèse des résultats, sous programme communication*, First Draft, janvier 1988.

88. This very long-term perspective does however lead to questioning certain possible choices in respect of the first generation ISDN for which not all the standards have been established. One may therefore see the discussions being held on standardisation influence the technical evolutions in regard to switching to a not inconsiderable extent during the nineties. It is not possible to envisage all the technico-industrial problems which are still in suspense; we will merely look here at one of the important questions for technical evolution. The decisions will be taken within the framework of the CCITT (International Telegraph and Telephone Consultative Committee) which, for the time being, has defined only two types of access, a basic access at 144 kbits/s (2B+D) and a primary access (30B+D) of 2048 Mbits/s and has provided for five interfaces (R,S,T,U and V) which have still to be standardised.

89. The ISDN is based on the standardisation of speech at 64 kbits/second with transmission by synchronous real-time multiplexing (cf paragraph 44). The development of signal compression techniques means that today less than 16 kbits/s will be sufficient for the transmission of digitised speech: the remaining 48 kbits/s represent over-provision and wastage. More or less everywhere in the world data transmission has developed on specialised networks in the packet mode with the well-established global X25 protocol. The present ISDN projects abandon these acquired advantages and the typical connection of a data transmission terminal blocks the use of "the line", even if its use is intermittent and with the necessary transmission rates well below the available capacity.... The ISDN should operate in effect in the circuit mode and not in the packet mode. Cerainly for bidirectionality, and especially for speech, the real-time constraint has to be maintained; however there is merit in making it flexible. Two technical trajectories are proposed today. The North Americans, with ATT, envisage Fast Packet Switching (FPS) in the case of Wide Band Packet Technology (WBPT). This involves the supression of the strictly synchronous character of the network of circuits with real-time switching by considering that the time interval allocated in the raster to a speech communication constitutes a kind of "packet" which can be shifted in the raster - or sometimes disappear if there are "blanks" - allocating it an explicit address for transmitting it under conditions which maintain the illusion of real-time, given the poor capabilities of our own audio-oral organs. Table I-10 shows the technical choices to be made in the nineties in regard to the necessary amendments to the proposed ISDN and the coming generations of switching exchanges.

Figure I-10 : NECESSARY DEVELOPMENTS IN SWITCHING TECHNIQUES : AMENDMENT TO THE ISDN



Notes : WBPT : Wide Band Packet Technology
FPS :Fast Packet Switching

Source : D'après Y. GASSOT, IDATE, Telecoms Magazine , n° 10, Dec. 1987-janvier 1988, p. 18.

3.3.3. Software and artificial intelligence

90. Every information processing machine uses an operating software which ensures that the machine functions, and also uses applications software which means that the functioning of the machine can be utilised for specific purposes. All progress in the hardware must be accompanied by progress in the software, both the operating and applications types. Part of the operating software for the systems is integrated into the hardware as firmware or applications software programs which can be used without any special knowledge and which facilitate the use of the hardware for processing information: in the case of typical applications these are termed dedicated programs. Until recently the techniques for writing the software had not developed greatly and remained essentially new, whereas there had been considerable developments in the hardware; this required the writing of increasingly long software programs with several tens of thousands of lines. The technical progress expected in the nineties, as described above, therefore demands progress in the software which is also reflected in the increasing length of the programs which have to be written. Many feel that this means that we have entered a period where software has become the critical point in the development of information processing machines.

91. This importance of software is reflected in the number of computer scientists who have to be devoted to software development. Hardware manufacturing enterprises must have them for the operating system; however in the case of applications software only a minimum number of staff may be needed, allowing other firms to grasp this opportunity. In certain cases, that of dedicated hardware, all the software has to be designed by the manufacturer, for example in the design of a switching exchange. Thus in the networks division of the BELL Laboratories of ATT more than 40% of the technical personnel are engaged on software development, This trend is likely to increase in the coming years and to become more widespread: more than 60% of working time in the production of electronics goods should be spent on the software.

92. Such a trend will lead to progress, probably in software engineering and the appearance of what are termed CASE (Computer Aided Software Engineering) tools. This means that software writing is no longer to be considered as an art with numerous clever devices but a task which should be structured in an extremely methodical manner so that a number of phases can be automated. We are starting to see the appearance of softwares which, starting from an ordinogram, are capable of writing a program in FORTRAN or ADA. One is also likely to see the development of tools providing aid to analysis and structured design, together with automatic code generators. The advantage of these techniques is also that they facilitate the maintenance of software since they retain "in their momory" the precise manner in which they were written. In a similar way this will facilitate their transfer to other hardware with different characteristics.

93. This continuity in the utilisation of applications programs, when the hardware changes, has become a considerable constraint, in particular in informatics. Informatics hardware is not dedicated but universal, and users have, thirty years after the appearance of informatics, a considerable and continually accumulating investment in applications programs which the new generations of machines have to accept. This, coupled with the objective of the possibility of communication between different systems (cf 3.2.3) , has led the major manufacturers to try to define together their next operating system. Faced with the past domination of IBM a coalition was formed to adopt UNIX, a system developed in 1969 by ATT and which had been improved in the American universities and then marketed in 1983 by ATT under the name UNIX System V. Its qualities led to its being widely adopted, and even IBM produced machines working under this system. However the chance operation of economic and industrial strategies led ATT to make an agreement in October 1987 with a dynamic work station manufacturer (SUN) for the development of a new version of UNIX without consulting its partners. Some of these joined in (the Americans UNYSIS and XEROX and the British ICL) whilst others reacted by creating in May 1988 the Open Software Foundation (OSF) in which other major European and American manufacturers participated, including IBM (but no Japanese, so far). The declared objective is to develop the next joint operating system, which will be transferrable. It is obviously difficult to predict the path of the delicate relationships between the various manufacturers; however it is probable that, under the pressure from users, an open system will finally emerge.

94. Software evolution will also involve the multiplication of the expert systems which form the special field of what has been termed artificial intelligence. This involves establishing within a given field a database of knowledge which is that of the expert, or of all the human experts in this field, and to develop a software capable of handling from this database any problem in this field, in the same way as an expert would do it. The first systems were written in the seventies and were particularly developed as an aid to the diagnosis of certain medical problems. Up to the present time they have been written in LISP (List Processing) or derived languages. The new generation of computers - the project for a fifth generation launched by the Japanese in 1981 - depends on using the Prolog (Programming in Logic) developed by a French engineer and this, from a certain point of view, constitutes an attempt to develop a universal expert machine. It is not very probable that general results will be obtained during the nineties. By contrast artificial intelligence should show considerable progress in a number of specialised fields as a result of software research, of work on establishing databases of knowledge and also of progress in the hardware. Apart frrom a larger number of expert systems the development of highly simplified modes of utilising information processing machines, the advances in the recognition of relative situations and forms in space and also in the linguistic syntax of sounds will form some of the points for technical evolution in the coming years. Figure I-11 summarises the forecasts made by a Japanese body belonging to the MITI.

Figure I-12 : EVOLUTION IN ARTIFICIAL INTELLIGENCE ACCORDING TO MITI (JAPAN)

	1985–1990	1990–1995	1995–2000	2000–
A. Systèmes experts 1) Conception automatisée		Logiciel CAO		Conception de nouveaux matériaux
2) Productique	Diagnostic de panne d'une partie d'installation		Conduite automatique de l'ensemble de l'installation	
3) Bureautique	Système de planning	Bureautique intelligente	Système d'aide à la prise de décision capable de modéliser	
4) Soutien opérationnel de grands systèmes			Gestion des réseaux électriques	Conduite des usines nucléaires
5) Consultation		Conseil pour l'utilisation de l'énergie Système général pour les problèmes domestiques		
6) Enseignement assisté (EAO)	Fourniture de matériel pédagogique	EAO spatiale	Formation à la conduite des centrales électriques	
B. Systèmes linguistiques 1) Traduction automatique	Traduction de de texte technique	Traitement de texte à traduction intégrée	Téléphone interprète	
2) Traitement de la langue naturelle		Machine à composer	Traitement de texte intelligent Machine à condenser automatiquement les textes	
C. Reconnaissance et traitement des images		Lecture de caractères chinois manuscrite Reconnaissance des figures manuscrites	Reconnaissance des images animées	
D. Reconnaissance et traitement de la voix	Traitement de texte vocal		Téléphone actionnable vocalement	
E. Robot intelligent			Robot mobile pour l'entretien des bâtiments	Robot autonome pour le travail dans les conditions extrêmes
Aspect du développement technique du traitement de la connaissance pour chaque période	Application des techniques de bases à des domaines particuliers	Utilisation fréquente du raisonnement logique	Raisonnement créatif avec fonction d'apprentissage	Application aux systèmes de grande taille

4. EVOLUTION OF PRODUCTION CONDITIONS

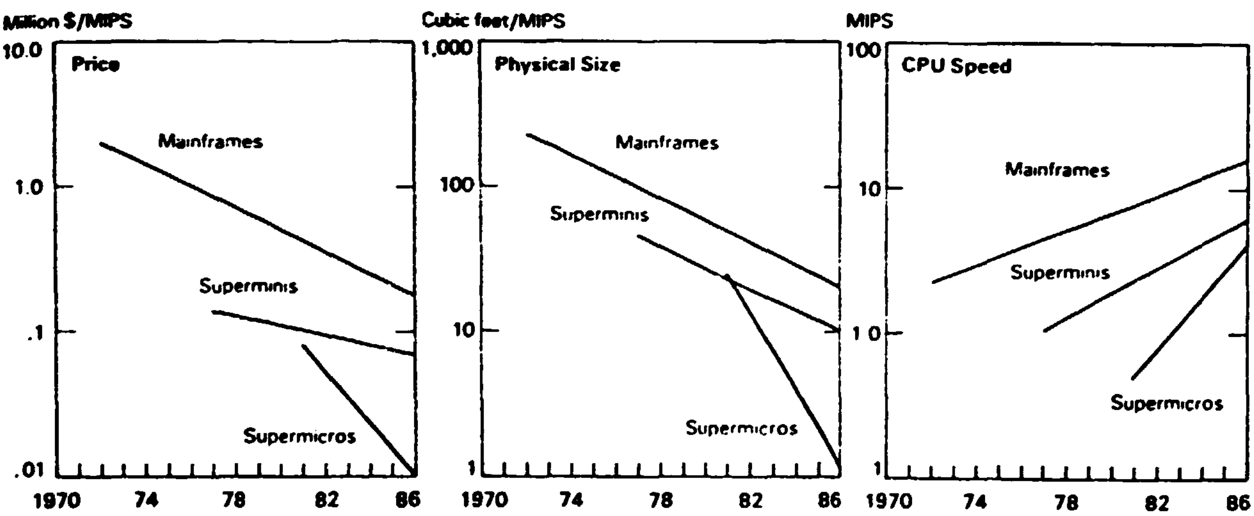
4.1. The general characters of a multi-intensive dynamic

4.1.1. Highly dynamic conditions

95. Whatever the product of electronics construction the fact that it belongs to the same technico-industrial complex is reflected by the same type of evolution in its production conditions.

96. This is principally marked by the relatively rapid and extensive renewal of the characteristics of the product which has to fulfil the same function or to render the same service, but with clearly superior performance and at a cost which is lower in absolute terms. Information processing machines must always be less expensive, smaller and faster. Figure I-12 shows this evolution at more or less constant annual rates for general computers since 1971 (and the IBM 370), the superminis since 1977 (VAX) and the supermicros since the IBM-PC.

Figure I-12 : COMPUTERS AND INFORMATION PROCESSING: CHEAPER, FASTER AND SMALLER



Notes: 1. MIPS—million instructions per second 2. Single processor models only 3 CPU—central processor unit
Source: International Trade Administration.

Source : U.S. Industrial Outlook, 1987, p. 28-3.

97. In more concrete terms one may note that prices are falling in absolute terms with improved performance for most products of generalised distribution. This is particularly the case in micro-informatics: for example between 1981 and 1985, that is to say between its launch and the sale of the millionth unit, the IBM-PC has undergone several official price reductions for the basic model, combined or not with improvements. From US$ 5455 at the time of its launching in August 1981 the price fell to US$ 4745 in May 1982 with a double-sided floppy disk drive. The price was then reduced in July 1982 to US$ 4175 and again in the August to US$ 3940 with an expansion of the central memory. The latter was again expanded in March 1983 with a new price reduction to US$

3339. By June 1984 the price of this improved version had fallen to US$ 2580, less than half the launch price. THis price was to be maintained up to March 1985 (Business Week, 25/3/1985).

98. In the case of products which do not have large sales figures it is the price in absolute terms of the basic service provided which has fallen spectacularly. In large system informatics this may be illustrated by the price per million instructions per second (MIPS). Table I-13 shows this significant decrease for different models in the IBM large computers range.

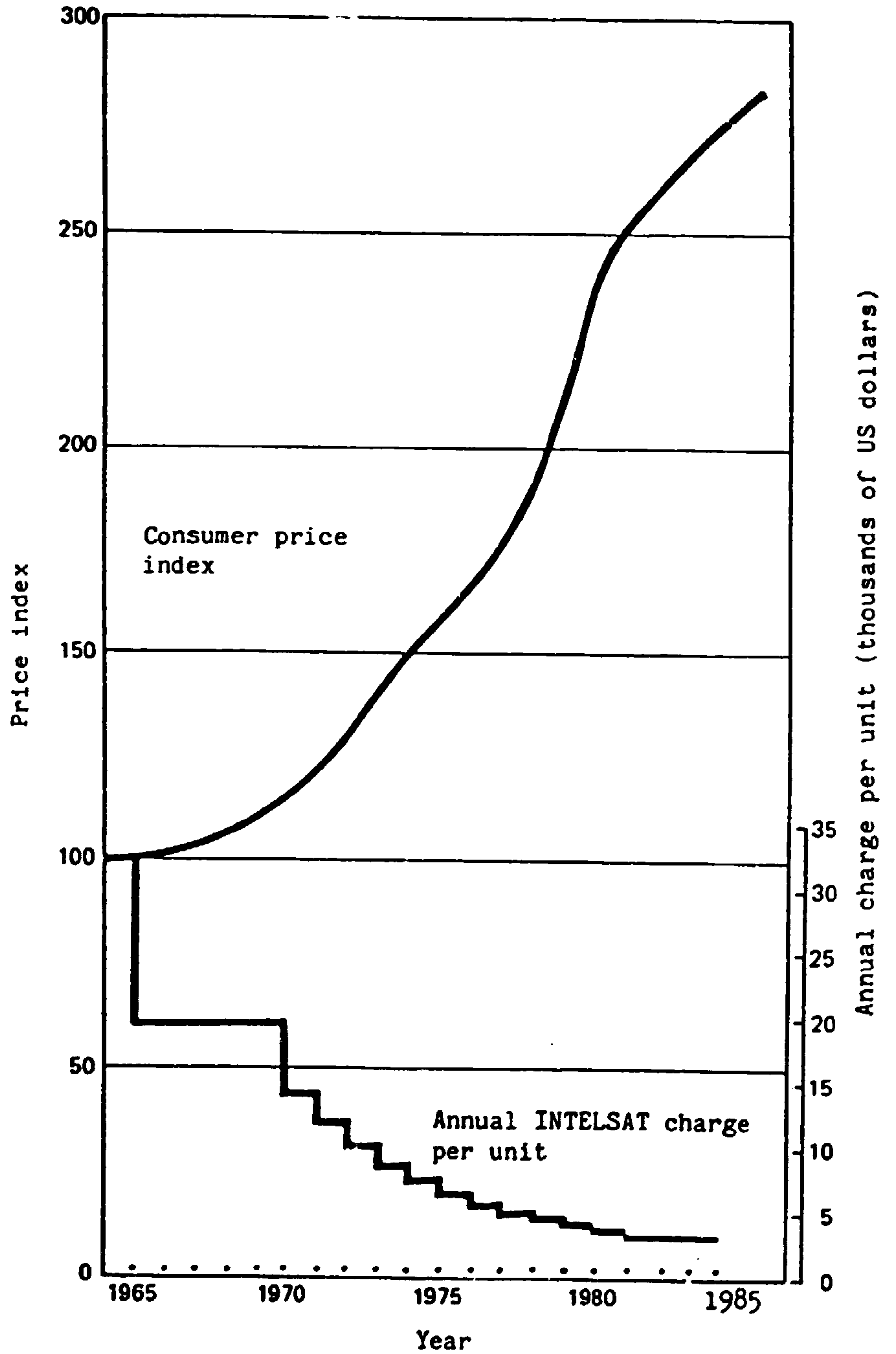
Table I-13 : MILLIONS INSTRUCTIONS PER SECOND (MIPS) PERFORMED BY VARIOUS MODELS OF IBM COMPUTERS DELIVERED BETWEEN 1965 AND 1987

Model	Year of delivery	MIPS	US dollars/MIPS
360/50	1965	0.2	7 018 000
370/155	1971	0.6	2 667 000
370/158	1973	0.9	1 628 000
370/158-3	1976	1.0	1 684 000
3031	1978	1.1	909 000
3033S4	1981	2.4	492 000
3083-E	1983	4.0	354 000
3083-CXO	1985	3.2	277 000
3090-200	1965	20.0	182 000
3090-400	1987	50.0	189 000

Source : The Telecommunication Industry - Growth and structural change, E.C.E.-United Nations, New-York, 1987, 292 pages, p. 35.

99. This can also be illustrated in many other fields, for example by the cost of telecommunications satellites. In the case of Intelsat Figure I-14 shows how the unit cost in absolute terms has changed in the inverse way to general consumer prices.

Figure I-14 : INTELSAT'S ANNUAL CHARGES, 1965-1984



<u>Source</u> : *The Telecommunication Industry*, U.N., 1987, op. cit, p. 169.

100. This is evidently linked to developments in the launchers, but also directly to the satellites themselves. Intelsat I, launched in 1965, had a working life of a year and a half, weighed 13 kg and could handle 480 telephone channels (bandwidth 50 MHz). Progress in launchers made it possible to launch Intelsat VI in 1986; this was 61 times heavier at 800 kg. Its predicted life was ten years - responsibility for progress cannot be entirely attributed to space techniques - and capable of handling 80,000 channels with a bandwidth of 3.5 GHz, more than 160 times more channels than in 1965. As everywhere evolution in the performance and price of components is reflected in that of the systems. This evolution in the components should continue to follow the same trend, so that it may be considered that systems will continue to follow the same trend. This is shown by all the forecast calculations, such as those for this same communications satellites sector. Table I-15 confirms this for us.

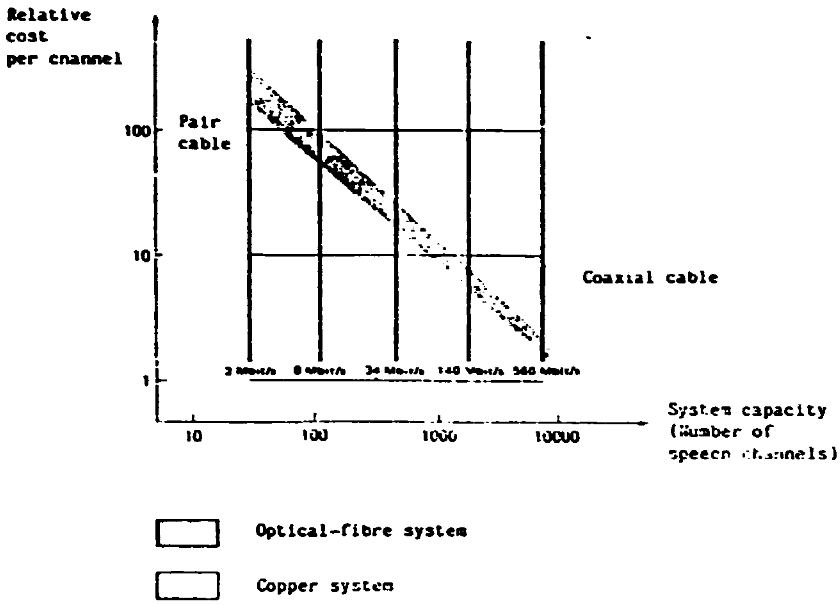
Table I-15 : SATELLITE COMMUNICATION COSTS, 1983-2000
(1983 US DOLLARS, HALF CIRCUIT PER YEAR)

Year	INTELSAT lease charge	Earth segment cost	Total cost
1983	4 680	8 820	13 590
1984	4 330	8 170	11 500
1985	4 000	7 400	11 400
1986	3 650	6 830	10 480
1987	3 240	6 170	9 410
1988	2 650	5 790	8 440
1989	2 230	5 250	7 480
1990	1 930	4 800	6 730
1991	1 630	4 370	6 050
1992	1 450	4 000	5 450
1993	1 250	3 700	4 950
1994	1 070	3 390	4 460
1995	910	3 100	4 010
1996	770	2 870	3 640
1997	660	2 640	3 300
1998	560	2 430	2 990
1999	480	2 240	2 720
2000	410	2 050	2 460

Source : *The Telecommunication Industry*, 1987, op. cit., p. 37.

101. More generally in the telecommunications industry the element comparable to the evolution in the cost of one million instructions per second in informatics is that of the evolution of the price of one telephone call. For example in 1983 £ sterling the cost of one call between the United Kingdom and the United States fell from £69 in 1930 to £29 in 1948, to £9 in 1967, to £3.85 in 1976 and finally to £1.63 in 1983 (The Telecommunication Industry, op. cit., p. 40). The use of electronics techniques should reduce costs even further, but perhaps for improved services provided. For example the technical prospects of ISDN and the use of fibre optics are only of interest in reducing costs per channel at rates in excess of 34 Mbits/second. This is underlined by Figure I-16.

Figure I-16 : COMPARISON OF THE COSTS OF OPTICAL-FIBRE SYSTEMS AND COPPER SYSTEMS FOR NEW CABLES



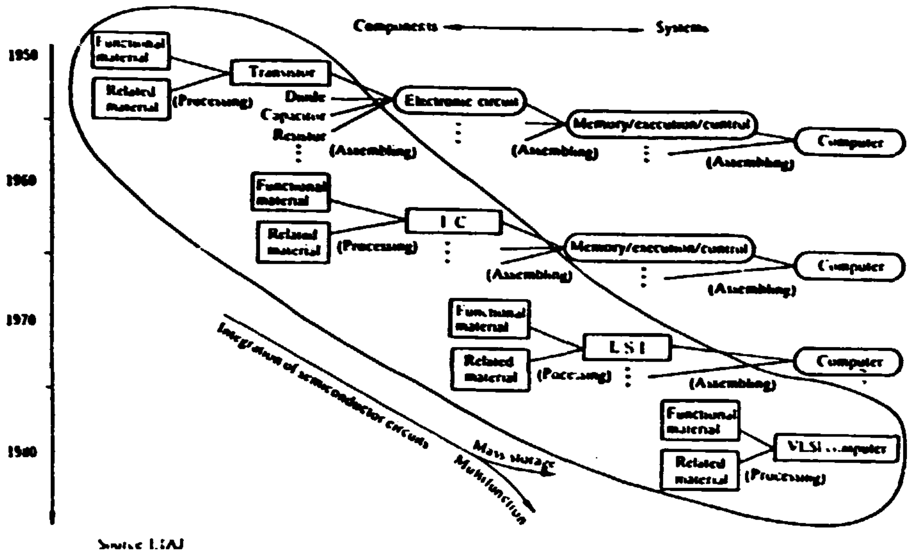
Source : *The Telecommunication Industry*, op. cit., p. 39.

102. Inasfar as the industry appears to be an assembly industry, where performance and prices improve because of progress in components, it might be thought that production conditions are of extreme interest since they certainly ensure outlets which, because of this progress, are rapidly increasing. This apparent facility masks the multi-intensive character of production.

4.1.2. But with difficulties linked to the multi-intensive character of production

103. The intensity of technical progress requires constant alertness if one is to be able to profit from the advantages of the greatest possible integration of the components and to envisage those suited to the specific needs of the various applications and which it is necessary to combine to form any electronics product, that is to say any given machine or any given system for the transmission and processing of information. This situation gives an advantage to producers who are very near the component manufacturers, at the same time that the components increasingly become systems, as is shown by Figure I-17.

Figure I-17



Source : Japan Electronic Almanac, 1987, DEMPA, p. 205.

104. This reason has encouraged many firms to integrate vertically. This is fairly general with the major informatics firms which have become producers of components for their own use, such as IBM which will be the largest producer in the world for semiconductors. Similarly the Japanese, producers and sellers on the integrated circuits market, have an advantage over their American competitors in that they are vertically integrated.

105. More generally the convergence of those branches which were relatively distinct in the past, such as informatics, telecommunications and mass consumer products, obliges producers in one particular segment to find ways of maintaining close contact with those in other segments and with component manufacturers, so that they do not lose any opportunities and become outdistanced, since rapid technical evolution is a race in which many competitors who vigorously dispute the market opportunities are engaged.

106. The high intensity of Research and Development becomes of increasing consequence as the components become systems (cf Figure I-17 above). When one has 32-bit micro-controllers with 25,000 lines of codes and 1 Megabit memories it is in order to develop an application which corresponds to a software program which is capable of solving a problem of considerable complexity. All these new product-systems which it is possible to develop generally require very long periods of research and development, for which highly qualified staff is required. To design an integrated circuit it is hoped that the progress in informatics aids will make it possible to achieve a capacity of 1000 transistors per day and per designer in five years time. That is to say that, for any entirely new circuit, a team of several persons will have to work for three or four years. The development costs of complex systems which make it necessary to invent several circuits, the way in which they are to be combined and the overall architectures, have arrived at considerable levels. At the beginning of the sixties IBM launched its IBM 360 wih R & D costs of US$ 400 million. Each of the large digital public

telephone exchanges has required, on average, US$ 750m. The costs to be accepted for the next generation are such that all the experts (cf DANG NGUYEN G., 1987, p.4) predict that the markets will only allow a small number of the existing constructors to recover these costs so that either a reduction in numbers or a major regrouping (or shakeout) of telephone exchange manufacturers is to be expected.

107. The high intensity of qualifications of the workforce does not arise solely from the increasing importance of R & D but also from the disappearance, in the production phase of electronics construction, of the assembly and cabling tasks which were traditionally important in this type of "construction" industry. What was called in the past "cabled logic" has become "integrated logic" and the electronics of cabling and even micro-cabling, of the soldering iron or even the soldering of gold wires under a binocular microscope, has disappeared or is on the way to disappearing. For example the SMD (Surface Mounted Devices) techniques (cf paragraph 69) inevitably lead to the automated production of printed circuit boards. The need for increasingly skilled staff is being felt not only because it is necessary to develop the software with the hardware but also because the production of the hardware is tending to be automated and so considerably reduces the need for physical tasks. Table I-18 shows how the type of jobs offered by Siemens, which is a major electrical and electronics enterprise, has altered: most of the enterprises concerned exclusively with electronics generally have engineers in 50% of their jobs whilst semi-skilled workers rarely account for more than 10% of the jobs.

Table I-18 : EMPLOYMENT AND ITS STRUCTURE AT SIEMENS (GERMANY)

	1972	1982
White-collar staff	16%	20%
Engineers and technicians	25%	30%
Skilled workers	20%	20%
Semi-skilled workers	39%	30%
TOTALS	198,400	169,800

108. Such costs obviously require, as a general rule and for "advanced" products, that an appreciable share of the world market is available; apart from the high fixed costs of the automated equipment this implies high capital investments to install the necessary production capacities and efficient distribution networks. For this reason the electronics industries have mostly become capital-intensive. As can be seen from Table I-19 there are nevertheless fields where production lags behind technical advances and where, as a consequence, the necessary capital investments, intended perhaps for a protected market, can remain modest because of the nature of the less sophisticated plant needed and the size of the market to be supplied. Furthermore the original specifications of the products may define a niche, that is to say a restricted global market within which relatively low capital investments would make it possible to obtain a significant share.

Table I-19 : TECHNICAL AND INVESTMENT LEVELS IN SOME PRODUCTS OF THE ELECTRONICS INDUSTRY

Sector	Examples of products	Level of technology		Investment
		Design	Manufacturing	
Advanced	Advanced semiconductors, computers, telecommunication equipment.	High	High	$100 M and above
Design Intensive	Mini/supermicro computers, software, simpler telephone switching equipment.	High	Medium/Low	$5-25 M
Medium Technology	Color Televisions, video cassette recorders, disk drives, microcomputers.	Low/Medium	Low/Medium	$5-50 M
Low Technology	Black and white televisions, passive components, simpler semiconductor devices.	Low	Low	$1-20 M

Source : Ashoka Mody, *The development of information industries*, 1987, conference at Brooking Institution on "Technology and government policy in telecommunications and computer", p. 10.

4.1.3. Copying to avoid the difficulties

109. However there still remains, despite this multi-intensive character of the dynamic of production conditions in electronics, the possibility in a not unimportant number of cases of avoiding the need for considerable R & D expenditure, of vertical integration, of the high intensity of software and of massive capital investments. This possibility consists of swimming in the wake of a large fish in some way.

110. In the information processing industry this was the policy, adopted in 1976 by AMDHAL, of manufacturing large computers which were compatible with IBM models, that is to say they were slightly less expensive and slightly more powerful copies of the IBM computers. IBM compatibility had been brought to an exceptional level after the IBM-PC came out in 1981. This time it was a much simpler machine. In the original configuration it consisted of three boards on a BUS from a microprocessor available from the Intel catalogue and an operating system, derived from the MS-DOS sold by Microsoft, a Japanese keyboard, a floppy disk drive from Singapore, etc. Clones of the IBM-PC proliferated, for the basic versions and also for the PC-XT and the PC-AT. The software compatibility made it possible to run all the softwares written for IBM, and in particular all the relatively inexpensive applications programs written by service companies, whilst the hardware compatibility made it possible to introduce various expansions intended for the original IBM-PC. Whilst there remained some distinguishing features - apart from aesthetics - these were very few in the case of many of the compatibles, coming down in the case of some of them to very minor details of architecture. It was a matter therefore of constructing a copy which was almost identical to one model of an information processing machine. This is obviously an easy situation for the copier: no need to recoup the same Research and Development costs, no need to gamble on the creation of a market. The leader establishes this market and, to the extent that the assembling is simple and the constituent parts available on the intermediate markets, the copier can offer very tempting prices. In the case of the IBM-PC there were many cases where the copier offered nothing more, whilst in other cases the versions offered were at the same time compatible and superior but at a lower price. The very large

number of these machines sold - several millions - and the multiplications of the applications software, also sold on a very large scale, created a de facto standard which left the non-compatibles (apart from APPLE and its MacIntosh who however offered an optional rapprochement) outside a very rapid dynamic of growth.

111. This standardisation of what it is necessary to make and to sell, often linked to some specific components or softwares, obviously poses the question of copyright. Since the beginning of the eighties most countries attempt to protect their software from being copied, in particular the software which is written on silicon, that is to say when an integrated circuit, a memory or a microprocessor is designed. This is not easy, and some difficult legal actions have been heard or are still in the courts. IBM accused the Japanese Hitachi and Fujitsu companies of spying when they attempted to find out in advance the characteristics of its new range so that they could prepare their future compatibles as rapidly as possible.... Intel accused the Japanese NEC firm of copying its circuits, whilst in their turn Japanese companies such as Hitachi have accused the Korean Samsung firm of copying their integrated circuits.

112. To avoid the difficulties linked wih the multi-intensive character of the dynamic of evolution of the conditions of production of electronics is therefore not all that obvious, in particular when it may be done at the cost of infringing the law. On the other hand producers may be led to do something fairly similar by agreement with the original producer of the equipment by way of the so-called Original Equipment Manufacturer (OEM) system in information processing and for other types of machines, or again by the so-called second source system in the case of semiconductors. In semiconductors most of the original American manufacturers have adopted the custom of signing agreement with other firms, generally European, so as to supply a vaster market and to supply their clients, without too much delay, when the cyclic demand is at a high point.

113. These general production conditions, which are found in a more or less marked manner for the various products of the electronics industry, are evidently supplemented in the case of each of them by special characteristics. We will examime integrated circuits, memories and television receivers in rather greater detail.

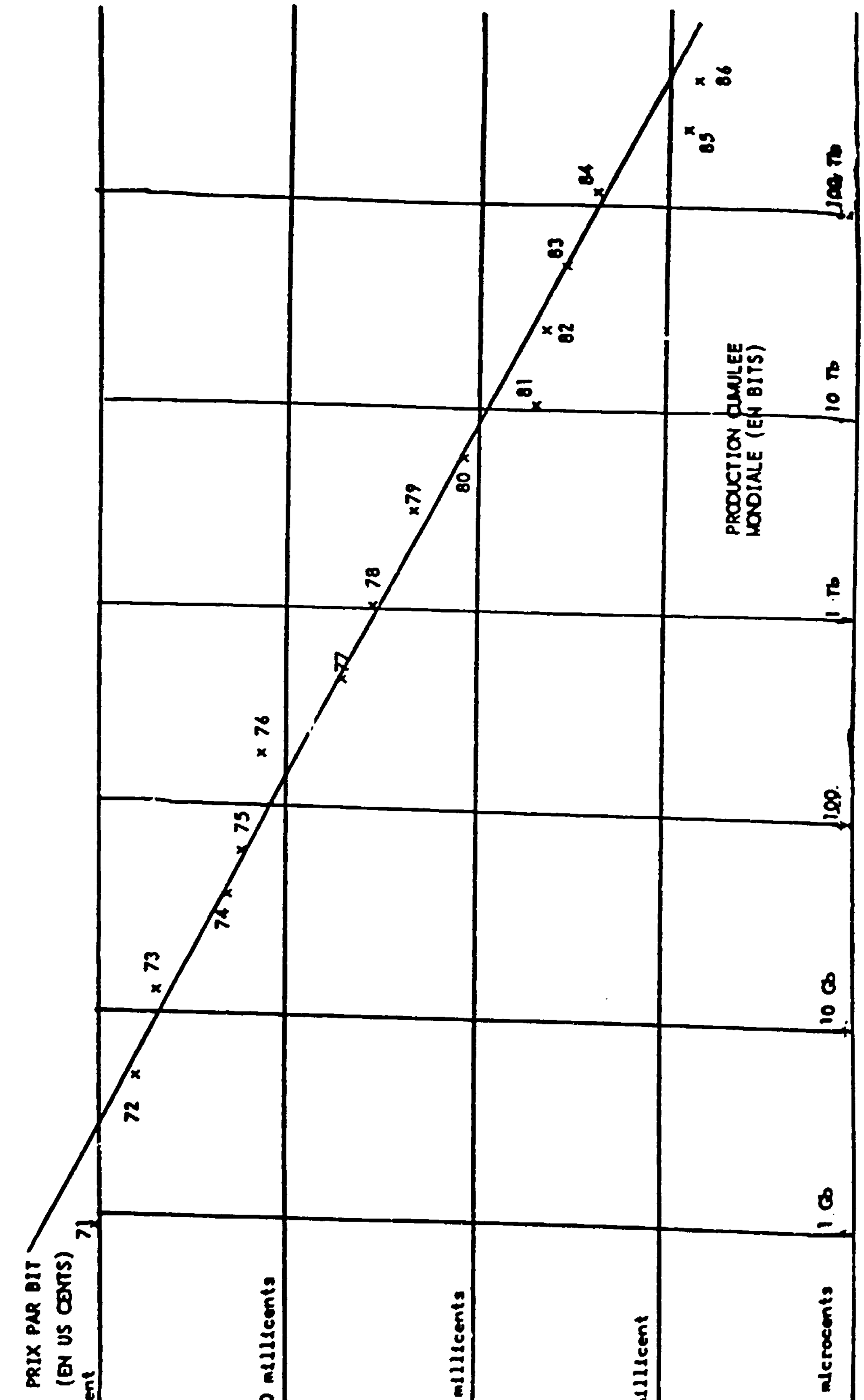
4.2. The case of integrated circuits - memories

114. The semiconductors industry thus offers the basic bricks necessary for the whole of the electronics industry and its operation consequently has a certain impact on the whole of this industry, the place of which is becoming very important in respect of all other industries. It is in this sense that this industry can be regarded as strategic. In this sub-group of electronic products one finds an already large number of actors. We identified 73 for 1984 (cf J.L. PERRAULT, 1985, p.8), selling their production on the world scene. One original characteristic can be noted immediately: the largest world producer of semiconductors does not offer its production on the market. By its in-house production IBM in effect covers a not unimportant part of its needs; these are obviously difficult to quantify accurately but they can be evaluated as in the region of US$ 2 billion to 3 billion. For example in 1985, according to the Integrated Circuit Engineering Corporation, out of a total North American production of integrated circuits, evaluated at nearly US$ 14b overall, it is necessary to count on a captive production of US$ 4.7b, or practically a third. Clearly what the analyst can really observe on this market are the merchant-producers.

115. The averagely concentrated structure of the merchant-producers shows a kind of "directing group" of about ten manufacturers which defines the situation in the industry. This is not to be understood as being a stable state, such as the oligopoly as we are accustomed to see it, with great price rigidity together with various trading conditions. However this directing group operates rather like an implicit cartel or a collusive oligopoly which seeks to maintain the domination of the directing group on the situation of the industry. This situation evolves very rapidly. What the directing group has to master is, firstly and in regard to prices, an "optimal trajectory" for decreasing prices and secondly to combine this decrease with the ongoing renewal of the technical characteristics of the product and the processes of its production. In order to specify the movement of evolution which the directing group attempts to guide and to master in order to maintain its domination: this may be illustrated by an example, that of the memories, which permit the electronic storage of all information put into the form of bits, the new universal alphabet.

116. This institutes a kind of "curve of global apprenticeship" which links, in a more or less perfect manner, the price per bit of memory in Dollars with the cumulative world production in bits, as may be seen from figure I-20.

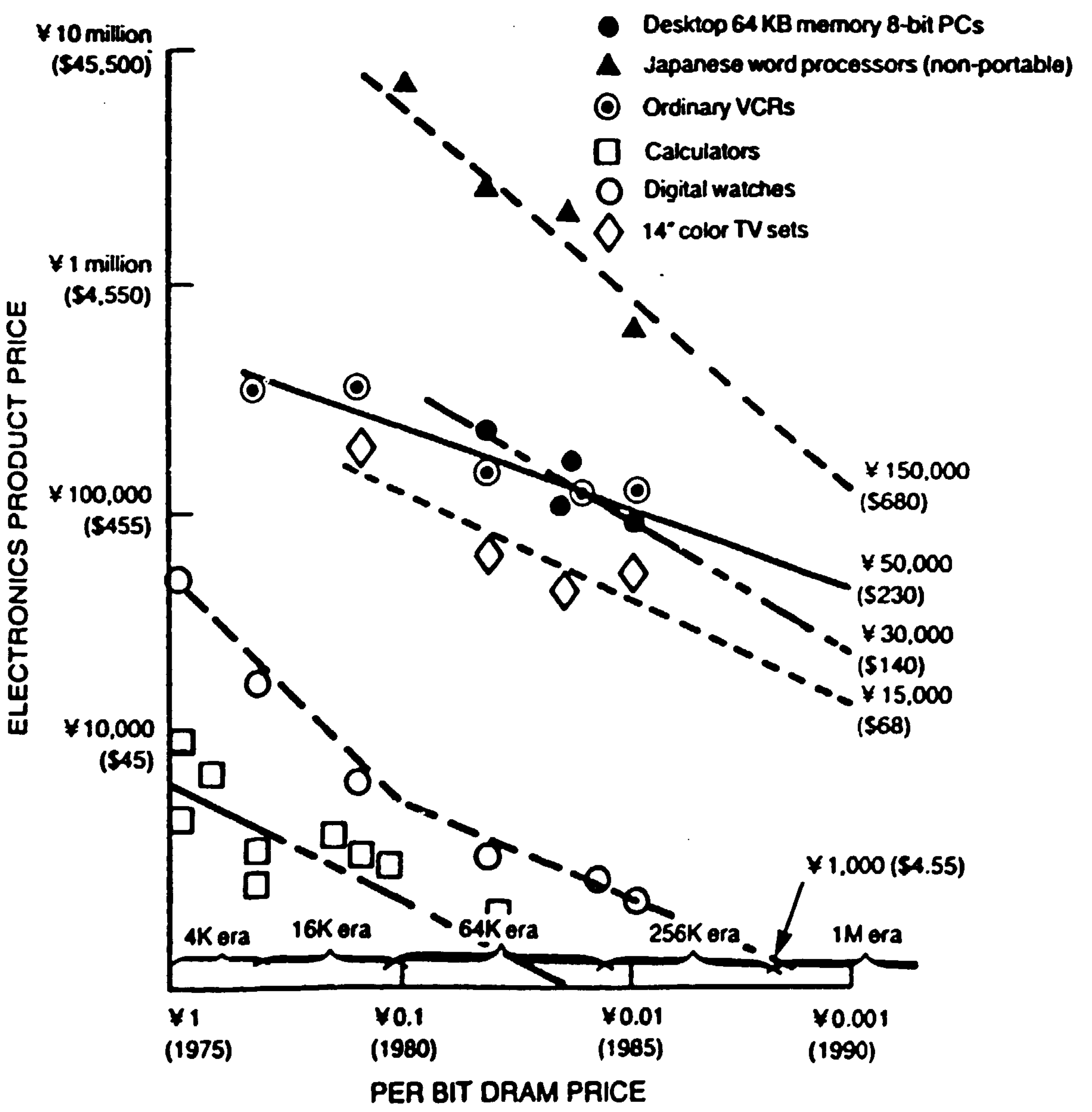
Figure I-20 : THE CURVE OF APPRENTICESHIP PER MEMORY-BITS



Source : E. de ROBIEN, 1986, op. cit., p.50.

117. This evolution in the bit price of memories has repercussions on the prices of all the products of the electronics construction industry. This has been shown by the EIAJ, the Electronic Industries Association of Japan, from which the following figure is taken.

Figure I-21 : EVOLUTION OF PRICES PER MEMORY-BITS AND OF ELECTRONICS PRODUCTS



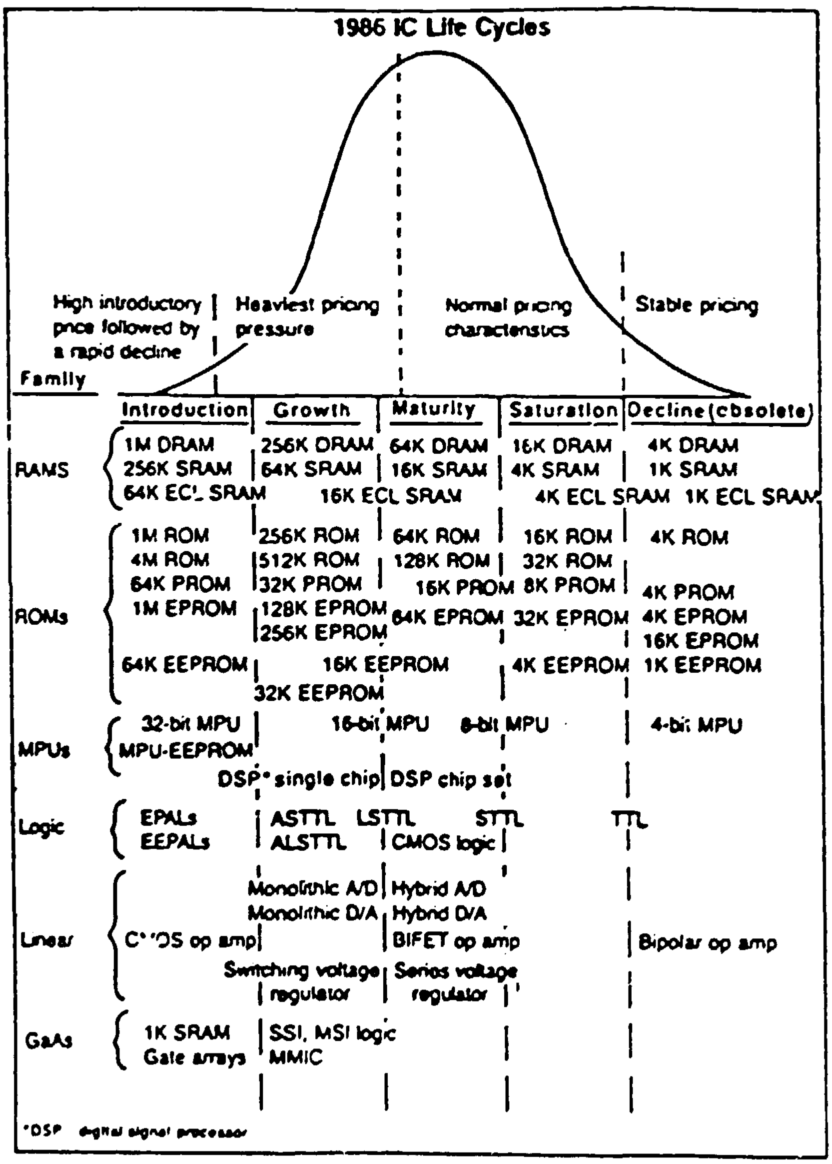
The per bit DRAM prices were calculated by NIRI. Product prices are based on manufacturers' suggested retail prices.

Changes in Per Bit DRAM Prices and Electronics Product Prices

Source : EIAJ Report, 1986

113. The falling trend in DRAM prices is linked with developments in their density of integration of the quantity of bits stored on the same chip (16k, 64k, 256k, 1M, etc.); this doubles about every 18 months. We should add that all categories of integrated circuits, and not only the DRAM memories, have a very short life and renewal cycle, as may be seen from Figure I-22. During each of these short cycles the price establishment process evolves. In each category of circuits the prices are initially very high, then sales are made at prices which anticipate the considerable internal scale economies: at this stage the prices become lower than those of the previous generation and so stimulate demand by the falling costs, whereas previously it was the prospect of technological improvement which had diverted part of the demand from the previous generation to the new generation. Finally the prices are fixed in a manner which is more in accordance with the state of the market, and finally the prices become stable with technological obsolescence.

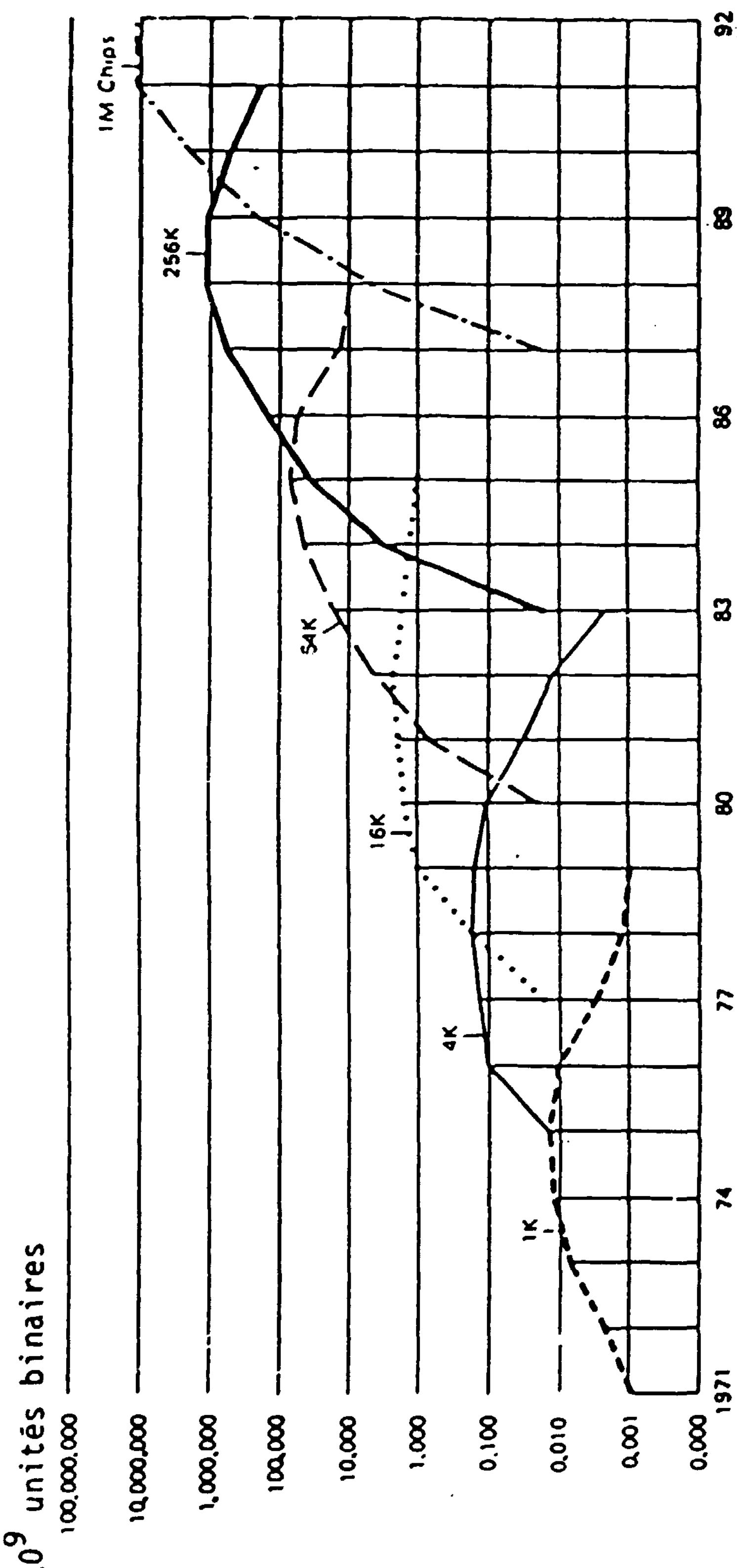
Figure I-22 : PRODUCT CYCLES IN INTEGRATED CIRCUITS



Source : After ICE Corporation and Semiconductor International, April 1986

119. Production and sales increase to a considerable extent from one generation to the next, obviously corresponding to the considerable global increase in electronics as already mentioned. Whilst some 1 million memories (DRAM) were sold at the beginning of the seventies by 1985 this figure was of the order of 1 billion. The cycles of sales from one generation to another thus rise in a kind of staircase for the various types of integrated circuits, as is shown by Figure I-23 for DRAM memories.

Figure I-23 : EVOLUTION IN DELIVERIES OF DRAM MEMORIES



Source : Bureau of Industrial Economics : "US Industrial Outlook : 1984"
US Department of Commerce, Washington, pp.30-7 and 30-8.

120. From generation to generation the costs of Research and Development and the time needed for it have increased greatly. Whilst the manufacturers hope to offset the rise in the time needed by having recourse to design assistance tools, it is however not possible to envisage reducing the costs. In 1987 National Semiconductor indicated the following orders of magnitude for the development of memories : one year and US$ 2m for the first 1k memories; two years and US$ 10m for the 16k memories and three years and US$ 100m for the 1 Megabit memories. In all the so-called high-technology industries the semiconductors industry is the one where the ratios of expenditure to turnover or to profits are the highest, and are increasing, as may be seen from the following table relating to the United States :

	RESEARCH AND DEVELOPMENT expenditure as a ratio of			
	turnover		profits	
	1978	1981	1978	1981
Medium				
High technology	4.0%	nd	65.4%	nd
Aerospace	3.7%	4.8%	93.0%	141.8%
Semiconductors	5.8%	7.1%	102.3%	174.0%

Source: After Electronics, 17.1.1980, p.83, quoted by D. ERNST in The global race in micro-electronics, Campus Verlag 1984, p.65, and Business Week, 5.7.1982

Taken over all the producers of semiconductors the R & D effort today represents about 10% of the turnover. In the case of the manufacturers producing the most complex products, such as microprocessors where the desire is to advance rapidly in the technology, the percentage may be even higher.

121. Manufacturing costs also rise very considerably from one generation to the next, if only for the reason that the increasingly costly equipment has to be amortised over an extremely short period. Amongst these manufacturing costs it is the lithography (cf paragraph 56) which alone accounts for a very considerable proportion: 40% to 45% according to experts such as M. BOREL, the head of technological research on integrated circuits at Thomson (Electronique Hebdo, No.44, October 1987, p.58). The price of this equipment tends to rise, logically, with the increasingly high optical and mechanical precision demanded from it. This is shown in Table I-24; the price of the equipment has been multiplied by ten whilst production has fallen.

Table I-24 : EVOLUTION IN LITHOGRAPHY EQUIPMENT

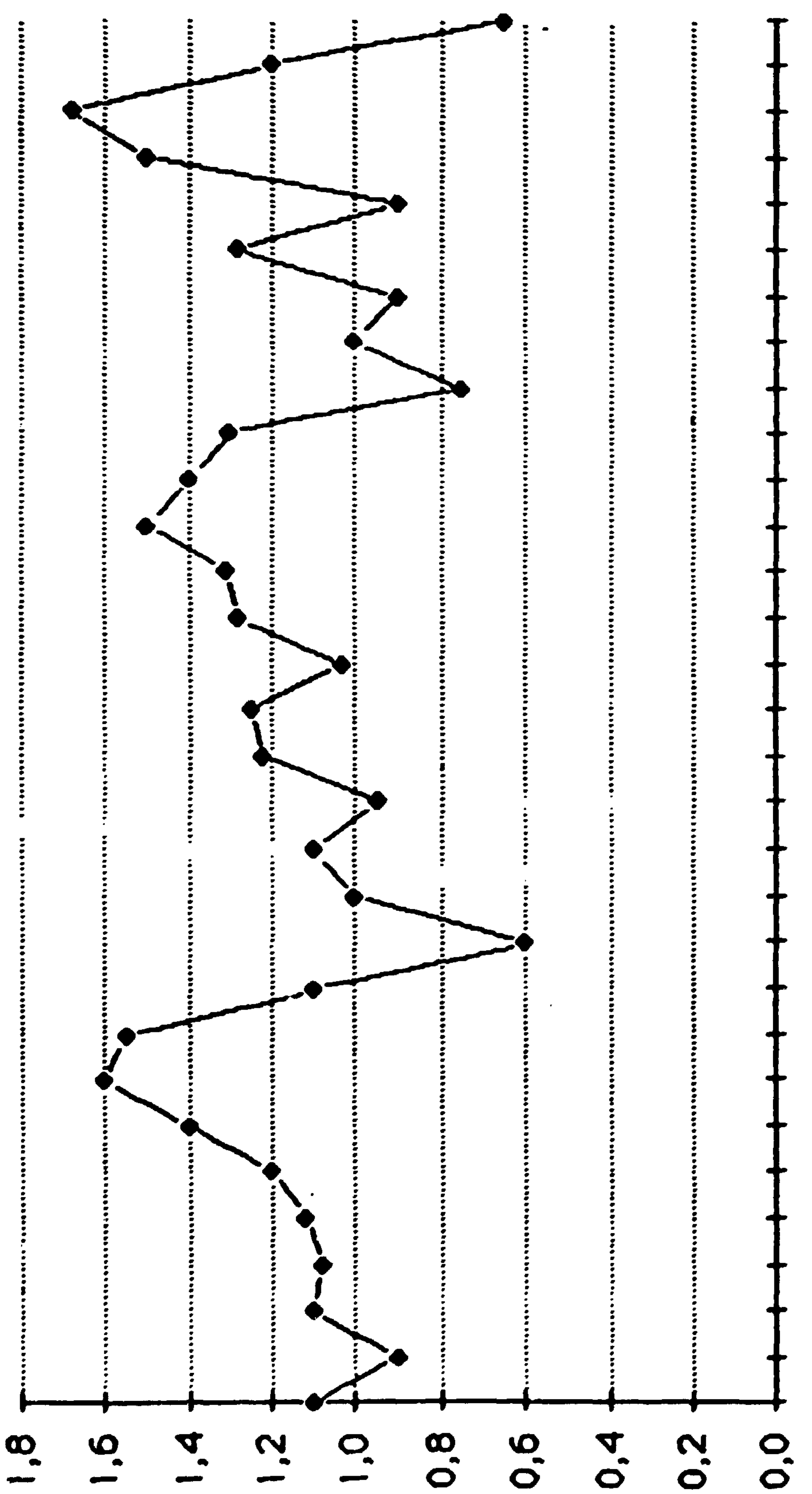
Lithography equipment	Year of development	Average cost, US$k	Production, wafers/hour
Proximity printing	1972	25-125	100
Projection printing	1973	250-750	50-80
Stepper	1976	350-1000	15-40
X-ray	1982	500	50
Electron beam	1983	1000-3000	5-15

Source : After P. DELMAS, The Cow-Boy and the Samourai, Ministry of External Relations, Paris, 1984, p.81

122. In order to maintain his position amongst those who set the pace for the industry every producer must therefore make major capital investments in plant whilst maintaining contact with the state of the art in technological matters. This assumes the regular re-investment of considerable sums in production which will increase from generation to generation of products. In 1984 the joint production of semicorductors in Japan and the United States could be evaluated at US$ 28.7 billion, whilst investments accounted for US$ 6.6b, representing a mean Investments/Turnover ratio of 23%. This ratio was of the order of 10% in 1975 and 16% in 1980 (according to M. FRENCH, The semiconductor industry: an overview, Datamation, April 1980, p.164). Taken overall, and for the most advanced manufacturers, it is necessary to devote half, if not more, of the turnover to capital investments and to Research and Development.

123. Under these conditions the directing group is therefore a kind of "leading rider" in a frantic race which constantly demands increasingly sophisticated equipment, and in which it is not always possible to maintain a place. The manoeuvres themselves are delicate, since the short-term evolution is much more disturbed than might be assumed from the long-lasting trends which we have described. After years with increases of the order of 40% there may follow real crisis years with negative rates of increase of sales, as in 1974-75, 1981-82 and 1985-86. Situated upstream of the electronics construction industry this production of the basic bricks obviously suffers from the phenomenon of the acceleration of the derived demand. The evolution of the customarily observed ratio of orders received to goods invoiced clearly shows this cyclic character, as may be seen from Figure I-25.

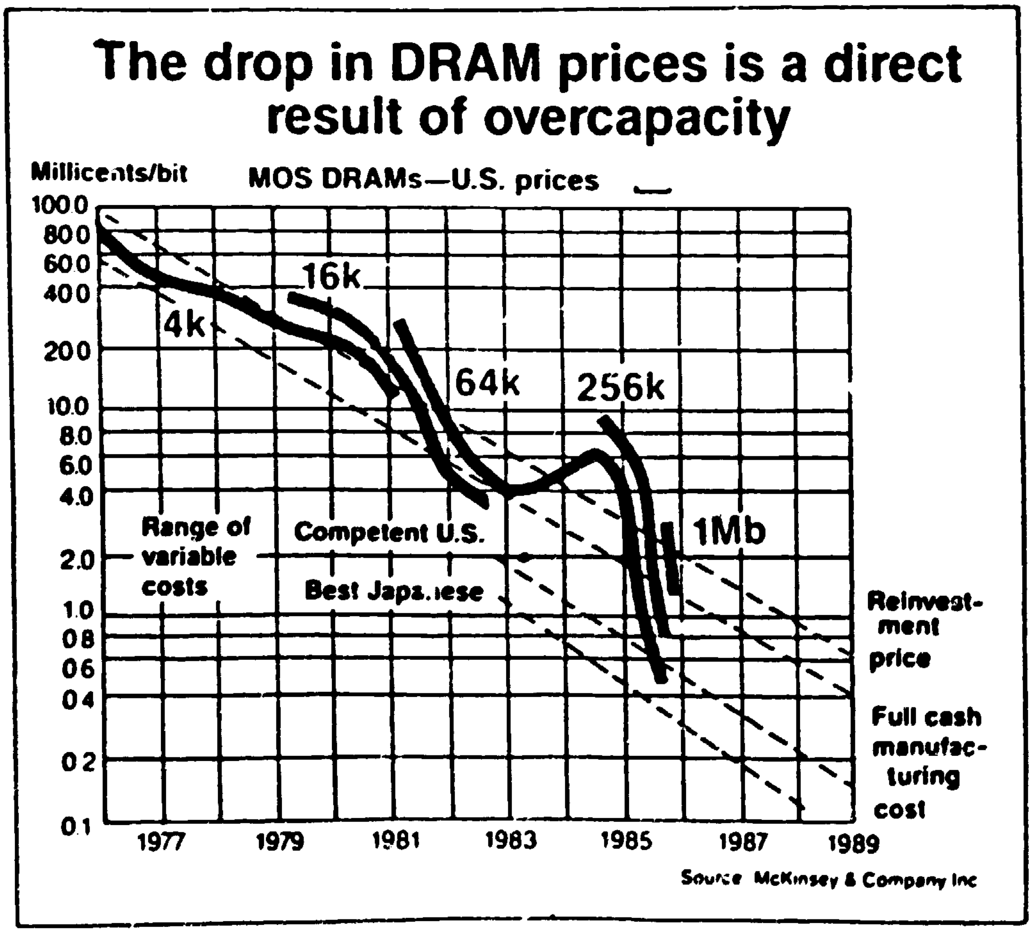
Figure I-25 : HALF-YEARLY RATIO OF ORDERS AGAINST INVOICES OF DRAM INTEGRATED CIRCUITS



Source · J. MIZRAHI, "L'échiquier électronique", Hachette, Paris, 1986, p. 131.

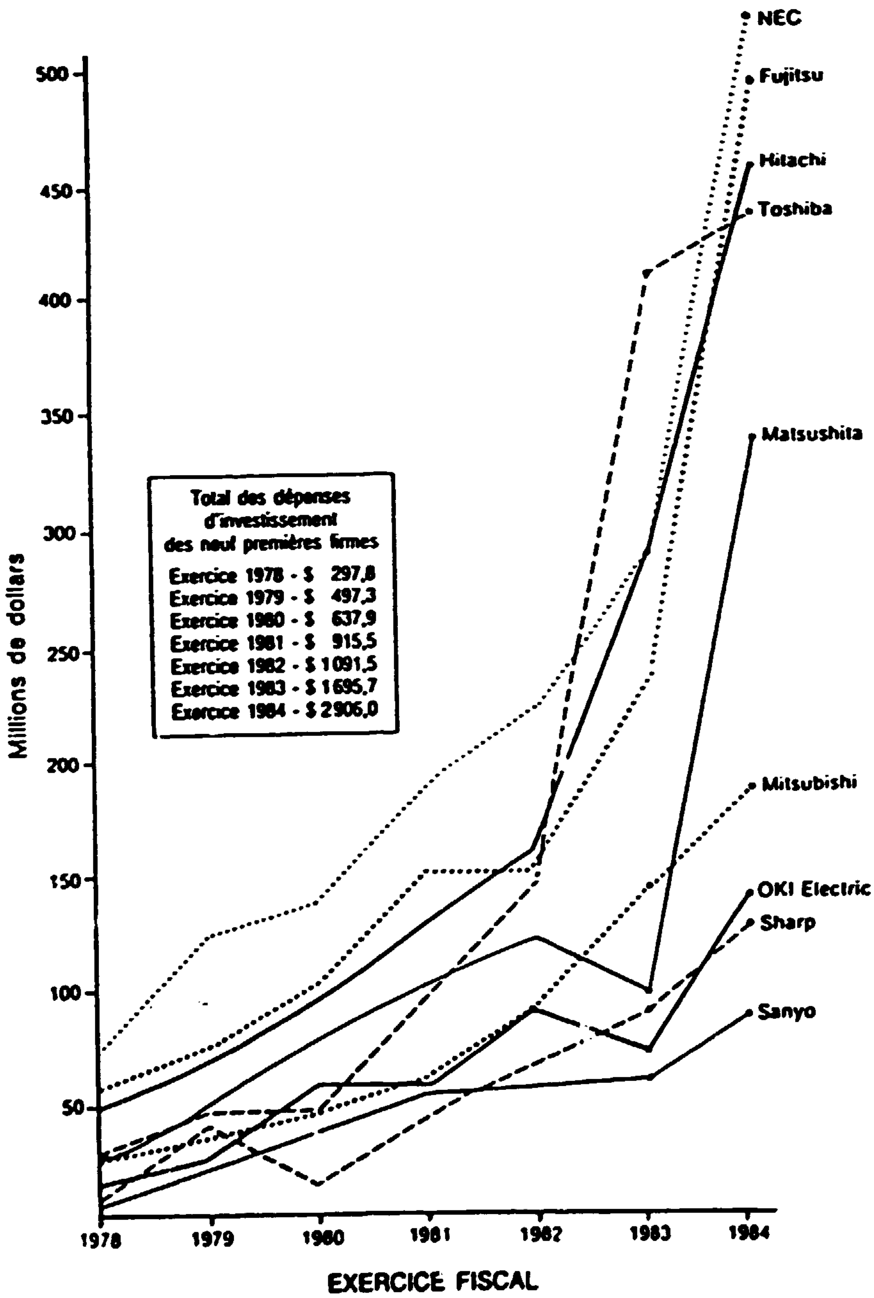
124. Price changes are affected not only by the phases of the life cycle of the product (cf paragraph 118) but also by the fluctuations in the demand and also in some cases by fluctuations in the supply position, amplified by the aggressive investment policies of some competitors. In periods of insufficient orders the fall in prices is held back, but the reaction of the suppliers, very desirous to move on to the following generations, may well lead to a high level of investments and a supply situation which can lead, if the demand is slow to become dynamic, to excess capacities. These can provoke an accelerated fall in prices without any assurance that future sales will be of sufficient volume to cover costs (increasingly high on the invested capital). This is what is shown by an article in Electronic Business of March 1986, from which Figure I-26 is taken, whilst Figure I-27 illustrates the course of Japanese investments. It may easily be understood that such a situation in the industry, which has no structural stability, resembles a permanent exploit involving the ascent of a succession of constantly more difficult peaks; this is not the result of a tacit harmony between individual firms but rather of a very vigorous competition. It has given rise to considerable tension between the United States and Japan despite an agreement (30 July 1986) which other producers feared because it had been set up at their expense, particularly in the case of the Europeans.

Figure I-26 : THE ABNORMAL FALL IN MEMORY PRICES



Source : Electronic Business, 1 March 1986, p.92

Figure I-27 : THE JAPANESE PATH OF INVESTMENT IN SEMICONDUCTORS



Source : Dataquest, Inc.

Source : After S. TATSUMO, Les technopoles ou la revolution de l'intelligence,
Les Editions d'Organisation, Paris, 1987, p.280.

4.3. The case of the television receivers industry

125. To begin with the supply of mass consumer electronics products was small, coming from producers stemming from the electrical and radio industries. The latter were able to profit from the granting of licences by RCA (United States), the company which had developed the first television receivers. Almost all of the enterprises present on this market operated over the whole of the mass consumer sector. The continuing expansion of the world market for television sets and the development of "peritelevision", that is to say all those services and products using the screen of the television receiver as a visual display unit, meant that the television set remained the pilot mass consumer product (now accompanied by the video-recorder) and the pivot of the new age of electronics in the house whilst awaiting global domestic informatics.

126. Today there are very few producers of significance, and it is possible to draw up the following list with their 1986 production :

		Millions TV units produced
Philips		6.2
Matsushita	Japan	4.7
Sony	Japan	3.8
Toshiba	Japan	3.2
Hitachi	Japan	3.1
Thomson/Thorn *	France	3.0
GE/RCA *	United States	2.8
Samsung	Korea	2.5
Sanyo	Japan	1.8
Sharp	Japan	1.7

* In 1987 Thomson bought the Mass Comsumer Electronics branch of GE/RCA, after having acquired that of Thorn EMI (GB).

Source : Bis Mackintosh

127. The potential expansion of the market required an increase in production capacities, but it is mainly the evolution of the techniques which, because of the large capital investments which resulted and which had to be amortised, made it necessary to move on to production in long runs. These two constraints have continued to operate. By way of a study of the structuring of the world market it is possible to demonstrate what the consequences have been.

128. During the sixties the structuring of the industry was effected by way of national concentrations. Thus in Great Britain the number of manufacturers of television receivers fell from about 40 in 1955 to about ten in 1965. The seventies were characterised by a further restructuring of the industry, this time at a global level under the impulse given by Japanese firms; this is still continuing. Initially the Japanese attacked the American market.

129. The Japanese tactic adopted two principal routes. The first consisted of massive exports of television sets which profited from the relative weakness of the Yen; these were followed by the establishment of marketing companies after ensuring the reputation of the brand name. The second was based on the American brand names, in particular by purchasing production units in the United States. Thus in 1976 Sony produced 300,000 colour TVs in

San Diego, whilst Quasar had been transferred by Motorola to Matsushita in 1974.

130. This was followed by the almost complete dismantling of the local American productive apparatus, helped by tactical errors on the part of the major local producers. Only RCA tried to resist, but the licences it had granted gave more benefits to the Japanese firms who had, in addition, manifestly succeeded in their winning strategy on the field of technico-commercial evolution; video-recorders and compact discs had been the lost opportunities which had decided the fate of RCA. So, whereas in 1974 there were fifteen colour TV manufacturers in the United States, 12 American and 3 Japanese, today the proportion is reversed.

131. From the middle of the seventies the Japanese manufacturers operated along other strategic axes. They practised the relocation of their production units to areas with low wages, in particular to South-East Asia such as the Hitachi plants in Singapore and Taiwan. In addition they moved on to the automation of their existing units. Since 1978 85% of Matsushita's production of colour TVs has been automated. Finally they have established joint ventures with local actors and are building production units in areas with major potential markets. From 1974 onwards Japanese firms were established in Europe in this way, firstly in Great Britain (Sony in 1973, Toshiba and Hitachi in 1978) and then in the principal consumer countries (Matsushita in Spain in 1985, Hitachi in West Germany in 1978 and Sanyo in Brazil).

132. The other large producers of television sets, principally European, had until then enjoyed protection by standards (SECAM in France and PAL in Germany) whereas Japan and the United States had the same standard (NTSC), but on the other hand they had not benefitted from the extent of the American market since the European market was partitioned. Faced with firms practising mass production and exporting the European firms were tempted to imitate them in some way, and this has resulted, since 1978, in a process of concentration on a European scale but moving into a global dimension. Two firms made efforts to arrive at this situation: Philips by way of a majority shareholding in Grundig and the purchase of Sylvania in 1981, and Thomson by the purchase of Normende (1978) and Dual (1982) in Germany, Thorn in Great Britain on 1986 and RCA/GE in 1987. In the same way there was a reorganisation of production and the search for optimal profitability.

133. Thomson proceeded to imitate Japanese know-how. Thomson could see that Toshiba had a plant which produced a million sets a year but had only 80 models, whereas at their Angers plant Thomson produced only 500,000 television sets in 1983 but could "boast" of 250 models (Usine Nouvelle, September 1984, p.92). Thomson moved to automation and reduced the production time for a television set from 9 hours in 1978 to 2½ hours in 1985. It also relocated part of its production in Singapore where the hourly wages cost in 1986 was 12.5 FF as against 85 FF in France. To this process was added the closing of many plants (Philips in Berlin in 1982) and considerable manpower reductions. Once conditions of profitability had been reestablished the firms were able, as a result of the margins achieved, to look towards innovation and to leave the market for products at the end of their life cycle to producers with the lowest production costs.

134. The growing uniformity of production conditions makes it possible to define the essential critical size at current prices: today this is regarded as being of the order of 2 million television sets per year (source: Usine Nouvelle, 17.12.1987). Amongst these production conditions account must be

taken of the magnitude of the Research and Development necessary to keep up with technological developments in television receivers. The need for scale economies relates principally to the magnitude of investments in production capacity (automation and plant development) and to the high productivity needed to achieve price competitiveness. This must not be allowed to obscure the fact that every producer must adapt to rapid technical progress if they are not actually to promote it.

135. The first technological break-point was the introduction of colour sets as replacements for monochrome sets in the middle of the sixties as a result of the impulse from RCA: the American firm was able to impose its apprenticeship curve on the following firms. Some were not able to master the necessary know-how and were therefore excluded from the market: this was the case, for example, with the Argentinian firms.

136. Other technological evolutions took place, and are continuing. One may note improvements in sound due to the improved performance of acoustic enclosures. Also to be noted is the movement towards reduced energy consumption (as a function of screen size) since 1960. In a general manner the introduction of the electronics of integrated circuits has been remarkable in various functions, particularly in signal processing since this has been effected in Japanese sets by a single chip since 1984. Figure I-28 shows the rapid advance of the introduction of micro-electronics in television sets. For the viewer the most remarkable feature is in another field, that of image improvement and the format of the screen, as a result of progress made on components and tubes. This involved firstly the introduction of tubes with square corners, then tubes with flat screens.

Figure I-28 : EVOLUTIONS IN TELEVISION SETS AND THE UTILISATION OF INTEGRATED CIRCUITS IN JAPAN

• Year	• TV Sets	• ICs
1960s	Mass production of TV sets utilizing monolithic ICs	Monolithic linear ICs for audio IF
	All IC color TV sets	Signal processing linear IC 6ICs/system
	TV sets with electronic tuners enabling the selection of channels by mere touch	ICs for channel selectors (linear and digital)
1970s	TV sets with remote control	ICs for transmission and receiving (I^2L or CMOS)
	Electronic tuner TV sets of the synthesizer type:	
	1) Voltage synthesizer	EAROM (MNOS) for memorizing tuning voltage
	2) Frequency synthesizer	Pre-scalers, PLL (ECL, I^2L) for high speed operations
	TV sets with sound multiplexer	Linear ICs for demodulation, and BBDs for enlarging sound field
	Flat TV sets	Small packaged linear ICs reduced power consumption
1980s	Liquid crystal TV sets	Liquid crystall displays and controllers
	Systematized TV sets	Analog switch ICs (CMOS, linear) for input switching
1983		Comb type filter ICs for improving image (linear, CCD)
	TV sets with character multiplexer	Decoder and LSI for displays (linear, MOS) RAMs (50 kb/unit) for memorizing image
	SHF receiving converters	GaAs ICs for down converter LSIs for PCM decoders
	Digital TV sets	LSIs for digital signal processing of videos, chroma, sound and deflection
	TV sets showing still pictures	High speed A/D, D/A converters Frame memories 2 Mb/unit
	High resolution TV sets	Linear ICs for high frequency wide band

Source : EIAJ, 1986 Report

137. The increased usage of specific components and the strategic importance of the tubes in the process of manufacuring receivers - the cathode ray tube accounts for a third of the selling price of a television set - means that the principal manufacturers practice vertical integration. Thomson (Videocolor) produce 3 million CRT's per year with SEL (bought by Nokia in 1987) producing 2 million units. The situation on the CRT market is such that the "traditional" producers fear the arrival of new entrants.

138. The Koreans arrived, knowing how to adapt themselves to technological evolution in the field of television sets. After having started at the bottom of the range (monochrome sets in the first half of the seventies) they now control about 10% of the world market with a foot in the American markets and, more recently, the European markets: for example Korean firms are established in Portugal and the British Isles. They are now turning in a logical manner towards the CRT market (more than 60 million sold in the world in 1987) where perhaps with other producers in South-East Asia they could generate excess production and be tempted to operate a price war.

139. Another consequence of the increasingly massive integration of components in television, as in all the mass consumer products, is that the R & D expenditure of the principal groups have increased markedly since the beginning of the eighties. For example Sony, which achieves practically all its turnover (TO) on the mass consumer market, the R&D/TO ratio increased from 5.3% in 1980 to 6.9% in 1982 and 7.9% in 1984. Thomson has a team of 500 research workers specialising in mass consumer products, and at Philips 250 researchers work only on new developments in television sets.

140. The digitisation of television sets necessitates increasing investments in Research and Development and production and makes the mass consumer sector a high technology industry. This results in the arrival of producers which up until now had specialised on the upper end of the range or on specialised products (for example the first combined television-telephone-computer of Loeuve Opta, West Germany) in the mass production market. Thus Nokia (Salora/Luxor) which produced 600,000 television sets in 1985 has increased its capacity by 100,000 units a year since that time. Furthermore this Finnish firm has purchased the TV branch of Electrolux (200,000 TV's/year) and SEL (1.?m TV's/year).

141. The technico-industrial battle of the end of the century started at the beginning of the eighties as the challenge of replacing nearly 500 million television receivers by 1995-2000 with high-definition sets (cf. 3.3.1.). Production methods will be similar, but the tubes and the principal components will be largely renewed for broadcasts which will mostly come from direct broadcasting satellites. If mass consumer electronics were seen by some in the seventies as hardly worthy of being related to the adult electronics of the very young microprocessor there is no room for such doubts today, but the conditions under which these products have to be manufactured have become extremely difficult.

REFERENCES TO CHAPTER I

(in the order in which they are quoted)

GILLE B. (1978)	Histoire des techniques Gallimard, Paris, La Pleiade, 1978, 1,652 pp.
MAUNOURY J.L. (1968)	La genese des innovations Paris, 1968
DAUMAS M. (1962 to 1979)	Histoire generale des techniques P.U.F. Paris, 5 volumes, In particular Vol.IV, 754 pp.
SCHUMPETER J. (1911)	"Theorie der wirtschaftlichen entwicklung" Duncker & Humblot, Berlin
HUMBERT M. (1988 a)	"Les regulations sociales face au systeme industriel mondial" Symposium "Regulation theory", Barcelona, June 1988, 31 pp.
MOUNIER A. (1974)	"La selection des innovations, elements pour une theorie" Thesis, Grenobles
HUMBERT M. (1984)	"La mutation technologique mondiale" GERDIC, Rennes, 1984, 126 pp.
DAUMAS M. (1981)	"Les grandes etapes du progres technique" P.U.F., Paris, 1981, 128 pp.
HUMBERT M.(Ed) (1988 b)	"Les strategies d'industrialisation dans l'electronique" GERDIC, Rennes, 1988, 364 pp.
PERRAULT J.L. (1981)	"La structuration de la branche informatique mondiale, 1950-1980" GERDIC, Rennes, 1981
GILLE L. (1987)	"Les filieres informationnelles face a la numerisation" R.E.I., No.39, 1st Quarter 1987, pp. 30-39
HUMBERT M. (1987)	"Les nouvelles industries de l'information et de la communication" R.E.I., No.39, 1st Quarter 1987, pp. 11-25
MAYO J.S. (1985)	"Three technologies that will reshape electronics" Electronics Business, Dec. 10, 1985, p. 132-136
GROUT F. (1988)	"Perspectives technologiques japonaises - Electronique-Infomatique-Telecommunications" DCSTD, Ministry for Foreign Affairs, April 1988, 62 pp.

de ROBIEN E. (1986) "L'electronique: un defi planetaire, un enjeu: l'Europe" Commission Prospective des Echanges Internationaux, Electronics Group, C.G.P., Paris, December 1986, 274 pp.

European Economic Commission (1987) "The telecommunication industry - growth and structural change" United Nations, New York, 1987, 292 pp.

DANG NGUYEN G. (1987) "Concurrence, cooperation et concentration dans l'industrie des telecommunications" Seminar on "Asymmetrical deregulation", Columbia University/Universite de Compiegne, Paris, 19-20 June 1987, 47 pp.

PERRAULT J.L. (1985) "Les pratiques de prix dans l'industrie des semi-conducteurs: les interactions entre prix et innovation" Paper delivered at the "Commerce International et Formation des Prix" meeting, GRECO-EFIQ, 41 pp.

CHAPTER II

THE IMPACT OF THE AGE OF ELECTRONICS ON ALL ECONOMIC ACTIVITIES

1. Chapter I has shown clearly the importance of the technico-industrial evolution of electronics since it has taken us into a new age of the industrial era. In Europe the public authorities congratulated themselves on the fact that their countries had recovered the levels of industrial production of 1928, which closely resembled that of 1913. Between 1913 and 1952 industrial growth, certainly interrupted by two world wars, had been slow; it was to become more rapid from 1952 to 1973 but then seems to have remained at a scaled down level. The industrial landscape had increased in density to some extent, but always around the same central subjects. Northern France and the German Ruhr still symbolised Industry with its waste tips and blast furnaces. At the start of the sixties the main flowering of industry was in iron and steel whilst the principal employer in the old Europe continued to be the textiles industry. Today the age of electronics has been installed and the age of steel is giving way to it. Steel and textiles are still produced, but in other ways. It is still necessary to work, but the necessary know-how will be different. The future no longer lies with steel and with its machines but with microprocessors and with communications. If one can identify here and there the changes which reflect this installation of electronics it would be misleading to try to measure them and to add together the isolated impacts: these are only the indications by which it is possible to understand, if it is not already understood, that an industrial mutation is taking place and that, to use commonly understood words, activities are being modernised.

1. AN EVALUATION OF THE DEGREE OF DIFFUSION OF ELECTRONICS

2. Evidence of the installation of the age of electronics is given by the spread of this technique throughout products and production processes. This has taken place as a result of systems which lead to other ways of producing but, in addition, by inserting electronics into pre-existing, and perhaps slightly transformed, products or systems. The electronics principally inserted are the integrated circuits, memories and microprocessors. An examination of the sales of integrated circuits and their destinations provides some indications on this diffusion of electronics.

3. The data in Table II-1 relate to two years, 1982 and 1986, and show the market situations of the principal consumers, the United States, Japan and Europe (and also the rest of the world in the case of 1986). A first comment concerns the rate of evolution of the markets: in the case of these three main markets the total rose from US$ 11.9 billion to US$ 31.2 billion, a mean annual rate of increase of nearly 27%. This rate was 16% for the United States, 34% for Europe and 45% for Japan. If military consumption is excluded (it does not exist in Japan) the civil demand in Japan for integrated circuits in 1986 was greater than that in the United States, whereas it only represented 43% of this in 1982. Although it is not possible to establish a firm statistical link between these data and macro-economic developments it is still possible to comment on the coincidence between the overall Japanese performance on the international scene and the more rapid diffusion of integrated circuits on its electronics markets than on other markets.

Table II-1 : DESTINATION IN PERCENTAGES OF INTEGRATED CIRCUITS, 1982 & 1986

	U.S.		JAPAN		EUROPE		REST OF WORLD
	1982	1986	1982	1986	1982	1986	1986
Military expenditure	17	15	-	-	5	5	-
Informatics	40	40	13	33	25	20	20
Telecommunications	21	18	10	18	20	27	14
Industrial uses	11	12	26	10	25	18	13
Consumer goods (MCE, cars, etc)	11	15	51	39	25	30	53
Value in US$b	7.3	13.2	2.6	11.5	2.0	6.5	2.7
Ratio, 1986/1982		1.8		4.4		3.2	

Source : 1982 OECD, after C. EDQUIST and S, JACOBSSON, "The integrated circuit industries of India and the Republic of Korea in an international technico-economic context.", Industry and Development, No.21, UNIDO, 1987, p.6.
1986 ICE, after Electronic Business, July 1987, p.31.

4. It must however be pointed out that the global increase of the different economies remains modest when compared with this 27%. Between 1982 and 1986 the GDP rose by an average of slightly more than 4% per year in Japan, slightly less in the United States and around 2% in Europe. These rates of growth - comparable to those of the 19th century - are regarded as too moderate. From our point of view one can say that new ways of producing, as a result of the spread of electronics, can be made more productive, that new products can offer services which are either vastly improved or even unknown until then, but that one or the other upset the former organisation of activities and the macro-economy without the electronics technique bringing with it any solution to the problems posed by its diffusion. It must also be pointed out that this spread of electronics is being pursued rapidly and thus involves the industrial mutation, but the matter of the diffusion of electronics and the industrial mutation which it permits needs to be distinguished from that of the overall rate of growth. We should note however that the modernisation of activities offers a high rate of growth to electronics and that, in due course, its increased importance in the productive apparatus means that its high rate of growth will influence, even more strongly and in an arithmetic manner, the growth rate of all sectors. Any production apparatus specialising in electronics will thus have an overall rate of growth which may be even higher than the others.

5. Several other comments could be made on this table, but we will only point out the case of consumer goods where, despite the very rapid annual growth, the demand for integrated circuits has increased from 22% of the total to 27%. This provides an index of the penetration of electronics into everyday life.

6. To look a little further at the penetration of electronics into enterprises we can consider the results of a survey carried out simultaneously in three European countries, Great Britain, Germany and France, and which was published in 1985 (NORTHCOTT et al.). The study relates to the years 1982 to 1984, covering all industrial activities with a sample of 700 to 1000

establishments in each country, representative of the totality of each of the industrial structures. The study is therefore concerned with the penetration of micro-electronics from two aspects, the introduction of micro-electronics into the products and the usage of electronics consumer goods.

7. Table II-2 shows the diffusion of micro-electronics as a percentage of the number of establishments and according to the industries. Electronics equipment has a diffusion which extends to all the sectors, whereas in the case of the products most of those involving the incorporation of electronics belong to a few branches: engineering, electronics and automobiles. But this is obviously linked to the nature of the goods: clothing or papers provided with integrated circuits are still only gadgets. The magnitude of the diffusion of such equipment reached a mean and significant threshold: between 40% and 50% of the establishments in these three European countries have introduced micro-electronics.

Table II-2 : EXTENT OF USE OF MICRO-ELECTRONICS BY INDUSTRY (WEIGHTED)

weighted for percentages of all manufacturing establishments

		food	chem metal(1)	metal goods(1)	mech eng	elec eng	vehicles	textiles	clothing	paper print	other	TOTAL
BASE	Britain	3.320	3.252	4 164	5.467	3 258	1.863	2 927	3 771	3 571	6 213	37.806
	Germany	4.100	5.426	2.307	5.056	4.512	2.700	1.812	3.227	2.750	8 291	40.181
	France	4 917	3.253	5.586	5.117	2 043	537	2.280	4.046	3.588	6.727	38.110
PRODUCT USERS												
	Britain	0	0	1	28	50	14	0	0	0	3	10
	Germany	0	7	5	42	42	9	1	0	6	3	13
	France	0	1	4	23	28	23	0	0	1	4	6
PROCESS USERS												
	Britain	60	51	40	45	51	33	30	27	62	36	43
	Germany	46	52	43	59	54	39	40	32	77	37	47
	France	39	43	38	31	33	58	34	23	50	28	35
ALL USERS												
	Britain	60	51	40	54	73	33	30	27	62	37	47
	Germany	46	53	44	67	66	41	41	32	80	38	51
	France	39	43	38	45	49	59	35	23	50	31	38
NON-USERS												
	Britain	40	49	60	46	27	67	70	73	38	63	53
	Germany	54	17	56	33	34	59	59	68	20	62	49
	France	61	57	62	55	51	41	65	77	50	69	62
TOTAL		100	100	100	100	100	100	100	100	100	100	100

(1) In the case of France the figures for metals are included under metal goods and not under chemicals.

Source : NORTHCOTT et al., 1985

8. Table II-3 reflects this overall insertion in the number of employees in the establishments concerned with this spread of electronics. Since such introductions are, on average, rather more frequent in the larger establishments the percentages are a little higher. Only 15% of workers in Germany and only 29% in France do not work in an establishment which had introduced micro-electronics.

Table II-3 : STAGE OF DEVELOPMENT IN USE OF MICRO-ELECTRONICS (WEIGHTED)

weighted for numbers employed and percentages of all manufacturing employment

	Germany		France	
	no.	%	no.	%
BASE	6.890.050	100	4 139.530	100
PRODUCT APPLICATIONS				
In production already	2.211.706	32.1	547.162	13.2
Under development	496.084	7.2	84.195	2.1
Feasibility investigated			38.028	0.9
TOTAL	2.707.790	39.3	669.385	16.2
PROCESS APPLICATIONS				
In production already	5.153.757	74.8	2.419.219	58.4
Under development	551.204	8.0	153.109	3.7
Feasibility investigated			136.653	3.3
TOTAL	5.704.961	82.8	2.708.981	65.4
ALL APPLICATIONS				
In production already	5.339.789	77.5	2.552.426	61.7
Under development	496.084	7.2	229.215	5.5
Feasibility investigated			166.592	4.0
TOTAL	5.835.873	84.7	2.948.233	71.2
NON-USERS	1.354.177	15.3	1.191.297	28.8

Source: NORTHCOTT et al., 1985

9. Tables II-4 and II-5 make it possible to make rather more precise what is to be understood here as the introduction of micro-electronics. In the case of the products it is a matter of integrated circuits which are ex-catalogue or more or less customised. If the latter circuits are used this generally involves, as may be seen from Table II-4, the additional use of standard ex-catalogue micro)rocessors. Programmable logic controllers followed by CNC machine tools are the ty[…] of equipment most widely used for production processes whilst robots (which have often inflamed imaginations because of their android character) have only a modest place.

Table II-4 : TYPE OF MICRO-ELECTRONICS COMPONENT USED : PRODUCT USES

percentages of establishments

	Sample establishments (unweighted)			All manufacturing establishments (weighted)		
	Britain	Germany	France	Britain	Germany	France
BASE	198	290	159	3.707	5.125	2.433
Standard industrial microprocessors offered on catalogue	67	86	78	72	85	78
Custom integrated circuits developed for user's specific application	34	36	35	29	32	22
Semi-custom integrated circuits	31	22	25	22	14	21
Others	-	20	61	-	15	54
TOTAL	132	164	199	123	146	167

Note Totals add to more than 100, because some respondents answered YES to more than one item

Source: NORTHCOTT et al., 1985

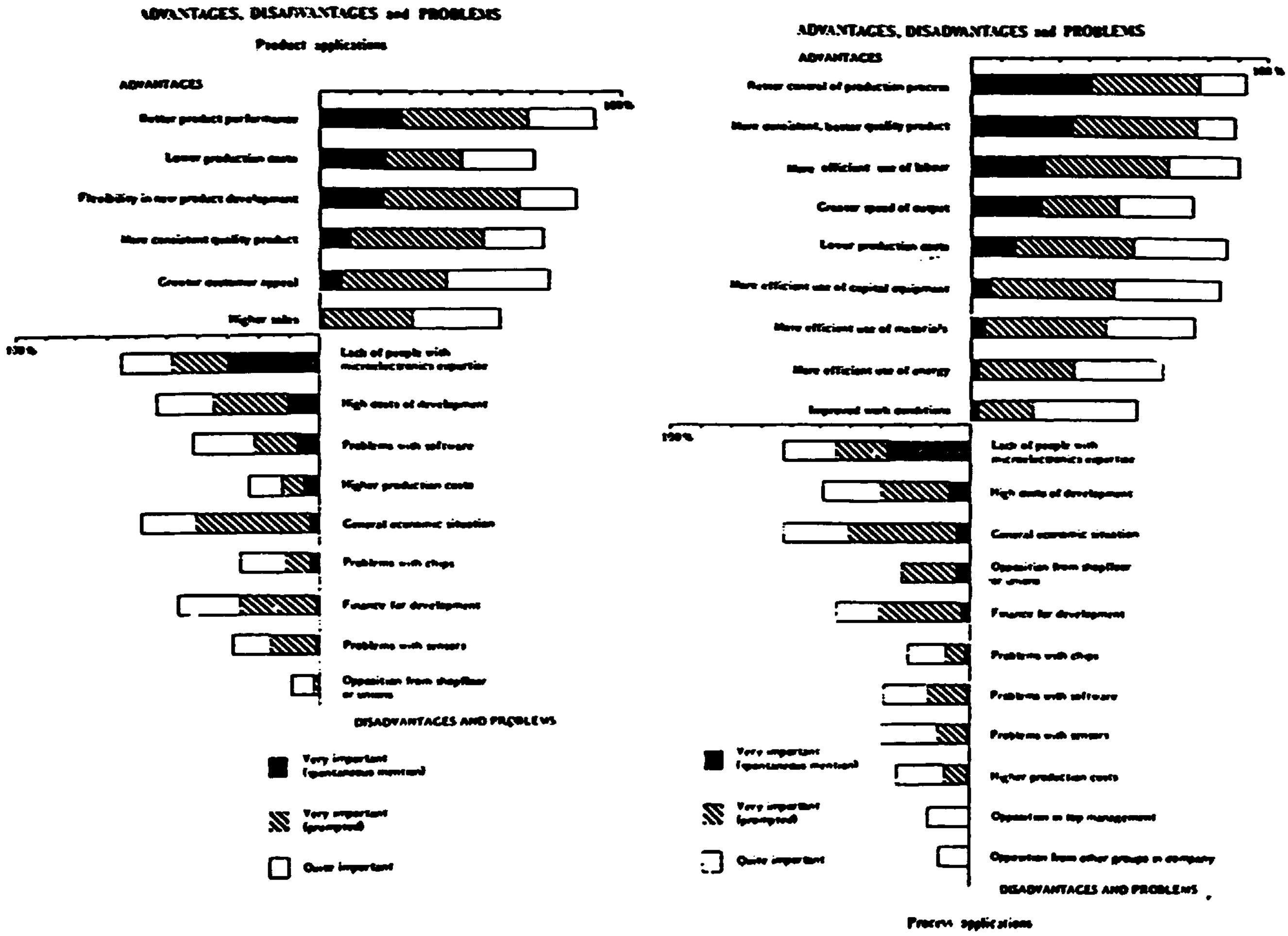
Table II-5 : TYPE OF MICRO-ELECTRONICS BASED EQUIPMENT USED : PROCESS USES (WEIGHTED)

	Percentages of all the manufacturing establishments with process applications			Percentages of all manufacturing establishments		
	Britain	Germany	France	Britain	Germany	France
BASE	16 386	19 083	13 416	37 806	40 181	38 110
TYPE OF EQUIPMENT USED						
CAD work stations	13	17	15	6	8	5
CNC machine tools	23	36	31	10	17	11
PLCs (programmable logic controllers)	29	41	40	13	19	14
Machine controllers	16	27	29	7	13	10
Process controllers	15	17	17	7	8	6
Pick-and-place machines	4	5	13	2	2	5
Robots	2	3	7	1	1	2

Source: NORTHCOTT et al., 1985

10. Figure II-6 and Table II-7 examine the advantages and disadvantages of the use of micro-electronics, as perceived by the enterprises covered by the survey. Top of the list of the advantages was better control of the product and its development or of the production process; following this were the attractiveness of the product for the consumer, its quality and reductions in costs. In the case of the production process the advantages again were costs and the more efficient use of labour. As far as the disadvantages or problems which could hold back the diffusion of electronics were concerned the same two came at the top of both the product and production lists: firstly the general economic situation and secondly the shortage of people with micro-electronics expertise. The spread of micro-electronics thus requires developing the training of the human resources and a generally favourable economic situation.

Figure II-6 : ADVANTAGES, DISADVANTAGES AND PROBLEMS (FOR GREAT BRITAIN ONLY)



Source : NORTHCOTT (J.), ROGERS (P.), 1982.

Table II-7 : MAIN DISADVANTAGES AND PROBLEMS IN USING MICRO-ELECTRONICS (WEIGHTED)

percentages of manufacturing establishments rating disadvantage very important

	PRODUCT USERS			PROCESS USERS			ALL USERS		
	Britain	Germany	France	Britain	Germany	France	Britain	Germany	France
BASE	*3,707*	*5,125*	*2,433*	*14,007*	*19,083*	*13,416*	*17,714*	*20,332*	*14,527*
General economic situation	48	28	23	42	23	16	43	24	17
Lack of people with microelectronic expertise	52	67	37	36	49	29	39	50	29
High costs of development	41	39	19	26	23	19	29	24	19
Lack of finance for development	36	28	19	29	20	18	30	21	17
Higher production costs	14	21	8	16	13	11	15	14	11
Problems with software	24	34	11	12	23	7	14	24	7
Problems with sensors	12	14	2	10	13	4	10	12	4
Difficulties of communications with subcontractors or suppliers	7	11	8	9	13	9	9	13	9
Problems with chips	6	18	5	8	15	3	7	15	3
Opposition from shopfloor or unions	3	18	13	7	12	9	6	11	10
Opposition in top management	3	7	0	5	3	0	4	3	1
Opposition from other groups in company	2	4	1	4	2	2	4	2	2

Source : NORTHCOTT et al., 1985

2. ANOTHER MANNER OF PRODUCTION

2.1. Mechatronics ("La mecatronique")

11. The mechanical engineering industry has been strongly revivified by the age of electronics, and it is the evolution of this industry which will condition the future of the entire industrial system. From the industrial standpoint the transition from mechanical engineering ("mecanique") to mechatronics ("mecatronique") is reflected by an in-depth modification of the "product" which is produced by this branch: instead of offering machines it must now deliver workshops or systems of machines. This product-complex which the mechatronics industry has to provide is an assembly of four types of elements :

- a system ("informatics") for the control, management and monitoring of the whole assembly;

- an assembly of machining centres consisting of machine tools with a wide range of tools and able to work on parts with different characteristics;

- a system for conveying the parts from the entrance of the workshop, from machining centre to machining centre and thence to the exit from the workshop;

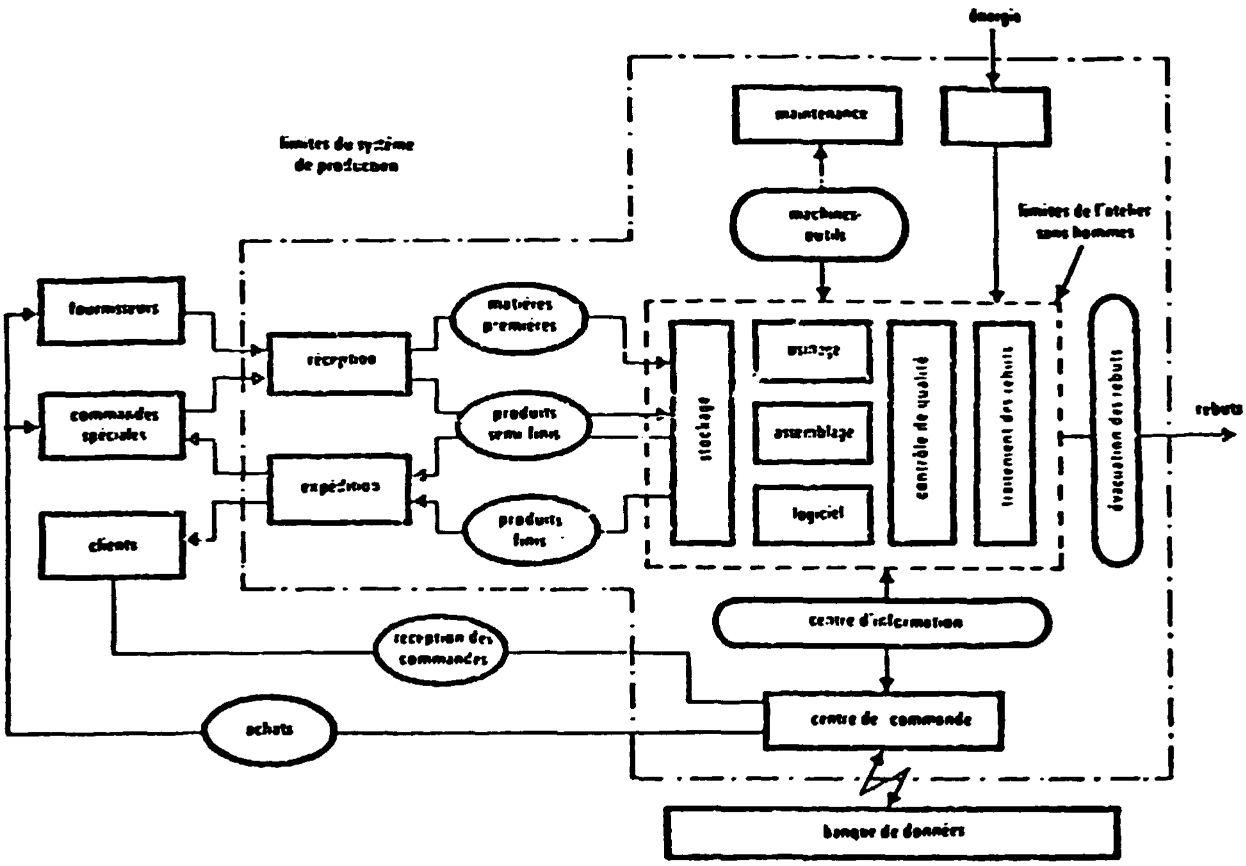
- an assembly of handling units for loading and unloading, that is to say the interfaces between the conveying system and the machining centres and to the entry, exit or intermediate storage areas.

12. This simple statement shows that any attempt to speak of robotics is a reduction of mechatronics to the point of caricature. The robot most frequently encountered, the robot-handler (or possibly welder, painter, etc.) is certainly present, but in a workshop which is totally renewed. Datamation emphasized, in its April 1984 issue, that "A robot is only really useful in a flexible environment". A 1983 OECD document pointed out that "However, the availability of robots, CAD/CAM, etc., does not imply that automation in discrete engineering is easy. Management skills and expertise are often very important in this context and can be the main barrier against the diffusion of new forms of automation [....]. The flexibility provided to batch manufacturing by new forms of confers on batch operation is not solely due to industrial robots. The increased flexibility is the result of the increasing use made of numerically controlled machine tools, the ability to integrate machine tools into machining centres, the integration of robots into systems and direct numerical control of manufacturing systems." Gerard GUILLEMETTE, of ASEA's Robot Division, has himself pointed out that "The electronics are not very important, but the mechanics are important for the continuous, hard and accurate work a robot has to perform in a factory."

13. The object of emphasizing these factors is to re-affirm (again) the paradox encountered in the evolution of the industrial system: breaks within continuity. From Joseph WHITWORTH to Prof. H. YOSHIKAWA, it is always the industry producing the machines; the standard screw thread put forward by Whitworth was a standardisation just like that being proposed today by AFNOR for the shanks of tools with a taper of 7/24 for automatic changing. But despite this history, which can only be built on the legacy of the past, it is a qualitative leap from the production of machines to the production of workshops which ensures the certainty of entering into the future, as was noted in 1981 by a report from the Club of Rome: "The prototype factory of

the future is already designed [...]. The entire factory layout and work organization must be redesigned and restructured if maximum benefit is to be obtained from the new systems." A Japanese, Prof. H. YOSHIKAWA, is regarded by many as the leading thinker behind flexible workshops and factories without workers. He is responsible for a layout of the factory of the future which has often been reproduced and which we set out below as Figure II-8.

Figure II-8 : A SCHEME FOR A FLEXIBLE WORKSHOP



- Prof. H. Yoshikawa of the University of Tokyo is the leading thinker behind flexible workshops and factories without workers. He feels that it is possible to define, within a production centre, a zone of very high automation and without any human presence. Clearly all the machine tools are directly numerically controlled by a computer and will be modular machines as is made necessary by the required flexibility.

Source : Le Nouvel Automatisme, 1982.

14. Can one extract any real advantages in efficacy from such an organisation? A priori conceptualisation would seem to demonstrate this, but today the Japanese experience can provide us with something better than a theoretical discourse: concrete examples show hourly productivities of factories multiplied by several units, whilst the productivity per worker is increased by a factor of more than ten. The lathe and machining centre manufacturing plant (all obviously numerically controlled) which YAMAZAKI has

installed at Minokamo is one of the finest flowers of the "Mechatronics Valley" and prefigures the System 21 (for the 21st century) of the Japanese strategy. As far as the flexible lathe production workshop (FMS 21) is concerned the following comparisons with a conventional system, as provided by this company (Table II-9), are very eloquent.

Table II-9 : THE ADVANTAGES OF A FLEXIBLE WORKSHOP (YAMAZAKI, JAPAN, 1984)

	System 21	Conventional system
Floor area	6,600 m²	16,500 m²
Number of machine tools	43	90
Number of operators :		
- factory	36	170
- production control	3	25
Total	39	195
Production times :		
- Machining times	3 days	35 days
- Assembly of the unit	7 days	11 days
- Assembly of the whole	20 days	42 days
Total	30 days	91 days

15. At the present stage the productivity of the workshop has been multiplied by three: the total cycle to produce a lathe now takes four weeks instead of twelve; with the number of workers being reduced to a fifth the productivity per worker has been multiplied by fifteen. When management of the workshop is optimal YAMAZAKI believe that they can do better, reducing the overall time for the production of a lathe to 7 days; the factors by which the productivity will have been multiplied will then be 12 and 48 respectively.

16. This example concerns the actual production of machines. It is here that the heart of the industrial system, of mechatronics, is to be found, it is here where production line working and the scientific organisation of work has not been able to increase productivity sufficiently because of the discontinuous character of the production process. In the light of the orders of magnitude relating to increases in productivity one can appreciate the interest there is in mastering it from upstream. In Japan about half the sales of machine tools go to the mechanical engineering industry itself and a quarter go to the automobile industry; unlike the USA or Europe one does not find the aeronautics outlet. It is possible to see the impulse given by the mechatronics evolution through capital equipment goods and a classic of durables consumption. The Japanese rise is not limited to electronics; it is also concerned, as is known, with the automobile industry since Japan has become the world's leading producer, and it also affects mechatronics itself.

2.2. Local industrial networks and logistics

17. Two communications problems concerning mechatronics merit special attention. The first is linked to the multiplication of intelligent units,

the rational usage of these requiring that they can communicate amongst themselves: this is the role of the local industrial networks. The second is concerned with utilising the increased flexibility of the production apparatus to rationalise inputs and production as a function of the output which is needed to satisfy the demand, and this is the problem which has to be regulated by the logistics.

18. The need to allow intelligent machines to communicate with each other resulted in the birth of the MAP (Manufacturing Automation Protocols) project launched by General Motors. This firm has sought to make a gigantic effort by way of electronisation to overcome what it saw as an inevitable decline in the light of the gap between its productivity and that of the Japanese manufacturers (vehicle costs US$ 2000 higher per vehicle). At the end of the seventies it was already using 20,000 programmable automats, 2000 robots and 40,000 intelligent units, but only 12% of these could inter-communicate. Since it wished to multiply its electronic equipment by a factor of at least five it was necessary to operate in such a way that they could be utilised in the most rational possible manner. The size of this client of the electronics industry is such that it was possible for it to launch a standardisation process with which groups of users were associated. Since it was launched in 1980 MAP has seen its successive versions become increasingly precise; from 1986 onwards the MAP Users' Group has had more than 1500 members in the United States including the largest American firms, whilst the Europeans have created their own EMUG (European MAP Users' Group) to which the large European firms (about 200) belong, and the Japanese have done the same. A demonstration of the inter-operability of machines using the MAP 3.0 version (cf Chapter V) took place in Detroit at the end of 1987.

19. The existence of MAP is very important since it establishes an international standard for the architecture of communication between industrial machines for cooperation between the constructors and the users. This is an entirely new phenomenon, one of the implications of which is that of facilitating the development of local industrial networks.

20. There has been talk of the automation of production activities for about a quarter of a century, and this had become more generalised with the multiplication of programmable automats. The programmable automat is generally supplied with the production machine, and this applies to all kinds of industries. It has taken its place in manufacturing industries employing major continuous or batch processes. From the small firm to the large one it most frequently carries out processing on the control part of the machines. It carries out sequential numerical automation and regulation operations, bordering on specialised regulators, numerical controls with their own control (which may be an automat), robots with their own control, micro-computers and also computer assisted management of production (CAMP), computer assisted design (CAD), automated testing, etc. To a certain extent what has developed is automation on isolated islands.

21. The management of production requires that one can envisage, at any moment, exactly what the automats are doing, certainly programmed in such a way that everything works harmoniously, but that as soon as a problem arises at any point the time needed for informing all the points concerned will be more or less lengthy and the time needed for devising the decisions to be taken so that coherence is re-established will be even lengthier. Briefly the supervision and the control of production are redoubtable tasks which give rise to many techniques, many forms to be completed and to be circulated, etc.

22. Without discussing either principles or objectives (for example the "five zeros" of the Japanese kanban or "just in time") it must be emphasized that it is obvious that the implementation of a real-time communication network between all the existing programmable automats makes it possible to think in terms of a centralised control with the rational management and supervision of all the tasks. For this purpose it is possible to provide the software resources for computer assisted design and computer assisted management of production. This obviously demands effective inter-communicability and even inter-operability. This also demands that there are no non-automated islands and that the sensors and actuators of various types be multiplied so that the system of industrial control is effectively and fully informed and can carry out a sufficient number of operations. The local industrial network also makes it possible for the local automats to make decisions automatically as a function of information sensed by more or less distant sensors, without the control system doing anything more than to verify that the automat is carrying it out correctly. Industrial control clearly does not prevent the operation of sub-systems.

23. Logistics thus attempts to link the management of production within the enterprise with its environment: its suppliers and its clients. The flexibility of the production management makes it possible, through the local networks, to take into account information on the products to be delivered and the products to be received in order to optimise their circulation and to eliminate dead time. As an example one can cite a large French footwear enterprise (ERAM) which receives every evening in its plants precise information on all sales of models and sizes and so can organise not only the supplies to its stores and the allocation of deliveries and journeys but also its production planning and its supplies of semi-products, accessories, packagings, etc. From automobiles to footwear, as from electronics to steel, is obviously another manner of production which has been established with the age of electronics.

3. A CRITICAL APPRECIATION OF THE EMPLOYMENT-PRODUCTIVITY DILEMMA

24. Ever since a situation of relatively high unemployment became generalised in the industrialised countries at the beginning of the seventies a considerable number of publications - more than a thousand in English and French alone - have raised questions as to the relationship which could exist between levels of employment and the "technological" evolution which increases productivity. No irrefutable demonstration has been able to resolve the opposing views and allow precise views. In the long term all, or practically all, the world will finally accept that history shows that technical progress is accompanied by increased employment, and that there is no reason to doubt that this will continue to be so. In the short term a very large number of experts continue to consider that technical progress will cause jobs to disappear. Numerous recent analyses, such as that of R. KAPLINSKY (1987) show however that job losses following the introduction of micro-electronics are, in the worst of cases, only small. This means, for the industrialised countries, that all the jobs which have been lost have been lost for other reasons to be found in the Third World countries, and that all the jobs which have not yet been created in industry are really the result of backwardness in technical progress.

25. The study of NORTHCOTT et al. (1985), which we quoted above (point 1.1.) also provides a survey of the effect of the introduction of micro-electronics on employment, and the results of this are given in Table II-10. One can also see here a globally slightly negative effect (a fall of between

0.5% and 0.8% over two years, according to the country concerned). This effect results from not negligible movements in the opposite direction which locates the existing problems in some other place than a close link between employment and the use of electronics.

Table II-10 : CHANGES IN EMPLOYMENT DUE TO USE OF MICRO-ELECTRONICS (AVERAGES AND TOTALS IN PAST TWO YEARS): ALL USERS

percentages and numbers of jobs

		Sample establishments			All manufacturing establishments (weighted)		
		Britain	Germany	France	Britain	Germany	France
BASE		*776*	*943*	*726*	*17.714*	*20 232*	*14.527*
PERCENTAGE OF ALL USER ESTABLISHMENTS WITH:							
Increase in jobs	%	8	10	6	8	9	6
No change in jobs	%	64	69	71	69	74	75
Decrease in jobs	%	20	19	11	17	15	10
DK/NA	%	7	2	12	6	2	9
AVERAGE CHANGE IN NUMBER OF JOBS:							
In establishments with increases	no.	-23	-19	-30	-13	+11	-12
In establishments with decreases	no.	-34	-35	-38	-17	-19	-15
In all establishments	no.	-5	-3	-3	-2	-1	-1
TOTAL PERCENTAGE CHANGE IN JOBS:							
In establishments with increases	%	-3.9	•	•	-5.6	-4.4	-8.8
In establishments with decreases	%	-3.8	•	•	-5.1	-4.6	-8.5
In all establishments	%	-0.7	•	•	-0.8	-0.6	-0.5
TOTAL CHANGE IN NUMBER OF JOBS:							
In establishments with increases	'000	•	•	•	-20	-17	-13
In establishments with decreases	'000	•	•	•	-54	-47	25
In all establishments	'000	•	•	•	-34	-30	-12

Source : NORTHCOTT et al. (1985).

26. As a result of the manner in which this productivity-employment dilemma is frequently presented one can only conclude, whatever the results of the surveys or the arguments advanced, that there has been a loss of jobs. In fact it is more often a question of studying the impact on employment of micro-electronics, carried out within a context of slowed-down growth and of unemployment. First of all the scapegoat, the guilty party, is designated: the machine which takes away a man's work. Technical change adopts an implacable character and the entrepreneur in order to at least rationalise the situation - and one could quote a thousand and one examples - replaces men by robots.

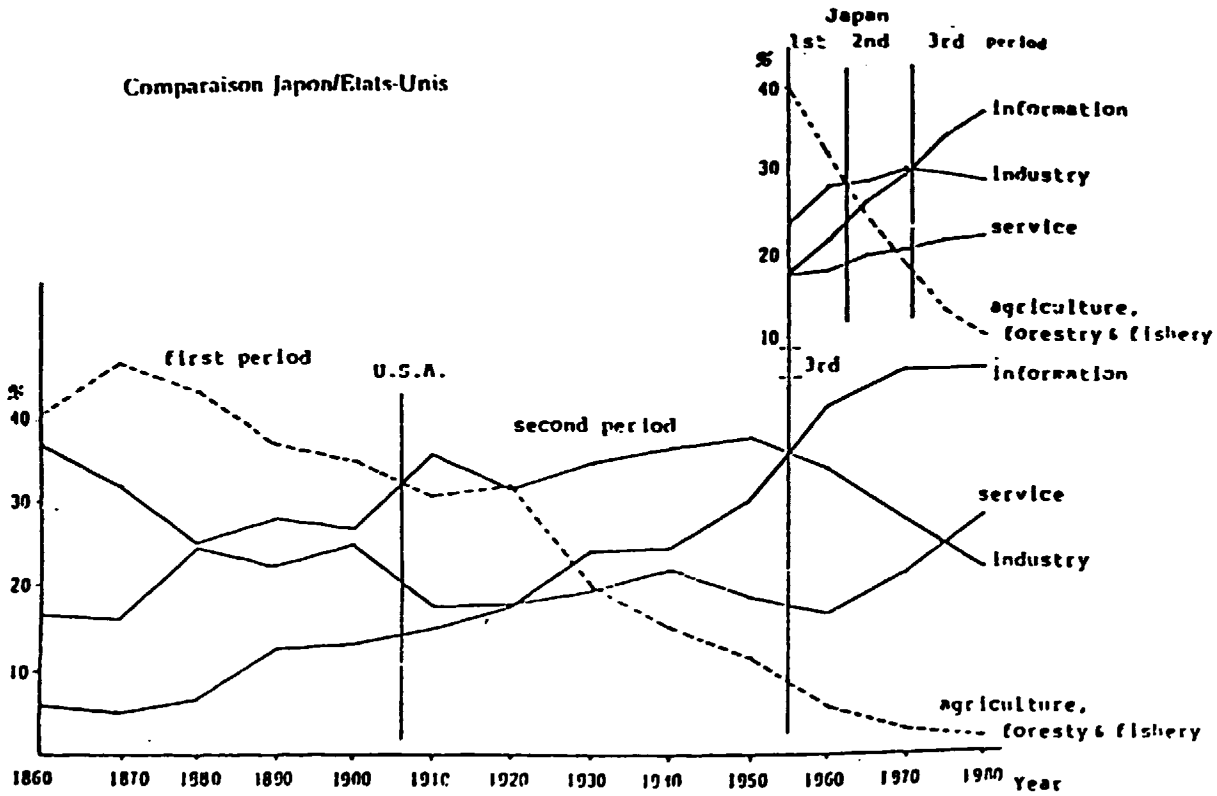
27. If it is viewed from a micro-economic point of view the question can be understood. In a workshop where there were 100 men the technical progress which introduced automation has no other reason than to make it possible to obtain, perhaps by 50 men not carrying out the same operations as previously and having to provide proof that they have other skills, a production which is at least equal to that obtained in the past. If this workshop is not able to

release twice as many products onto the market then the enterprise will not take the decision to open up a second workshop. More generally, and in a context of limited growth, technical progress will, at the micro-economic level, pose employment problems.

28. However it is not very probable that the wages paid to the employees will be doubled. The company's turnover being unchanged it will be used for something. The wages not paid by this company will however be returned into the economic circuit in one way or another and may serve somewhere else to provide jobs and to pay wages. This means that the problem of employment is also a macro-economic problem.

29. On this point it must however be added that there has already been a decline in jobs in agriculture and, more recently, a decline in employment in industry to the benefit of the service industries. Table II-11 shows us how this change has taken place at different rates in the United States and Japan. The technico-industrial evolution increased the productivity of industry and the services sector and hence the overall potential for production rises. For as long as the demand is not saturated the production can also rise. In fact the past organisation of work and the technical resources which are available make increasing production difficult. The passage to the age of micro-electronics slips the bolt: it does not cause unemployment but provides the technical resources for increasing productivity and hence production. However it is necessary to organise these new technical resources, at the macro-economic level so that they effectively make it possible to reduce unemployment. At a time when economies are being implemented on a global level this reorganisation cannot be considered within exclusively national contexts but must on the contrary be the result of international cooperation. In regard to that which is strictly our concern we must remember that electronics is not the cause of unemployment but rather the means of increasing the job potential.

Figure II-11 : EVOLUTION OF THE SECTORIAL STRUCTURE OF JOBS : A COMPARISON BETWEEN JAPAN AND THE UNITED STATES



Source : Seisuke KOMATSUZAKI, Research Institute of Telecommunications and Economics (RITE), "Approches japonaises de l'economie et de l'industrie informationelles", IDATE Bulletin No.16, July 1984, pp. 31-49, p.44.

4. AN INCOMPLETE LIST OF MODERNISED ACTIVITIES

4.1. Steel

30. P. JUDET (1985, p.18) states that "No iron and steel industry can escape, in the long term ... from the entry into informatics. This poses, amongst other matters, a training problem. Faced with the very extensive technical possibilities opened up by informatics it is necessary, if they are to be seized, not only to have specialised personnel but also to ensure that all the personnel can be inserted into the networks which are then established.

31. Every steelworks in the world must today equip itself with information processing systems, that is to say a local industrial network with extremely powerful central processing computers. Process computers operate with slow codes in the same languages so that they can communicate, and industrial control hinges around the control of management. Up to the present time it is the Japanese steelworks which have the highest levels of information processing in the world, but most of the iron and steel industries of the

industrialised countries are already well advanced into their own process of introducing informatics.

4.2. Chemicals

32. The continuous processes of the chemicals industry have been centralised by means of information processing systems for many years now. Modernisation is, in this sense, already very old, but the link with the electronics industry will continue in the future since this industry is a very important client with a very dynamic demand: materials for integrated circuits, optical fibres, various types of plastics and different films. Speciality chemicals should reach sales of US$ 15 billion to the electronics industry by 1990 (J.L. ALEXANDRE and K. BLUNDEN, 1986, p.61).

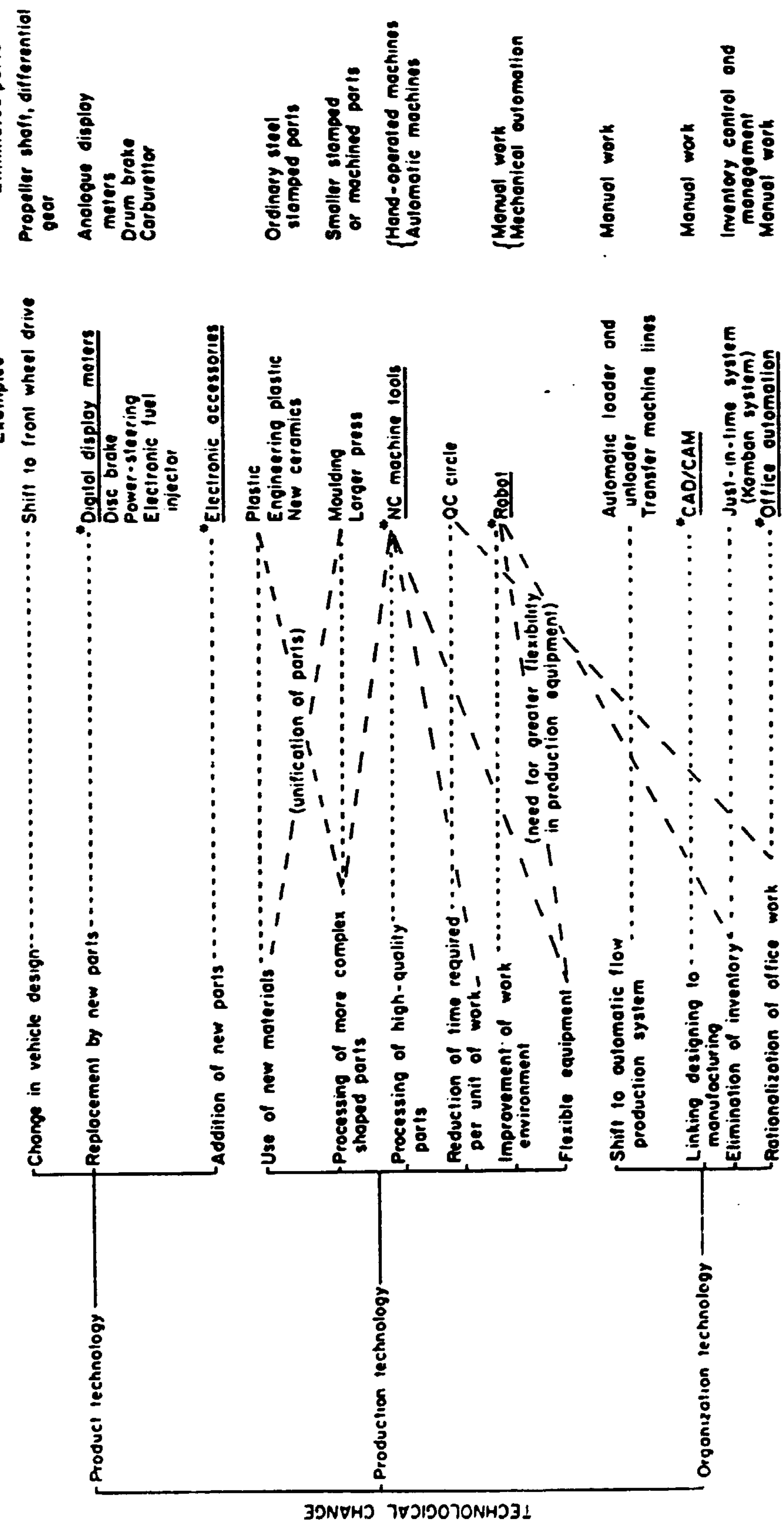
4.3. Petroleum

33. Practically all the segments of the petroleum industry are today operated with the support of electronics, from research to refining, from management to distribution and even down to the petrol pump with the usage of credit cards with magnetic strips or chips. The reduction of costs in offshore operations in the North Sea (NOROIL Review, October 1985), or the cost of refining by overall automation since the end of the seventies and, perhaps soon, that of distribution centres, will make the petroleum industry one with the highest level of information processing.

4.4. Automobiles

34. For a long while now the automobile industry has benefitted from all the automation techniques and all the developments concerning machines. It often includes amongst its manufacturers those who also construct machine tools: it was in the automobile industry that robots first flowered and where the first flexible workshops operated. It was in this industry, it will be recalled, that the MAP concept was born at General Motors. Technological evolution continues, including in the Japanese automobile industry which is already the most modern in the world. Figure II-12, taken from S. WATANABE (1987, p.49), shows us where the evolutions are. In particular it can be seen that electronics are invading the production and management processes, and also the product itself. According to Electronic Business (August 15, 1986) an average vehicle could contain about US$ 1400 worth of electronics in 1990, and this does not represent the kind of intelligent vehicle like the luxury models which are beginning to reach the market.

Figure II-12 : RECENT TECHNOLOGICAL CHANGES IN THE JAPANESE AUTOMOBILE INDUSTRY



Source · S. WATANABE, 1987, op. cit., p. 49.

4.5. Textiles and clothing

35. The textiles and clothing industries are on the way to becoming knowledge-intensive industries according to most of the experts in these industries (e.g. C. DERVELOY and L. MYTELKA, 1986). The design and manufacture of the products are carried out with the aid of informatics, whilst management and distribution are also transformed by the use of the resources of the electronics industry. As an illustration of this we may cite something which may seem simple but which is important for the industry: the automation of fabric inspection. Very expensive systems (2-3 million FF) operating with lasers inspect and check the quality of the fabric at a high speed, covering the entire width at 250 metres/minute! What is best known in the clothing industry is the informatics system for cutting out from patterns (LECTRA in France) which allows savings in materials, time and labour. The textiles industry forms one of those activities which have been profoundly transformed by electronics.

4.6. Agriculture

36. By contrast agriculture has still been very little affected by this movement. It is, however, starting to be influenced by it in the industrialised countries in the field of farm management, not solely of accounts but using software to follow up production and even using expert systems for the diagnosis of animal or vegetable diseases. In countries with a shortage of agricultural labour robot fruit pickers are appearing (Sciences et Techniques No.26, May 1986). Within the framework of joint European research the EUREKA system includes an Anglo-Dutch project for a cereals management system for farms. In France several expert systems for disease diagnosis can be consulted by way of the French Videotex and Minitel (a terminal provided free of charge to all telephone subscribers) and about ten thousand farmers possess micro-computers whilst forty thousand use the services of a shared computer system. The computer has come to the farm.

LITERATURE REFERENCES

(in the order in which they are cited)

NORTHCOTT J. et al. "Microelectronics in industry. An international comparison: Britain, Germany, France"
(1985) P.S.I., AGF, January 1985, 104 pp.

NORTHCOTT J., ROGERS P. "Microelectronics in industry: what's happening in Britain"
(1982) P.S.I., March 1982, 128 pp.

O.E.C.D. "Robots industriel - Leur role dans l'industrie manufacturiere"
(1983) O.E.C.D., Paris, 1983, 247 pp.

KAPLINSKY R. "Microelectronics and employment revisited - A review"
(1987) ILO, Geneva, 1987, 181 pp.

JUDET P. "The world crisis of the iron and steel industry and its impact in the development of this industry in developing countries"
(1985) UNIDO, ID/WG/458.3, 21 November 1985, 56 pp.

ALEXANDRE J.C., BLUNDEN K. "La chimie, une industrie multinationale"
(1986) Report of the "Chemicals" working group, Commission Prospective des Echanges Internationaux, August 1986, Commissariat General du Plan, Paris, 80 pp.

WATANABE S. (ed) "Microelectronics, automation and employment in the automobile industry"
(1987) Wiley, ILO, Chichester, 1987, 203 pp.

DERVELOY C., MYTELKA L. "L'enjeu du textile francais, le marche mondial"
(1986) Report to the Commissariat General du Plan, Paris, October 1986, 166 pp.

CHAPTER III

AN EVALUATION OF THE STRATEGIES OF FIRMS AND OF NATIONAL PERFORMANCES

1. THE FIRMS : THE BOILING UP

1.1. A planetary dimension

1.1.1 The strategy : a global vision

1. Competition on the electronics markets has changed radically in intensity since the mid-seventies. The macro-economic context undoubtedly constitutes one of the determinants of this change whilst budgetary and fiscal policies have played a role in the contrasting results of the national "champions" in the United States, Japan and Europe. The globalisation of these activities constitutes a response to the erratic variations in national economic situations, where interdependence has not yet been completely achieved. Faced with differentiated costs of capital and with the undifferentiated tastes of consumers companies are seeking flexibility in the market and the expansion of their outlets. Relocation, with agreements, becomes a prime strategy for achieving these objectives.

2. However relocation can no longer take the form of the subsidiary, ready to take over and acting as a kind of sales counter responsible for distributing the products of the group. Companies have to become real industrial complexes, developing autonomous divisions in the major geographical zones of Europe, Japan and the United States. With the emergence of these oligopolistic complexes within the Big Three (K. OHMAE, 1985) there is a risk that numerous small companies will disappear. Unlike the period 1975-1985, during which there was a boiling up with the creation of enterprises, the next ten years were to be seen as years of consolidation (R. CONRADS, 1985, p.162). Numerous segments of the market had, in fact, arrived at a premature maturity. Too many competitors with excess productive capacity entered into price wars and caused an even greater segmentation of the market. For example the major informatics firms which were IBM's competitors, the BUNCH (Burroughs, Univac, NCR, CDC and Honeywell) were crushed between IBM, the dominant company, Japanese competitors like NEC and FUJITSU and new companies such as Sun Microsystems, Prime Computer and Stratus Computer. They therefore had to regroup: UNIVAC and BURROUGHS merged to form UNISYS and changed market segments, NCR progressively abandonned universal informatics whilst HONEYWELL quit informatics altogether.

3. With the convergence of the market structures towards an oligopoly scale and range economies become preponderant in every field of activity from development up to marketing and including production. Even software is subject to this logic of seeking an optimal size, the level of which is increasing. Consequently whereas up to the present time available capital would risk financing the creation of enterprises on the basis of a new idea the nineties could be years in which it would be the large companies which would be best able to manage innovation and the rate of development of products.

4. The search for a minimum optimal size has contributed towards an explosion in the number of agreements, alliances and mergers between firms of the same or different nationality. The objective of many of these agreements has been to share products or components manufactured on a large scale in the plant of one of the two partners; others reach agreement to develop new processes and products or to share a marketing network. However the multiplication of agreements does not mean that they are always observed, and a large number of them are cancelled on the grounds of having been administered in an incorrect manner. If they are to continue in force these alliances must benefit from an adequate structure and special management. As a consequnce of this a company cannot envisage multiplying them, and it is probable that the vast movement taking place at the present time will progressively slow down (R. CONRADS, 1985, p.163)

5. Apart from the agreements relocation may also find its inherent limits in the organisational problems of the enterprise. The dismemberment of their productive apparatus by the North American transnationals complies with the CLEE model, that is to say the search for advantages linked with low labour costs and sales on attractive markets. However this model is obsolete because of mechatronics and the manifest protectionism of the large industrial countries (K. OHMAE, 1985, pp.67-68). Furthermore the Japanese groups, inserted into a territorial network of sub-contractors, either subsidiaries or not, encounter many problems in segmenting the productive processes. The two models (CLEE and Japanese) are mutually exclusive, whilst the European groups attempt to establish major automated production units, vertically integrated and located in the proximity of the national market.

6. To these factors of uncertainty one must add today the ri~ing cost of R & D activities or, if one prefers, the stagnation or decrease of the productivity of research. This situation leads, at the same time, to making increasingly risky those technological gambles which require ever-larger capital investments (cf Chap.I). This gives an advantage to the larger groups: they alone would seem to be able to finance, to launch and to support the development of a product-system such as a uiversal computer or a digital switching unit. Since they cannot develop these in-house these groups seek to collect together all the pieces of the puzzle in joint subsidiaries or by buying smaller companies. Finally the rising cost of R & D explains the frenzy which surrounds its appropriation and the hardening of the legal actions taken against competitors.

7. With the consolidation of their positions on the markets of the Big Three firms in the electronics industry are confronted with unsuspected factors of uncertainty. Technological prospects, the stability of agreements and the legal systems specific to each nation add to the uncertainty provoked by variations in exchange rates and rising rates of interest. With this increasing uncertainty and the need to react very rapidly the firms are led to seek in the flexibility of organisation and of production the margin of manouvre which they have lost in other fields. This requires a revision of the culture of the enterprise.

1.1.2. The structure : a global oligopoly

8. The present trend in the electronics industry is towards international concentration, hence to global concentration and so to the increasing domination of the major industrial groups. Today the electronics industry is already a strong and concentrated industry: of the total turnover of

US$ 528 billion in 1986 half was realised by the twenty leading groups (see Table III-1).

9. These twenty firms may be regarded as the leaders in the electronics industry; their orientations will determine the overall evolution of the branch. Amongst these twenty are nine American firms (IBM, ATT, General Motors, GE-RCA, Xerox. Unisys, Digital Equipment, Hewlett-Packard and Motorola), seven Japanese firms (Matsushita, NEC, Hitachi, Fujitsu, Toshiba, Sony and Sanyo) and four European firms (Philips, Siemens, CGE and Thomson).

10. The market is characterised by a national structuring which is still very marked. As a general rule the market of the country of origin remains the primary outlet of the present participants in the industry. The modes of organisation and operation of these markets retain specific characters which influence the activities of the firms. The major participants in the world electronics industry today form a relatively differentiated whole.

11. The structure of the production still remains highly contrasted according to the main global zones of production , as may be seen from Table III-2. A relative similarity may be seen between the American and European structures.

RG	FIRMES	PAYS	CA ELEC.	% TOT	% CUM	% LEADER
1	IBM	USA	51200	10	10	100
2	MATSUSHITA	JAP	19400	4	13	38
3	PHILIPS	P-B	16500	3	17	32
4	ATT	USA	15000	3	19	29
5	GENERAL MOTORS	USA	14900	3	22	29
6	NEC (SUMITOMO)	JAP	14800	3	25	29
7	GE-RCA	USA	13000	2	27	25
7	SIEMENS	RFA	13000	2	30	25
9	HITACHI	JAP	12600	2	32	25
10	FUJITSU	JAP	12400	2	35	24
11	TOSHIBA (GE)	JAP	10000	2	37	20
12	XEROX	USA	9400	2	38	18
13	CGE (1)	FRA	9200	2	40	18
14	UNISYS (1)	USA	8800	2	42	17
15	DIGITAL EQUIPMENT	USA	8400	2	43	16
16	SONY	JAP	7700	1	45	15
17	THOMSON	FRA	7300	1	46	14
18	HEWLETT-PACKARD	USA	7100	1	48	14
19	MOTOROLA	USA	5800	1	49	11
19	SANYO FISHER	JAP	5800	1	50	11
21	GEC	G-B	5300	1	51	10
22	BOSCH	RFA	4900	1	52	10
22	MITSUBISHI ELECTRIC	JAP	4900	1	53	10
24	OLIVETTI	ITA	4800	1	53	9
25	TEXAS INSTRUMENTS	USA	4700	1	54	9
26	BULL (1)	FRA	4500	1	55	9
26	ROCKWELL	USA	4500	1	56	9
28	ERICSSON	SUE	4400	1	57	9
28	NORTHERN TELECOM	CAN	4400	1	58	9
30	NCR	USA	4350	1	59	8
31	RAYTHEON	USA	4300	1	59	8
32	HONEYWELL (1)	USA	4200	1	60	8
33	SHARP	JAP	4000	1	61	8
34	CANON	JAP	3700	1	62	7
35	SEIKO	JAP	3600	1	62	7
35	TRW	USA	3600	1	63	7
37	RICOH	JAP	3500	1	64	7
38	CONTROL DATA	USA	3400	1	64	7
39	WESTINGHOUSE	USA	3100	1	65	6
40	FORD	USA	3000	1	65	6
41	IRI	ITA	2800	1	66	5
41	LITTON	USA	2800	1	67	5
41	LOCKHEED (1)	USA	2800	1	67	5
44	3M	USA	2700	1	68	5
45	STC (ITT)	G-B	2670	1	68	5
45	WANG	USA	2670	1	69	5
47	MARTIN-MARIETTA	USA	2650	1	69	5
48	THORN-EMI	G-B	2440	0	70	5
49	MC DONNELL DOUGLAS	USA	2300	0	70	4
49	OKI	JAP	2300	0	70	4
	TOTAL		371590	70		726

Source : Thomson, 1987, p. 37

Table III-2 : STRUCTURE OF 1985 PRODUCTION BY THE MAJOR ZONES AS PERCENTAGES

	Etats-Unis	Europe	Asie
Biens d'équipement	73,8	73,5	38,8
Composants	22,8	17,6	33,5
Biens de consommation	3,4	8,9	27,7

Source : Panorama de l'industrie électronique mondiale, E.I.C., 1987.

12. The industrial structure of each of these zones remains highly specific. In a general manner the American constructors are more highly specialised than their foreign homologues: they realise an important part of their turnover in a limited number of sectors. By contrast the Japanese groups are characterised by the high degree of diversity in their activities. Between these two extremes Europe includes firms like Bull and Nixdorf, which are specialised in informatics, and others like CGE and Siemens, which are highly diversified.

13. Although electronics products are now increasingly homogeneous across all world markets it would appear that the principal producers do not constitute an undifferentiated category. The differences in the national industrial structures have orientated the forms of the international division of labour and hence the specialisation of firms on a world scale. The opening up of markets to the outside has been effected on the basis of the competitive capacities of the groups, themselves founded on the specific advantages furnished by the domestic environments from which they started. The Japanese find their forces in the rapidity of diffusion of new mass consumer goods and in the search for quality in their production operations. The American firms depend upon the high level of development of their domestic market, the base for the emergence of innovations. Thus Japanese firms occupy important parts of the market in the mass consumer electronics and in certain fields of semiconductors such as 64k and 256k DRAM's. American suppliers dominate the production of information processing equipment.

14. Furthermore the internationalisation strategies of the electronics groups take their national specificities into account. It may also be pointed out that the American firms have chosen to develop on an international scale by way of the creation of subsidiaries abroad, firstly at the points of marketing, then seeking out advantageous wage costs. Europe is therefore penetrated by American investments and so the approximating of its industrial structure to that of the United States can be seen to be accelerating. The large Japanese firms, for their part, having based their competiveness on a domestic production capacity for standard products with a high level of quality, are now constrained to export products rather than manufacturing techniques. Their penetration of world markets has moved from those consumer goods which do not require the implementation of an extensive network for customer services to elementary components and before moving on to products with a higher value added. In order to market their production the Japanese firms have often operated strategies of alliance with European or American firms; recently, however, with the rise of the Yen against the Dollar and European currencies, the establishment of subsidiaries has accelerated. The European groups, caught between the technological advances of the Americans and the efficacy of Japanese production methods, and not having the optimal volumes of outlets on their territories of origin, have often only been able to carry out local resistance operations against foreign penetration. In

order to palliate these deficiencies they sometimes attempt to become internationalised by external cross-operations (Olivetti in the United States).

1.1.3. The actors : an exclusive club

15. The present state of the competition and of an industry on an international scale limits the list of candidates to the largest existing groups. In order to be able to play a major role in the constitution of the industry at world level it is necessary to possess considerable resources. Firms must possess very extensive financial resources if they are to face up to competition which is now on a global scale, and away from those zones which are sheltered by national policies. It is also necessary to devote considerable sums to research and development.

16. Secondly the groups must possess a broad spectrum of know-how and competences. Most of them already occupy positions of strength in several industrial segments concerned with electronics technologies (see Table III-3).

17. The formation of an oligopoly will be accompanied by a major industrial restructuring, inasfar as this will be the result of vigorous competition between the various candidates, all of whom know that their survival is at stake. The conflict can only be resolved by the disruption of many positions acquired on the major national markets. This must necessarily come about by the imposition of new rules for the functioning of industry and hence by a new definition of its frontiers and its organisation.

18. Reducing the principal actors to a small number implies that these will be seen as suppliers of complete and integrated solutions rather than as offering isolated goods. Several trends militate against this route. One finds, first of all, that the evolution of the technology of components is increasingly orientated towards increasing their degree of integration. The component increasingly approximates to a system. In the situation on the existing market, dominated by a price war, only those groups capable of controlling very high volume production outlets can face up to the competition and benefit from the value added in the downstream stages of component manufacture. The captive producers are those which are best able today to resist the crisis of overproduction in this segment of the industry.

Table III-3 : THE TEN LEADING GROUPS IN THE WORLD, AS CLASSIFIED BY THEIR ELECTRONICS TURNOVER

	Total 1987 US$ m	1987 R&D US$ m	Inform. rank, 87	Telecomm. rank, 86	Int. Circ. rank, 87
IBM	54,217	5,434	1	9	1
MATSUSHITA	31,906.1	1,832.4	17	-	11
PHILIPS	26,023.1	2,154.3	18	10	9
ATT	33,598	2,453	23	1	5
GM	101,781.9	4,071.2	31	-	nd
NEC	18,236.8	1,711.4	5	4	2
GE	40,515	1,194	53	-	nd
SIEMENS	28,615.7	3,455.7	7	5	17
HITACHI	33,070.6	2,179.3	6	14	4
FUJITSU	13,103.2	1,154.7	4	11	10
TOTALS	381,067.4	25,640			

Source : Datamation, 15.6.1988; Thomson, 1987; FORTUNE, April 1988

19. Finally it must be noted that penetration of an increasingly vast field of applications, from management to production, through electronic techniques to information processing, leaves users increasingly at a loss when faced with the problems posed by the installation of systems in which complexity increases without cease and which today cause difficulties because of the lack of compatibility of the various elements from which they are built. Furthermore commissioning a system from its component parts becomes a competence in itself. The leaders of the oligopoly will therefore become vast integrated groups offering complete solutions. This will be followed by a reduction in the degree of specialisation of the principal actors (E. de ROBIEN, 1986, p.179).

20. The competition in regard to complete solutions on a world market and the reduction in the degree of specialisation of the participants will definitively lead to the growing similarity of the organisational and operational characteristics of the principal protagonists. The existing differences which we have noted between the American and European groups on the one hand and the Japanese on the other, will become less as a result of the implementation of a global oligopolistic unity.

21. The advance to integration will, in the last resort, take off from a double point of departure: that of production competence, or that of utilisation. It is found, in fact, that the principal actors consist on the one side of groups which come from the traditional segments of the electronics industry, such as IBM, ATT, Philips or NEC and on the other side of newly-arrived firms from major user sectors and with formidable financial resources such as General Motors or even General Electric. The first category justify themselves by the fact that, as enterprises already engaged in this type of activity, they have the design and production know-how which allows them to construct an assemblage of competences which integrates all the complementary elements necessary for establishing a supply of complete systems. The second category are founded principally on a capacity for integration by enforcing the standardisation of the components and on their financial power which can encourage them to extract advantage from this successful integration to become assemblers in their turn. In this respect it is particularly interesting to note that this strategy will lead to a gradual falling away of the organising power of the industry, from the public powers to private powers, which is fully in line with the trend towards the constitution of a global oligopoly.

22. The consolidation of the global oligopoly allows one to predict the weight of the groups at the start of the twenty-first century. Table III-4 sets out the possible evolutions of the five American groups when account is taken of the growth perspectives of the various market segments. This exercise leads to the emergence of mastodons with turnovers which will in all cases exceed US$ 100 billion. One may ask whether it will be necessary to redefine anti-trust laws as virulent as those of the fifties.

Table III-4

PROSPECTS FOR THE NORTH AMERICAN MEGAFIRMS

Source : CERDIC, d'après les rapports annuels et les prévisions de croissance.

	Matériel électronique							Services			Autres	Total
	Informatique	Communications	E.G.P.	Composants (3)	Mécatronique et automatismes industriels (7)	Autre électronique	Total électronique	Logiciels / maintenance	Services Télécom.	Autres services		
1984												
I.B.M.	33,0	3,4	-	(2,7)	0,9	-	37,3	8,4	0,2	-	-	45,9
A.T.T.	0,6	16,8	-	(0,5)	-	-	17,4	0,1	15,7	-	-	33,2
G.E.-R.C.A. (1)	ε	1,8	2,2	-	8,5 (6)	-	12,5	0,8	7,9	2,3	19,5	38,0
Xerox	1,1	-	-	-	-	2,5 (4)	3,6	0,4	.	-	5,1	8,9
G.M.-H.A-E.D.S. (2)	-	4,0	-	0,5	0,1	2,8 (5)	7,4	0,8	.	-	81,4	89,6
1990												
I.B.M.	80,0	7,5	-	(6,5)	1,5	-	89,1	25,0	1,0	-	-	115,0
A.T.T.	1,9	23,7	-	(1,0)	-	-	25,6	0,3	16,5	-	-	62,4
G.E.	ε	5,2	5,2	-	21,4	-	31,8	2,1	4,7	2,7	31,9	73,2
Xerox	3	-	-	-	-	4,0	-	.	.	-	7,3	15,5
G.M.	-	11,0	-	1,5	1,0	5,8	19,3	2,3	.	-	89,0	110,6
1995												
I.B.M.	130,0	15,0	-	(12,0)	10,0	-	155,0	50,0	3,0	-	-	208,0
A.T.T.	3,6	32,3	-	(2,0)	-	-	35,9	0,6	81,5	-	-	120,0
G.E.	ε	10,5	8,5	-	38,5	-	57,5	4,2	7,0	3,3	44,0	116,0
Xerox	4,5	-	-	-	-	5,0	9,5	2,5	.	-	10,0	22,0
G.M.	-	20,5	-	3,5	4,0	9,0	37,0	5,0		-	105,0	147,0
Croissance composée 1984-1995 (%)												
I.B.M.	13,0	14,4	-	(14,5)	24,4	-	13,8	17,6	7,9	-	-	14,7
A.T.T.	17,0	6,1	-	(13,4)	-	-	6,8	17,7	16,4	-	-	12,3
G.E.	-	17,3	13,0	-	14,7	-	14,9	16,2	8,3	3,3	7,6	10,7
Xerox	13,6	-	-	-	-	6,5	9,2	18,1	.	-	6,3	8,5
G.M.	-	16,0	-	18,7	44,4	11,1	15,7	18,0	.	-	2,3	4,6

(1) General Electric R.C.A.
(2) General Motors - Hughes Aircraft - Electronic Data Systems
(3) Les données entre parenthèses sont en intraconsommation
(4) Bureautique
(5) Electronique automobile
(6) Y compris machines-outils classiques
(7) Y compris C.A.O./F.A.O.

1.2. The strategic revision

1.2.1. Relocation reconsidered

23. The establishment of Fairchild in Hong Kong in 1962 was the start of the continuing wave of relocation of North American electronics firms. In fact from the beginning of the sixties Japanese firms had begun to contest the American advance in the field of active components. In 1957 American firms produced 29 million transistors and the Japanese 6 million: by 1961 the figures were 191 million and 180 million transistors respectively. The ratio had thus fallen from 4.83 in favour of the United States to 1.06 (J. GRUNWALD and K. FLAMM, 1985, pp. 68-70). Such a threat led the American producers, until then dominant, to modify their production processes: PHILCO totally automated its production, FAIRCHILD chose relocation. The choice made by PHILCO made it difficult to make changes in technology in an industry where the life cycle of the product is known to be very short. Some years later the firm had to abandon its semiconductors activity. Most manufacturers followed the example of FAIRCHILD.

24. It was also Japanese competition which led the manufacturers of television receivers to relocate. GENERAL ELECTRIC opened up a production unit in Singapore in 1968, and a year later RCA established plants in both Taiwan and Mexico to manufacture or assemble television sets. In 1971 ZENITH followed the same route. At the same time the US Tariff Commission accused Japanese manufacturers of dumping. This resulted five years later in the implementation of the Orderly Marketing Agreement (OMA) which was simply a system of quotas for importing colour television sets into the United States. This procedure, which came into force in 1977, was to have a limited impact on the industry, firstly because North American producers, all established abroad, came under the tariff, and secondly because the Japanese firms had meanwhile established themselves on the American market. SONY had set up in California in 1972, MATSUSHITA bought QUASAR, the TV division of MOTOROLA in 1974, and finally SANYO bought WARWICK, the principal supplier to the SEARS chain of shops, in 1976 (OTA, 1983, pp. 116-119).

25. In their relocation the North American firms adhered to the CLEE model (cf. 1.1.1.). The low cost of labour was the crucial factor in their decisions, apart from the fact of evading customs' barriers. In fact the production units set up in Japan or in Europe should be considered as "tariff factories". Whether this is so or not after more than thirty years of relocation the North American electronics firms had nearly 1½ million employees outside the United States (Table III-5) of which 39% are in informatics and 25% in measuring and precision instruments (US Department of Commerce, 1985). Europe alone accounts for 53% of these employees whereas Latin America and Canada account for only 19%. It seems therefore that these are tariff factories based on the CLEE model.

26. Clearly the intensification of world competition and the modification of cost structures have resulted in an extension of the objectives and have changed the strategies for the international segmentation of production processes in the electronics industry (Michael McGRATH, 1988, p.144). International production makes it possible to increase sales significantly. Thus, as shown in diagram III-1, when the percentage of European sales is plotted against the proportion of production in Europe of the North American firms a high level of correlation is found. It can be seen that up to 20% of turnover can be achieved in Europe with little or no local production, but beyond this point local production becomes necessary. A firm like COMMODORE is not just relocated but is also perceived as being autochthonous in West

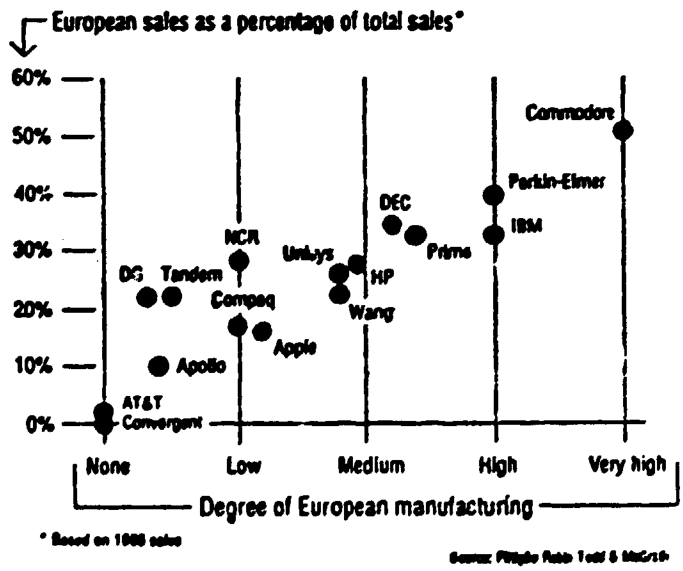
Germany or in the United Kingdom. According to K. OHMAE such a characteristic constitutes one of the conditions allowing a company to become "triadic" (K. OHMAE, 1985, pp. 299-304).

Table III-5 : MANPOWER IN THE SUBSIDIARIES OF NORTH AMERICAN ELECTRONICS FIRMS IN 1982

MANPOWER	Total	%	Canada	Europe	Japan	Lat.Am.	Asia	Others
Office and general informatics	339600	39.72	28900	220300	32600	24700	-	-
Radio, TV and communications	187700	21.96	9100	62700	10200	46900	51600	27600
Components and accessories	104400	12.21	6700	33500	3600	5600	53100	9100
Measurement and precision	215400	25.20	16000	135000	16600	27900	6400	46700
TOTAL electronics	847100	99.09	60700	451500	63000	105100	111100	181700
Software and informatics services	7800	0.91	800	4700	0	-	-	-
OVERALL TOTAL	854900	100.00	61500	456200	63000	105100	111100	184000
ALL ACTIVITIES	6640200	12.87	913800	2766700	302000	1350600	526800	1384300

Source : GERDIC, from data from Electronic Business

Diagram III-1 : CORRELATION BETWEEN SALES AND MANUFACTURING



Source : Electronic Business, 1 May 1988, p.144

27. North American firms were not the only ones to opt for relocation. European and Japanese firms have been very active since the beginning of the eighties, and the movement is becoming intensified. Table III-6 gives the position regarding foreign electronics firms in the United States: two of them, Philips and Matsushita, realise 54%, and most of them have production units in the United States. One can see the significant share of these groups on the North American market which was evaluated by the BEP as being US$ 190.8 billion without software and automation systems and as US$ 240.5 billion by the EIC with these two branches included. This brings the share of the North American market held by the groups set out here to 18.6% and 14.7% respectively.

28. Initially concentrated on their own territory the Japanese firms have subsequently been led to follow the relocation movement. Protectionist tensions and variations in exchange rates have amplified the phenomenon. Japanese electronics firms now have 501 establishments outside Japan, 82 (16%) being in the United States, 61 (12%) in Europe and 279 (56%) in Asia. The search for lower labour costs, which guided the first wave of Japanese relocation, is still therefore apparent in these figures. It must, however, be borne in mind that the 501 overseas establishments represent a negligible number when compared with the 17,541 electronics companies listed in Japan.

Table III-6 : THE ELECTRONICS TURNOVER OF FOREIGN GROUPS IN THE UNITED STATES

Millions de dollars		1986-87	%	1985-86	%
MATSUSHITA		6700	18,86%	6520	17,76%
PHILIPS	E	3993	11,24%	3430	9,34%
HITACHI		3030	8,53%	2920	7,95%
NORTHERN TELECOM		2860	8,05%	2870	7,82%
SONY		2634	7,41%	2250	6,13%
TOSHIBA		2000	5,63%	1310	3,57%
NEC		1948	5,48%	1450	3,95%
SHARP		1600	4,50%	1460	3,98%
SIEMENS	E	1500	4,22%	1340	3,65%
JVC		1335	3,76%	950	2,59%
MITSUBISHI		1200	3,38%	1000	2,72%
SANYO		1200	3,38%	1200	3,27%
FUJITSU		1170	3,29%	650	1,77%
CANON		1150	3,24%	1090	2,97%
GEC	E	1100	3,10%	980	2,67%
CGE	E	865	2,43%	320	0,87%
OLIVETTI	E	835	2,35%	620	1,69%
SAMSUNG ELECTRONICS		800	2,25%	550	1,50%
KYOCERA		542	1,53%	485	1,32%
C.ITOH		500	1,41%	500	1,36%
RACAL	E	475	1,34%	470	1,28%
SCHLUMBERGER		450	1,27%	900	2,45%
TDK		450	1,27%	430	1,17%
LEX SERVICES	E	442	1,24%	390	1,06%
THORN EMI	E	430	1,21%	430	1,17%
THOMSON CSF	E	425	1,20%	300	0,82%
ERICSSON	E	400	1,13%	310	0,84%
BAYER	E	370	1,04%		0,00%
ALPS		325	0,91%	240	0,65%
PLESSEY	E	280	0,79%	260	0,71%
COMMODORE		230	0,65%	360	0,98%
BROTHER INDUSTRIES		185	0,52%	138	0,38%
BOSCH	E	180	0,51%		0,00%
AEG	E	140	0,39%	100	0,27%
MITEL		139	0,39%	130	0,35%
NIXDORF	E	130	0,37%	130	0,35%
MANNESMANN	E	120	0,34%	120	0,33%
CANADIAN MARCONI		98	0,28%	110	0,30%
TOTAL		35531	100,00%	30193	82,24%
dont européennes		11685	32,89%	9200	25,06%

Source : GERDIC, from data in Electronic Business

Table III-7 : THE OVERSEAS ESTABLISHMENTS OF JAPANESE ELECTRONICS FIRMS

		Corée	Taiwan	HK.	Malaisie Singapour	Autres ASEAN	Total ASE	Amérique du Nord	Amérique Latine	Europe	Autres	Total
EGP												
	50-65	0	2	1	1	2	6	2	2	0	1	11
	66-69	0	3	0	5	5	13	0	2	1	7	23
	70-74	6	6	0	11	6	29	3	7	6	9	54
	75-79	2	2	1	5	3	13	10	3	7	6	39
	80-85	-1	8	6	2	-5	10	13	11	17	-12	37
Composants												
	50-65	0	3	1	1	1	6	1	0	0	1	8
	66-69	1	13	0	0	1	15	0	3	0	4	22
	70-74	31	25	2	16	1	75	1	7	1	4	88
	75-79	8	9	2	17	4	40	5	3	3	1	52
	80-85	2	12	0	10	12	36	26	10	17	0	89
Biens d'équip.												
	50-65	0	2	0	0	0	2	2	0	0	1	5
	66-69	0	1	0	0	0	1	1	2	1	1	6
	70-74	1	2	0	2	0	5	2	3	0	1	11
	75-79	2	0	0	1	0	3	4	1	1	1	10
	80-85	7	7	1	5	5	25	12	0	7	0	44
Total												
	50-65	0	7	2	2	3	14	5	2	0	3	24
	66-69	1	17	0	5	6	29	1	7	2	12	51
	70-74	38	33	2	29	7	109	6	17	7	14	153
	75-79	12	11	3	23	7	56	19	7	11	8	101
	80-85	8	27	7	17	12	71	51	21	41	-12	172
Grand Total		59	95	14	76	35	279	82	51	61	75	501
Nbre de sites		42	65	14	67	27	215	54	[illegible]	41	15	364

Source : J.L. PERRAULT, 1988

Table III-8 : THE FIFTY LEADING ELECTRONICS FIRMS ESTABLISHED IN JAPAN AS AT 1 JANUARY 1985

FILIALE :	INVESTISSEUR ETRANGER :		EFFECTIF	CREATION		CAPITAL ETRANGER %
IBM Japan, Ltd	1 IBM WORLD TRADE CORP	EU	16740	JUIN 1937		100
Fuji Xerox Co., Ltd	2 RANK XEROX LTD	GB	10190	FEVR 1962		50
Texas Instruments Japan Ltd	3 TEXAS INSTRUMENTS INC	EU	49[illegible]	MAI 1968		100
Nippon Univac Kaisha, Ltd	4 SPERRY RAND CORP	EU	4884	MARS 1958		34
NCR Japan, Ltd	5 NCR CORP	EU	4500	FEVR 1920		70
Yamatake-Honeywell Co., Ltd	6 HONEYWELL INC	EU	3400	AOUT 1949		50
Yokogawa-Hewlett-Packard, Ltd	7 HEWLETT PACKARD	EU	3000	SEPT 1963		75
Burroughs Co., Ltd	8 BURROUGHS CORP	EU	2650	JANV 1973		100
Toppan Moore Co., Ltd	9 MOORE CORP LTD	CAN	2200	JUIN 1965		45
Sumitomo 3M Ltd	10 MINNESOTA MINING & MFG CO (3M)	EU	2008	DECE 1961		50
Nihon Digital Equipment Corp.	11 DIGITAL EQUIPMENT CORP INTL.	EU	1800	AOUT 1982		100
Olivetti Corp. of Japan	12 OLIVETTI INTL SA (Luxembourg)	IT	1400	SEPT 1961	*	100
Nippon Motorola Ltd	13 MOTOROLA INC	EU	1300	JANV 1982		100
Nippon Avionics Co., Ltd	14 HUGHES AIRCRAFT CO	EU	1250	AVRI 1960		49
Japan Business Computer Co.	15 NIHON-IBM K.K.	EU	1170	AOUT 1983	**	34,75
Gadelius K.K.	16 GADELIUS AB	SUE	1050	NOVE 1970		100
AMP (Japan), Ltd	17 AMP INC	EU	1000	JUIL 1957		100
New Japan Radio Co.	18 RAYTHEON CORP	EU	1000	SEPT 1959		30,3
Nichiden Anelva Co., Ltd	19 VARIAN ASSOCIATES INC	EU	1000	OCTO 1967		19
Sony/Tektronix Corp.	20 TEKTRONIX INC	EU	900	MARS 1965		50
Marantz Japan, Inc.	21 PHILIPS GLOEILAMPEN, N.V.	PB	846	MAI 1946		54
Nippon Data General Corp.	22 DATA GENERAL	EU	810	FEVR 1971		85
Daiichi Denshi Kogyo K.K.	23 BUNKER RAMO- ELTRA CORP	EU	693	OCTO 1963		34
Oki Univac Kaisha, Ltd	24 SPERRY RAND CORP	EU	670	NOVE 1963		45,00
Nippon Office Systems, Ltd	25 IBM JAPAN, LTD	EU	616	SEPT 1982	**	35
Molex-Japan Co., Ltd	26 MOLEX INC	EU	600	JUIN 1970		100
Burndy Japan Ltd	27 BURNDY CORP	EU	531	MAI 1963		50
Yokogawa Medical Systems, Ltd	28 GENERAL ELECTRIC	EU	501	MAI 1982		51
Teijin Memorex Co., Ltd	29 NIHON-MEMOREX CO, LTD	EU	500	DECE 1978	**	49
Toshiba Electronic Systems, Ltd	30 GENERAL ELECTRIC	EU	468	JANV 1963		40
Intel Japan K.K.	31 INTEL CORP.	EU	450	AVRI 1976		100
CBS/Sony Group Inc.	32 CBS INC	EU	441	MARS 1968		50
Simeo Seimitsu	33 LUCIEN MEROZ	SUI	426	JANV 1963		6,6
Electrolux Japan Ltd	34 ELECTROLUX	SUE	420	JUIN 1975		100
Furukawa Precision Engineering	35 W.C. HERAEUS GMBH	RFA	368	OCTO 1972		50
Japan Computer Science Co., Ltd	36 SHINAN INVESTMENT HOLDINGS SA	LUX	350	DECE 1984		12,5
Nihon-Memorex Co., Ltd	37 MEMOREX CORP	EU	340	AOUT 1968		60
Nemic Lambda K.K.	38 VEECO INSTRUMENTS INC	EU	327	JUIN 1978		60
Cosmo 80 Co., Ltd	39 NISSEC LTD FAIRCHILD SC DIV.	EU	310	JUIL 1984	**	20
Nichicon Sprague Co., Ltd	40 SPRAGUE ELECTRIC CO	EU	310	SEPT 1970		45,3
Shinano Tokki Corp.	41 ABU DHABI INVESTMENT CO	EAU	300	SEPT 1984		22,61
IBM Japan Sales Co., Ltd	42 IBM JAPAN, LTD	EU	300	JUIN 1981	**	100
Siemens K.K.	43 SIEMENS AG	RFA	300	OCTO 1970		83
Siemens Medical System K.K.	44 SIEMENS K.K.	RFA	260	MARS 1979	**	100
Furukawa Circuit Foil Co., Ltd	45 YATES IND. INC	EU	252	SEPT 1970		50
Information Services Intl Dentsu	46 GENERAL ELECTRIC	EU	251	DECE 1975		34
Nippon Fairchild K.K.	47 SCHLUMBERGER	FAN	250	NOVE 1969		100
Avx K.K.	48 AVX CORP	EU	240	MAI 1979		97
NMB Semiconductor Co., Ltd	49 PICTET INTERNATIONAL	BAH	230	MAI 1984		17,87
Miyado Audio Co., Ltd	50 MARANTZ JAPAN (PHILIPS)	PB	220	OCTO 1972	**	100
	TOTAL/MOYENNE :		78912	1968		

Source : GERDIC fichier IMPLETJAP

29. Symmetrically with the initially weak movement of relocation of Japanese firms the level of foreign establishment in Japan was modest. The fifty leading foreign electronics firms employed 78,900 person in 1985 (Table III-8), hardly 6% of the 1.2 million employees in the electronics industry in this country. Furthermore the 251 foreign subsidiaries in electronics listed by GERDIC account for 88,300 jobs. It is obvious therefore that the movement towards globalisation of firms remains incomplete and, if the hypothesis of K. OHMAE is verified, we are likely to see a very sustained expansion of Direct Investment abroad. But this movement meets nationalist pressures, for example in the United States, which could prevent it from taking place.

30. Irrespective of its degree of achievement this globalisation results in increasingly large intra-firm flows. The 1982 Benchmark makes it possible to retrace, in the United States and for the electronics industry, the trade flows between the parent companies, their subsidiaries and the rest of the world. This data is set out in Table III-9. It shows the magnitude of these flows which now represent US$ 226 billion, from which are to be deducted US$ 127b sold by the parent firms in the United States and which thus do not enter into international trading. In total US$ 36b are exchanged within the North American multinationals, or 26% of the US$ 140b worth of electronics which were traded in the world in 1982.

Table III-9 : TRADING FLOWS OF AMERICAN MULTINATIONALS IN ELECTRONICS IN 1982 (US$m)

Exported TO	Parent	Subsid.	Other US	Other	Total	(%)
FROM						
Parent		16308	126936	8315	151559	66.9
Subsidiary	5272	14856	460	51100	71688	31,6
Other US		348			348	0.2
Other	2984				2984	1.3
TOTAL	8256	31512	127396	59415	226579	100.0
Percentage	3.6	13.9	56.2	26.2	100.0	

Source : GERDIC, from US Department of Commerce, 1985

31. Progressively, with this globalisation of production, there is a decoupling between the production of firms and their territorial base. In Table III-9a we provide a breakdown of the turnover of firms in the major zones of the Big Three. With the exception of Europe, and despite major trading deficits, the national production by nationals remains dominant (the diagonal of the table) and in total practically a quarter of sales within the Big Three are made by firms of a different nationality from that of the purchasing country. As a proportion of the market the sales made by foreign subsidiaries exceed 10% in all the zones, tending towards 15% in the United States. It would seem therefore that there is a threshold, when one considers the protectionist tensions revealed today.

Table III-9a : A COMPARISON OF TERRITORIAL PRODUCTION AND LOCAL TURNOVER OF FOREIGN FIRMS IN 1984 (in US$ millions)

C.A. des des firmes : implantées dans les zones suivantes :	Japonaises	Nord américaines	Européennes	TOTAL	(1) TOTAL Etranger	(2) Marché Apparent	(1)/(2) (%)
Japon	78000	7500	1000	86500	8500	50800	16.7%
	90.17%	8.67%	1.16%	100.00%	9.83%		
Etats Unis	16000	150000	8500	174500	24500	186100	13.2%
	9.17%	85,96%	4,87%	100,00%	14,04%		
Europe	7000	38000	35000	80000	45000	88200	51.0%
	8,75%	47,50%	43,75%	100,00%	56,25%		
TOTAL	101000	195500	44500	341000	78000	325100	24.0%
	29.62%	57.33%	13.05%	100.00%	22.87%		

Source : GEREIC

1.2.2. Cooperation in all directions

32. During the sixties the joint subsidiaries with foreign firms had as their objective a reduction in costs and so followed the proposals of the CLEE model. Since the eighties the significance of these alliances has been quite different, being essentially to affirm the competitive advantage of their associates. Previously the coalition was tactical, that is to say that, limited in extent and in time, it allowed less costly and more rapid access to the markets and the technology. Now it is strategic and links competitors in a structured manner (M. POTTS and P. BEHR, 1987, p.27).

33. Purchases or mergers, often preferred to cooperation, have come to the fore since the beginning of the eighties. In the field of software and informatics and services alone purchases had increased by 49% in 1985 in the United States. The present wave started in 1982, finding its origin in several events. Firstly the latent inflation of the seventies resulted in a considerable under-evaluation of assets. Then risk capital became in short supply for new firms; this is why some of them sought buyers. Finally the accumulated excess production capacities in numerous sectors led to mergers between former competitors. In the electronics industry these mergers were spectacular. Table III-10 shows some of these purchases in the United States. The first four such mergers alone cost more than US$ 17b. But this movement had been favoured in the United States by the macro-economic context and fiscal legislation. It is known, for example, that the 1981 Economic Recovery Tax Act allowed North American firms to release very considerable liquidities by accelerating certain amortisation procedures. Furthermore a legal decision of 1935 removed the taxation of plus-values on the sale of intangible assets; the latter is encashed by the seller and recorded in the intangible assets of the purchaser who can then amortise it.

34. Parallel to the merger movement there was a considerable phenomenon of disinvestment on the part of certain firms. There were many reasons for this: some were financial, For example assets had a higher sale value when they were amalgamated with an industrial group or with a conglomerate. Once again inflation had meant that share profits increased less than the intangible assets. Then the almost disappearance of inflation led, in the case of groups in debt, to difficulties in financing their growth by the lever effect. This is why one observed the restructuring of older conglomerates such as LITTON. ITT, for example, sold 66 of its divisions up to 1984 and then 19 during the first six months of 1985. TEXTRON Inc. sold four companies so that it could buy AVCO, SINGER sold three of its electronics divisions, etc.

35. In addition to the financial choices it was the checks to mergers which often explained disinvestments. McKINSEY Consultants examined a sample of 58 acquisitions between 1972 and 1983: 32 of them did not provide a yield which would make the capital profitable, whilst 30 did not improve the competitiveness of the group (S.E. PROKESCH, 1985, p.65): one acquisition out of three is abandonned. Between 1980 and 1984 the number of disinvestments increased by 35%, becoming the effect and the cause of "mergermania". Observing acquisitions exceeding US$ 100 million in 1986 McKINSEY found that 75% of the purchasers soon abandonned the new assets which had been acquired. This figure was only 20% at the end of the seventies (J.H. DOBRZYNSKI, 1988, p.58).

36. In fact much of the value of the "high tech" companies lies in the scientific potential of its engineers and technicians. Thus at the conclusion of an OPA it is frequently seen that the teams disperse towards

competitors rather than remain in the bought-out firm: the purchaser has thus purchased an empty box, often at a high price. More than half of these occur in high technology sectors.

37. In 1983 the number of cooperations announced in the United States in these industries was higher than all those previously announced in these sectors. R.N. OSBORN and C.C. BAUGHN (1987) observed the formation of joint Japanese/United States subsidiaries between Autumn 1984 and Autumn 1986. They listed 189 of these, 67 being in the electrical and electronics industries, divided up as follows :

Electrical and electronics industries	11
Telecommunications	14
Precision engineering	11
Information processing	18
Software	4
Semiconductors	5
Mechatronics	4

These relationships rest on the specialisation of the two partners and force them to respond to capital additions or in limited technology. If the older alliances, in the sixties, depended on an asymmetry of resources of the partners they are now concluded between companies of comparable technological level. This explains why R & D plays an important role and why joint subsidiaries, which show the desire to make cooperation last, are preferred to licensing agreements. This also explains why joint subsidiaries where one of the partners is American are more numerous in Japan and why more Japanese firms than those of other countries form joint subsidiaries in the United States (D.B. CHRISTELOW, 1987, p.11). Table III-11 shows the fifty leading joint subsidiaries established in Japan in the electronics industry, classified according to the criterion of number of employees. It will be seen that 84% of the employees belong to subsidiaries in which one partner is an American group; this confirms for the electronics industry the more general observations of D.B. CHRISTELOW.

38. European firms have not ignored this movement towards cooperation. Examination of a sample of 497 agreements involving European firms in 1980 and 1985 L.K.MYTELKA and M. DELAPIERRE (1987) found that scarcely 25% of the agreements are concluded between European firms, whereas 54% of them are established with North American firms. These geographical choices reflect the search for partners whose technology is complementary to that of the European groups: they also rest on the specialisation of the groups. By contrast one also sees within Europe that very active mergers are being effected including for example that between STC and ICL or the purchase of DATASAAB by L.M. ERICSSON. The European programmes have contributed towards multiplying intra-European agreements but have not however modified the opening up of European groups to the Big Three (Figure III-2).

Table III-10 : A SAMPLING OF RECENT MEGADEALS IN THE ELECTRONICS INDUSTRY

A sampling of recent megadeals in the electronics industry

Buyer/seller	Price paid ($ millions)
General Electric Co./RCA Corp.	$6,280
General Motors Corp./Hughes Aircraft Co.	$5,000
The Signal Companies Inc./Allied Corp.	$4,950
IBM/MCI Communications Corp. (16%)	$1,000
MCI Communications Corp./Satellite Business Systems	$460
Dow Jones & Co./Telerate Inc.	$460
Pacific Telesis Group/Communications Industries Inc.	$431
American Express Co./First Data Resources Inc. (remaining 25%)	$239
British Telecommunications Plc./Mitel Corp. (51%)	$217
Ameritech/Applied Data Research Inc.	$215
Investor Group (Welsh, Whitney)/Mohawk Data Sciences Corp. (five U.S business units)	$180
Eastman Kodak Co./Verbatim Corp.	$175
Investor Group (Management)/ Times Mirror Microwave Communications Co.	$175
Siemens AG/Telecom Plus International Inc.	$145
Sterling Software Inc./Informatics General Corp.	$144
Continental Telecom Inc./American Satellite Co. and Space Communications Co.	$105
Bell & Howell Co./University Microfilms Inc. (Xerox unit)	$100
Resources Inc./TRT Communications Inc.	$56
AT&T/Communications Satellite Corp. (50% of three Earth stations)	$55
Continental Telecom Inc./IPC Communications	$55
Systems Designers International Plc./Warrington Associates Inc.	$26
Atlantic Research Corp./Systematics General Corp.	$24
National Business Systems Inc./DEK Identification Systems (division of Mohawk Data Sciences Corp.)	$13
McDonnell Douglas Information Systems Group/ Applied Research of Cambridge, UK	$13

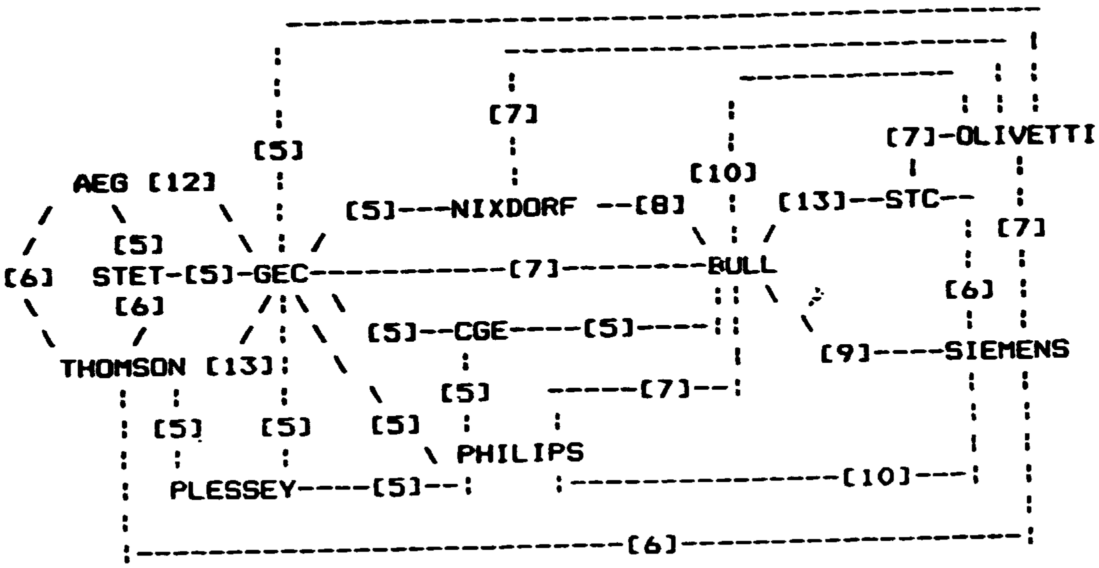
Sources: The Corporate Report, Quality Services Co

Table III-11 : JOINT SUBSIDIARIES IN JAPAN AS AT 1 JANUARY 1985
(Number of employees and date of creation)

Nippon Univac Kaisha, Ltd	MITSUI, OKI, MITSUBISHI ET ALII	SPERRY RAND CORP	EU	4884	MARS	1958
NCR Japan, Ltd	MITSUBISHI, MITSUI ET DAI-ICHI	NCR CORP	EU	4566	FEVR	1920
Yamatake-Honeywell Co., Ltd	FUJI BANK, YASUDA TRUST & BANK	HONEYWELL INC	EU	3400	AOUT	1949
Toppan Moore Co., Ltd	TOPPAN PRINTING CO LTD	MOORE CORP LTD	CAN	2260	JUIN	1965
Sumitomo 3M Ltd	NEC, SUMITOMO ELECTRIC	MINNESOTA MINING & MFG CO (3M)	EU	2088	DECE	1961
Nippon Avionics Co., Ltd	NIPPON ELECTRIC CO LTD	HUGHES AIRCRAFT CO	EU	1250	AVRI	1960
New Japan Radio Co.	JAPAN RADIO CO LTD	RAYTHEON CORP	EU	1000	SEPT	1959
Sony/Tektronix Corp.	SONY CORP	TEKTRONIX INC	EU	900	MARS	1965
Marantz Japan, Inc.	TAIYO KOBE BANK, INDIVIDUEL	PHILIPS GLOEILAMPEN. N.V.	PB	846	MAI	1946
Nippon Data General Corp.	KOZO KEIKAKU ENGINEERING INC	DATA GENERAL	EU	810	FEVR	1971
Daiichi Denshi Kogyo K.K.	FUJIKURA LTD, IWATSU ELECTRIC CO	BUNKER RAMO- ELTRA CORP	EU	693	OCTO	1963
Oki Univac Kaisha, Ltd	OKI, MITSUBISHI, NIPPON UNIVAC	SPERRY RAND CORP	EU	670	NOVE	1963
Nippon Office Systems, Ltd	KANEMATSU GOSHO LTD	** IBM JAPAN, LTD	EU	616	SEPT	1982
Burndy Japan Ltd	FURUKAWA ELEC., SUMITOMO ELEC.	BURNDY CORP	EU	531	MAI	1963
Yokogawa Medical Systems, Ltd	YOGOGAWA HOKUSHIN ELECTRIC WORKS	GENERAL ELECTRIC	EU	511	MAI	1982
Teijin Memorex Co., Ltd	TEIJIN LTD	** NIHON-MEMOREX CO, LTD	EU	500	DECE	1978
Toshiba Electronic Systems, Ltd	TOSHIBA CORP	GENERAL ELECTRIC	EU	468	JANV	1963
CBS/Sony Group Inc.	SONY CORP	CBS INC	EU	441	MARS	1968
Simeo Seimitsu	CITIZEN WATCH CO LTD	LUCIEN MEROZ	SUI	426	JANV	1963
Furukawa Precision Engineering	FURUKAWA ELECTRIC CO LTD	W.C. HERAEUS GMBH	RFA	368	OCTO	1972
Nihon-Memorex Co., Ltd	KANEMATSU GOSHO LTD	MEMOREX CORP	EU	340	AOUT	1968
Nichicon Sprague Co., Ltd	NICHICON CAPACITOR LTD	SPRAGUE ELECTRIC CO	EU	310	SEPT	1970
Siemens K.K.	FUJI ELECTRIC CO LTD	SIEMENS AG	RFA	300	OCTO	1970
Shinano Tokki Corp.	TEAC K.K.	ABU DHABI INVESTMENT CO	EAU	300	SEPT	1964
Furukawa Circuit Foil Co., Ltd	FURUKAWA ELECTRIC CO LTD	YATES IND. INC	EU	252	SEPT	1970
Amx K.K.	SUMITOMO METAL MINING CO LTD	AMX CORP	EU	240	MAI	1979
NMB Semiconductor Co., Ltd	MINEBEA CO LTD	PICTET INTERNATIONAL	BAH	233	MAI	1984
Koyo Lindberg, Ltd	KOYO SEIKO CO LTD	GENERAL SIGNAL	EU	220	JUIL	1967
Newtronics Co, Ltd	MITSUMI ELECTRIC CO LTD	COMMODORE ELECTRONICS LTD	BAH	205	JUIL	1963
Sumitomo Eaton Nova Corp.	SUMITOMO HEAVY INDUSTRIES LTD	EATON CORP	EU	200	AVRI	1982
RVC Corp.	VICTOR CO OF JAPAN	RCA INTERNATIONAL LTD	EU	161	OCTO	1975
Showa Information Systems Co.	MITSUI LEASING & DEVELOPMENT LTD	HENDERSON BARING JAPAN FUND	BAH	193	AOUT	1964
Advance Systems Technology Devt	MITSUBISHI CORP, COSMO 80 CO	** NIHON-IBM K.K.	EU	175	NOVE	1982
Computer Systems Leasing, Ltd	ORIENT LEASING CO LTD	** IBM JAPAN, LTD	EU	170	JANV	1983
Hirose Cherry Precision Co., Ltd	HIROSE ELECTRIC CO LTD	CHERRY ELECTRICAL PRODUCTS CORP	EU	160	JANV	1973
Tel Varian Ltd	TOKYO ELECTRON LTD	VARIAN ASSOCIATES INC	EU	150	FEVR	1982
Yamatake & Co., Ltd	YASUDA FIRE & MARINE INSURANCE	** YAMATAKE HONEYWELL CO LTD	EU	145	AVRI	1942
Sanken Airpax Co., Ltd	SANKEN ELECTRIC CO LTD	* NORTH AMERICAN PHILIPS CORP	PB	125	JUIL	1966
Ikuno Elec-Trol Inc.	IKUNO SEISAKUSHO	ELEC-TROL INC	EU	124	NOVE	1970
ASCO (Japan) Co., Ltd	KONAN ELECTRIC CO LTD	AUTOMATIC SWITCH CO	EU	100	JANV	1970
KOA TRW Inc.	KOA DENKO K.K.	TRW INC	EU	105	SEPT	1981
Tokyo Higashi Xerox Hanbai K.K.	KODANSHA LTD	*** FUJI XEROX CO LTD	EU	100	MARS	1981
Standard Technology Inc.	HORIBA, SHIMADZU, DENKI KAGAKU	** BECKMAN INSTRUMENTS (Japon) LTD	EU	80	JANV	1974
Ittcannon Ltd	JAPAN AVIATION ELECTRONIC IND	ITT SCHADOW INC.	EU	65	AVRI	1979
Advance Systems Technology Inc.	MITSUBISHI CORP ET ALII	** NIHON-IBM K.K.	EU	60	NOVE	[illegible]
Niigata Xerox Sales Co., Ltd	TSUZUKI SANGYO K.K.	*** FUJI XEROX CO LTD	EU	60	OCTO	[illegible]
Asahi Microsystems Inc.	ASAHI CHEMICAL INDUSTRY CO LTD	AMERICAN MICRO SYSTEM INC	EU	70	OCTO	1973
TEL-Genrad Ltd	TOKYO ELECTRON LTD	GENRAD INC	EU	65	AOUT	[illegible]
Fujiyama Enterprises Corp	MITSUBISHI BANK LTD ET ALII	TIE/COMMUNICATIONS INC	EU	64	FEVR	1984
Nippon Jarell-Ash Co.	KINSHO MATAICHI CORP	ALLIED HEALTH & SCIENTIFIC	EU	62	MAI	1961
TOTAL/MOYENNE				31998		1970

Source : GERDIC. fichier IMPLET JAP

Figure III-2 : THE NUMBER OF INTER-EUROPEAN AGREEMENTS SIGNED WITHIN THE FRAMEWORK OF ESPRIT



NB : The diagram excludes pairs of companies having less than five projects in common.

Source: L.K. MYTELKA and M. DELAPIERRE, 1987, p. 248

39. The relaxing of the anti-trust legislation has undoubtedly amplified the wave of bilateral collaboration which we can see. However it would seem to us that it meets a structural rather than an economic necessity: how else are we to understand how NEC, the principal competitor of INTEL after MOTOROLA, is also its leading client in Japan. Technical complexity demands collaboration. But cooperation also makes it possible to evade those protectionist national policies which prevent penetration of a market by simultaneously prohibiting acquiring enterprises there.

1.3. Zooming in on the sectors

1.3.1. Informatics : the new datum

40. Since the beginning of the eighties evolution in the architectures of information processing systems has accelerated with the convergence of telecommunications and informatics and, also, the multiplication of micro-computers in the field. The highly centralised systems have had to evolve rapidly towards a distributed architecture, at the same time demanding the establishment of communications networks. The producers of computers experienced many difficulties in satisfying the new needs of the users in regard to connections, integrated applications or coexisting interfaces. The principal cause of these problems was the absence of communications standards, and all manufacturers therefore attempted to develop and to promote the Open Systems Interconnection (OSI) standard.

41. The formation in 1984 of an informal association of twelve European manufacturers, the Standard Promotion and Application Group (SPAG) stimulated the development of the standardisation work undertaken by the International Standards Organization (ISO). It was as a result of an ISO initiative that the seven-layer structure or OSI was published in 1978. In response to the European initiative all the major North American manufacturers joined to form the Corporation for Open Systems (COS) in order to implement the OSI standard. Finally in 1985, on the initiative of MITI, the Japanese industrialists created the Promotion Conference for OSI in Japan (POSI) (E. DE ROBIEN, 1987, pp.224-226). The desire for standardisation of interconnections resulted in one further step being taken by the European manufacturers when they created, in December 1987, the European Workshops for Open Systems (EWOS), a federation of standards bodies. Simultaneously in the United States the American Workshop was created around the National Bureau of Standards whilst in Japan the Asian and Oceanian Workshop was created around POSI (P. DE LAUBIER, 1988).

(42) 43. This active search for standardisation arose from the technological evolution of micro-computers. For example a multi-user micro-computer, designed around a Motorola 68000 or 80286 microprocessor, such as the Series 1000 of Areta Systems, can carry out the same tasks as DEC's VAX 780 mini-computer at a purchase price of under US$ 100,000. Using the UNIX operating system these machines can also avoid the cost of developing new software, since they can use all the UNIX compatible applications programs. The arrival of the 32-bit micro-computers, built around the Intel 80386 and Motorola 68030 microprocessors, have extended the usage of these systems. For the manufacturers this means that, in the future, the use of multi-supplier informatics installations (that is to say equipment grouping together units from various producers) will be the general rule. As a result clients demand flexible and universal interconnections to link their work stations together or to link them to the major systems. Open (and universal) Local Area Networks (LANs) will provide the competitive challenge.

44. Technological evolution has transformed information processing equipment into a "product" which buyers can purchase at moderate prices and install in such a way as to meet their needs. One of the principal characteristics of informatics will thus disappear since, before the proliferation of micro-computers produced in long runs, each manufacturer had his own systems architecture and his own software. After having bought the hardware from a manufacturer the site was "locked in ", since software and the peripherals added to the system could not be transferred to another machine. Obviously the manufacturers obtained their margins on these two classes of product, and a producer dominant in central processing units could establish his de facto domination in peripherals and software. Examination of the results of informatics groups in 1987 shows this older state of affairs since there is still, in the case of manufacturers of universal computers, some proportionality between the market shares held in each of the three fields of mainframes, peripherals and software. IBM, Unisys, Fujitsu, Bull or STC (ex-ICL) are present in each of these fields (Table III-12). By choosing small systems the users can avoid getting "locked in" in this way.

Table III-12 : THE POSITIONS OF THE TWENTY LEADING WORLD GROUPS IN INFORMATICS BY MARKET SEGMENT IN 1987 (Informatics turnover only)

Millions de dollars	Mainframe	(%)	Mini	(%)	Micro	(%)	Periph.	(%)	Logiciels	(%)	Autres	Total	(%)
1 IBM	11193	46,52%	4300	28,85%	7007,7	42,66%	8725	24,17%	6836	51,65%	12424	50463,7	35,70%
2 Digital Equipment		0,00%	3248,4	21,80%	50	0,30%	2764,7	7,66%	691,1	5,22%	3637,1	10391,3	7,35%
3 Unisys Corp.	1427	5,93%	426	2,86%	1075	6,54%	1307	3,62%	1163	8,79%	3344	8742	6,18%
4 Fujitsu Ltd	3318,2	13,79%	804,3	5,40%	463,3	2,82%	2164	6,00%	515,9	3,90%	1474,3	8740	6,18%
5 NEC Corp	3082	12,81%	157,5	1,06%	933,2	5,68%	2270,1	6,29%	676	5,11%	1111,7	8230,5	5,82%
6 Hitachi Ltd	1850,4	7,69%		0,00%	141,4	0,86%	3036,2	8,41%	443,8	3,36%	806,9	6278,7	4,44%
7 Siemens AG	695,5	2,89%	311,6	2,09%	239,2	1,46%	1502,3	4,16%	550,8	4,16%	2403,6	5703	4,03%
8 NCR Corp	200,3	0,83%	483,4	3,24%	341	2,08%	1806,4	5,01%	140,6	1,06%	2104	5075,7	3,59%
9 Hewlett Packard		0,00%	1221	8,19%	499	3,04%	1735	4,81%	415	3,14%	1130	5000	3,54%
10 Olivetti Spa	95,8	0,40%	603,9	4,05%	1176	7,16%	855,5	2,37%	347,9	2,63%	1558,1	4637,2	3,28%
11 Toshiba Corp.		0,00%	919,6	6,17%	800	4,87%	961,1	2,66%		0,00%	760,6	3441,3	2,43%
12 Wang Labs		0,00%	909,8	6,10%	213,2	1,30%	567	1,57%	225	1,70%	1130,7	3045,7	2,15%
13 Apple Computer		0,00%		0,00%	2269,2	13,81%	700	1,94%	72	0,54%	0	3041,2	2,15%
14 Groupe BULL	962,8	4,00%	193,3	1,30%	193,3	1,18%	1172,1	3,25%	193,3	1,46%	292,7	3007,5	2,13%
15 CDC	510	2,12%	20	0,13%		0,00%	974,3	2,70%	110	0,83%	1386,4	3000,9	2,12%
16 Nixdorf Computer	128,1	0,53%	566,6	3,80%		0,00%	1250,9	3,47%	405,8	3,07%	470,1	2821,5	2,00%
17 Matsushita Electric		0,00%	29,5	0,20%	436,7	2,66%	1165,1	3,23%		0,00%	997,2	2628,5	1,86%
18 NV Philips		0,00%	375,2	2,52%	197,5	1,20%	839,2	2,33%	162,9	1,23%	1026,8	2601,6	1,84%
19 Xerox Corp.		0,00%		0,00%	400	2,44%	1560	4,32%	75	0,57%	380	2415	1,71%
20 STC Plc	596,8	2,48%	333,7	2,24%		0,00%	715	1,98%	207	1,56%	271,4	2123,9	1,50%
TOTAL	24059,9	100,00%	14903,8	100,00%	16425,7	100,00%	36093,1	100,00%	13226,1	100,00%	36667,6	141406,2	100,00%
GRAND TOTAL	26900	89,44%	21700	68,68%	23600	69,60%	53200	67,84%	17000	77,80%	36667,6	208900	

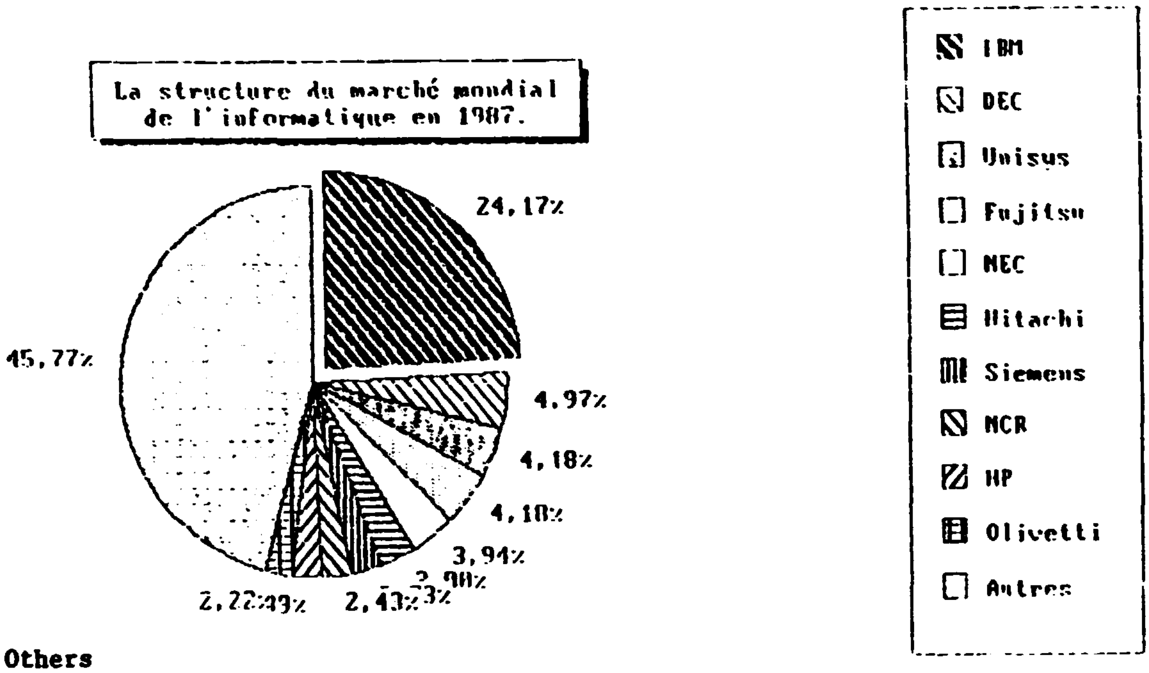
Source : GERDIC d'apres DATAMATION, 15 juin 1988.

45. The massive diffusion of micro-computers has reduced informatics to an industry of fairly ordinary goods and has re-int duced competition through prices. Since the sales of micro-computers represent a growing proportion of their income the producers of universal computers are becoming vulnerable. Without being in danger IBM presents deceptive results: an increase of 5.9% in 1987 with a reduction in net profits of 18% in the second quarter of 1988 because of the restructurings undertaken. Firms who had developed their won software attempted to acquire expertise in communications by buying independent software companies or by collaborating with them.

46. Despite the major price reductions on its Personal Computer (PC) IBM has not been able to maintain its market share which, according to Dataquest, fell from 71% in 1984 to 34% 1986. In order to keep itself aloof from a market which it was failing to master the Armonk company was forced to put forward a PC, the PS/2, which was difficult to imitate and which runs under its own operating system. Delivered from 1987 onwards, in its Model 80 version, the PS/2 has brought with it an increase in the market. The determination of IBM to stem the rise of compatibles for this model is clearly shown. The company has compatibility tests which allow it to discover the "clones" which infringe its patents. However the growth of the market and the need to develop new applications has been such that IBM has had to grant production licences to competitive firms such as TANDON. However users are refusing to tie themselves to a single manufacturer, the more so since competitive firms, such as COMPAQ, have for a long while been offering 32-bit machines which are perfectly compatible with other PCs running under MS-DOS or UNIX.

47. Within this context the dominant producers have been led to accelerate technological progress, to shorten the life cycle of their products and to define rapidly the standards for interconnection. Firms with their own standards, such as DEC, IBM or APPLE, have resisted standards which would have opened up their systems and subjected them to the same levels of competition. This has led to some rapprochements, such as DEC-IBM and DEC-APPLE, to try to integrate the hardware of one into the systems of the other. With the low margins inherent in hardware competition will be increasingly exercised in software and, above all, in networks and network nodes (C. LEWIS, 1987, p.84). For IBM, as for the other producers of universal computers, the challenge involves transforming their machines into the leading unit in the network of a company.

Figure III-3 : THE STRUCTURE OF THE WORLD INFORMATICS MARKET IN 1987



Others

Source : GERDIC, after DATAMATION, 15 June 1988

1.3.2. <u>Software : consolidation</u>

48. The market for software and informatics services is directly subject to the restructurings operating in informatics. Users are looking for integrated applications programs which preserve past investments by proving to be compatible and of offering interfaces suitable for the user. The wide variety of the hardware makes it necessary to take different processors and different architectures within heterogeneous networks into account. The transparency of systems is far from being achieved but two prospects are open to the industry. Firstly there is the development of architectures which provide interfaces for applications with a very wide range of other machines: secondly there is the development of architectures which facilitate horizontal connection between the computers in a department. The constraints are of two orders: perfect compatibility with the standards of the Integrated Services Digital Network (ISDN) and those of the OSI (cf 1.3.1.). The increasing complexity of the software offered leads to a revision of the marketing structure of the sellers which has to be at the same time vertical (by type of user) and horizontal (by technique).

49. This trend has resulted, in many cases, in marketing costs becoming the largest item in the expenditure of informatics integrated services suppliers, including R & D. Thus when LOTUS launched its SYMPHONY applications program and its new version of 1.2.3, the marketing costs accounted for 20% of the turnover. Failing this the product would not be integrated into the worldwide network of retailers. As in informatics software becomes a product, no longer remaining a minor technological marvel and not excluding television spots. Parallel to this providing training and information for retailers demands rising budgets. The market becomes organised and the sales directors try to enlarge their portfolios of products from the dominant

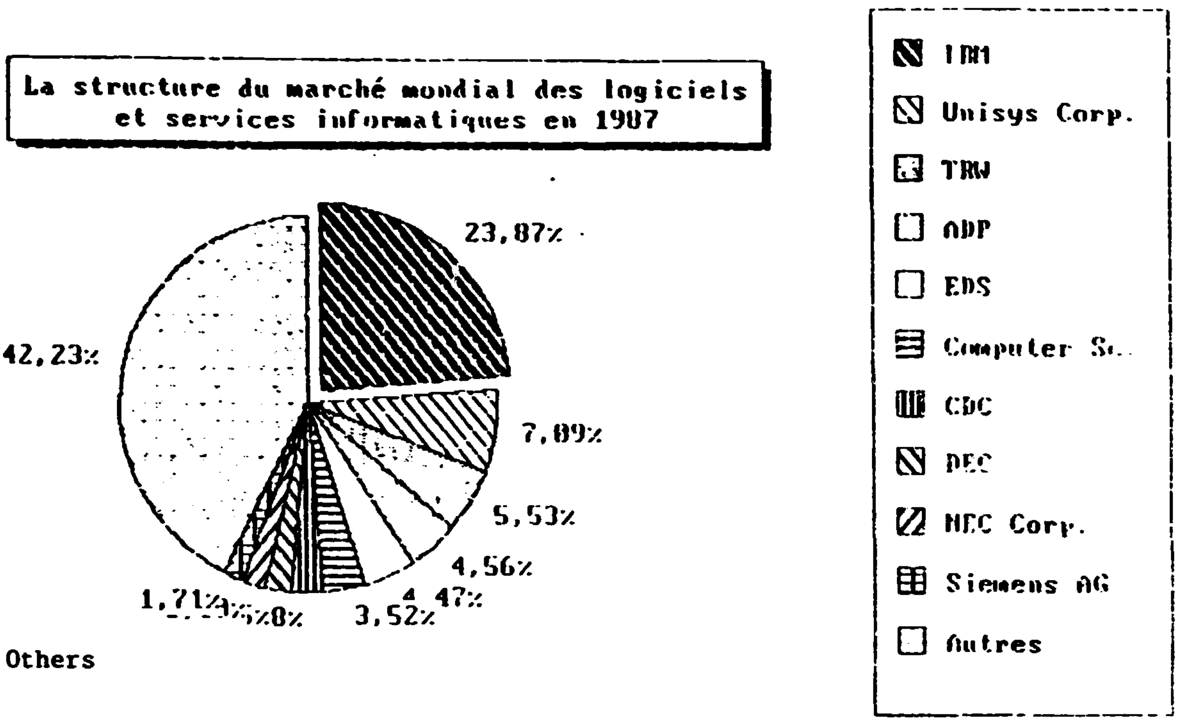
companies so as to maintain their growth when their classical software reaches its stage of maturity.

50. New difficulties are accumulating for this industry which developed in the seventies as a result of the establishment of new enterprises (ASHTON-TATE was founded in 1981). In the United States the retirement funds which had, until the present time, provided a regular source of risk capital, evaporated after the stock market crash. The creation of young companies risks being limited by this phenomenon whilst, at the same time, firms with private capital were obliged to defer their entry onto the stock market. This leaves firms little choice between leaving the industry, being bought out or merging. This movement is now in operation; since the first nine months of 1987 there were, in the United States alone, 65 mergers or acquisitions in the software and informatics services industry, totalling US$ 1.78 billion, and this has accelerated in 1988: Thomson-CSF has bought the SII Division of DUN & BRADSTREET, CAP GEMINI SOGETI has launched an OPA on the largest firm in the field, DATALOGIC, and has bought 51% of the capital of SESA, 36% of that of CISI and 28% of that of CAP GROUP, whilst WANG has acquired GIS.

51. From their side the hardware manufacturers are seeing their hardware margins collapse whilst succeeding in maintaining them in software. Furthermore the software makes it possible to differentiate systems between the machine producers and also to distinguish the latter from the Independent Software Vendors or ISV. Further examination of Table III-12 shows the relative weight of the software turnover of the major firms: 13.5% for IBM, 13.3% for UNISYS and 6% for BULL. And these figures do not take into account those services covered by the heading "Others": if these are taken into account the ratio is 15.2% for IBM, 26.1% for UNISYS, 10.5% for NCR, 14.5% for WANG and 33.5% for CDC. Analysts forecast that the software income of the principal computer manufacturers should increase by 20% to 30% per year until the start of the nineties (M.J. FOLEY, 1988, p.86). This is a challenge for companies structured to sell hardware and this is why they are tending to cooperate with the ISV rather than to accentuate the competition with them.

52. The relations between IBM and Microsoft show clearly how micro-informatics has demanded strategic revisions on the part of the manufacturers. Now offering integrated solutions to the users they are gradually becoming "producers of services". To do this they must multiply their alliances, which can take different forms. Some consist of exclusive distribution contracts, such as the IBM-HOGAN SYSTEMS or DEC-NCR agreements. Others opt for marketing agreements such as that between HEWLETT-PACKARD and COMPUTER SOLUTIONS, or for informal arrangements. Seeking lasting relationships the manufacturers have often been tempted to purchase these informatics services firms, but as we have already seen this is a risky choice in high technology because of the high turnover rate in personnel. The services companies are themselves regrouping in this way, with MICROSOFT purchasing FORETHOUGHT and ASHTON-TATE acquiring DECISION RESOURCES. The double movement of agreements and mergers is thus the operation which should lead to a defining of the still very competitive industrial structure of this branch (Figure III-4).

Figure III-4 : STRUCTURE OF THE WORLD MARKET FOR SOFTWARE AND INFORMATICS SERVICES IN 1987



Source : GERDIC, after DATAMATION, 15 June 1988

1.3.3. Telecommunications : the challenges of ISDN

53. The deregulation of ATT in the United States in January 1984 established a kind of reference point for the telecommunications industry. Its effects, which it is still too early to evaluate fully, have above all been to introduce competition through prices in telecommunications equipment and to accelerate the establishment of the Integrated Services Digital Network (ISDN). When completed the ISDN will make it possible to transmit digitised images, speech and data simultaneously. The interfaces must naturally be defined by way of global standards on which the ITTCC (CCITT) is working. Many manoeuvres are taking place around the ISDN and Bell Operating Companies, the former local ATT operators, are acting very vigorously. From its side ATT is trying to adapt its numerical 5 ESS switching unit to the ISDN: the first test was carried out in Chicago in 1986. The European giants in their turn are trying to profit from the advance offered to them by their national telephone organisations: most of the European constructors (Siemens, Philips, Ericsson and Plessey) have had prototypes since 1985.

54. The frenetic activity of the groups concerned with this project is explained by the collapsing of further growth in the public and private switching market. In order to face up to this situation the groups came together. Northern Telecom enlarged its range of transmission equipment by creating a joint subsidiary with Standard Telephones and Cables (STC) which it bought with the General Electric Company (GEC). Furthermore Plessey bought the American Stromberg-Carlson company which opened the United States market to it. Siemens AG after having bought Transmissionn Systems from GTE in 1987, acquired a shareholding in the British Northern Telecom firm. Finally, and more spectacularly, the transfer of the telecommunications branch of ITT to CGE in 1987 shows the tensions operating on this market. The

multiplication of agreements and alliances, foreshadowing an imminent restructuring, is thus even more characteristic of this branch than those discussed above (Table III-13).

55. IBM itself has not ignored this shift towards the intelligent network. In June 1985 it purchased 40% of the shares of Satellite Business Systems (SBS), an activity it lacked. Then it acquired 26% of the capital in MCI, the principal competitor of ATT in long-distance communications. It transferred SBS to MCI, after having cleared its debts. Simultaneously it signed agreements with Siemens AG or L.M. Ericsson to develop interfaces between its computers and their respective switching units. In addition, and within the framework of agreements with United Telecommunications Corporation, and obviously also with MCI Communications, it worked on defining software for the nodal points, that is to say the nodes of the networks which would contain the databases for the value added networks which will be offered either by the network operators or by independent firms. However the transfer in July 1988 of IBM's shares in MCI indicates a withdrawal by IBM from the telecommunications field (but not from the networks) in order to reinforce it positions in informatics (cf. 1.3.1.).

56. Following in the track of the ISDN the semiconductors industry is expecting considerable returns. Most manufacturers offered prototype semiconductors in 1985 or 1986. It is true that telecommunications represent 20% of the world market for integrated circuits and the semiconductors/ISDN segment is promised a high rate of growth; it had already trebled in the United States between 1982 and 1985, reaching US$ 1.6 billion. ATT has already signed agreements with MOTOROLA for a circuit capable of controlling certain network management functions. With an initially high cost these circuits should fall from a price of US$ 25 to about US$ 1.5 under the effect of experience.

Table III-13 : A BLOSSOMING OF AD HOC AGREEMENTS FOR -

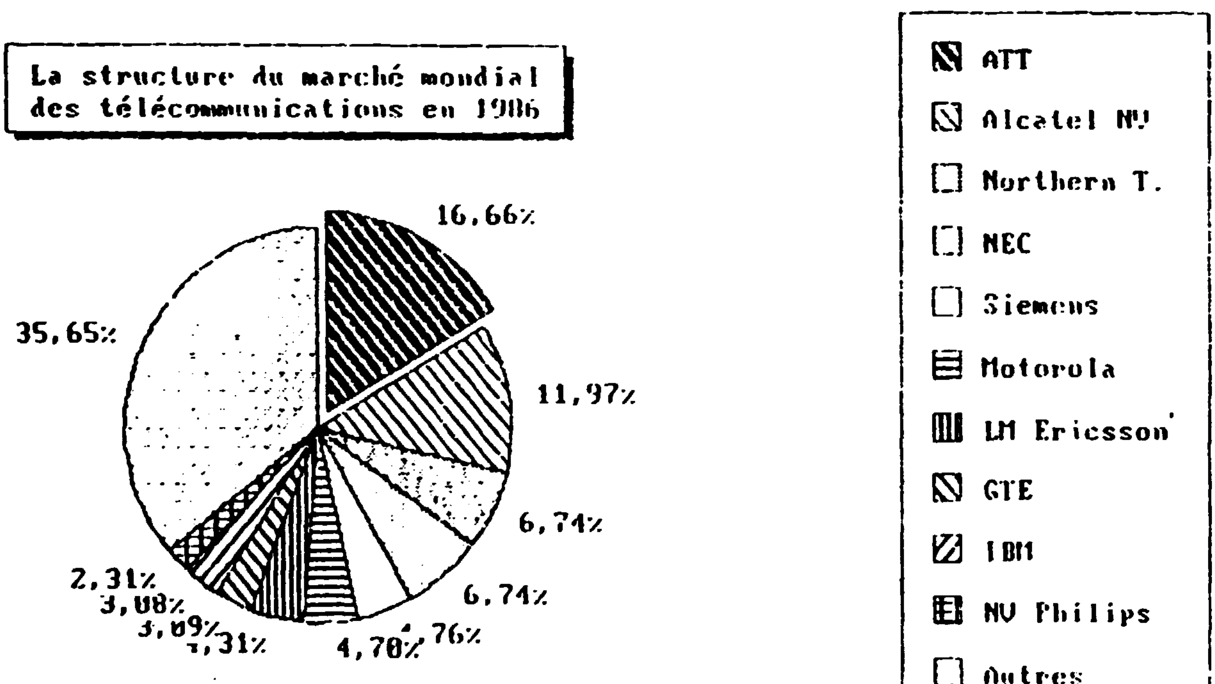
- INFORMATICS/TELECOMMUNICATIONS COMPATIBILITY (OR MARKETING) :

APPLE	**Northern Telecom**	1985	Couplage du système d'autocommutateur privé Meridian de Northern avec le Mac Plus d'Apple
	Ericsson	Juil. 1986	Connexion produits Apple aux produits Ericsson
BULL	**Jeumont Schneider**	1986	Connexion des produits Bull aux autocommutateurs Jeumont Schneider
COMPAQ	**GTE**	1985	Accord de commercialisation du Telecompaq Computer
	Siemens	1985	Tel plus communication commercialisera Telecompaq, c'est une joint-venture Siemens, Pacific Telesis, Compaq
	Pacific Telesis		
DEC	**Northern Telecom**		Connexion entre le matériel DEC et Northern
	Ericsson	Sept. 1986	Intégration des systèmes VAX et des produits bancaires Ericsson
HEWLETT-PACKARD	**ATT**	1985	Connexion produits Hewlett-Packard PABX d'ATT et de Telettra
	Telettra		
HONEYWELL	**Ericsson**	Juin 1983	Joint-venture pour réaliser un PABX intégrant voix données, le Delta Plus 2000, matériel vendu dès 1984
ICL	**Mitel**	1982	Accord commercial, les PABX Mitel sont intégrés à l'offre bureautique d'ICL
NIXDORF	**Hagenuk (Salzgitter)**	Avril 1986	Hagenuk développera et fabriquera des téléphones pour Nixdorf
OLIVETTI	**Northern Telecom**	1981	Accord de commercialisation des autocommutateurs privés de NT en Italie. Résilié lors de la signature de l'accord avec ATT
SPERRY	**Northern Telecom**	1984	Accord commercial, les systèmes de Northern sont intégrés à l'offre de Sperry
WANG	**ATT**	1984	Coopération avec ATT pour développer des interfaces de documents
	Northern Telecom	1984	Coopération pour connecter le réseau Northern aux produits Wang
	Ericsson	Mai 1986	Connexion produits Wang aux produits Ericsson
	... DE PRISES DE PARTICIPATION EN PRODUCTION ...		
FUJITSU	**GTE**	Déc. 1986 1er avril 1987	Joint venture : Fujitsu GTE Business Inc : 80 % Fujitsu 20 % GTE. Fabrication et commercialisation de matériel télécommunications privé.
ICL	**STC**	1985	Acquisition d'ICL par Standard Telephone & Cable (STC) filiale britannique à 24 % d'ITT
OLIVETTI	**ATT**	1983	Distribution exclusive par Olivetti en Europe des produits ATT téléphone privé et téléphone de bureau
		Sept. 1986	Olivetti fabriquera dans ses usines une version adaptée au marché européen des PABX système 75 d'ATT. Elle sera commercialisée en Italie puis dans le reste de l'Europe
WANG	**Intecom**	Mai 1984	Wang acquiert 20 % dans Intecom fabricant de PABX voix données
	Telenova	Août 1985	Participation de 15 % de Wang dans Telenova, fabricant de PABX de 10 à 100 lignes
	... OU DANS LES RESEAUX A VALEUR AJOUTEE		
BULL	**General Electric**	1986	Accord en discussion
ICL	**Mercury**	1986	Réseau transmission de données 75 % Cable & Wireless (Mercury), 25 % STC (ICL)
	Geisco (GE)		Réseau à valeur ajoutée : entrée sur le marché américain
OLIVETTI	**EDS**	Mars 1987	Fourniture de systèmes intégrés de gestion et de production aux industriels

Source : J. ARLANDIS, 1987, p. 70.

57. The telecommunications industry, which in the eyes of many observers is insufficiently concentrated, needs to be restructured. In public switching units this phenomenon has begun. Thus GEC, Plessey and STC have come together to develop System X, whilst GTE and ITALTEL are working together on the Proteo UT-10. There is a progressive oligopolisation of the supply. There is even a move towards a duopolistic structure of the major markets (ATT-Northern Telecom in the United States, Plessey-Ericsson in Great Britain and Siemens-SEL in West Germany). According to G. DANG NGUYEN the telecommunications industry has, after a long phase of immobilisation, begun a major restructuring. The establishment of the ISDN means for the European or Japanese (NRR) telecommunications bodies an anti-deregulation arm which makes it possible to avoid competitive anarchy. But the manufacturers are seeking to expand into external markets whilst still hoping to maintain their privileged links with their national operators (G. DANG NGUYEN, 1987, pp.35-36). It is within this context that the alliances will be consolidated or denounced, in the latter case leading to a multiplication of mergers which are preferred to fragile alliances.

Figure III-5 : THE STRUCTURE OF THE WORLD TELECOMMUNICATIONS MARKET IN 1986



Others

Source : GERDIC, from data from Electronic Business

1.3.4. Mass Consumer Electronics (MCE) : new prospects

58. At a world level the principal MCE firms are Japanese. Matsushita is the world's largest firm; its turnover in mass consumer electronics products represents 16% of the total 1986 turnover of the fifty leading firms in the branch (Table III-14). It is followed by Philips with a turnover which is less than half of Matsushita's. Out of the ten leading firms in this branch seven are Japanese.

59. The leading firms are principally from the developed countries, but the table shows that there are six firms in the newly industrialised countries.

Three firms in South Korea have honourable positions amongst the fifty leading firms of the branch: LUCKY GOLD STAR in 17th position, SAMSUNG in 20th position and DAEWOO in 27th position. LUCKY GOLD STAR manufactures mass consumer electronics products, and has introduced new technologies in its domestic electrical appliances. SAMSUNG is a conglomerate; 10% of its turnover comes from mass consumer products. The domestic informatics branch was one of the entry routes into production in the electronics branch for firms in the developing countries in the sixties and seventies. The high level of competition at world level, and the automation which brings with it the necessity of manufacturing in long production runs, form increasingly major barriers to entry for these firms.

60. The firms in domestic informatics are those firms operating in mass consumer electronics and also in domestic electrical appliances, because of the increasingly frequent introduction of electronic components in household appliances. The domestic electrical appliances industry therefore represents a vast market for electronic components such as microprocessors, clocks and sensors (cf Chapter V). It is estimated that between 1.5 and 3 million domestic electrical appliances use some type of electronic control; in 1987 this only represented 5% to 10% of all such appliances.

61. The juxtaposition of different productions is not organised in a random manner, certain industrial configurations being much more frequent than others. The first configuration is specialisation in mass consumer electronics products: this is the case with some of the Japanese firms such as SONY and PIONEER. The second configuration is specialisation in domestic informatics, the coming together of mass consumer audio-visual products and domestic electrical appliances within the framework of firms resolutely orientated towards the mass consumer market, such as GENERAL ELECTRIC. The third configuration is that of firms engaged in different segments of the electronics segment, such as SHARP, which produces office equipment and mass consumer products, and CASIO which is orientated towards informatics. The fourth configuration is the diversification of firms in the electronics branch. These firms, such as Philips and Thomson, manufacture professional or military electronics products as well as mass consumer products. Finally the fifth industrial configuration which one finds in domestic informatics firms is that of diversification in other branches of activity such as automobiles. This is the case with GENERAL MOTORS, BOSCH and FORD, and generally involves American firms.

Table III-14 : MASS CONSUMER PRODUCTS : TURNOVER IN US$m in 1986

RG	FIRMES	PAYS	G.P	% TOT	% CUM	% LEADER
1	MATSUSHITA	JAP	11200	16	16	100
2	PHILIPS	P-B	6900	10	25	[illegible]
3	SONY	JAP	6300	9	34	56
4	SANYO FISHER	JAP	5800	8	42	52
5	HITACHI	JAP	4500	[illegible]	49	40
6	GE-RCA	USA	3500	5	54	31
6	TOSHIBA (GE)	JAP	3500	5	59	31
8	SHARP	JAP	2300	3	62	21
9	THOMSON	FRA	2200	3	65	20
10	PIONEER	JAP	2000	3	68	18
10	SEIKO	JAP	2000	3	70	18
12	MITSUBISHI ELECTRIC	JAP	1400	2	72	13
12	THORN-EMI	G-B	1400	2	74	13
14	GENERAL MOTORS	USA	1300	2	76	12
15	ZENITH	USA	1230	2	78	11
15	CASIO	JAP	1200	2	80	11
17	BOSCH	RFA	1100	2	81	10
17	LUCKY GOLD STAR	COR	1100	2	83	10
17	NEC (SUMITOMO)	JAP	1100	2	84	10
20	CLARION	JAP	1000	1	86	9
20	SAMSUNG	COR	1000	1	87	9
22	FORD	USA	900	1	88	8
23	SMH	SUI	650	1	89	6
24	AMSTRAD	GB	600	1	90	5
25	CITIZEN	JAP	550	1	91	5
25	TRIO KENWOOD	JAP	520	1	92	5
27	AKAI (MITSUBISHI)	JAP	500	1	92	4
27	CGE (1)	FRA	500	1	93	4
27	DAEWOO	COR	500	1	94	4
27	NIPPON COL (HITA)	JAP	500	1	94	4
31	AIWA (SONY)	JAP	400	1	95	4
31	CHRYSLER	USA	400	1	96	4
31	FUJITSU	JAP	400	1	96	4
34	EMERSON RADIO	USA	380	1	97	3
35	NOKIA	FIN	350	1	97	3
36	LITTON	USA	300	0	98	3
36	SANSUI	JAP	300	0	98	3
38	GENERAL CORP.	JAP	200	0	98	2
38	HONEYWELL (1)	USA	200	0	99	2
38	TANDY	USA	200	0	99	2
38	TATUNG	FOR	200	0	99	2
42	DIEHL	RFA	130	0	99	1
43	ASEA+ELECTROLUX	SUE	100	0	99	1
43	TEAC	JAP	100	0	100	1
45	HASLER/AUTOPHON (1)	SUI	70	0	100	1
46	TADIRAN (KOOR)	ISR	60	0	100	1
47	ELECTRONSKA IND.	YU	50	0	100	0
47	LEAR SIEGLER	USA	50	0	100	0
47	OMRON [illegible]	JAP	[illegible]	[illegible]	100	0
50	ISKRA	YU	[illegible]	[illegible]	100	0
	TOTAL		71220	100		636

Source : Thomson, 1987, p. 31.

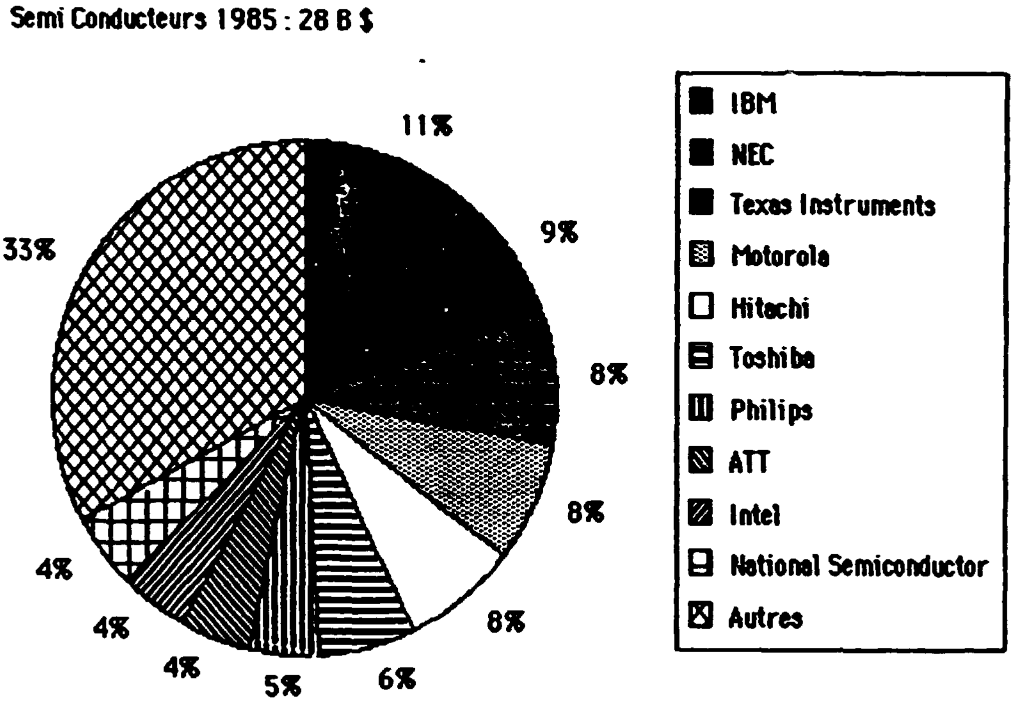
62. Since the middle of the seventies there has been, in world domestic informatics, a concentration of world production in Japan which has resulted in mergers of firms in other countries such as General Electric and RCA, Telefunken and Thomson, and then the MCE Division of RCA was sold to Thomson. Finally there was the emergence of firms in the newly industrialised countries, essentially South Korea and Yugoslavia. These manoeuvres have taken place whilst the products of domestic informatics are becoming more complex and addressed to more sophisticated buyers. The colour television receiver, once standing solitary in the middle of the living room, has become an audio-visual product integrated with the video recorder and able to become a Teletext terminal. Simultaneously the sustained fall in the prices of semiconductors with improvements in their performance offer to the MCE producers an opportunity for growth by offering new products as promising as television in the sixties or the video recorder today. It is also an opportunity for European and North American producers, shipwrecked by the Japanese offensives.

1.3.5. Components : the major upheavals

63. The components industry is largely dominated by the Japanese manufacturers; amongst the fifteen leading firms one finds nine Japanese firms, five American firms and only Philips to represent Europe. The characteristic of the components market is that it is concerned with intermediate products for the electronics industry which can be used by a large number of downstream branches. Table III-15, which gives the turnovers in components, is not therefore sufficient to indicate to us the real dominance of the firms. To obtain an exhaustive view of the semiconductors market it is necessary to be able to estimate the captive market of all the users.

64. If one is interested in the market for semiconductors (which represent about half the components) it can be seen from Figure III-6 that the American firms are more present on this market than appears from Table III-15. In fact IBM is the largest producer of semiconductors with a captive production (11% of the market) and ATT holds 4%, but observation of the commercial market alone shows just how the Japanese firms have recently upset the structure of the world market (Figure III-7).

Figure III-6 : THE STRUCTURE OF THE 1985 WORLD MARKET FOR SEMICONDUCTORS (including captive productions)



Source : GERDIC

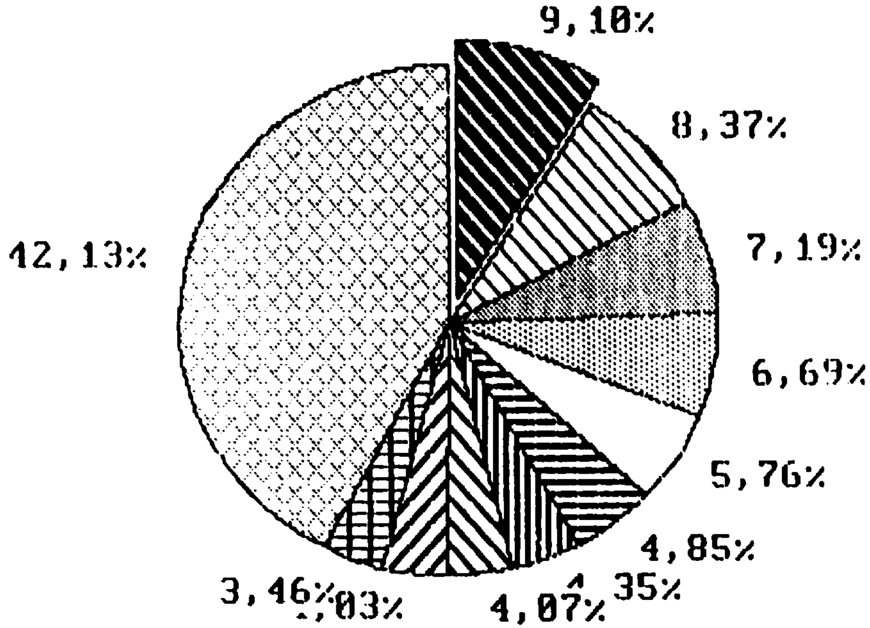
65. The components industry, because of its diffusion through all the branches of the electronics industry has therefore a primary strategic character. Amongst the structural characteristics of this industry (particularly that of the semiconductors) must be noted the magnitude of the research and development effort and its increasingly capitalistic character and hence the necessity for international alliances between enterprises. In an industry characterised by an extremely sustained rate of innovation the level of R & D expenditure is one of the most important criteria of competitiveness. In an international environment which favours the diffusion of innovations, and hence equally the accelerated obsolescence of generations of products, R & D in the fields of the technology of products and production processes functions as an increasingly constraining barrier to entry: the international market for semiconductors is today structured around the major groups, essentially in informatics and electronics. Access to the technology is thus essential for any firm wishing to retain an important share of the market or even to survive. The strategic character of research and development makes it possible to understand the alliances between companies which are necessary in it and the concentration which results therefrom. In effect mastery of technical innovation is not sufficient to ensure that an enterprise holds a dominant position. In a context where protection by patent or copyright is not sufficiently effective these alliances make it possible to delegate the task of meeting the demands of clients whilst concentrating on the ongoing innovation of the partners.

Table III-15 : 1986 TURNOVER IN COMPONENTS in US$ millions

RG	FIRMES	PAYS	COMP.	% TOT	% CUM	% LEADER
1	MATSUSHITA	JAP	3100	5	5	100
2	PHILIPS	P-B	3000	5	10	97
3	NEC (SUMITOMO)	JAP	2800	5	15	90
4	TOSHIBA (GE)	JAP	2600	4	19	84
5	HITACHI	JAP	2300	4	23	74
6	TDK	JAP	2280	4	26	74
7	TEXAS INSTRUMENTS	USA	2070	3	30	67
8	FUJITSU	JAP	2000	3	33	65
9	AMP/PAMCOR	USA	1900	3	36	61
10	ALPS ELECTRIC	JAP	1800	3	39	58
10	MOTOROLA	USA	1800	3	42	58
12	GE-RCA	USA	1400	2	44	45
13	KYOCERA	JAP	1300	2	46	42
14	MURATA	JAP	1200	2	48	39
15	3M	USA	1100	2	50	35
15	SIEMENS	RFA	1100	2	52	35
17	INTEL (IBM)	USA	1000	2	54	32
17	MITSUBISHI ELECTRIC	JAP	1000	2	55	32
17	N.S.C.	USA	1000	2	57	32
20	OMRON TADEI	JAP	950	2	58	31
21	ITT	USA	900	1	60	29
21	THOMSON	FRA	900	1	61	29
23	SHARP	JAP	850	1	63	27
24	RAYCHEM	USA	800	1	64	26
24	SAMSUNG	COR	800	1	65	26
26	B.A.S.F.	RFA	740	1	67	24
27	BAYER AGFA	RFA	700	1	68	23
28	AMD (SIEMENS)	USA	620	1	69	20
29	EATON	USA	600	1	70	19
29	LITTON	USA	600	1	71	19
31	FAIRCHILD S-C (SCHL.)(1)	USA	500	1	72	16
31	GEC	G-B	500	1	72	16
31	MITSUMI	JAP	500	1	73	16
31	OKI	JAP	500	1	74	16
35	LPL (1)	USA	490	1	75	16
36	ROHM	JAP	470	1	76	15
37	FUTABA	JAP	400	1	76	13
37	NIPPON CHEMICON	JAP	400	1	77	13
37	PENN CENTRAL	USA	400	1	78	13
37	TRW	USA	400	1	78	13
37	VARIAN	USA	400	1	79	13
37	WESTINGHOUSE	USA	400	1	80	13
43	IRI	ITA	380	1	80	12
44	MOLEX	USA	350	1	81	11
44	WESTERN DIGITAL	USA	350	1	81	11
46	GENERAL MOTORS	USA	300	0	81	10
46	GOULD (1)	USA	300	0	81	10
46	HONEYWELL (1)	USA	300	0	82	10
46	LUCKY GOLD STAR	COR	300	0	82	10
46	SEIKO	JAP	300	0	83	10
	TOTAL		51150	84		1650

Source : Thomson, 1987, p. 33.

La structure du marché mondial
des semi-conducteurs en 1987



Source :GERDIC d'après Electronic Business, 1 mars 1988.

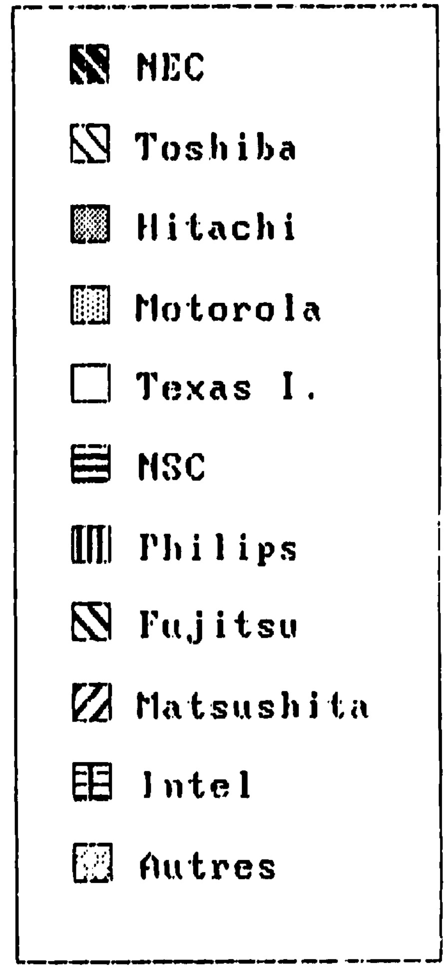


Figure III-7 : STRUCTURE OF THE WORLD SEMICONDUCTORS MARKET IN 1987

66. As far as manufacture is concerned the semiconductors industry fifteen years ago was a labour-intensive industry, which explains the investments by American groups in countries with low wage rates for the assembling and encapsulating phases (cf. 1.2.). Since the beginning of the eighties the Japanese and North American enterprises have rapidly become automated so as to improve the quality of their products and to reduce production costs. Furthermore, taking advantage of the synergism between the semiconductor activities of certain groups and their activities in the field of automation, they have installed flexible assembly systems. In this way they improve their productivity and test their production equipment on actual sites. Amongst the electronics groups which use their own automatic equipment may be cited IBM, General Electric, Hitachi, Toshiba, Mitsubishi Electric, Fujitsu and Matra. The semiconductors industry thus becomes increasingly capitalistic, which contributes towards increasing the financing needs of the producers and constitutes a considerable barrier to entry. It is in fact estimated that the investment needed to generate US$ 1 of turnover has increased from US$ 0.2 in 1972 to US$ 0.5 in 1982.

67. The success of the Japanese firms is explained by their mastery of these variables, whereas a mere ten years ago the American domination was crushing. The Japanese firms have upset the structure of the world market by capitalising on their competitive advantages. Their integration is very intensive, and the manufacture of semiconductors does not account for more than 20% of their turnover. Furthermore they give priority to productive investments (automation, increasing productivity and quality). They choose their branches of activity with the greatest precision, preferentially opting for the mass markets rather than the high value added technological "niches". Belonging to financial groups they can finance themselves by long-term indebtedness to a higher degree than their American competitors. Finally their policy of international alliances allows them, by depending on their own competences, to acquire product technology and to obtain direct access to the North American market.

68. In addition to the new domination of the Japanese groups the world semiconductor industry is subject to erratic variations in exchange rates. In an industry where price wars are very intense in standard products this has led to producers sometimes abandoning their foundries, that is to say the production units in which the semiconductors are manufactured, and to prefer to limit themselves to the design of circuits or the production of masks. Many young firms in Silicon Valley are limited to circuit design, so lowering the entry barriers to this industry: the cases of Vitelic Corp. or Xilinx Inc may be cited. Today the principal North American manufacturers are following this example so as to gain some flexibility in respect of the major fluctuations in the demands made of them. Firms such as Advanced Micro Devices (AMD) or National Semiconductors (NSC) admit to having recourse to subcontractors. In the case of Intel, the microprocessor manufacturer, the amount of production which is subcontracted is evaluated at 20-30%; the same figure applies to Motorola (Electronic Business, 1.3.1988).

69. Such a practice is not really new. In the case of assembly, which is admittedly a much less complex operation, many Asiatic enterprises have developed as suppliers to North American clients. It is estimated that there are about thirty subcontractors in Korea, the Philippines and Hong Kong which assemble American circuits: a quarter of this production passes through their hands. At the present time this applies not just to assembly by also to foundry operations. The market is not negligible, since invoicing from subcontracting or independent foundries reached US$ 940m in 1987 and should reach US$ 1.2b in 1988.

These foundries are mainly Asiatic: for example Hyundai Electronics in South Korea and NMB Semiconductor in Japan manufacture chips for Texas Instruments, whilst Intel subcontracts its circuits to Samsung Electronics and to Mitsubishi Electric. It is, without any question, the South Korean producers who profit most from these opportunities. Very often they prefer a subcontracting agreement to a licensing agreement on which they have to pay royalties. According to Korean executives operating a foundry makes it possible to regulate and stabilise the production technique more rapidly. The Japanese firms also profit from the movement, and the agreements between Seiko Epson and Xilinx and between Sharp and Waferscale Integration may be cited. In both cases the American firms have had to divulge their technology. Profiting from this opportunity independent foundries such as the Taiwan Semiconductor Manufacturing Company, established in 1986, have appeared. These forms of subcontracting relationships are being grafted onto the other forms of agreements signed by industrialists and make the network of coalitions, within which some are lasting and some are not, extremely complex.

1.4. CONCLUSIONS

70. With the eighties a period of profound restructurings in the electronics industry was initiated. In all the branches technology had led to a major turning-point in terms of marketing or research. Simultaneously barriers to entry and to mobility seem to have been raised up, leading companies to engage in two approaches. Firstly recentring is found to be necessary for financing the new technological orientations and growth. The traditional electronics firms had acquired companies, as a result of the profitability of their activities, from a financial standpoint, or they may not have known how to choose a "metier". In both cases, as is shown by the spectacular examples of Thomson, General Electric-RCA or ITT, reconversions are necessary. But recentring is not sufficient to valorise a competitive advantage. Complementarities exist with other companies, requiring the multiplication of alliances and coalitions throughout the world. This is why one can see all the market structures tending towards oligopolies with, however and fairly frequently, an important competitive fringe, the market power of which remains negligible.

2. THE NATIONS : THE BREAK-POINT

2.1. THE GEOGRAPHY OF WORLD ELECTRONICS

2.1.1. Production : a reflection of industrial strategies

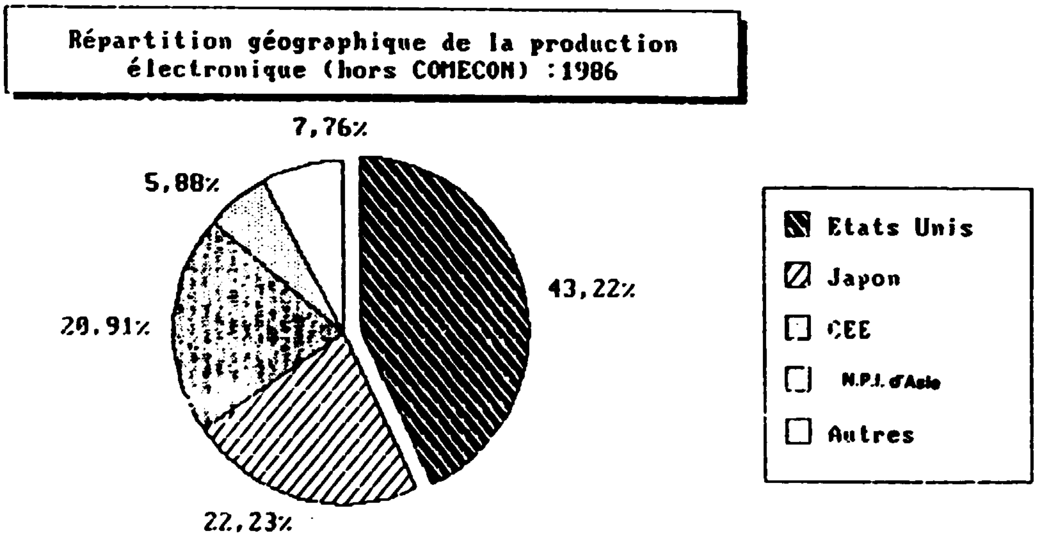
71. At the end of the Second World War the North American electronics industry had acquired an undeniable superiority. Largely dominated by the production of civil or military equipment goods, underpinned by major financial or research resources and unequalled governmental support, the North American electronics industry accounted for 80% of world production.

Table III-16 : ELECTRONICS PRODUCTION IN THE PRINCIPAL INDUSTRIALISED COUNTRIES (US$ millions)

	1957	%	1962	%
Etats-Unis	12 560	75	16 300	73,1
Japon	620	3,7	1 600	7,2
R.F.A.	1 130	6,7	1 200	5,4
Royaume-Uni	1 130	6,7	1 300	5,8
France	590	3,5	1 050	4,7
Canada	480	2,8	450	2
Italie	240	1,6	380	1,8
Total	16 750	100	22 280	100

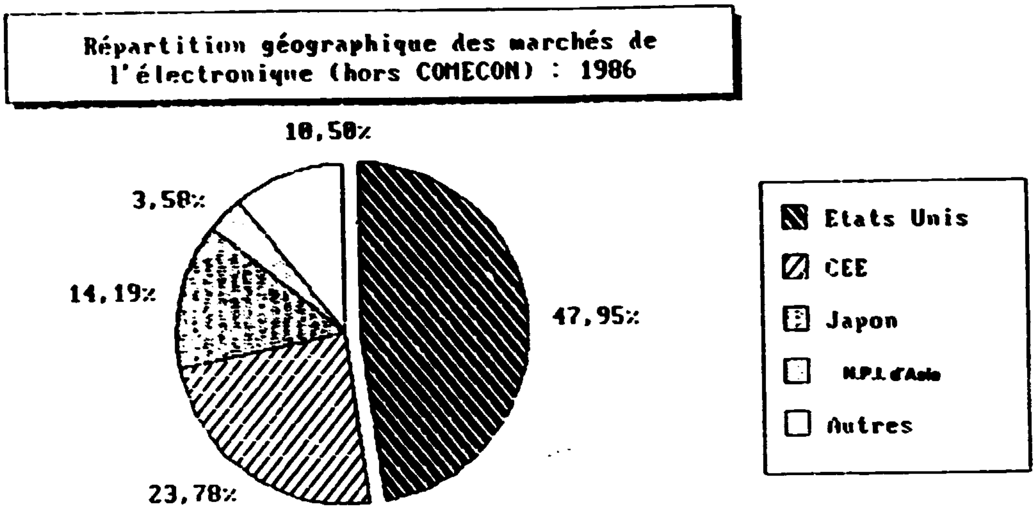
Source : GERDIC d'après le Conseil Economique et Social, 1966.

Figure III-8 : GEOGRAPHICAL DISTRIBUTION OF 1986 ELECTRONICS PRODUCTION (excluding COMECON)



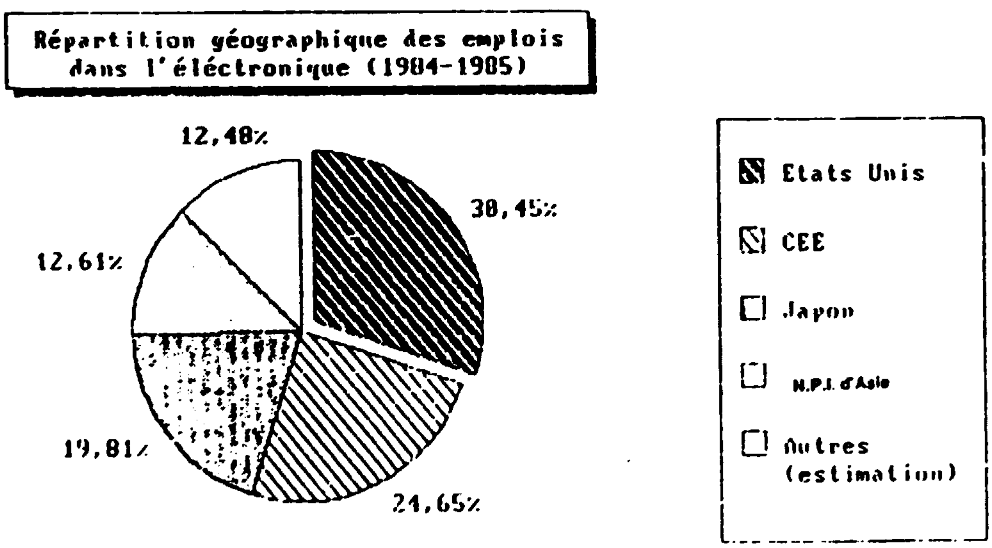
SOURCE : GERDIC d'après annexe A1

Figure III-9 : GEOGRAPHICAL DISTRIBUTION OF 1986 ELECTRONICS MARKETS (excluding COMECON)



SOURCE : GERDIC d'après annexe A1

Figure III-10 : GEOGRAPHICAL DISTRIBUTION OF EMPLOYMENT IN THE ELECTRONICS INDUSTRY (1984-1985)



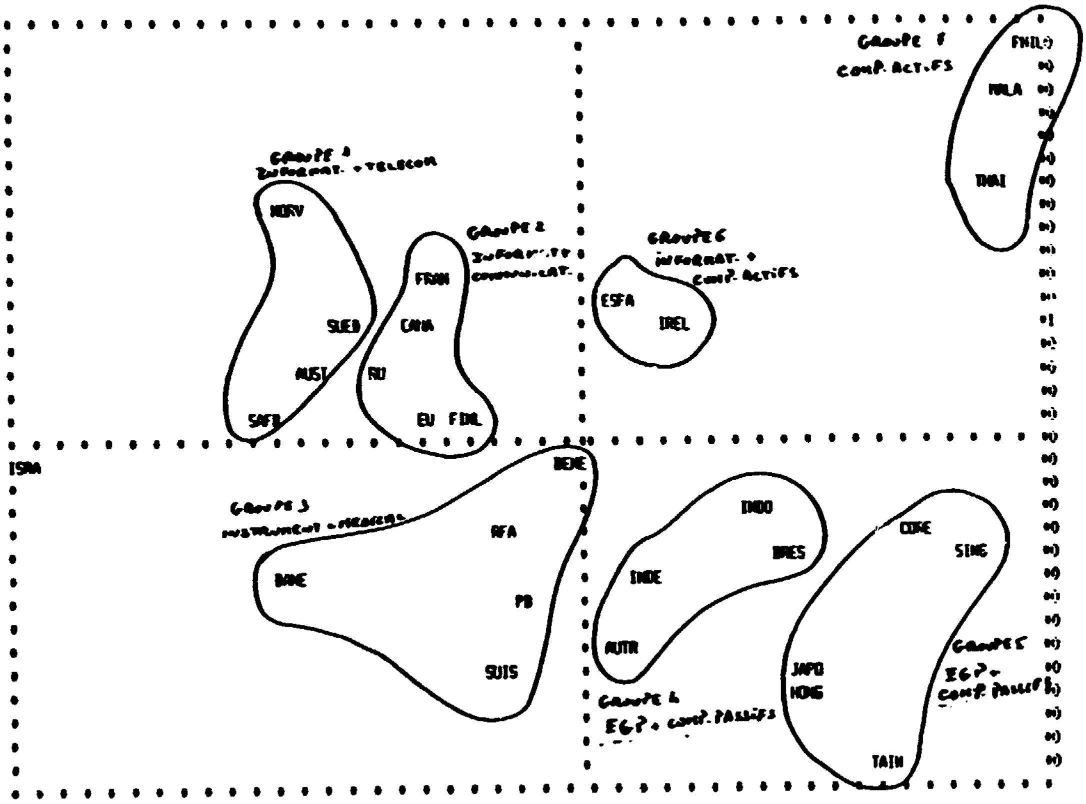
SOURCE : GERDIC d'après annexe A1

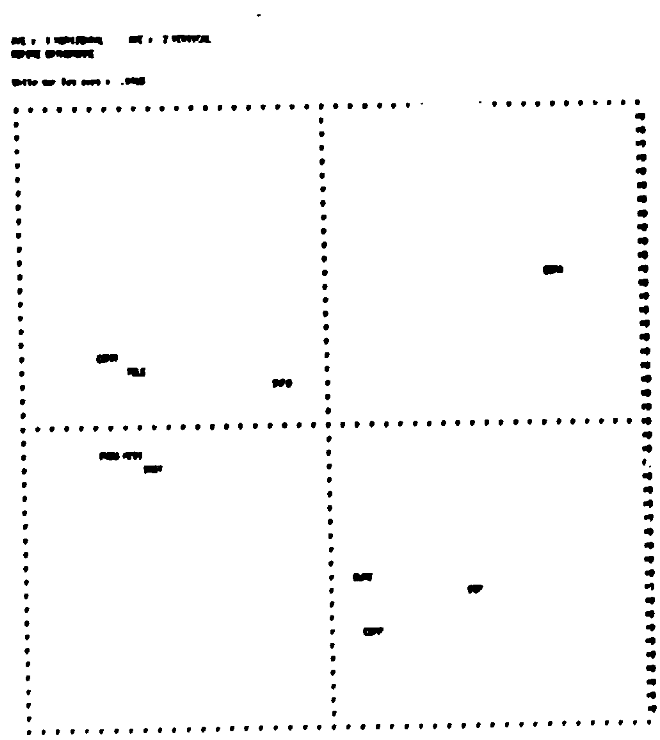
72. However the magnitude of the relocation of North American firms and the industrial policies carried out in Europe or Asia have overturned this territorial hierarchy. Despite the maintenance of considerable dependence on the United States in certain fields, Europe had acquired honourable positions in sheltered sectors such as telecommunications or military applications. Japan, by contrast, organised concentration on the competitive sectors of mass consumer electronics and then active components. Finally the establishment of foreign firms in Asia or Latin America gave these zones a role which was in no sense commensurate with the size of their national productive apparatus. Nevertheless these establishments have allowed the development of local industrial structures within which are juxtaposed national small and medium sized enterprises, foreign groups and, sometimes, national groups as in South Korea, India, Brazil and Taiwan.

73. This technological catching-up had upset the hierarchy of the nations, and whilst the European countries individually held positions which were more fragile than at the end of the war the European Communities accounted for more than 20% of world production. Having arrived at second place in the world electronics industry in 1961 Japan has subsequently maintained that position and produced in 1986, on its own territory, more than 22% of world production. The United States remained the leading production zone in the world, but at 43% this represents a major regression as compared with their position in the fifties (Figure III-8).

74. Employment is not strictly proportional to production because of inter-sectorial differences in labour intensity or productivity. Thus the electronics industry in the EEC employs about 25% of world manpower but only realises 21% of the production. In Japan, by contrast, only 20% of the world manpower is employed for 22% of the production. Productivity and labour legislation partly explain this difference. But, in particular in the case of the Newly Industrialised Countries (NIC), it is the variations in the combination of production factors which explain the major difference between the structures of employment and of production. Finally it is clear that the quality of specialisation is not neutral, as is shown by the case of the United States where 30% of the manpower produces 43% of world production. It is the high value added products which make up the North American production since much of this is either military or informatics electronics. An analysis into principal components (APC) makes it possible to visualise the types of specialisation of the different nations. After having introduced the data on the structure of production of thirty countries in 1986 (Annex A3) a typology of the territories appears very clearly. The active variables are the relative weights of each branch of electronics in the production of a country; the individuals and the countries. The first two pairings are represented on the diagram for the individuals and for the variables (the APC data will be found in Annex D). Those countries with a highly imbalanced structure of production are immediately apparent. The Philippines, Malaysia and Thailand have productions dominated by active components: only Thailand has a significant MCE pole. Ireland benefits from a very considerable production of informatics hardware which exceeds 60% of its electronics production and differentiates it from other nations. Then comes the group of four Asian NICs, with Singapore slightly separated because informatics has a weight more proper to that of the industrialised countries. Taiwan, Hong Kong and North Korea have a structure dominated by MCE and active components. Korea and Indonesia are distinguished by the weight of telecommunications. In the industrialised countries, more specialised in high value added products, the structure of their production depends mainly on the existence or not of a military-directed industry or a telecommunications pole (see Annex A3).

Figure III-11 : ANALYSIS INTO PRINCIPAL COMPONENTS OF THE STRUCTURE OF PRODUCTION





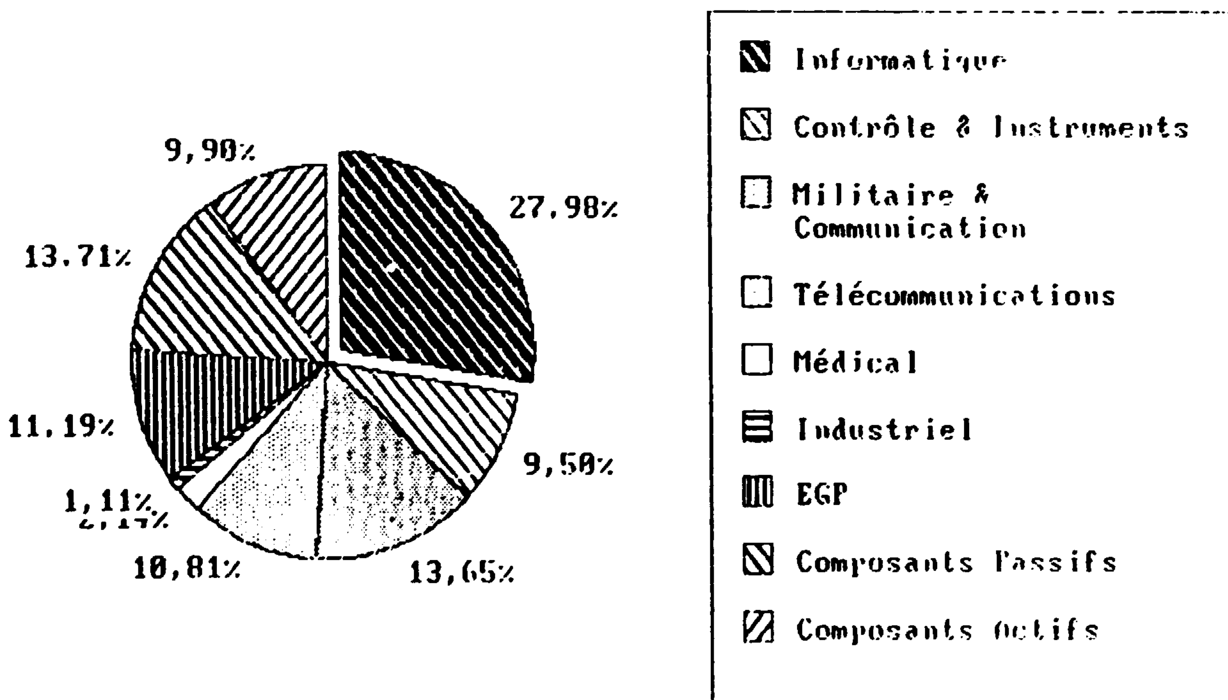
Source : GERDIC

2.1.2. Markets and trading : factors for tension

75. Markets and productions are dominated by the major pole of informatics and office informatics which accounts for 28% of the whole, and accepting that software and services are not included in the BEP statistics. According to the EIC software and services would represent 12% of the whole. The two other major poles are military/communications and passive components (Figure III-12) but it does not clearly distinguish the other branches, the contribution of which varies between 10% and 11% with the exception of medical and industrial (signals, laser systems, security) the contribution of which ranges around 1%. Automation, which does not figure in the data, corresponds according to the EIC to about 6% of the total market.

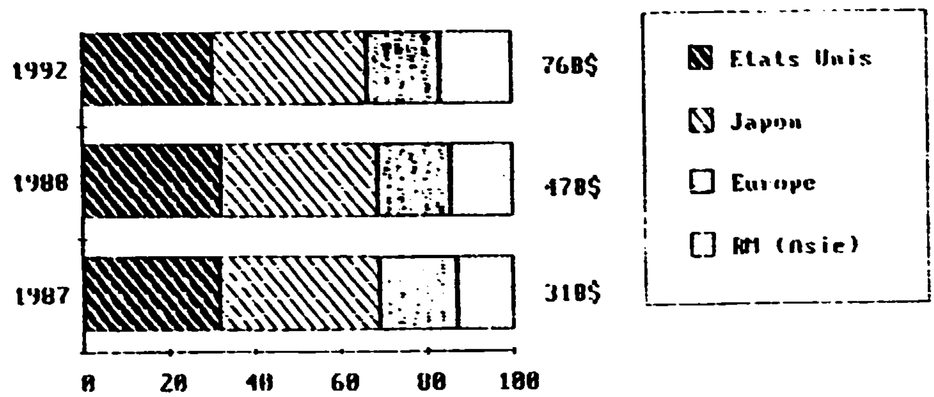
76. The electronics markets, estimated by the BEP at US$ 442 billion in 1986, should have benefitted from a growth of 17%, but a large proportion of this is due to changes in exchange rates. The real growth is in fact much more modest, in the region of 1%, with a fall in the demand in the United States of 1.6%. The year 1987 will have been characterised by a recovery, since world markets have increased by 4.7% in real terms, reaching more than 10% in the Asiatic countries with the exception of Japan (BEP, 1988, Vol.II, p.19).

Figure III-12 : WORLD MARKETS FOR ELECTRONICS IN 1986



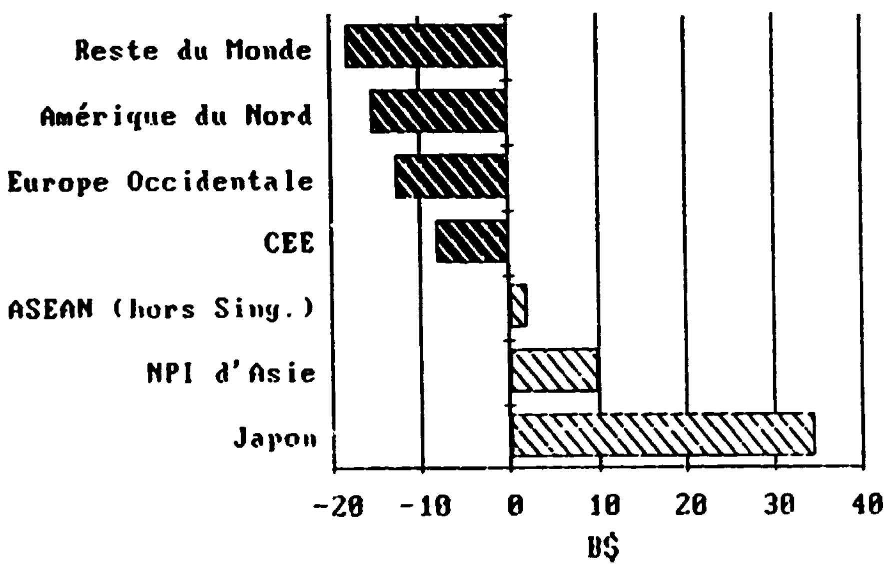
Source : voir annexe A-4

Figure III-13 : FORECASTS FOR THE WORLD SEMICONDUCTORS MARKET (as percentages)



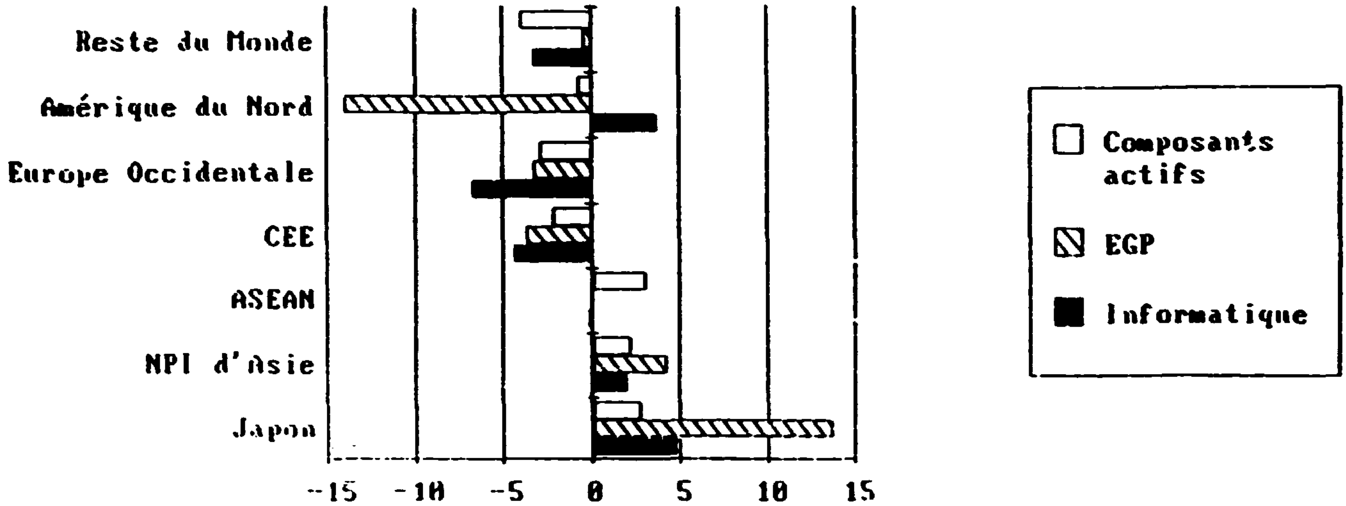
Source :GERDIC d'après Dataquest.

Figure III-14 : THE 1986 TRADING BALANCE IN ELECTRONICS



Source : GERDIC d'après les statistiques de P.E.P.

Figure III-15 : THE MAJOR ITEMS IN THE 1986 TRADING BALANCE
(US$ billions)



Source : CERDIC d'après les statistiques de B.E.P.

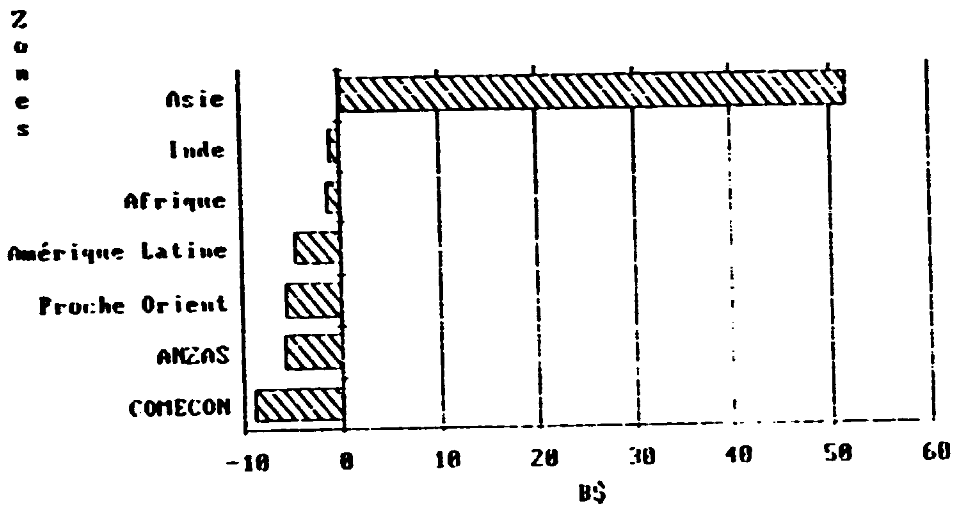
77. The production of electronics materials is moving from Japan to the countries of Pacific Asia. Countries like South Korea, Singapore and Malaysia are attaining rates of production growth of the order of 24% whilst the traditional Far East countries, Taiwan and Hong Kong, are meeting competition from the Asean countries and see their growth reduced to the region of 10%. This dynamic has led to an increase in the consumption of semiconductors in Asia of more than 65% in 1987, and should remain around 40% in 1988 according to Dataquest. The transfer of the Japanese activities towards the "Four Dragons" of South Korea, Taiwan, Hong Kong and Singapore, or to the other Asean countries, makes it possible to predict a major increase in the demand for semiconductors in this zone where domestic and foreign producers operate side by side. The forecasts are such that this zone should, by 1992, consume as many semiconductors as Europe (Figure III-13).

78. Although the markets remain polarised in the industrialised countries and the big five alone represent 78.5%, the introduction of certain newly industrialised countries into the world market seems to have been achieved (cf Annexes A4, A5, A6 and Figure III-9). The Brazilian and Korean markets now approach, in absolute value, that of Holland and exceed that of Sweden, even if the populations are very different. But if 92% of the markets are concentrated in the industrialised countries only 90% of the production is located there (Annex A2). These two points of difference in a market of US$ 400b, amplify the tensions between the United States and Europe in regard to the Asiatic countries. They are, in effect, added to the structural imbalance caused by Japan, whose market represents slightly more than 14% of the world market but whose production exceeds 22% of the world total. With Japan it is this 10% of the world production which defines the structural deficit in electronics in certain geographical zones.

79. Figure III-14 recapitulates for 1986 the imbalances in world trade. Western Europe and North America have deficits of US$ 12.8b and US$ 15.5b respectively, whereas the Asean and Asian newly industrialised countries (Taiwan, Hong Kong, Singapore and South Korea) have an excess of US$ 11.5b: Japan itself has a positive balance of US$ 34.4b. The CEPII statistics, although not identical with those of the BEP, do allow us to define more

precisely the deficit of the rest of the world (Annex B) which is US$ 27.4b (including opto-electronics) or US$ 18.5b without COMECON. These results are equivalent to the deficit of US$ 18.3b as evaluated by the BEP. Figure III-16 breaks down these deficits by geographical zones.

Figure III-16 : THE MAJOR IMBALANCES BY ZONES IN 1986 (US$ billions)



Source : GERDIC d'après les données du CEPII (CHELEM)

2.2. THE MERCANTILIST TEMPTATION

2.1.1. The United States : Rejecting GATT?

80. Since 1980 the North American trading balance in high technology goods has continued to worsen steadily. By 1986 it was in deficit under the double constraints of the considerable revaluation of the Dollar and the hardening of international competition. The products of the electronics industry are at the heart of this worsening, and the American Electronics Association estimates the sector deficit as US$ 13 billion in 1986. Although there has been a deficit with Japan since the seventies it has increased dramatically to reach US$ 20.4b or 12% of the North American trading balance (Figure III-17). This situation has led to several reactions from the American public authorities including bilateral negotiations with the most dynamic commercial partners; these agreements have often gone against the GATT rules.

81. The most spectacular measure was the signing in September 1986 of the US-Japan Semiconductor Agreement. Under the terms of this agreement the Japanese producers of semiconductors undertake to market their problems on the North American market at a "minimum" price. This measure should result in an improvement in the trading balance in this branch. It came into effect just over a year after the suppression by President REAGAN, within the framework of the 1974 Trade and Tariff Act, of the customs duties of 4.2% on semiconductors imported into the United States. The disappearance of the tariff and the high value of the Dollar rapidly eroded the positions of North American firms which had already been made fragile by the shortening of the life cycle of integrated circuits. Seeing no signs of the situation improving the Japanese government created, on 4 March 1987, the International Semiconductor Research Center (INSEC), the purpose of which was to favour the buying of foreign semiconductors by Japanese industry, thus offering North American producers a way of overcoming the famous "non-tariff barriers" which are so often evoked. Although it allowed the consolidation of the margins of Japanese manufacturers in the United States the agreement of September 1987 did not allow any great reduction in the Japan-United States deficit in electronics products.

82. Despite a perceptible stabilisation of the deficit in regard to Japan (US$ 9.4b in the first half of 1987 against US$ 9.9b in the first half of 1986), despite a considerable fall in the value of the Dollar and although a raising of the minimum price imposed on Japanese firms under the 1986 agreement had been negotiated, the American government considered that the results achieved in the first round were insufficient. The Defense Scientific Council produced a report which indicated that out of 25 types of semiconductors Japanese firms were in the lead in the production of 12 of these, North American firms were in the lead in the case of five semiconductors and there was equality between the countries in the case of eight types of semiconductor. Under the pressure of these arguments, and under the influence of the Pentagon which in December 1986 criticised the intention of Fujitsu to purchase Fairchild Semiconductor and the domination of the ceramics market by one company, the Japanese Kyocera, the American government made known on 17 March 1987 its intention to take retaliatory actions against Japan. As from 17 April 1987 supplementary duties of 100% were applied to imported Japanese products with an overall value of US$ 300m. Never applied since the Second World War this procedure applied to colour television sets, micro-computers and semiconductors.

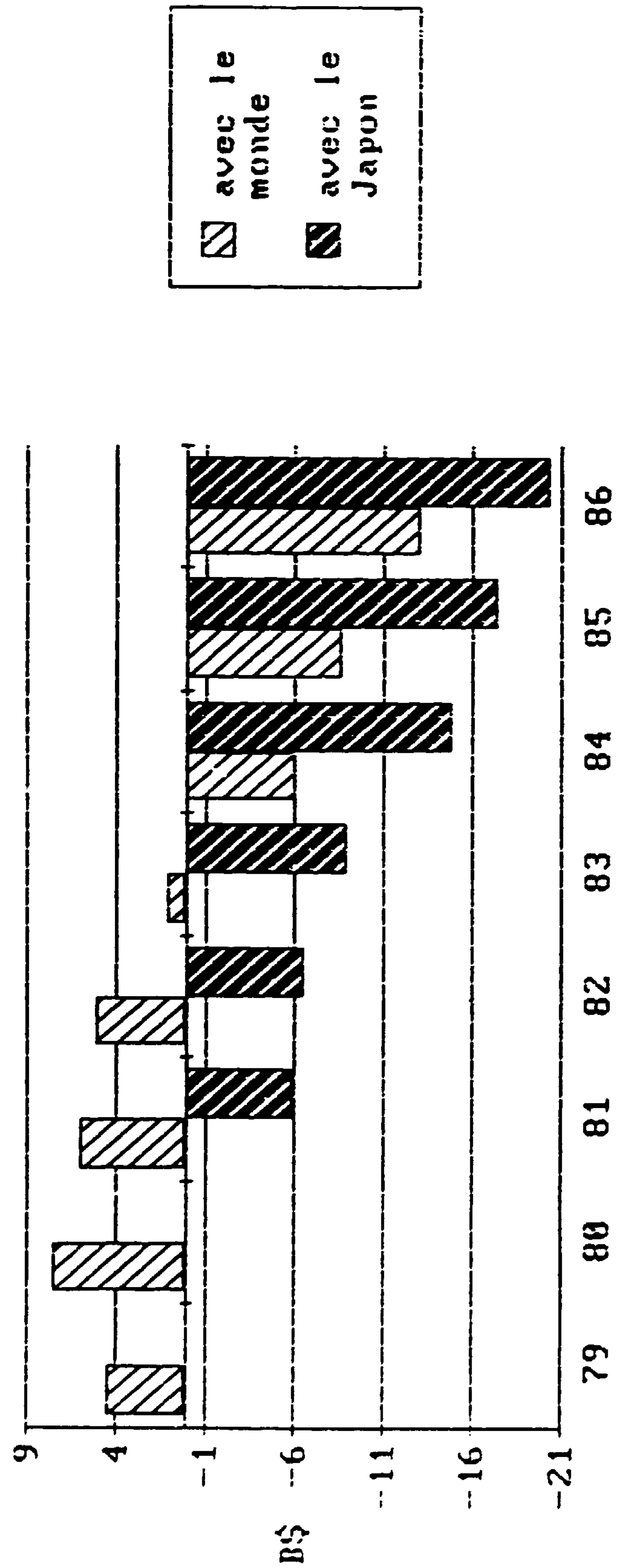
83. These retaliatory measures, although spectacular in their form, affected only 0.3% of Japanese manufactured products exported to the United States. On Tuesday 21 July 1987 the American Senate adopted, by a crushing

majority of 71 to 27, a draft law, now known under the name of the Senate Trade Reform Bill, which was to amend the 1974 Trade Act. The text passed by the Senate provided for the systematic implementation of temporary protection measures in favour of threatened industries. It also put forward the possibility of opening bilateral or multilateral negotiations and the revision of several principles governing the GATT. The arguments behind this mercantilist project are always the same. The restoration of the competitiveness of North American industry demands investments and training and, in the words of Stephen Levy :

> "As a nation we must make international trade a national priority and give it the same status as Defense of the State .... We cannot have a powerful National Defense without a powerful economy" (Electronic Business, 1 November 1986, p.29).

Although this draft law was vetoed by President REAGAN it was, in a softened down form, voted in by the Chamber of Representatives in July 1988. The Japanese asked President REAGAN to apply his veto again. But progressively, with the worsening of the North American technological advantage, the dominant discourse approximated to the ostensible prtotectionism in the inter-war years. Territory was seen as a challenge in international trade and rehabilitated as a space to be defended: this option reached its apogee in April 1988 when a survey revealed that 84% of those questionned were hostile towards foreign acqisitions in property and 82% wanted the establishment of restrictions on the acquisition of American companies prcducing high-technology equipment.

Figure III-17 : THE UNITED STATES TRADING BALANCE IN ELECTRONICS PRODUCTS (in US$ billions)



Source :GERDIC d'après les données de l'A.E.A.

84. The protectionist measures which were adopted and the revaluation of the Yen offered the North American electronics industry a whiff of oxygen in the competition engaged in with the Japanese producers. However since they were linked to the Dollar the currencies of the Four Dragons (Singapore, Hong Kong, Taiwan and South Korea) did not reflect the competitive devaluation of the Dollar against the Yen. In 1985 20% of North American exports of high-technology products went to these four countries whilst 25% of imports in the same fields came from these countries. If one adds Canada, where the currency was not revalued in respect of the Dollar, one third of North American trade in goods is with these five countries. With the weakening of the Dollar the competitiveness of these geographical zones increased, resulting in the relocation of establishments from Japan, the United States or Europe. The CEPII data show, in this context, a North American deficit in regard to the four Asian NIC of the order of US$ 8 billion in 1987 for electronics alone (cf. Annex B3), This situation explains in part Section 105 of the Senate Trade Reform Bill which suggests the establishment of minimum standards in working conditions in order to prevent the failure to respect the rights of workers. Furthermore since 1986 several economists have envisaged the revaluation of the currencies of these countries.

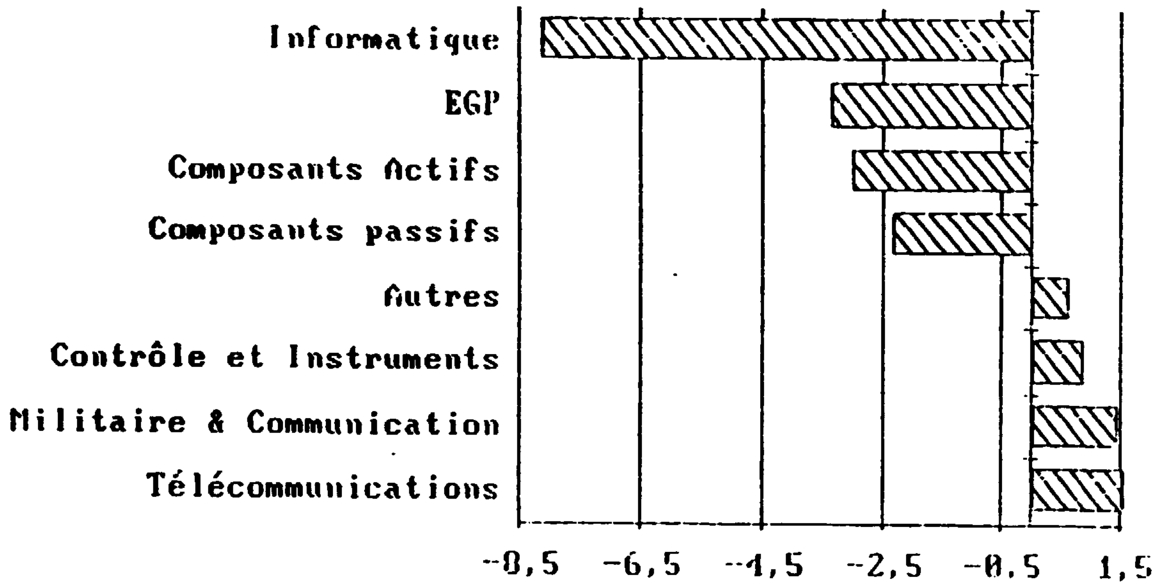
85. The reiterated refusal of the Four Dragons to revalue their currencies has resulted in intense pressure from Washington since 1987 on the governments of these countries. However with the exception of Taiwan, which had a current surplus of the order of 20% of its GNP, the others urged the existence of their international indebtedness to avoid any adjustment of their parities in respect of the Dollar. Put forward by European industrialists but rejected by the authorities in Brussels, the proposal for the exclusion of certain NICs from the Generalized System of Preferences (GSP) was seized on by Washington, which announced on Friday 29 January 1988 its rescinding of the tariff concessions granted to Taiwan, Hong Kong, Singapore and South Korea. The American decision, which should come into effect on 2 January 1989, should affect 20% (US$ 10b) of the exports to the United States from these four countries. Although this mainly affects "low-tech" products such as footwear, textiles and steel this measure also threatens the products of the electronics industry. This is why, after the wave of relocation of the Japanese firms which began in 1984, one sees Korean and Taiwanese firms establishing production units in Thailand (Goldstar Electronics) or in Costa Rica, Jamaica and the Dominican Republic so as to obtain easier access to the North American market. In this way Taiwan should double its investments abroad in 1988 (US$ 200m). Finally these countries are endeavouring to redirect their exports to new geographical zones, particularly Japan but also the Middle East.

2.2.2. Europe : the last trump card?

86. Western Europe is not a vacant market: DATAQUEST forecasts fairly considerable rates of growth over the next five years: 50% for 32-bit computers, 30% for digital telecommunications and 26% for cellular radio. It is however the growth of the market since the beginning of the eighties which has contributed to the deficit: in 1986 the BEP statistics show a deficit of US$ 12 billion, and only West Germany and Ireland have a balance in surplus or in equilibrium. The CEPII data show a deficit of the order of US$ 10.8b (cf. Annex B2, p.14), and US$ 12.6b with Japan. But the deficit is not the same in all the branches: Figure III-18 distinguishes. using the BEP data, the various items in the electronics balance. Informatics accounts for more than half of this deficit with US$ 6.8b (56%). Three other headings reflect the fragility of the European positions: active components, passive components and mass consumer electronics. These three branches account for US$ 8.7b of

the European deficit. In total the cumulative deficit exceeds US$ 16.8b, whilst surpluses in the reserved technologies (military, telecommunications and medical) total just US$ 4.7b.

Figure III-18 : THE MAJOR HEADINGS OF THE EUROPEAN TRADING BALANCE IN 1986 (US$ billions)



Source : GERDIC d'après les statistiques de D.E.P. (annexe A-7)

87. The reactions of the European public authorities faced with this failure have taken several forms. Chapter IV will detail their strategy for a renaissance of the European electronics industry by means of the ESPRIT, RACE or BRITE programmes for the EEC and EUREKA for the whole of Europe. However in addition to the conventional industrial policies Europe, and in particular the EEC, have endeavoured since 1985 to contain Japanese domination by means of procedures restricting trade.

88. In 1984 the EEC examiners carried out a survey into possible dumping by the Japanese producers Matsushita, Sharp, Brother and Canon. In the absence of cooperation in their surveys the data obtained on the Japanese producers are those supplied by their European competitors. In June 1985, with dumping having been proved, a customs tariff of 35% was established by the EEC on electronic typewriters. Shortly afterwards a complaint made by the Committee of European Copier Manufacturers (CECOM) led the EEC to carry out a survey on dumping procedures in the photocopier market. Twelve Japanese manufacturers who held 85% of the European market, and including Canon, Fuji, Minolta and Ricoh, were subjected to this procedure, as a result of which evidence was found of dumping of the order of 7% to 63%. As a consequence of this a supplementary customs duty was imposed on 27 August 1986 on the normal duty of 8.7%. An unusual feature of this supplementary duty is that it varies from 7.2% to 15.7% according to the manufacturer. These two procedures encouraged the Japanese companies to multiply their establishments in Europe: according to the EIAJ these increased from 44 in 1984 to 56 in 1986, and parallel to this some establishments were reconverted (Table III-17).

Table III-17 : NUMBER OF JAPANESE ELECTRONICS ESTABLISHMENTS IN EUROPE

	E.G.P.	Biens d'équipement	Composants	Total
1984	23	6	15	44
1985	26	4	17	47
1986	31	9	21	56

Source E.I.A.J.

89. However the Commission began a series of offensives at the end of 1987. Seven manufacturers of computer printers formed the Europrint Association to defend their interests, and required the Commission to carry out a survey on probable Japanese dumping. This assertion having been proved to be correct the EEC has imposed anti-dumping duties on the printers of fourteen Japanese manufacturers since 26 May 1988. The latter had succeeded in increasing their share of the European market from 49% in 1983 to 73% in 1986, whereas the producers within the EEC (Olivetti, Philips, Mannesman and Bull) were no longer able to sell a single printer in Japan although they had sold a thousand in 1983.

90. By multiplying their European establishments the Japanese companies hoped to be able to evade the exorbitant tariffs imposed on them by the Community. Very much on the offensive, and as result of a new complaint from several European producers, the Community examined the conditions of application of the 1985 regulations. It discovered that the producers of electronic typewriters and weighing machines were using a very high proportion of components coming from Japan (76% to 96% of the value added) and were not procuring at least 40% of their components in the EEC as required by the decree. In March 1988 it dropped its actions against BROTHER INDUSTRIES but imposed personalised unit duties on the other manufacturers as follows :

	Duties (ECUs)
CANON Brittany	44
MATSUSHITA, SHARP & SILVER REED	40
TEC	66

91. Simultaneously, and again very much on the offensive, the Commission launched an anti-dumping enquiry on the Korean producers of video cassettes and small TV sets. In December 1987 it removed this country from the Generalized System of Preferences, imposing Community customs duties on all Korean manufactured products, representing about 50 million ECUs for Korean companies. The anti-dumping procedure on video cassettes was started at the request of CEFIC, the federation of European chemical industries. As far as the small television sets were concerned European imports had increased from 9000 in 1983 to 358,000 in 1986, with the market share of the Korean companies jumping from 0.3% to 16% over the same period with prices nearly 40% lower than those of the European industry.

92. Like the United States the EEC was unwilling to see its industrial fabric subjected to price wars in which the Asiatic firms always emerged

victorious. At no time since the Second World War had the principles which governed the GATT been so systematically questioned by the trading partners (raising tariffs, dumping and bilateral agreements). It would seem that the States were prepared to come to the forefront of the stage as and when their industries were faced with difficulties. As a strategic industry the electronics industry had contributed to the revising of those principles which had governed the period which had elapsed since 1944.

3. CONCLUSIONS

93. Since the beginning of the eighties the electronics industry has been subjected to tensions induced by technological evolution. Within this context the companies have been led to revise their strategic options. They have modified their relocation objectives and multiplied their approaches to bilateral cooperation. Every branch of electronics is subject to this process of restructuring and consolidation in which the major groups seem to be able to play a privileged role to such an extent that it is probable that most of the world markets will be structured as oligopolies.

94. Faced with the rise of the private industrial powers the major dissymmetries in commercial trading have led the public authorities to react. The structural character of the commercial deficit in electronics products in the United States and in Europe has led governments, under pressure from their national producers, to contest the legitimacy of the competition exercised by Japanese producers. Not hesitating to cast aside the principles of the GATT, and even if this involves opposing the executive (Ronald REAGAN's veto) the public authorities have utilised their customs tariffs and hence the prerogatives of their frontiers to contest the advantages of the Japanese firms.

95. To these measures the governments have added industrial policies structured so as to organise or to maintain the technological advantage of their industries.

LITERATURE REFERENCES

(in the order in which they are cited)

Kenichi OHMAE
"La Triade: emergence d'une strategie mondiale de l'enterprise" Flammarion, 1985, Paris, 309 pp.

Robert CONRAD
"Global Electronics requires a global commitment" Electronic Business, 10-12-1985, pp. 162-162

Olivier E. WILLIAMSON
"The Economic Institutions of Capitalism" The Free Press, 1985, New York, 450 pp.

THOMSON C.S.F.
"La concurrence mondiale en electronique" duplicated, Paris, June 1987, 41 pp.

Emmanuel de ROBIEN (under the direction of)
"L'electronique: un defi planetaire, un enjeu: l'Europe" C.G.P., Paris, December 1986, p. 274

Joseph GRUNWALD and Kenneth FLAMM
"The Global Factory", The Brookings Institution, Washington, 259 pp.

Office of Technology Assessment
"International Competitiveness in Electronics" U.S.-G.P.O., Washington, 1983, 546 pp.

U.S. Department of Commerce
"U.S. Direct Investment abroad: 1982 Benchmark Survey" U.S.-G.P.O., Washington, December 1985, 373 pp. plus annexes

Michael McGRATH
"Strategies for International Manufacturing" Electronic Business, 1-5-1988, pp. 144-146

Jean-Louis PERRAULT
"Une odeur de soja dans l'industrie japonaise" Cahiers d'Economie Mondiale, vol. 2, n° 1, January-June 1988

Fred McGRAIL
"Merger Mania: The pack quickens" Electronic Business, 15-2-86, pp. 28-29

Mark POTTS and Peter BEHR
"Forging Strategic Business Alliances" Economic Impact, 1987, pp. 24-29

Steven E. PROKESCH
"Do Mergers really work" Business Week, 3 June 1985, pp. 64-67

Judith H. DOBRZYNSKI
"A new strain of merger mania" Business Week, 21 March 1988, pp. 56-60

Richard N. OSBORN and Christopher C. BAUGHN
"New Patterns of the Formation of U.S./Japanese Cooperative ventures: The role of technology" Columbia Journal of World Business, Summer 1987, pp. 57-65

Dorothy B. CHRISTELOW
"International joint-ventures: how important are they?" Columbia Journal of World Business, Summer 1987, pp. 7-13

Lynn K. MYTELKA and Michel DELAPIERRE
"The Alliance strategies of European Firms and the Role of Esprit" Journal of Common Market Studies, Vol. XXVI, N° 2, December 1987, pp. 231-253

Emmanuel DE ROBIEN
"Les strategies de normalisation dans le domaine de l'information" Revue d'Economie Industrielle, N° 39, 1987, pp. 220-227

Philippe DE LAUBIER
"EWOS: naissance d'un veritable institut europeen de normalisation" Informatique, 18-1-1988, p. 8

Geoff. LEWIS
"Computers: the new look" Business Week, 30-11-1987, pp. 78-85

Mary J. FOLEY
"Computer makers change the fabric of their software strategies" Electronic Business, 15-3-1988, pp. 86-94

Jacques ARLANDIS
"Le dilemme des 40 fabricants" Telecom Magazine, N° 8, October 1987, pp. 58-65

Michel FENEYROL and Philippe GAILHARDIS
"L'echiquier mondial de la communication" France Telecom, April 1988, pp. 32-52

Goddefroy DANG NGUYEN
"Concurrence, cooperation et concentration dans l'industrie des telecommunications" Symposium "La dereglementation asymetrique", Paris, 19-20 June 1987, 47 pp.

Philippe DELMAS
"Le cow-boy et le samourai" M.R.E., Paris, January 1984, 200 pp.

"The Newshell Game" Electronic Business, 10-3-1988, pp. 36-40

B.E.P. "Yearbook of World Electronics Data 1988; Volumes I and II Luton, March 1988, 226 pp. and 229 pp.

E.I.C. L'electronique dans le monde: Europe, Etats-Unis, Japon" Paris, 1987, 181 pp.

CHAPTER IV

AN OVERVIEW OF PUBLIC AUTHORITIES' STRATEGIES IN THE INDUSTRIALISED COUNTRIES

1. The role of the strategies of the public authorities has been of fundamental importance in orientating the global technico-industrial evolution of the electronics industry. Obviously it is the authorities of the most industrialised economies which exert the greatest weight when determining this orientation. Thus it is the North American public authorities which can undoubtedly claim paternity for the advance of electronics. From the seventies they had to face up to a challenger which gradually became dominant in an increasing number of fields under the action of the firms but also, and mainly, because of the strategies of the public authorities. The older industrialised countries in Europe followed, with some delay, the American electronics evolution and, finding themselves somewhat outdistanced, saw that the timid and national measures which had been taken up to that time were insufficient. As a consequence, and within the frame work of the European Community, they implemented the European Strategic Programme for Research and Development in Information Technology, ESPRIT, designed to put them back on course again. It is in effect in the electronics field that the real technological race between the industrialised countries was being run with their public authorities supporting them or even replacing them. Even in the case of the so-called deregulation of telecommunications one can observe the intensity of this global competition.

2. The traditional tools which were utilised, and which were found everywhere, included : public orders, the organisation of enterprises or associations, restructuring under the aegis of the public authorities, protective standardisation, direct subsidies and aids to industry and, more especially, the high level of participation of the public authorities in Research and Development expenditure.

1. <u>THE FOUNDERS : THE UNITED STATES</u>

3. In the United States the ambitions for power in the military and aerospace fields were the reasons for the very powerful and effective involvement of the Federal Government from the forties to the sixties. The pressing military demand for firing tables or aircraft profiles was the origin of the progress from electromechanical calculators to electronic computers. The various US forces signed major contracts with several universities, giving an impulse to a movement which resulted in the the development of ENIAC, the Electronic Numerical Integrator and Computer, in 1946. Its university promoters founded a firm which, bought by Remington-Univac (IBM did not want to buy it, and NCR hesitated for too long), constructed a first computer, the BINAC, for the NORTHROP aviation company and a second and more powerful one, the UNIVAC 1, in 1951 also for the American administration, this time for the Census Office. The Department of Defense (DOD) ordered from IBM and Burroughs in 1951 the Semi-Automatic Ground Environment or SAGE system, intended to protect the United States (even at that date) from surprise aerial attack: this was an enormous programme of US$ 1.6 billion for seven years' work. Amongst other spin-offs it allowed the development of the SABER network for the automatic booking of airline seats for American Airlines. In 1961 the Atomic Energy Commission signed a US$ 5.5m contract with Control Data for a computer, the CDC 6600, whilst NASA ordered equipment costing US$ 2.5b

from the principal manufacturers, including 101 UNIVAC 1108 computers for the APOLLO programme! These actions had an effect on industrial policy: for example they are the origin of the superiority of Control Data and UNIVAC in scientific computers and in industrial informatics, even over IBM. In 1965 the Federal Government paid out US$ 200m in contracts on informatics research, representing a third of all the research expenditure of the manufacturers.

4. In the field of the basic bricks one of the revolutionary steps was the invention of the transistor in 1948. This was done by a laboratory team at BELL, an enormous entity which had a monopoly of all the telecommunications services in the United States, in the service of which it had become one of the world's leading manufacturers of electronics products. Its research work was therefore largely financed by the state of American legislation in this field. The transistor was used first of all in certain items of telecommunications equipment and mass consumer receivers; by contrast to this the first transistor computer was only produced in 1959. However the miniaturisation of the transistor for signal processing was of particular interest to the forces for their flying objects, especially when they were automatic such as rockets, and the Federal Government was responsible for a massive intervention targetted on this industry. The TINKERTOY project was launched in 1952 for the miniaturisation and development of semiconductors. Four manufacturers received US$ 13m: General Electric, RCA, Sylvania and Texas Instruments. The public interventions were clearly orientated towards specific technological advances: speed, miniaturisation and reliability. In 1956 the DOD (Department of Defense) distributed US$ 40m for the development of integrated circuits. The firms which succeeded in this (but on the basis of a legal battle on patents) were not those which had received the funds for it, but the DOD had encouraged all the teams to emulate the others by means of an implicit promise of a formidable market - but also the only market, since there was no equivalent civil market. In 1959 the DOD bought 45% of American semiconductors: in 1963 it bought 94% of the integrated circuits. After 1962 NASA systematically used integrated circuits and space became, with the conventional forces, the intermediary for the national re-allocation of resources towards the electronics industry. The APOLLO and MINUTEMAN projects had a major impact on industrial and technological policy. Texas Instruments alone received, from 1959 to 1964, US$ 32m from the US Air Force for research projects on integrated circuits, and sold in every month of 1964 for MINUTEMAN more integrated circuits than it had sold in the whole of 1962! There was therefore a very strong public implication in the way in which the United States built what was, by the middle of the sixties, a world leadership in electronics as a consequence of their desire for world military and space domination.

5. From the middle of the sixties onward there was a very marked drop in the level of Federal financing of research in the United States (from 2% in 1964 to 1.2% in 1979, expressed as a percentage of the GNP) together with a decline in the military and space markets. American technological dynamism remained very important, however, sustained by the commercial exploitation, on a worldwide level, of the technological advantages procured by public expenditure in the previous period, and by the phenomenon characterised by the development of Silicon Valley. Nevertheless it was during this period that the progress of the Japanese electronics industry began to disturb the American authorities, and from 1978 onwards the DOD reactivated its research activities by launching new programmes. In 1980 it was the VHSIC (Very High Speed Integrated Circuit) plan for the period 1981-1987 with about US$ 1b of projects centred on integrated circuits and processors. This plan was subsequently integrated into the enormous Strategic Defense Initiative (SDI) or "Star Wars" programme, in principle voted US$ 25b for 1984-1990. The

Defense Advanced Research Projects Agency (DARPA) implemented at the same time another very ambitious programme, the Strategic Computer Program, with US$ 1b for the period 1984-1990. Table IV-1 shows the extent of the spectrum of this programme and hence the magnitude of the involvement of the US forces in the technico-industrial development of the electronics industry.

Table IV-1 : THE FIELDS OF THE DARPA STRATEGIC COMPUTER PROGRAM IN THE UNITED STATES

Major goals	Develop a broad base of machine intelligence technology to increase national security and economic strength
Military applications	Autonomous systems Pilot's associate Battle management system
Technology base Intelligent functionality	Vision Speech Natural language Expert systems Navigation Planning and Reasoning
Technology base Systems architecture	High-speed signal processing Symbolic processors General-purpose systems Multi-processor software
Technology base Microelectronics	Silicon and GaAs technology VLSI systems
Infrastructure	Networks Research machines Rapid machine prototyping Implementation systems, foundries Interoperability protocols Design tools

<u>Source</u> : d'après E. ARNOLD et K. GUY, 1986, p. 40

6. The efforts of the American public authorities were also continued, taking a new direction, that of intervention in the organisation of the industry. Until now the only interventions were those designed to ensure that the laws concerning competition were respected, that there were no cartels or excessive concentrations which would lead to dominant positions. Whilst the military programmes made the American firms operate in an independent manner the public authorities were to favour joint work by several firms.

7. Two projects launched in 1982-1983 constitute, by reason of their size, a reference point concerning this change in the American mentality in this field, which was to be confirmed by legislation in 1984 and 1986. The first of these projects was launched by the major informatics manufacturer Control Data in January 1982, the second during 1981 by IBM. The project launched by Control Data, the Micro-electronics and Computer Technology Corporation (MCC), is a private non-profitmaking association, the partners in this being companies which supply research workers for a joint laboratory; they also supply general financing together with specific financing for the projects which they are supporting. The patents belong to the association but for three years only the participating companies can operate them. Finally licenses are granted and the participants share the expenses with the association. It is thus a regrouping to share R & D costs which could, under the anti-trust legislation, constitute a distortion of competition. The National Cooperative Research Act of October 1984 gave legal status to this type of association which was relatively widely operated at the time the legislation was introduced: about forty such associations were registered. The second project, launched by IBM, resulted in the creation in 1982 of the Semiconductor Research Corporation (SRC). This non-profitmaking association has its headquarters in the North Carolina Research Triangle Park, and its objective is to coordinate research on semiconductors, to be carried out in university or private laboratories. The SRC can also give assistance to centres of excellence and bursaries to research workers. Its objective is to build a pilot centre capable, inter alia, of producing a 16 Mbit memory and to design one for 1 Gbit (one billon bits!). If a concrete preoccupation is far from being absent one of the objectives not found in the previous project is that of placing fundamental university research at the service of industry. This outlook is reinforced by the Federal Technology Transfer Act of 1986 which should permit a privileged transfer of fundamental research work from North American laboratories to the companies of that country.

8. Whilst the previous two projects attempted to organise the transfer of national scientific potential towards industry for the civil market, and even to share costs for developing their technological potential to be exploited in the civil markets, there was also a current of opinion in the United States which wanted to see the DOD finance civil industry since American security required that this semiconductors industry remained competitive and independent. It was this desire which was behind two other current projects: the first of these is the project of the Semiconductor Industry Association to create SEMATECH which would be concerned with both the joint development and manufacture of the most technologically advanced electronics components with an initial funding of US$ 250m and the proposal to request the support of the DOD. The second project was in fact the result of a report from the scientific council for defence whose director was Norman AUGUSTINE, the president of Martin MARIETTA. The report proposed that the DOD should grant US$ 200m a year for an SMTI (with the same objectives as SEMATECH) which would be a consortium of high-technology firms; this would carry out advanced R & D and establish production units for devices selected as a function of the needs of the DOD.

9. The American forces naturally wished, for reasons of sovereignty, to avoid having recourse to foreign firms for their sophisticated circuits. This particularly concerned the Japanese who were the direct competitors of their American rivals in this field. For example in March 1987 Fujitsu had to relinquish taking control of Fairchild, which until then had been held by the European SCHLUMBERGER company but which had signed an agreement with Fujitsu in October 1986: the Pentagon could not consider having a privileged supplier controlled by a Japanese company. Fairchild meanwhile accumulated considerable losses over several years and had to be taken over by the American NSC company. In order to avoid a repetition of this the forces had to inject Dollars, and they did this by way of multiple contracts. For example in 1987 DARPA launched a three-year contract for US$ 20m for a gallium arsenide (GaAs) integrated circuits production line. The contract-holder, ATT-Bell Laboratories, had two sub-contractors, Hughes Aircraft and McDonnel-Douglas: the specifications were set out and DARPA even indicated that it was ready to add another US$ 10m for even more advanced circuits.

10. It is clear that, despite the official non-existence of an industrial policy in the United States, a non-existence pursued despite a major debate on its oportuneness which has exercised the political environment in recent years, the reality of a military-industrial complex did exist, and it may be stated that its implicit objective was to prevent the United States losing their global technico-industrial leadership, particularly in electronics. Furthermore in regard to commercial policy the United States has always hesitated to play a really liberal role. Today protectionist temptations are very strong (cf Chapter III, 2.2.1.). One may recall what has happened in world trade in memories where, faced with Japanese domination, the United States made the Japanese sign a bilateral agreement in July 1986 which imposed a "Fair Market Value" price which in fact corresponds to the price at which the American producers could, in principle, survive. It is also known that the United States decided that, as from 1 January 1989, a number of countries would no longer benefit from the GSP (Generalized System of Preferences) reserved for Third World countries: South Korea in particular will then be excluded.

2. THE DOMINANT CHALLENGER : JAPAN

11. Japan sought to catch up with the West: before and even more after the Second World War this was an economic development objective. At the end of the American occupation in 1952 Japan was a country with an economy which was still staggering along but which, despite the wartime destruction, possessed high-quality human resources which the process of development since the MEIJI era had built up. A country without raw materials resources Japan seemed even to the occupying power to need to effect its own recovery through industry. This is the reason why General Douglas MACARTHUR legally granted immense powers to MITI, the Ministry of International Trade and Industry, formed in 1949, so that it could have control of its external trade, exchange rates, capital investments, joint ventures and transfers of technologies. This law, which the General regarded as temporary, remained in force until 1979. MITI operated a strongly protectionist policy in regard to the entry of goods and investments whilst facilitating purchases of technology. Simultaneously it stimulated a high level of competition between Japanese enterprises and favoured the accumulation of capital and gains in productivity by offering financing facilities to high-performance firms and, finally, it actively promoted exports by encouraging small enterprises to form exporting cartels and by reinforcing the position of the trading houses. Briefly, therefore, MITI made available to its strategy for industrial development a complete palette of tactics which were, here and there, elevated in the development economy to the rank of mutually exclusive strategies.

12. The field of action of MITI was that of the already well-established and vast enterprises of long experience, from Toyota to Hitachi, and also of the field of new enterprises in the image of Sony, created in October 1945 in the ruins of Tokyo by Akio MORITA. There was also the field of research workers whose attraction towards electronics was not neglected although it was a time for the reconstruction of heavy equipment and also because not everyone had realised that the transistor would replace the valve in all its applications. MITI and the NTT (an enterprise created in 1952 by MPT, the Ministry for Posts and Telecommunications) had each carried out research on transistors in their own electronics laboratories (ETL and ECL); both were successful, the first being NTT with its transistor which was exhibited in June 1953. This was therefore five years after the Americans, but it was greater at the commercial level, and this explains the policy carried out by MITI.

13. In 1973 the position of Japan did not disturb the United States. Taken overall Japan exported 29.2% of its production, but more than three-quarters of the products exported were mass consumer electronics (where the level of exports was already 46%) and simple components. Japan still produced few integrated circuits and exported practically none, covering 70% of its own needs. The fact that it could produce any at all was the result of a hard battle fought in 1967-1968 to obtain the transfer of American technologies and in particular the granting of an agreement with Texas Instruments. This firm granted a licence with moderate royalties, forming a 50/50 joint venture with Sony and agreeing to limit its production to 10% of the Japanese market. This battle was closely linked with the fact that a very dynamic catching-up policy was being developed both by MITI and by industrialists. Europe in the fifties was still concerned with coal and steel, the industry of the 19th century, and with Euratom, a potential source of energy resulting from the military programmes. After many difficulties the only common policy was that concerning agriculture. Japan was imbued with the concept of ongoing

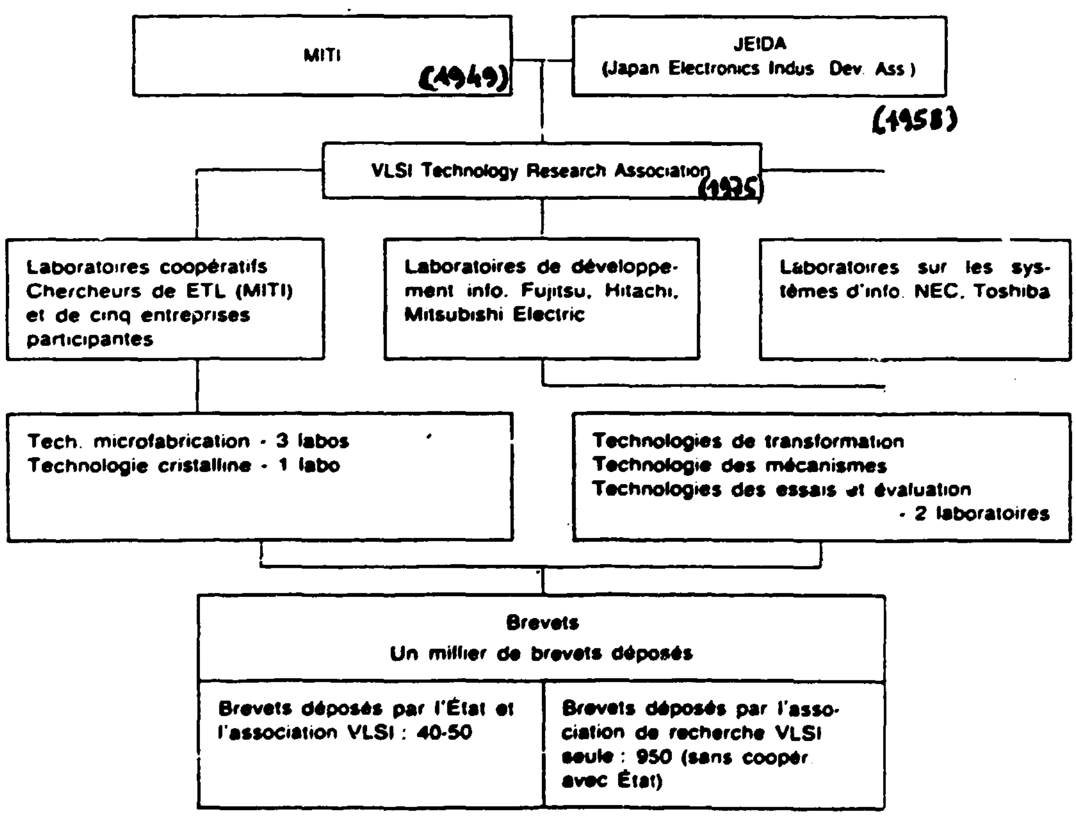
technological evolution, and the MITI seemed to have had a very early intuition of the strategic importance of the electronics industry in a kind of industrial mutation.

14. In 1956 and 1957 two laws (on Temporary measures for the promotion of the engineering industry, and Temporary measures for the promotion of the electronics industry) trace out a path which was to be increasingly trodden. Faced in 1960 with imports of computers which covered 70% of the national market the MITI took a number of customs' measures, public orders, industrial promotions and leasing systems (aided by the Japanese Development Bank) in order to limit the hold of the foreign enterprises, essentially IBM. The latter had been authorised to establish itself subject to signing reciprocal licencing agreements with about ten Japanese manufacturers, these agreements being renewed (with 15 buyers) in 1971. To consolidate these efforts the MITI encouraged the major Japanese manufacturers to establish a research institute (Japan Information Processing Centre) which, jointly with the MITI's own laboratory, established the Super High Performance Electronic Computer Development Project (1966-1979) which was funded with US$ 28 million. In 1971 the two laws of 1956 and 1957 were reinforced by being integrated into a new law (Kidenho) for promoting specific engineering and electronics industries : computers, integrated circuits and magnetic disks, a first series of actions which proved to be ephemeral but which led to the first important results in informatics and which thus opened up the way to the following operations.

15. The NTT and the MITI were the origin of major R & D programmes, the object of which were to allow the Japanese to acquire state-of-the-art know-how in integrated circuits. The NTT was obviously orientated towards specialised telecommunications applications, whilst the MITI was primarily concerned with informatics. In 1975 the NTT formed a consortium with Fujitsu, Hitachi and NEC. The research objectives were specified under the aegis of the NTT and the engineers from its laboratory directed the research carried out in the laboratories of the firms. There was no direct financing but there were subsidies by way of the issuing of contracts. In 1978 orders from the NTT represented 10% of the Japanese consumption of semiconductors, that is to say US$ 230 million.

16. The MITI was also the origin of the creation of the VLSI (Very Large-Scale Integration) Research Association, formed in 1975 by the five largest computer manufacturers, FUJITSU, HITACHI, MITSUBISHI, NEC and TOSHIBA (subsequently joined in 1979 by OKI and SHARP), under the general direction of Yasuo TARUI of the MITI Electrotechnical Laboratory. The Association was given six fields of research : "The technology of micro-production (electron beams and X-rays), processing large diameter silicon wafers with a low defect rate, computer assisted design, VLSI processes and equipment, VLSI test apparatus and VLSI logics and memories (64k DRAM)" (S. TATSUNO, 1987, p.48). Figure IV-2 shows the organisation of this research in three laboratories and the magnitude of the results of this five-year plan (1976-1980). To this end the members of the project have received US$ 300m in loans from MITI ("hojokin"), 40% of this being without interest and repayable from the subsequent profits. These plans are accompanied by the law of 1978 which changed the law of 1971 into a law for the promotion of the engineering and informatics industries and which led Japan into mechatronics, that is to say the complete reconstruction of the machine which is at the heart of all production processes: the engineering industry became electronised. Table IV-3 gives the chronology of the Japanese plans: the pursuit of past efforts can be clearly seen.

Figure IV-2 : THE ORGANISATION OF THE JAPANESE VLSI RESEARCH PROJECT (1976-1989)



Source : Daniel Okimoto, « Pioneer and Pursuer : The Role of the State in the Evolution of the Japanese and American Semiconductor Industries », Working Paper, 1983. Voir D. Okimoto et al., *Competitive Edge : The Semiconductor Industry in the U.S. and Japan* Stanford, CA : Stanford University Press, 1984

Source : S. TATSUNO, op. cit., p. 279.

Table IV-3 : CHRONOLOGY OF THE JAPANESE ELECTRONICS RESEARCH PROGRAMMES

	Durée du programme	Budget du programme millions de Yens	Organisme public de tutelle
1. - INFORMATIQUE			
Ordinateur hyper performant	1966-1981	10 125	AIST (1)
Développement de matériel informatique	1972-1976	50 000	
Système de traitement informatique de tous caractères (2)	1971-1980	22 000	AIST (1)
Ordinateur de 4e génération	1976-1979	153 000	
Développement de logiciels	1976-1979	6 000	
Périphérique avec entrée-sortie en japonais	1979-1983	23 500	MITI
Calculateur scientifique ultra-rapide (10 Md de flops) (11)	1981-1989	23 000	LGE (3) (4)
5 G.C.S. (100 méga à 1 giga lips)	1982-1981	100 000	ICOT (7)
Développement de progiciels pour P.M.E.	1983-		
Compilateur de logiciels (SIGMA)	1985-1989	25 000	JIPDEC (8)
2. - COMPOSANTS			
Projet VLSI	1976-1980	30 000	MITI
VLSI pour télécommunications	1975-1980	40 000	NTT
Logiciels pour VLSI (CAO/FAO)	1979-1983	22 000	
VLSI de dernière génération (JISEDAI) dont :	1981-1990	25 000	MITI (6)
- matériaux macromoléculaires électroconductibles	1981-1980	nd	
- élément ultra réseau	1981-1990	nd	
- élément de circuit tridimensionnel	1981-1990	nd	
- élément renforcé anti-environnement	1981-1968	nd	
Exploratory Research for Advanced Technology (ERATO)	1982-1987	30 000	JRDC sous contrôle AIST
3. - ROBOTIQUE ET AUTOMATISME			
Premier programme NCMI	1971-1977	[illegible] 000	
2nd programme NCMI	1977-1984	10 000	
Recherche fondamentale en automatisme	1976-1983	45 000	
Automatisation maximale de processus avec laser (petites séries)	1977-1983	13 700	AIST (1) (4)
Mesure et contrôle opto-électronique de processus	1979-1986	18 000	AIST (1) (4)
Recherche fondamentale en robotique	1981-1988	30 000	
Fabrication automatisée de vêtements	1982-1989	13 000	AIST (1) (4)
Robot JUPITER pour environnement critique	1983-1990	40 000	AIST (1) (4) (5)
4. - TELECOMMUNICATIONS			
Dendenkosha Information Processing System (9)	1975-1980	40 000	NTT
Information Network System	1982-2000	20 000 000 (12)	NTT

(1) L'Agence des Sciences et Technologies Industrielle, ou KOGYOGI JUTSUIN, crée en 1948, dépend du MITI

(2) Pattern Information Processing System ou PIPS

(3) DENSHIGIJUTSU SOGO KENKYUSHO ou Laboratoire Général d'Electricité dépend de l'AIST avec 15 autres laboratoires.

(4) Fait partie des grands projets nationaux du MITI, les *"OOGATA PROJECTO"*.

(5) Coopération franco-japonaise

(6) JISEDAI SANGYO GIJUTSU KENKYU KAIHATSU ou Programme de R.D. des techniques pour les industries de la prochaine génération.

(7) Institute for NewGeneration Computer Technology, financé par le MITI à hauteur de 50 % du projet.

(8) NIPPON JOHOSHORI KAHATSU SENTA, Agence japonaise pour le développement des technologies de l'information.

(9) Très grands ordinateurs pour le temps partagé.

(10) Le programme ERATO ne concerne pas que l'électronique. Il porte sur les matériaux (polymères SC).

(11) Concerne, en fait, le développement des composants AsGa, HEM et Josephson.

(12) Y compris les investissements d'infrastructure.

Source : GERDIC d'après :

Japon Economie, n° 140, 30 mai 1981, p. 4-9 ;

Problèmes Politiques et Sociaux, n° 493-494, 24/08/84, p. 17, 25, 32 et 44.

Electronic Business, 15 juin 1985, p. 84-85.

3. OLD EUROPE'S SOMERSAULT

3.1. A general overview of some national interventions

17. For various reasons the public authorities in the European countries did not intervene in the functioning of their electronics as rapidly as in Japan. The first reason is certainly because they had other problems with their old industrialisation and they had found it necessary to "defend" their textiles industries since the beginning of the sixties. The second reason, symmetrical with the first, related to the fact that their electronics industry did not seem to be doing too badly from the point of view of the conventional indicators, such as those of foreign trade. The third looks at the second in another manner: whilst the balance of payments were satisfactory this was, in particular, because Europe was unlike Japan in extending a welcome to the American multinationals. So it was necessary to wait until the end of the sixties to see the appearance of the first European measures. West Germany began to support its informatics and electronics industries in 1967, and it was also in this year that France launched its CALCUL plan after America had refused to sell it the computers it needed for its nuclear programme. In 1968 Great Britain restructured its informatics industry round ICL. In this way there began an epoch of increased interventions in the electronics industry and of subsidies to industry. Table IV-4 shows the relative rise of these subsidies for eleven European countries, and Table IV-5 sets out in parallel the interventions in the electronics industries between 1968 and 1984 by the public authorities of the three major European countries.

Table IV-4 : SUBSIDIES TO PRIVATE COMPANIES AS A PERCENTAGE OF THE GNP

	1970	1982		1970	1982
Belgium	1.3	1.6	Denmark	2.8	3.2
France	2.0	2.2	West Germany	1.7	1.8
Great Britain	1.7	2.0	Italy	1.5	2.9
Netherlands	1.3	2.5	Norway	5.1	6.5
Austria	1.7	2.9	Sweden	1.6	5.0
Switzerland	0.8	1.3			

Source: Bundesministerium der Finanzen (1985), p. 20.

Source : d'après G. JUNNE et R. VAN TULDER, 1988, p. 162

Table IV-5 : PUBLIC INTERVENTIONS: AID AND RESTRUCTURING IN THE ELECTRONICS INDUSTRY IN FRANCE, THE UNITED KINGDOM AND WEST GERMANY

FRANCE							
1968	*1970*	*1973*	*1975*	*1978*	*1978-9*	*1981-2*	*1983-4*
Government fosters SECO (Thomson) and COSEM (CSF) merger to create SECOSEM (Thomson) heavily supported by state	EFCIS (semi-conductors) created as joint venture between Thomson and CEA (Atomic Energy Commission)	Creation of UNIDATA (computers), a joint venture of CII, Siemens and Philips. Uncertain government attitude	Failure of UNIDATA. Government supports merger of CII and Honeywell-Bull	Thomson takes over semiconductor division of LTT and SILEC	Government supports joint ventures of: Saint-Gobain-National Semi-conductor; Matra/Harris; Thomson/Motorola. Saint-Gobain entry into CII and Olivetti. Support of Radio-Technique (Philips). (5 poles of production)	Nationalization of CGE Thomson, Saint-Gobain, CII-HB (becomes Bull); majority stake in Matra	Concentration of computer activities of Thomson, Saint-Gobain and CGE with Bull. Thomson takes over: the joint venture of Saint-Gobain and National Semiconductor (Euro-technique) and the semi-conductor business of CGE. Of the 5 poles of production, only two remain. Saint-Gobain withdraws from Olivetti. CGE takes a 10% share in the Italian firm
GERMANY							
	1970	*1973*	*1975*	*1978-9*	*1979-80*	*1983*	*1984*
	Creation of DATEL. Joint venture of state, Siemens, AEG-Telefunken, Nixdorf (in computer applications)	Creation of UNIDATA (see above). Favourable government attitude	Siemens takes over big computer division of AEG (approved by state)	Rescue of AEG-Tele-funken by a consortium of banks. Indirect Federal support	Plans for the establishment of a joint research laboratory of the three major firms and public agencies (Berlin Synchrotron Projekt)	Semiconductor division of AEG merged with Mostek (United Technologies) in a joint venture. Telefunken taken over by Thomson	Joint research in Germany of ICL, Siemens and Bull (in computers and information technology). Takeover of Grundig by Philips (after disapproval by the Bundeskartelamt of the same effort by Thomson)
UK							
1968		*1976-8*		*1978*	*1980*		*1984*
Joint venture between Mullard (Philips) and GEC, taken over by the former. Series of mergers lead to ICL (computers) 10.5% owned by state		NEB buys shares in Ferranti (computers, semiconductors, military, etc.) and in various small and medium firms in software, industrial and consumer electronics		Constitution by NEB of INMOS (VLSI memories and MPUs). Entirely publicly financed	Conservative Government sells ICL and Ferranti to private market		Government sells its 75% share in INMOS to Thorn-EMI. STC (25% owned by ITT) tries to acquire ICL

Source: data 1968-80 from Dosi (1981), p. 94; after 1980 from own observations.

3.2 The German Policy

18. In West Germany, as in the United States, there is officially no industrial policy. However, since the creation of the BMFT (the Federal Ministry for Research and Technology) in 1972 Germany has a kind of single office to assist and guide Research and Development in German enterprises and thus to favour, to a certain extent, those which seem to it to be preferable. Between 1967 and 1979 Germany has had three informatics plans in succession. In 1974 it launched a first five-year plan (1974-1978) for electronic components (Elektronische Bauelemente) followed by a micro-electronics programme (Zeitungsplan Mikroelektronik) for 1979-1983.

19. In 1984 Germany provided DM 3 billion for a unified information technologies plan (1984-1988): this was financed not only by the BMFT but also, for the first time, by the ministries for the economy and the post. Table IV-6 sets out the principal programmes supported by the German public authorities. One can easily see the extent of the fields covered and the magnitude of the financial backing.

Table IV-6 : THE PROGRAMMES SUPPORTED BY THE GERMAN PUBLIC AUTHORITIES IN INFORMATION TECHNOLOGIES

Project	Structure and institutions involved	Duration	Budget (DMm.)
Components			
Microperipherals	Joint projects and 'indirect support'	1985–88	330
CAD for ICs	Industry, universities, FhG, VDI	1984–88	90
	Technical Centre, GMD, Heinrich Herz Institute		
Submicron technology (basic research)	Focus on FhG, universities	1984–88	600
New components technology (basic research)		1984–88	200
Integrated optics	New centre at Heinrich Herz Institute/joint co-operation	1984–88	90
Key microelectronics components (applied research into technological and systems engineering)	BMFT	1984–86	90
Data processing			
CAD for hardware and software design	Joint projects	1984–88	160
New computer structures, e.g parallel processing		1984–88	160
Knowledge processing for experts systems and pattern recognition for quality testing of components	Joint projects	1984–88	200
Encryption techniques	Interdepartmental committee run by Minister of Defence		
Software	Possible increased support Labour Cost Subsidy programme		
Industrial automation			
Production engineering programme will		1984–87	530
(a) introduce CAD/CAM to medium-size enterprises:	Joint projects		
(*b*) promote development of robots;			
(*c*) promote development of flexible manufacturing systems.	Joint projects		
Telecommunications			
Optical technology (basic components research)	BMFT	1984–88	240
Broadband networks	DBP	p.a.	1–2,000*
High-definition TV	BMFT	1984–88	60
Research infrastructure			
Research network based on PSTN	BMFT	1984–88	100
Education			
Application of IT to vocational training			20–25
Studies			
On technology impact for Conference '1984 and thereafter'	BMFT	1984	
On IT at the workplace	BMFT, Economics and Labour Ministries	1984 onwards	
Five-year ISDN development plan	BMFT		
Ten-year ISDN development plan	BMFT		
On DBP structure	Post and Telecoms Committee (new)	late 1985	

*This overall figure includes projects listed separately above
Source EEC, 1984a, Section 5.

Source : ARNOLD et alii, op. cit., 1986, p. 143-144.

3.3. The British policy

20. Shortly after the war it was the Post Office in Great Britain which aided the electronics industry by favouring the creation in 1956 of the Joint Electronic Research Committee to coordinate the efforts made by British industry to develop new switching exchanges. In informatics the public authorities favoured the creation of ICL and then consistently supported it until its merger with STC in 1984. There were many interventions by the public authorities, with considerable financial support, as may be seen from Table IV-7. For example one sees the creation in 1978 of INMOS, a public company to manufacture integrated circuits; however this firm returned to the public sector in 1984 (see Table IV-5). Similarly in that year British Telecom, the nationalised telecommunications company which had been split off from the Post Office in 1981, was privatised. The British public authorities wished tc disengage themselves: however in 1983 they launched a five-year ALVEY programme which was effectively regarded as terminated in 1988. This was a response to the fifth-generation computer project to which they had been invited, like the other industrialised countries, by Japan. With funding of £ 200 million the ALVEY programme is very ambitious but equally very much upstream of the market, which allows its promoters to explain that concrete effects will not be felt immediately on the market.

Table IV-7 : PUBLIC MEASURES IN RESPECT OF INFORMATION TECHNOLOGY IN GREAT BRITAIN

Year(s)	*Title*	*Value*	*Notes*
1968	Industry restructuring	10.5 per cent of equity in ICL	Government-backed merger of ICT and English Electric's DP Department
1968–73	R&D grants for ICL, unrepaid loans	£7m £40m	Government funds for development of independent technology
1973–82	Software Product Scheme	£9m	25–30 per cent grants to costs of developing package software
1973–8	Microelectronics Support Scheme	£10m	Support for domestic microelectronics firms
1973–8	Advanced Computer Technology Project	£2m pa $5m pa	Support for domestic semiconductor firms
1976	Component Industry Scheme	£5m $9m	Support for domestic components firms
1978	Microelectronics Industry Support Scheme (MISP)	£55m $110m	50 per cent grants to R&D and 25 per cent to cost of productive investments
1978–81	Microprocessor Application Programme	£41m $73m	For diffusion of microelectronic applications in industry
1978	Creation of INMOS	£50m $100m	NEB sponsored, to create memory device firm in Britain
1979	Microelectronics in Education Programme	£10m $18m	For diffusion of microelectronic applications in schools
1981	MISP extended	£30m	IT R&D support
1982	CAD/CAM scheme	£6m	Increase awareness and courses in CAD/CAM
1982–6	Flexible Manufacturing Systems Scheme	£60m	50 per cent grants for consultancy, 33 per cent for development costs
1982–3	Software Product Scheme	£10m	Programme revamped
1983	Software Product Scheme	£25m	Increased funding
1983	Alvey Programme	£200m	50 per cent grants to cooperative IT R&D projects

<u>Source</u> : P. JOWETT et M. ROTHWELL, 1986, p. 14.

3.4. The French policy

21. The tradition of intervention by the public authorities in the economy, the so-called "Colbertism", has meant that all governments in France are interested in the functioning of industry, but in the case of the electronics industry this has mainly been the case since 1967. This intervention is accompanied by larger or smaller levels of financing (cf. Table IV-8) and by frequent restructurings. Recently the most sustained attempt at intervention was carried out during the socialist government of 1981, the first which France had had for nearly twenty-five years. The State proceeded to establish the designation and configuration of national poles in various fields : components, general and office(*) informatics, telecommunications, production(**) informatics, professional electronics and mass consumer electronics. Simultaneously the State nationalised or assumed a majority shareholding in all the major French groups around which these national poles had been constituted. The whole was more or less included within the framework of a Four-Year Plan (1983-1987) of 140 billion French Francs (55b FF charged to the State) and the Plan d'Action Filiere Electronique (PAFE, or Action Plan for Electronics Production) of which the public authorities had great hopes, including a very rapid increase in employment, the balancing of external trading, the recovery by French industry of its former technological level and, obviously, rising production. Within the plan, side by side with a weakly-structured PAFE, there were also a mini-informatics plan, a micro-electronics plan, a plan for passive components, an imaging plan, a "productique" plan(**) (for modernising the converting industries), a PUCE(***) programme (so that small and medium sizes firms could introduce French electronics components into their products) and a super-calculator plan called MARISIS. The overall guidance (and part of the financing) of PAFE is the responsibility of the DGT (Direction Generale des Telecommunications) which was also continuing the Telematique plan, launched after the 1978 NORA report. France was engaged in the creation of a data transmission network, TRANSPAC, with a consumer version which resulted in MINITEL and its first electronic directory service launched in 1983. This videotext service is the largest of all other national trials (several million users). The DGT has also launched a cable plan, with relatively modest results. After 1986 a new government launched a privatisation programme which affected most of the electronics firms, which had not however waited for this to happen before taking decisions which were not in accordance with State directives. Whilst the State continues certain financing operations it seems, for the time being, to have abandonned the idea of regrouping them into a massive structured whole.

(*) "Bureautique" in the original French.
(**) "Productique" in the original French.
(***) "Puce" is the French for "chip".

Table IV-8 : FRENCH STATE AID FOR THE ELECTRONICS INDUSTRY (1967-1981)

Branche	Firmes bénéficiaires	Période 1967-1971
Grosse informatique	C.I.I.	400 millions de francs pour frais et marchés d'étude, 125 millions de francs de prêts + 10 millions de francs (1)
Péri-informatique	S.P.E.R.A.C.	100 millions de francs (marchés d'étude et crédits de développement) (2)
Composants	Sescosem	100 millions de francs subventions (2)
Télécommunications	C.I.T.-Alcatel, câbles de Lyon (groupe C.G.E.) G.3.S., A.O.I.P., L.M.T., L.T.T., C.G.C.T. (groupe I.T.T.) Ericsson	12 milliards entre 1954 et 1965 (2ᵉ, 3ᵉ et 4ᵉ plans) 4 milliards par plan 12 milliards pendant le 5ᵉ plan (1966-1970) (3)

In 1971 the 2nd "Calcul Plan" was instituted: the State signed a four year agreement with industrialists (1971-1975) with a budget of 1315 mFF for informatics, peripherals, components, software and research. This was also the time of major investments intended for extending the telephone system (*) with support for research through the CNET for digital telephone exchanges.

1974-1981

	AIDES ETATIQUES MF = Million de francs	FIRMES BENEFICIAIRES
GROSSE INFORMATIQUE	1 200 MF de subventions (1976-1980) 930 MF : aide accordée à l'occasion du rachat de C.I.I. par HONEYWELL (1975) 4 050 MF commandes publiques (1976-1980)	C.I.I. puis C.I.I.-H.B.
MINI-INFORMATIQUE	[illegible]30 MF aides + subventions (1976)	S.E.M.S. (THOMSON)
PERI-INFORMATIQUE	110 MF aides (1977-1980)	S.E.M.S. (THOMSON), TRANSAC, SINTRA (C.G.E.), BENSON, LOGABAX, INTERTECHNIQUE, PYREL (RHONE-POULENC)
COMPOSANTS	600 MF aides (1978-1982) Création du C.N.E.T. – Grenoble (opérationnel fin 1981)	SESCOSEM, EFCIS (THOMSON), R.T.C. (PHILIPS), SAINT-GOBAIN, MATRA
E.G.P., BUREAUTIQUE	Aides du CODIS ([illegible])	VIDEOCOLOR (THOMSON), C.I.T.-ALCATEL (C.G.E.)
TELECOMMUNICATIONS	[illegible] MF d'autorisation de programme ([illegible])	THOMSON, C.G.E., A.O.I.P., C.G.C.T. (I.T.T. FRANCE)

(*) The growth of the French telephone system has been spectacular, from 5 million lines in 1972 to 10 million in 1977 and 20 million in 1982

<u>Source</u>: J. BARREAU, A. MOULINE, 1987, pp. 48, 62, 138

3.5. The ESPRIT programme

22. The halting of the ALVEY programme in Great Britain and the slowing down of the plans in France are in contrast to the more marked voluntarism of West Germany, but all are accomodated within an effort made at regional level within the framework of the European Economic Community. Amongst the various programmes which touch on electronics and which simultaneously involve several European countries is ESPRIT, the European Strategic Programme for Research and Development in Information Technologies, a very interesting example for several reasons making it the only existing programme which operates effectively as a cooperative programme, uniting several States and several industrial groups.

23. The formation of ESPRIT is due to Vicomte DAVIGNON, Commissioner for Industry at the European Communities, who put forward the idea of such a programme at the meeting of the European Council at Dublin in November 1979. Vicomte DAVIGNON, the king-pin of the project, succeeded in making a group of the most important European electronics companies, including AEG, Bull, CGE. GEC, ICL, Nixdorf, Olivetti, Philips, Plessey, Siemens, Stet and Thomson, meet together to form the round table of the "12". The proposal put to them was quite clear: if at least two different nationalities work together on a joint research project then for every ECU invested in it the Community would add another ECU. This was nothing more nor less than the launching of an idea for a research association on the lines of the MCC (cf paragraph 7) whereas such a project in one or other European country could seem ridiculous because of a lack of firms and manpower. This was not easily achieved since the firms concerned were competitors, many were national champions with a protected market and European nationalism (including that of language) remained very conspicuous, so that the initial steps were hesitant.

24. It was also necessary to convince the politicians and not to fall foul of the laws of the Treaty of Rome, in particular those on competition. If there were to be projects it was necessary to ensure, in one way or another, that the width of their scope should allow any competent team to take part, irrespective of the firm to which it belonged: this was clearly in the interest of all. Similarly, and although the programme was essentially concerned with industrialists' projects - this being the MCC side - it would also be of interest to effect an opening up to university or public research centres, as in the case of the SRC (cf paragraph 8).

25. ESPRIT was to go beyond the MCC and SRC forms of association, which had been implemented at the same time. In fact ESPRIT had a Task Force for Telecommunication and Information Technologies (TFTIT) which in 1987 became DG XIII, which forms part of the European Communities Commission and which piloted the programme: a plan of work established by consultation and dialogue with more than 300 experts resulted in the defining of a call for tenders. The teams involved met to set out their proposals and a meeting of the proposers (there were 800 participants in 1985) for subsequent discussions on harmonisation. Finally meetings of independent experts selected them, subject by subject, after analysis, discussion and a final report. This is much less directive than operations of the type of MITI or the VLSI Plan: the participating enterprises were not nominated and the projects were not drawn up by one specific laboratory. However there are similar points: the actions are targetted and contained within a whole which is designed to raise the level of European scientific and technological potential in regard to electronics.

26. A pilot phase started up in 1983 and ESPRIT was adopted by the Council on 20.2.1984 and so was launched for a period of ten years. A first phase, ESPRIT I, was to cover the period 1984-1988 but the proposed EEC budget of 700 million ECU was soon totally committed in 201 projects involving 240 industrial partners (130 of these being firms with fewer than 500 employees) and 2900 research workers. In the autumn of 1986 it was therefore envisaged that ESPRIT II should be launched. After some delay this was agreed with a budget twice as large and with ten times as many research workers, all to be integrated into an overall EEC programme for the promotion of research. ESPRIT II was designed to involve less fundamental research and more technological research directed towards the products of the future. The principle nevertheless remained that of pre-competitive research which avoided coming under the scope of laws on competition.

27. The programmes which were implemented seemed to progress the scientific and technological potential of the partners effectively in fields which were known to be backward. ESPRIT I and ESPRIT II attacked, amongst other subjects, integrated production by computer, a field of considerable importance since it corresponds to what we have termed mechatronics when considering the history of the actions of the Japanese MITI. By contrast it was necessary to emphasize the weakness of Europe in informatics and in micro-electronics. In informatics the emphasis was placed on the establishment of European standards, on the possibilities for inter-operability of equipment to allow real competition. Great progress has already been made in this direction. Let us look briefly at another field in which Europe is weak, micro-electronics. The projects which are in progress, and which are now well advanced, give rise to hopes of recovering a return to the world level of technology in this field: it is here that the importance of these programmes is to be seen. Table IV-9 shows, by way of illustration of this, some of the micro-electronics projects of ESPRIT I.

Table IV-9 : SOME MICRO-ELECTRONICS PROJECTS LAUNCHED WITHIN THE FRAMEWORK OF ESPRIT I

No	Titre	Organisations participantes
14	Interconnexion avancée pour VLSI	Plessey Research Ltd (UK) AEG Telefunken (D), GEC(UK Thomson CSF (F)
97	Algorithmes avancés, architectures et techniques de tracé pour VLSI spécialisés dans le traitement des signaux	IMEC v.z.w.(B), Bell Tel.MFG Co.(B), Silvarlisco N.V.(B), Philips (NL), Siemens (D), Ruhr Univ. Bochum (D)
232	Matériaux composés pour semi-conducteurs et circuits intégrés - I	Allen Clark Res.Centre(UK), Philips (F), Siemens AG (D), Thomson CSF/DMM (F)
243	Technologie bipolaire submicronique I	Thomson CSF/DCI (F),Plessey Research Caswell (UK), Telefunken Electronic (D), Thomson CSF/LCR(F) Rhône-Poulenc Multitech.(F), Univ. de Toulouse (F)
263	Circuits optoélectroniques à base d'InP	CSELT (I), AEG Telefunken(D) CNET (F), GEC (UK),HHI (D), SEL (D),Thomson CSF/LCR(F), CGE (F), STL(F)
281	Technologie biopolaire submicronique-II	Siemens AG(D), RTC Compelec (F)
412	Procédé CMOS bipolaire à haute performance pour circuits VLSI	Nederl. Philips Bedr.(NL), Siemens(D), Univ. de Stuttgart(D)
443	Ingéniérie moléculaire pour optoélectronique	CNET (F), ICI PLC (UK), Thomson CSF (F), Univ. de Namur (B)
514	Dispositifs semi-conducteurs quantiques	GEC (UK), Thomson CSF/LCR(F)
554	Technologie CMOS Submicronique	CNET (F), Brit. Telecom UK), IMEC (B), Matra-Harris Semicond.(F), SGS Microelettronica (I), Univ. de Leuven (B)
843	Circuits intégrés à composés semi-conducteurs	STL (UK), GEC (UK),Philips-LEP (F), Siemens (D), Thomson-CSF/DMM (F), Plessey Research Caswell(UK) Farran Technology (Irl)
887	Projet européen d'intégration CAO (ECIP)	Bull (F), Alcatel (F), ICL (UK), Philips (NL), SGS Microelettronica (I) Siemens (D)
888	Aides à la conception de circuits intégrés avancés (AIDA)	Siemens (D), ICL (UK), Thomson Semi-conducteurs(F), Bull (F), IMAG/TIM3 (F), UMIST (UK)
971	Technologies des circuits intégrés bipolaires en AsGa-GaAlAs	CNET (F), Plessey Research Caswell (UK), GEC (UK), Farran Technology(Irl), Plasma Technology (UK)
991	Système de conception VLSI intégré, hiérarchique et multifenêtre avec gestion répartie sur postes de travail	Delft univ.of Technol. (NL) British Telecom (UK), ICS Holding BV (NL), PCS GmbH (D), Tech. Univ. Eindhoven (NL), Univ. of Essex(UK)
1058	Système cognitif d'aide à la conception de modules VLSI	IMEC v.z.w. (B), Philips(NL) SILVAR-LISCO N.V. (B)
1128	AsGa semi-isolateur à large diamètre	LEP (F), Wacker Chemitronics (D), U.C.L. (B)

Source : Document ESPRIT

4. TECHNOLOGICAL COMPETITION BETWEEN THE NATIONS

28. The overview which we have provided of the programmes launched by the various industrialised countries provides evidence that all countries feel implicated at a collective level by the renewal of their industrial apparatus so as to bring them into the age of electronics. This seemed to them to be a necessity if they were to make good showing in the International Division of Labour and to put back into order their economies which for at least fifteen years had moved away from full employment and growth to enter into a period of crisis. This general desire for industrial change centred on electronics stimulated a technological race in which cooperation was seen as well as rivalries: nations, like firms, appeared as competitors. Simultaneously their multiple actions are convergent. They are designed to convert the machines industry into mechatronics (Table IV-10) and to facilitate and to multiply communications, since it would seem that information was, with mechatronics, the way to make major improvements in productvity. This has also led more of less everywhere to promoting the deregulation of telecommunications (Table IV-11) and, finally, to wish that the machines which process the information should do so in a non-mechanical but intelligent manner, and so they have launched projects in the field of artificial intelligence (Table IV-12).

4.1. Mechatronics

Table IV-10 : SOME PUBLIC PROGRAMMES FOR THE DEVELOPMENT OF MECHATRONICS IN THE EUROPEAN COUNTRIES

Country	*Nature of programme*
GERMANY (production and diffusion)	New Production Technology Programme (1984–7: DM5∪J million); CAD development (DM160 million). Estimated total grants between DM200 and DM300 million per year (Federal plus Lander support).
FRANCE (production and diffusion)	National Machine Tool Plan (1981–4: FF2.3 billion); Fonds Industriele de Modernisation (FIM): aims at mobilizing savings for investment in advanced manufacturing; Automatics and Advanced Robotics (ARA) Programme; etc.
ITALY (production and diffusion)	Mechanical Engineering Technologies Project (follow-up of 1979–84 'Industrial Automation Project): LIT31 billion over 5 years; Special Fund for Technological Innovation: from 1982 appr. LIT3.650 billion; since 1983 Bill N 696 supporting SMEs to buy NC machine tools: 1983–5 period LIT90 billion in funds.
UK (production and diffusion)	Department of Trade and Industry programmes (1981–6): production techniques (£90 million); production and development of microelectronics (£50 million); Microelectronics Applications Programme (£50 million); use of Science and Engineering Research Council in programme on the Application of Computers to Manufacturing Engineering (ACME) £4 million in 1983.
NETHERLANDS (diffusion)	Demonstration projects for introduction of flexible manufacturing systems; 1983 budget around DFL12 million. Stimulation of Innovation (INSTIR) project supports wage costs (DFL1100 million).
BELGIUM (diffusion)	Action plan for microelectronics technology. Robotics budget: BF100 million (total budget: BF2.655 million). CAD/CAM support only for R&D for applications in the design and production of integrated circuits.
DENMARK (diffusion)	Technological Development Programme 1985–9 promotes information technology in main industrial sectors (total budget: DKR1525 billion).
SWEDEN (diffusion)	'Robot-84' campaign; provision of risk capital for demonstration projects and awareness campaign; feasibility studies are undertaken and support for training programmes of around SEK108 million since 1983.

Source: Social Europe, special supplement 1986; own observations

Source : G. JUNNE, R. VAN TULDER, 1988, p. 170.

4.2. Deregulation of telecommunications

Table IV-11 : DEREGULATIONS OF TELECOMMUNICATIONS IN THE UNITED STATES, GREAT BRITAIN AND JAPAN *

Etats-Unis

Les grandes étapes

1959 : Autorisation de réseaux hertziens privés.
1968 : Introduction de la concurrence sur les équipements terminaux.
1969 : Autorisation du réseau interurbain spécialisé de MCI.
1973 : Computer Inquiry I, le «Yalta» informatique-télécommunication. ATT est confiné au transport de l'information.
1976 : Droit de louer des liaisons spécialisées pour partager et revendre du transport.
1980 : Computer Inquiry II. Le service de base reste réglementé. Les services enrichis sont soumis à la concurrence.
1982 : Décision du juge Greene. A partir de 1984, ATT sera coupée en 7 compagnies régionales indépendantes. Elle conserve l'interurbain et l'international, ses usines et acquiert le droit de faire de l'informatique et de se lancer sur les marchés étrangers.
1984 : Mise en place de la structure séparant ATT des compagnies locales BELL.
1986 : Computer Inquiry III. La FCC (Federal Communication Commission) revient en arrière.
1986 : ATT et les BOC (Bell Operating Companies) ne sont plus contraints de constituer des filiales séparées pour commercialiser matériels et services à valeur ajoutée.

Les principes

Distinction entre les services de base (transport transparent d'information), et les services enrichis par un traitement intermédiaire de l'information. Les premiers sont régulés et les autres soumis à la concurrence.

Qui fait quoi?

Autorités régulatrices : Elles dépendent du législatif. Au niveau fédéral : la FCC (Fédéral Communication Commission). Au niveau de chaque Etat : la commission des services publics (PUC).

Trafic local et régional courte distance : Monopole des 7 sociétés régionales BELL ou de compagnies indépendantes (GTE est la plus grosse). Les compagnies sont réglementées, assujetties à des contraintes de service public : desserte des zones non rentables, tarifs péréqués,. .

Trafic interurbain grande distance : c'est le régime de la concurrence réglementée. Trois opérateurs principaux : ATT (85 % du marché), MCI (6 %, IBM à 16 % des actions), GTE-SPRINTS US (4 %). Les tarifs sont approuvés par la FCC.

Trafic international : concurrence d'ATT-MCI-COMSAT et des revendeurs.

Services enrichis (Télématique). La règle est la concurrence. Les opérateurs offrant des services de transport peuvent concourir à condition de ne pas subventionner ces services par les gains réalisés avec le transport.

De fait, la nouvelle réglementation a incité les opérateurs de transport à intégrer de nouvelles activités : locations, ventes de matériel, services informatiques, implantations étrangères (ATT en Europe...).

Japon

Les grandes étapes

1949 : Séparation de l'administration des postes de celle des télécommunications.
1952 : Création de l'entreprise publique Nippon telegraph and telephone pour le réseau national et de KDD, entreprise privée, pour le réseau international.
1984 : Loi sur les télécommunications et loi sur le statut de NTT qui commence à devenir une entreprise d'économie mixte.

Les principes

La réglementation distingue les possesseurs d'infrastructures et les autres opérateurs qui offrent des services télématiques.

Qui fait quoi?

Autorité régulatrice : la Diète (lois) et le ministère des PTT (règlements).

Réseau local : le monopole est confié à NTT qui doit raccorder sans discrimination tout concurrent. Les tarifs sont contrôlés. NTT est soumis à des contraintes de service public.

Réseau interurbain : concurrence, régime d'autorisation avec contrôle des PTT. Six concurrents de NTT sont autorisés.

Réseau international : monopole de KDD. Le ministère des PTT prépare l'ouverture à la concurrence.

Services télématiques : on distingue deux catégories :

Les services spéciaux mettent en œuvre des réseaux importants (plus de 500 circuits à 1 200 bit/s) offerts à une clientèle vaste et diversifiée. Ils peuvent être ouverts sur l'étranger. L'opérateur doit obtenir une autorisation où il s'engage à déposer ses tarifs et à ne refuser aucune connexion.

Les services ordinaires correspondent à la majorité des services télématiques. Il suffit d'une simple déclaration. On compte déjà deux cents services de ce type.

Grande-Bretagne

Les grandes étapes

1969 : Le British Post Office devient un établissement public (corporation)
1981 : Révision de la législation. Deux lois, une pour les télécommunications, une pour la diffusion. British Telecom naît par séparation de la poste. La concurrence est introduite pour les terminaux.
1982 : Création de Mercury
1984 : Séparation des fonctions réglementation et opérateur. British Télécommunication est en partie privatisée.

Les principes

On distingue :

— les opérateurs publics, qui gèrent les installations permettant le pur transport d'information; ils sont au nombre de deux, British Telecom (BT) et Mercury; leurs droits et devoirs sont fixés par une autorisation spéciale, stipulant les contraintes de service public, l'interdiction de subventions croisées et les domaines interdits.

— Les opérateurs de réseaux à valeur ajoutée (services télématiques); ils sont autorisés par une licence générale identique pour tous.

Qui fait quoi?

Le pouvoir réglementaire est exercé par le ministère du commerce et de l'industrie, DTI, qui peut le déléguer en partie à un office (OFTEL).

Réseau local : BT a le quasi monopole. Mercury a des connexions directes avec les grands comptes à Londres, dans la City.

Réseau national et international : concurrence entre BT et Mercury. La part de marché de Mercury est très petite. Mercury construit un réseau en fibres optiques et quelques commutateurs téléphoniques.

Services à valeur ajoutée (VAN) : régime de concurrence sous licence en cours de redéfinition.

La situation actuelle se caractérise par une nouvelle dynamique de BT qui œuvre pour que l'Angleterre devienne la plaque tournante des télécommunications internationales de l'Europe.

Source : France Télécom, n° 62, juin 1987

* Ce sont les trois pays ayant à ce jour pris des mesures importantes de déréglementation

4.3. Artificial intelligence

Table IV-12 : THE THREE PRINCIPAL GLOBAL PUBLIC PROGRAMMES FOR RESEARCH INTO ARTIFICIAL INTELLIGENCE

Organisme	DARPA (DoD)	ICOT (MITI)		SERC (Dept. of Industry)	
Projet	Strategic Computing	5 GCS		Alvey Programme	
Durée	5 ans (puis prolongé)	10 ans		5 ans (f)	
	10^6 \$	10^9 Y	10^6 \$ (a)	10^6 £	10^6 \$(a)
1982	-	0,4	1,6	2,0	3,5
1983	-	2,7	11,6	28,5	43,2
1984	50	5,1	21,5	48,0	64,0
1985	95	4,8	21,7	56	81,9
1986 (p)	150	12,0	55,0	64,5	94,4
1987 (p)	155	12,0	55,0	64,5	95,8
1988 (p)	150	12,0	55,0(e)	-	
...	-	...	...	-	
Total des fonds publics	600	100,0	400,0(c)	264,5	383,0
Grand total (b)	600 (d)	250,0	1000	352,0	558,0
Fonds publics en %	100	4	-	75	-

(a) aux taux de change courants, sauf après 1985 :
1 \$: 220 Yens et 1,463 £

(b) au taux de change de 1982

(c) 550 M \$ avec le privé si tout est réalisé

(d) la DARPA planifie un total d'un milliard de dollars d'ici à 1990-1992

(e) la somme est de 221 en 1988

(f) une faible partie d'Alvey (environ 10 %) est spécifiquement orientée IA

Source : CERDIC, d'après les données des tableaux précédents.

LITERATURE REFERENCES

(in the order in which they are cited)

ARNOLD E., GUY R. (1986) "Parallel convergence: national strategies in information technology" Frances Pinter, London, 1986, 220 pp.

TATSUNO S. (1987) "Les technopoles ou la regulation de l'intelligence" Les Editions d'Organisation, Paris, 1987, 305 pp.

JUNNE G., VAN TULDER R. (1988) "European multinationals in core technologies" John Wiley & Sons, IRM, Geneva, 1988, 286 pp.

JOWETT P., ROTHWELL M. (1986) "The economics of information technology" Macmillan, London, 1986, 108 pp.

BARREAU J., MOULINE A. (1987) "L'industrie electronique francaise: 29 ans de relations Etat-groupes industriels (1958-1986)" LGDJ, Paris, 1987, 240 pp.

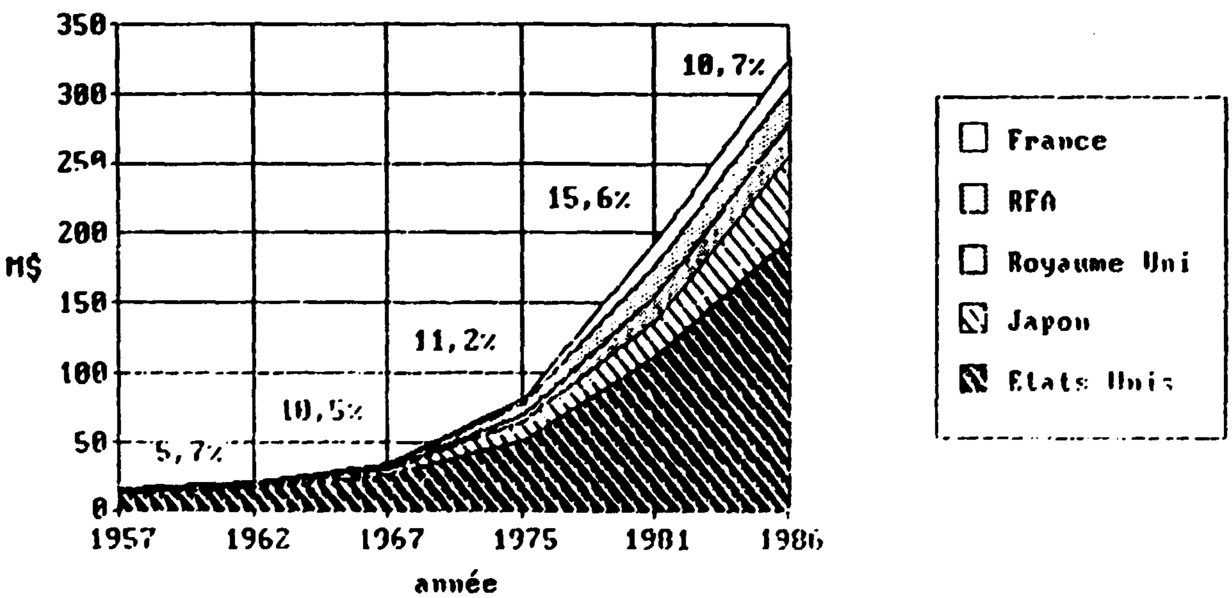
CHAPTER V

CHARACTERISTICS AND TRENDS OF THE PRINCIPAL WORLD MARKETS FOR PRODUCTS AND SERVICES

1. THE GENERAL MOVEMENT

1. The electronics industry has developed by a double movement of growth in the existing markets coupled with the multiplication of its applications. Amongst the latter the processing of information, or informatics, is certainly the most spectaular of all the "new" applications, new, that is, if one refers to the inter-war years when the dominant branch was mass consumer electronics (MCE). One of the characteristics of the post-war electronics industry, particularly during the seventies, was the replacement of consumer goods by capital equipment goods. Thus between 1957 and 1986, in the five leading industrialised countries, the share of MCE in the electronics equipment market fell from 30% to 15% (see Annex A8), giving way to industrial equipment. The second characteristic of the past evolution of the electronics industries is the considerable fall in the price of equipment, a fall which has been faster than that of the price of the electronic components and the raw materials used in their manufacture. Whilst facilitating the diffusion of new applications this situation has nevertheless made competition more intense (cf. Chapter III). However very rapid technological evolution has made an effective contribution to the dynamism of the market. The ephemeral nature of the market can be shown by the fact that 53% of the turnover at Hewlett-Packard was contributed by products less than three years old: 21% was due to products which had appeared during the year. This is the dynamic which has contributed towards the growth of the markets for the electronics industry in the major industrialised countries (Figure V-1).

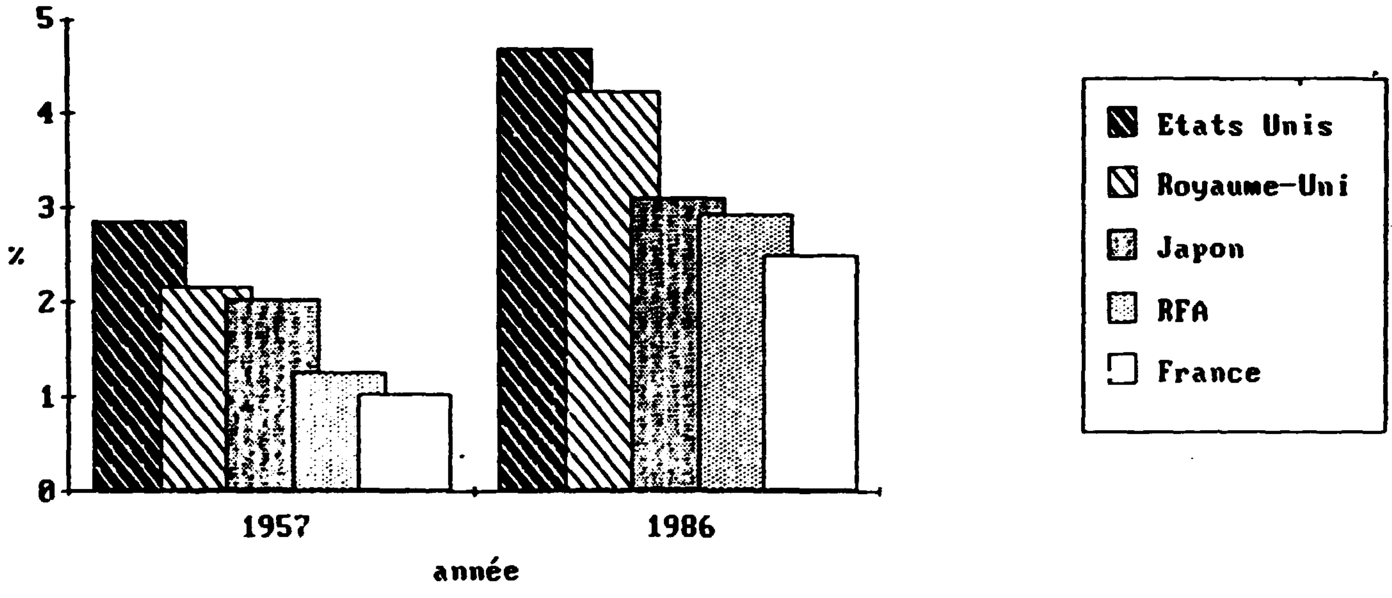
Figure V-1
GROWTH OF THE MARKETS FOR ELECTRONICS IN THE MAJOR INDUSTRIALISED COUNTRIES



Source :GERDIC

2. As a result of this considerable growth the markets for the electronics industry finished by representing a considerable proportion of economic activity. Taking into account the available figures for some industrialised countries (US, France, West Germany, Japan and the UK) it is possible to estimate the share of these markets in the GDP: in 1957 the figure was already 2.5%, by 1986 it was 3.9% (Figure V-2). It should be noted that this rise took place despite the rise in the contribution of services in Western economies, and also despite the persistent inflation of the seventies. Electronics products had, as we have already seen and unlike other sectors, fallen in value over the whole of the period. One may consider, therefore, that this ratio is characterised by a numerator effectively calculated in terms of volume and a denominator (the GDP) calculated in current values. We know that, in the United States, the electronics industry accounted for 7.5% of the total manufacturing production in 1975 and 15% in 1986. By the year 1995 this ratio should have reached about 32%, or one Dollar out of every three in manufacturing production would represent electronics.

Figure V-2
THE ELECTRONICS MARKETS AS A PERCENTAGE OF THE GDP



Source :GERDIC

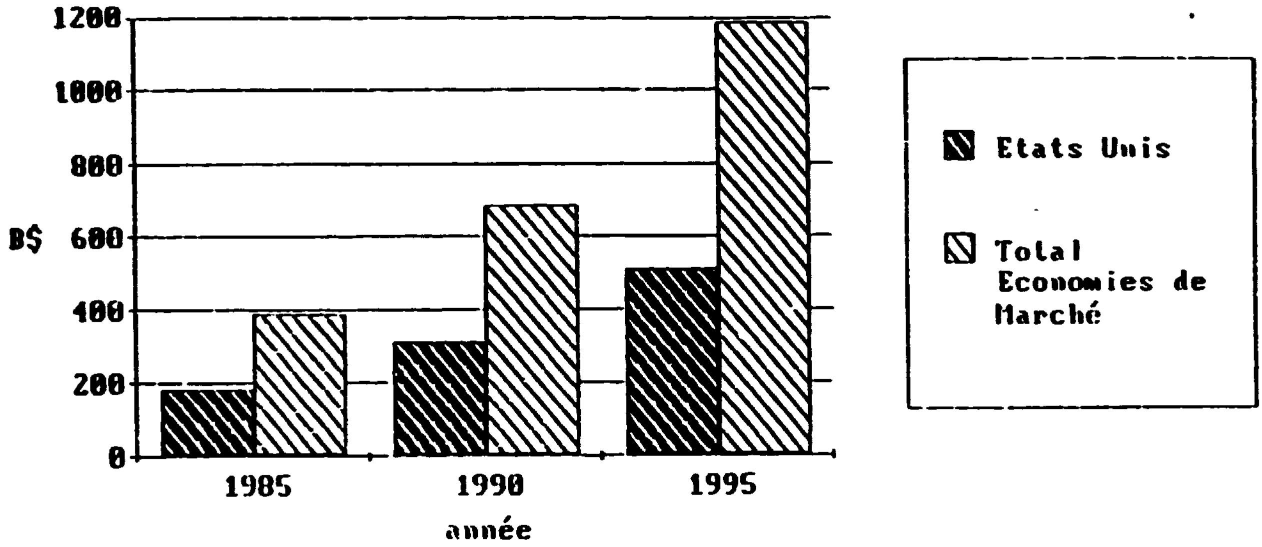
3. The end of the eighties was a severely disrupted period for world industry. After the strong recovery of 1982-1984 there followed a period of recession, and then of moderate growth, which particularly affected the electronics industries since the competition engendered the accumulation of excess production capacities, in particular in semiconductors and in informatics. The Stock Exchange crash of 19 October 1987 also cast a shadow on the prospects of growth, even though the previous pessimistic forecasts were exceeded. In fact the forecasting institutes are agreed in envisaging an honorable level of growth for the electronics industry. In the United States the increase should be 7.2% in 1988 according to WHARTON. In all fields investments in equipment goods seem to be recovering. MCE

should grow by 9% and the semiconductors market by 9.1%. The same trends seem to be operating in Europe, the more so since investment income is only a transitory and marginal part of the income of Europeans. The influence of the Stock Exchange crash will probably be even more moderate in this region. According to Dataquest the European markets should increase, between now and 1992, by 50% for 32-bit micro-computers, 30% for digital telecommunications and 26% for cellular radio. Finally in Japan the domestic market should be the driving force behind the growth of the electronics industries. The recovery plan of July 1987 will have contributed to a not inconsiderable extent to the maintenance of growth. Thus in 1987 electronics production in Japan increased by only 2.6% but exports fell by 2.2% (25.4% of this for MCE). The domestic market showed an increase of 7.3%, 11% for MCE. As a result of this recovery on the domestic market the EIAJ is counting on an increase in production of 7% in 1988; this indicates that Japanese electronics production will exceed US$ 150 billions.

4. The prospects for electronics do not therefore seem to be troubled by the cyclic variations in the world economy. Most recessions in these industries are provoked by endogenous causes. However, most experts consider that the growth of the electronics industries over the coming ten years will, with the exception of software, be less than that of the previous ten years, all other things being equal. This forecast will not be valid within the context of a revision of the position of the IMF or of the major world banks in respect to the debts of the developing countries. Whatever the position the consultants Henderson Ventures consider that the production of electronics equipment (that is to say excluding components) should rise in all the market economy countries by 11.8% between 1985 and 1990 but by 10.3% between 1988 and 1990 as compared with 11.6% between 1990 and 1995. In the United States alone, and over the same periods, the rates of increase will be respectively 11.2%, 9.4% and 10.5% (Figure V-3). At a more detailed level, but in a shorter term, the BIPE shows very different evolutions in the various segments of the market. These data, summarised in Table V-1, show the favoured fields of automation (mechatronics), opto-electronics and laser disk drives.

Figure V-3

WORLD MARKET FORECASTS FOR ELECTRONICS EQUIPMENT
(US$ billions)



Source : GERDIC d'après les statistiques d'Henderson Ventures.

Table V-1 : ANNUAL RATES OF GROWTH IN VARIOUS FIELDS OF ELECTRONICS (1984-1990)

Zone géographique	FRANCE		EUROPE		MONDE	
DOMAINE	TAC	Valeur du marché 1985 (MF)	TAC	Valeur du marché 1985 (M$)	TAC	Valeur du marché 1985 (M$)
Télécommunications						
Commutation	- 0,2	8 500	4,71	5 500	3,3	19 900
Transmission	- 2,4	2 400	1,10	2 100	7,9	9 200
Câbles	1,5	2 000	0,9	2 000	1,4	5 000
Terminaux	6,6	4 900	5,9	2 000	4,5	5 500
Spatial	11,9	200	3,8	300	- 3,1	2 300
Services	11,5	75 500	10,2	52 000	8,6	223 000
Informatique						
Ordinateurs, matériels	17,8	60 900	17,8	35 900	14,3	119 800
Bureautique	11,5	11 800	13,2	4 200	10,7	22 400
Services	18,2	23 400	19,4	14 400	18,8	74 800
Professionnel						
Militaire, Radio com	5,8	14 600	5,9	8 500	5,5	48 100
Radio Tv (professionnel)						
Automatique	22,4	6 800	22,4	4 700	23,4	19 100
Mesure	6,0	14 100	5,8	8 500	5,8	30 800
Médical	6,0	3 000	5,4	2 100	4,1	7 300
Grand Public						
TV	2,9	5 900	2,9	4 300	2,7	19 200
Lecteur CD	21,0	200	22,2	125	32,2	600
HIFI	5,2	3 100	4,5	2 000	7,5	6 300
Composants						
Tubes	0,0	2 600	1,1	1 600	0,9	6 600
Opto électronique	22,0	300	20,7	250	19,7	1 300
Circuits intégrés	12,9	6 500	13,5	3 700	13,3	22 000
Circuits passifs	6,2	9 700	6,2	5 800	6,5	28 400

TAC : Taux Annuel de Croissance (%)
Période 84/90

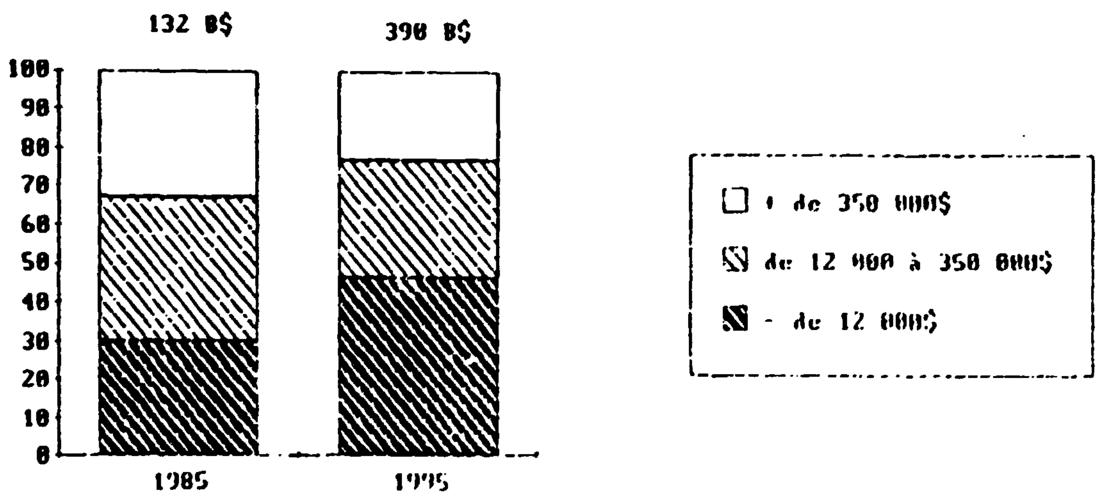
(1 $ (1985) = 9 F

Source : MEITO "Les industries de la filière électronique dans l'Ouest", février 1988, Rennes, 63 pages, d'après les données du B.I.P.E.

2. <u>Informatics : increasing power</u>

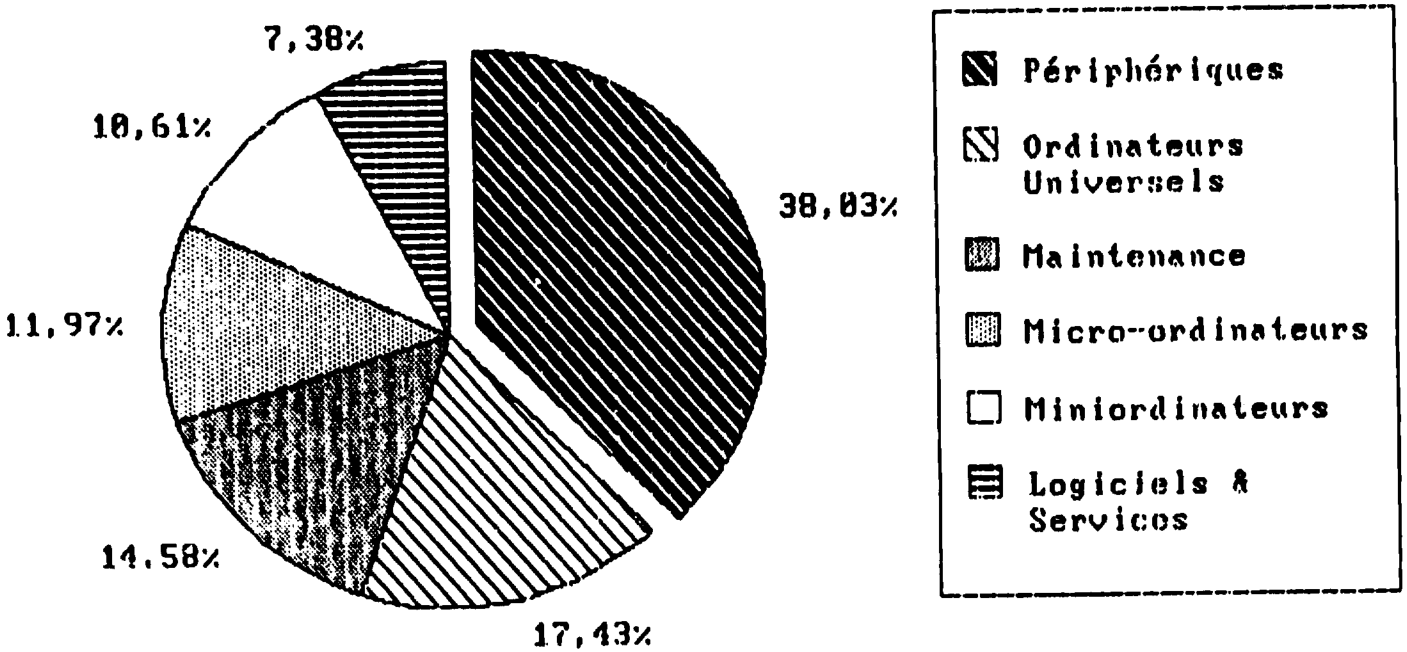
5. The most characteristic branch of the electronics industry since the Second World War is <u>the information processing or informatics industry</u>, which remains a challenge to global competition. Whilst the beginning of the eighties was notable for the diffusion of "elementary" micro-informatics the market has now opted for micro-informatics systems at the top of the range. Already the multi-user microcomputers of Sun Microsystems or Apollo Computer Inc. are coming into competition with mini-computers and even the universal computers in the fields of CAD and CAM. In the United States in 1995 <u>microcomputers should represent a considerable part of the market (Figure V-4)</u>. Such an evolution should result in the disappearance of minicomputers and will require a complete redefining of the product ranges by firms such as DEC, Data General, Nixdorf, Hewlett-Packard and Philips. By way of illustration the Series 1000 system of Arete Systems Inc. is capable of carrying out tasks at present handled by DEC's VAX 780, but is very considerably cheaper. Even the dominant groups in the BUNCH (BURROUGHS, UNIVAC, NCR, CDC and HONEYWELL) or IBM will be required to manoeuvre since <u>medium and large universal computers will no longer be built using exclusive hardware and software</u>. Locking the client into non-transportable software will no longer be considered, as was formerly the case. Victims of their basic hardware the producers of mainframes (universal computers) or minicomputers run the risk of remaining fixed to the architectures of the traditional systems (Von Neumann processors) and, furthermore, they manifest some lethargy in locating themselves in the new field of competition. However they have adequate cashflows and their historical acquisitions to operate a spectacular reconversion.

Figure V-4
THE STRUCTURE OF THE INFORMATICS MARKET IN THE UNITED STATES



Source : GERDIC d'après les statistiques d'InfoCorp.

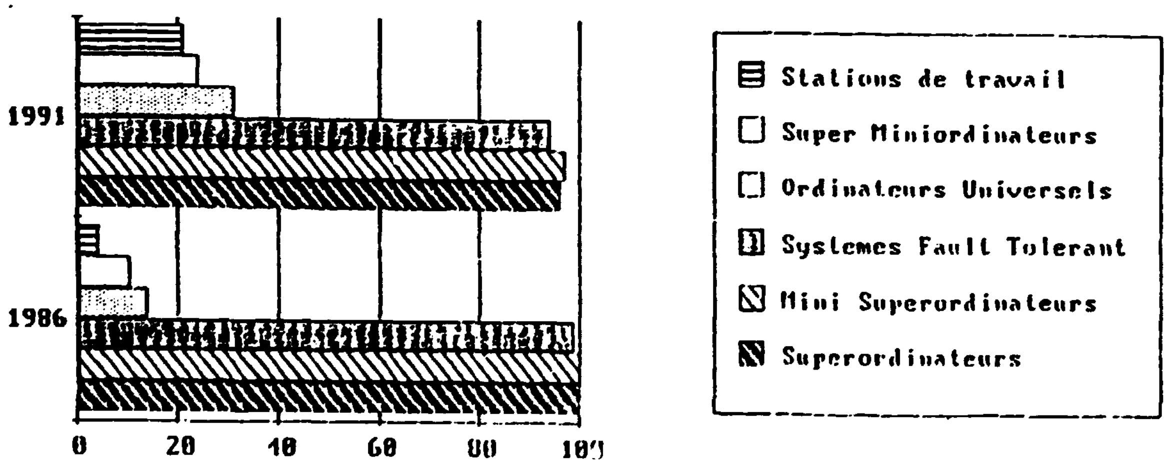
Figure V-5
THE STRUCTURE OF THE WORLD INFORMATICS MARKET IN 1986



Source : GERDIC d'après Datamation.

6. Whilst most computers handle data in series the newer machines are built around parallel processors which allow data to be processed simultaneously. In 1986 the world market for such machines remains embryonic, representing about 50,000 machines and a total value of US$ 31m. The value of this new type of architecture is that it considerably increases the speed of calculation. Many projects remain in the laboratory, but the major constructors have already announced products of the fifth generation of computers. IBM has shown its RISC (Reduced Instruction Set Computer), ATT is working with DARPA, an agency of the Ministry of Defense, on a parallel computer with speech recognition, and DEC has defined, with the Carnegy-Mellon University, a Parallel Process Architecture (PPA). However the introduction of this new generation will result in the sudden obsolescence of all ranges of machines at present in use, the more so since the software will not be transportable to the new operating systems, often based on ATT'S UNIX. This is why the principal sellers of vectorial machines are small independent firms such as SEQUENT COMPUTERS, ALLIANT COMPUTERS, N-CUBE or PARALLEL COMPUTERS. Called Crayettes, by way of allusion to Cray Research, the super-computer manufacturers, they offer minicomputers of very high power which are now competitive with the traditional computers, as we have seen in the previous paragraph. Despite the reticence of the traditional manufacturers this "parallel processing" will extend outwards into all types of hardware (Figure V-6) and should account for more than 30% of mainframes and 25% of super-minicomputers by 1991: it is already used in most super-computers.

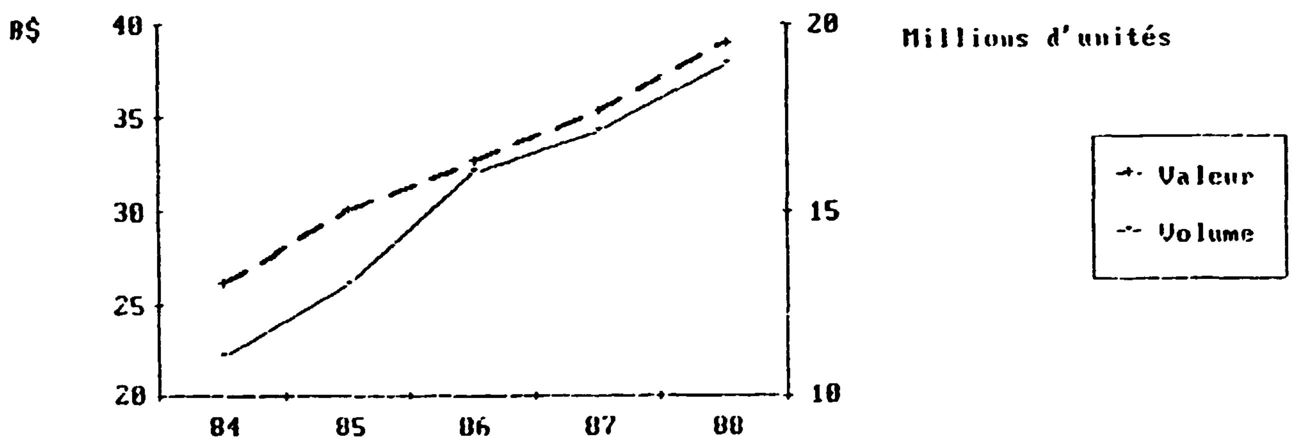
Figure V-6
WORLD APPLICATIONS OF PARALLEL PROCESSORS UP TO 1991



Source : GERDIC d'après les statistiques d'Electronic Trend.

7. Personal computers have also turned the profile of the industry upside down by allowing the development of companies such as Apple, Compaq or Tandon. Since its birth at the beginning of the eighties this market has benefitted from a double-figure level of growth in such a way that many firms have been tempted to enter it, leading to incessant price wars particularly since households have abandoned home computers to adopt the IBM PC-XT or its compatibles. The introduction of the new IBM model, the PS/2, built around the Intel 80386 32-bit microprocessor and using Microsoft's OS/2 operating system, has increased the dynamism of this market and has led Apple to announce price reductions on its MacIntosh II and MacIntosh SE models. Evaluation of this market is difficult, given the large number of producers in the world. The EIC values it at US$ 20 billion in 1986 and expects a growth of 12% between now and 1992. From its side DATAMATION estimates the 1987 market at US$ 23.7 billion: this would seem to be slightly underestimated when compared with that by Dataquest (Figure V-7).

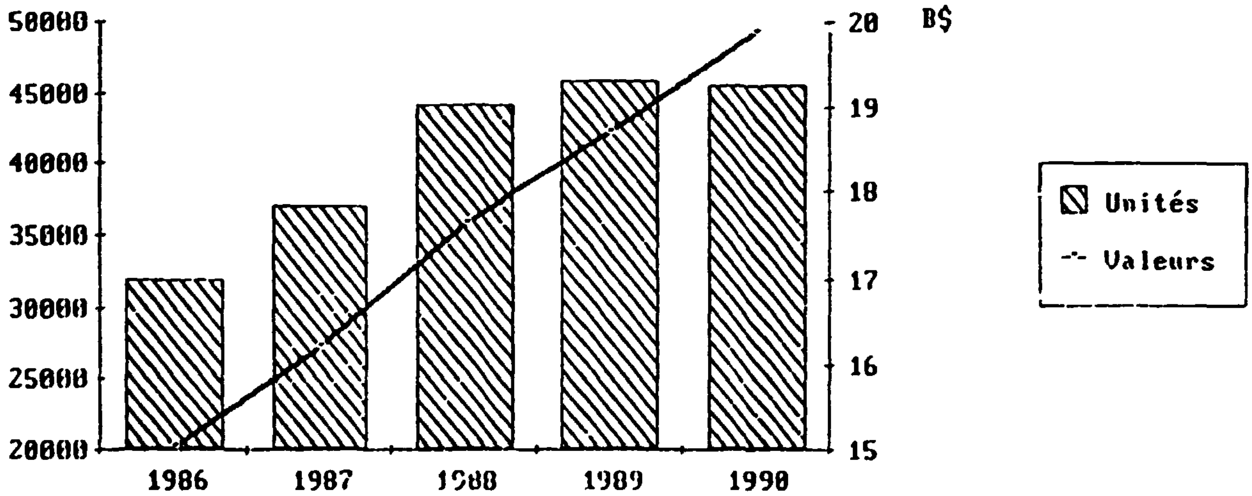
Figure V-7
WORLD SALES OF MICROCOMPUTERS BY AMERICAN PRODUCERS



Source : GERDIC d'après Electronic Business.

8. Taking these evolutions into account the market for minicomputers is subject to major upsets, particularly at the top of the range (machines costing more than 500,000 FF). Caught between the super-minis and the super-micros (microprocessor-based systems) the response of the industry is to propose vectorial processors (cf. 6): DEC is preparing its Vector VAX and IBM has announced its Silverlake. Despite that, the growth of this market is not likely to reach that of the other segments of the informatics market. A stagnation in the number of units is more than probable, the growth in the market being carried forward by the increasing power of these computers. It should at least reach 9% (Figure V-8). The manufacturers of mini-mainframes risk being amongst the victims of this change (Data General, Prime Computer and Wang), whereas those firms which have chosen niches (NCR, Siemens and Tandem Computers) will be less affected, particularly when then have opted for a UNIX environment. By contrast the market for the super-minicomputers, still dominated by IBM (22%), DEC (17%) and Hewlett-Packard (15%) should continue to grow significantly at more than 20% a year to reach US$ 13 billions in 1988 as against US$ 8.5b in 1986, that is to say about 100,000 machines sold every year as compared with 65,000 in 1986.

Figure V-8
PROSPECTS FOR WORLD SALES BY AMERCICAN PRODUCERS
OF TOP OF THE RANGE MINICOMPUTERS



Source : GERDIC d'après les données d'IDC.

9. The other segment of the market which has been disrupted by technological evolution is that of the universal computers or mainframes. Analysts consider that two-figure growth is now part of the past of this industry. Most buyers are now turning from large systems and buying smaller and less expensive systems or superminis. The redistribution of calculating power between a number of systems rather than being carried out by a central processing unit is becoming widespread. In fact with the arrival of 32-bit office or desktop computers, which can carry out several million operations per second (MIPS) the price/performance ratio is well

below that of the traditional machines. By contrast the cost per MIPS has risen, in the IBM range, with the number of MIPS the system is capable of carrying out. Finally the market is suffering from the relative scarcity of suitable applications programs. This explains the poor results of IBM in this segment of the market. The Armonk company, for which it represents 25% of its turnover, has suffered from a collapse in sales of the 3090 Sierra (-20%) to such an extent that the growth of IBM is now in the hands of micro-informatics (its OS/2 model) and software. With an expected growth of 7% in 1988 this still healthy market will definitely have reached its maturity, and reconversions or difficulties are now apparent in the case of some producers. The market represented US$ 26.9 billion in 1987.

Table V-2 : MAINFRAMES TURNOVER OF THE PRINCIPAL PRODUCERS

(millions de $)	1986	1984	%
IBM Corp.	14450	13131	10,04%
Fujitsu Ltd	2469,7	1399,7	76,44%
NEC Corp.	2274,9	913,8	148,95%
Unisys Corp.	2200	2901,1	-24,17%
Hitachi Ltd	1371.4	771,8	77.69%
Groupe Bull	821,9	500	64,38%
Honeywell Inc.	740	665	11,28%
Siemens AG	582,9	807	-27,77%
Cray research Inc.	525,5	169,7	209,66%
Amdahl Corp.	497,6	400	24,40%
STC Plc	486	362,9	33,92%
Control Data Corp.	400	813	-50,80%
National Semi.	300	250	20,00%
BASF	276.5	134	106,34%
Mitsubishi Electric	184,6	150	23,07%
NCR Corp.	174,2	1345	-87,05%
Sous TOTAL	27755,2	24714	12,31%
Autres	344,8	355,1	-2,90%
Grand TOTAL	28100	25069,1	12,09%

Source : GERDIC d'après DATAMATION.

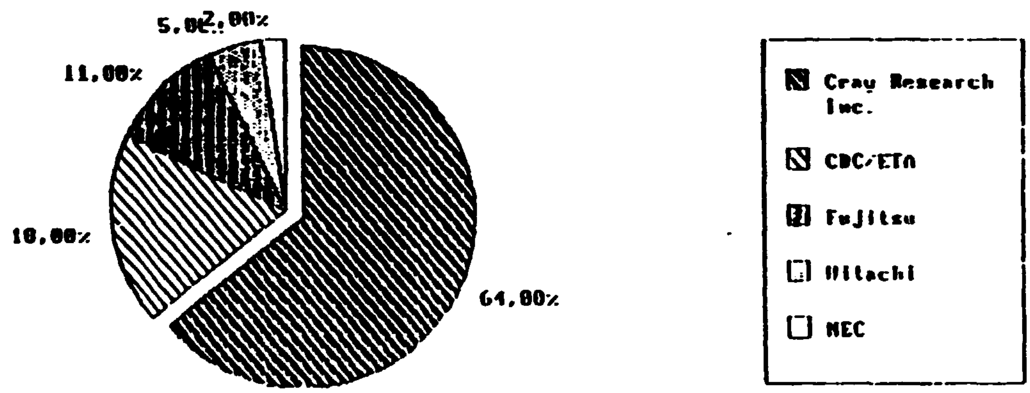
10. Competition is also becoming more severe on the super-computers market: there are now more producers than ever before. The dominant firm, Cray Research, after having dethroned Control Data, is now experiencing competition from Japanese and North Americam firms (Figure V-9). In Japan the three principal constructors, Fujitsu, Hitachi and NEC, are in violent conflict with NEC being the most active, trying to penetrate the American market by way of an agreement with Honeywell. The latter will market the SX-2 in North America. Furthermore Control Data (CDC) has facilitated the creation of a new company, ETA Systems Inc, in which it has an 89% shareholding. The ETA 10 is marketed in Europe through the CDC network. As far as the new firms like CHOPP Computer and SAXPY Computer are concerned their role on the market remains negligible. In Europe the prototype SUPERNODE which is a result of ESPRIT was shown in the Autumn of 1987. The price ranges of these machines show to what an extent the buyers club is favoured (70 new machines a year). However the market is growing very rapidly, at between 25% and 30% a year, whilst prices are falling; the Cray I, launched in 1976, cost US$ 10 million whilst a machine twice as fast such as the ETA-10Q costs US$ 8m. The high rate of growth is also explained by the increasing needs for modelling techniques in the aeronautics, automobile and nuclear industries. However

this segment of the market remains limited since it only accounted for US% 705m in 1987 if one excludes vectorial processors, minisuper-computers and the top of the range of mainframes.

Price of a configuration (US$ millions)

ETA-10	8-22
NEC SX-2	15-25
CRAY-MP	4-20

Figure V-9
MANUFACTURERS ON THE SUPER-COMPUTERS MARKET IN 1986

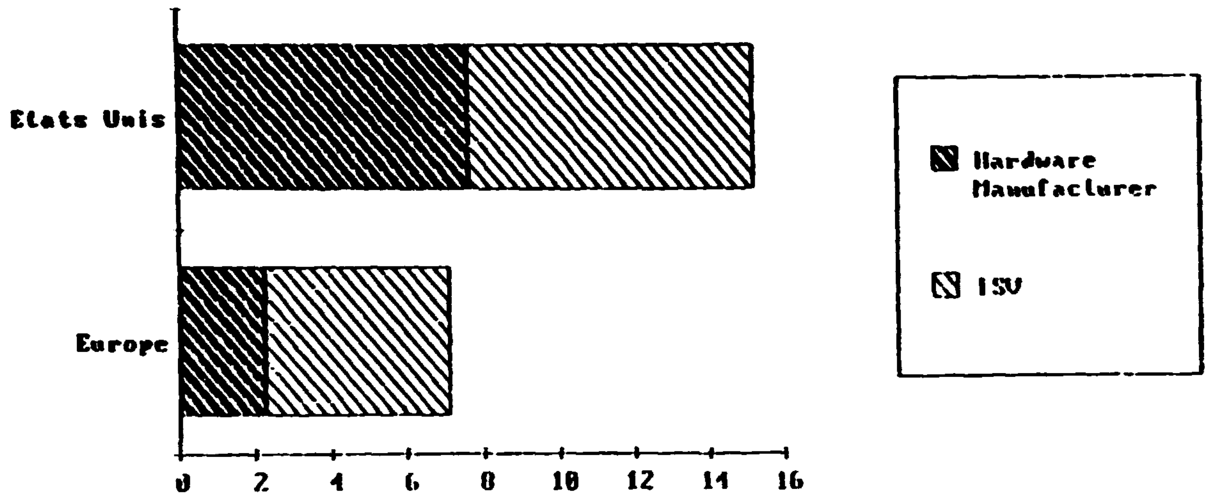


Source :CERDIC d'après Electronic Business.

3. SOFTWARE : THE CROSSROADS

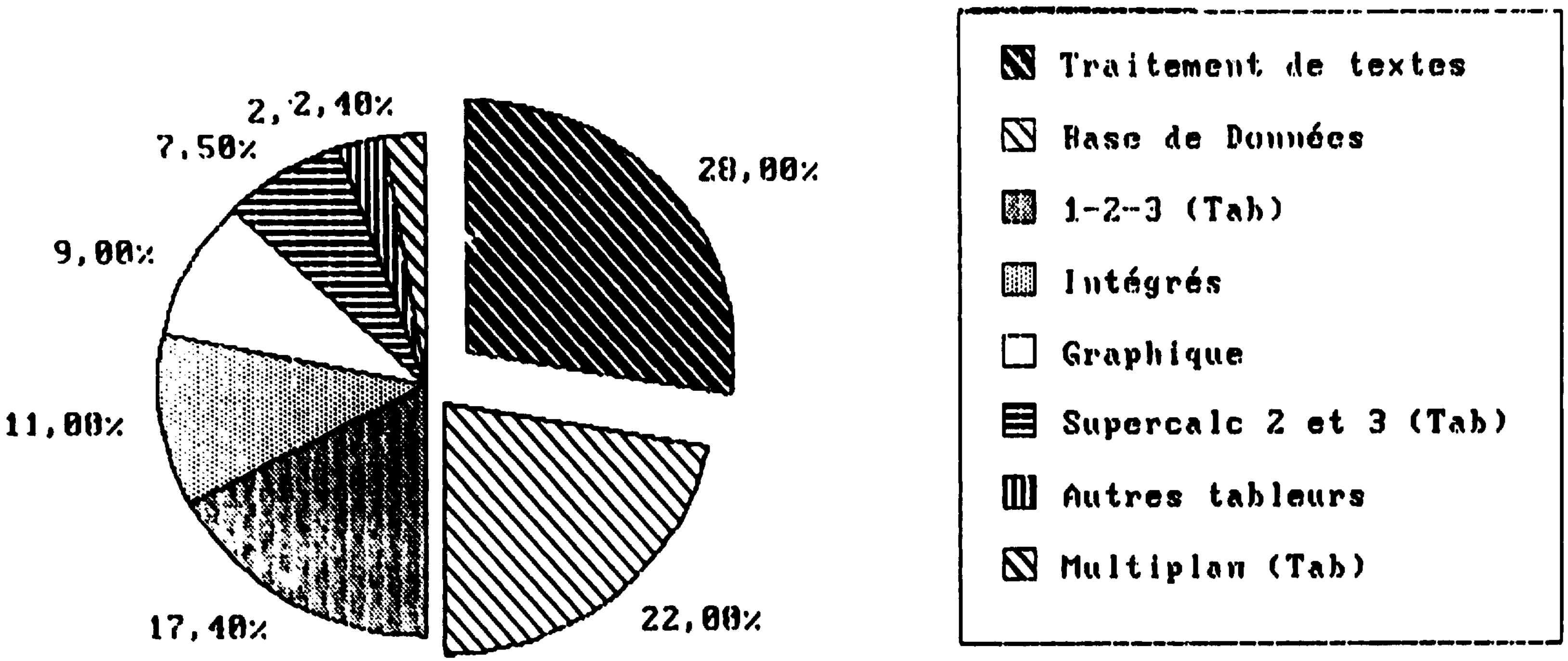
11. It was in the middle of the seventies that the real measure of the crucial role of software in the world electronics industry could be taken. The value of this market is very difficult to evaluate, depending on whether informatics services or software maintenance are incorporated in it. Whilst the hundred leading firms in the world software industry had a total turnover of US$ 17.0b and US$ 15.2b respectively for software and services, according to the DATAMATION magazine. EIC, the Electronics International Corporation evaluates the market at US$ 66.5b, of which applications programs and customised software account for US$ 38b. With an extremely low entry cost this industry has enjoyed a level of growth which has remained between 10% and 20% per year, and it should maintain this level up to the middle of the nineties. Decentralised informatics, born with the mini-computer and widely disseminated with the development of micro-computers, has considerably modified the profile of this industry. The adoption by IBM in 1981 of the MS/DOS operating system from the independent firm Microsoft characterises this new situation of the eighties when the ISV's (Indepndent Software Vendors) were able to impose their standards (Figure V-10). The explosion of the market led in 1984 to the establishment of the first international software exhibition, SOFTCON, in New Orleans.

Figure V-10
BREAKDOWN OF THE SOFTWARE MARKET BETWEEN HARDWARE MANUFACTURERS AND INDEPENDENT SOFTWARE VENDORS



Source : GERDIC d'après Electronic Business et Datamation.

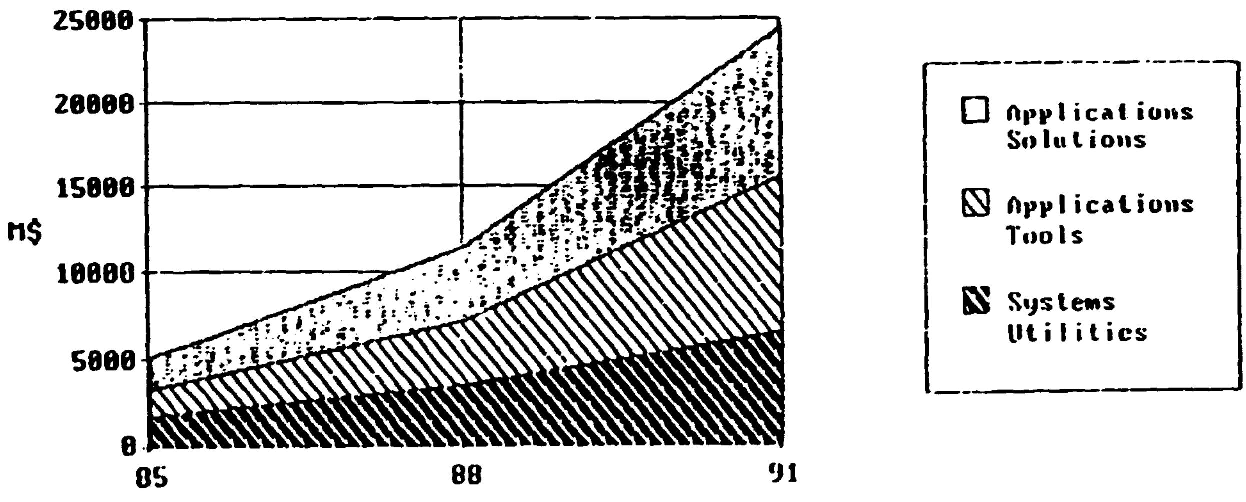
Figure V-11
THE STRUCTURE OF APPLICATIONS PROGRAMS BY APPLICATIONS



Source : GERDIC d'après Romtec et Lotus

12. However this industry still has recourse to archaic production methods. Whilst the power of computers is doubling every two or three years, and the length of the programs increases by 25% a year, the number of programmers is only increasing by 4%. Furthermore the older softwares, installed some twenty years ago, have been modified to keep up with evolutions in needs and hardware. Modifying these programs is found to be increasingly difficult, and reduces their efficiency. The maintenance of software now absorbs 60% of information processing budgets. These constraints have favoured the development of CASE (Computer Assisted Software Editing). Initiated by France and Great Britain within the framework of an ESPRIT project with financing of US$ 690m CASE has now been taken over by Japanese industrialists in the SIGMA project (US$ 200m). According to Texas Instruments expert CASE systems should represent a market of US$ 2 billion by 1992. The spread of CASE clearly influences the forecasts for the growth of the market. International Data Corp. evaluates the 1990 United States market for applications software as about US$ 40b: according to this company it was US$ 8b in 1983 and US$ 21b in 1986. In Europe the market will tend towards US$ 25b by the date of the application of the Single Act as against US$ 5b in 1982 (Figure V-12). The EIC forecasts slightly more modest rates of growth, of the order of 20% to 22%, but these will nevertheless remain very satisfactory.

Figure V-12
FORECASTS FOR THE EUROPEAN APPLICATIONS PROGRAMS MARKET
(US$ millions)



Source : GERDIC d'après les statistiques d'IDC.

13. As in the case of the conventional software the operating systems (OS) are also lagging behind the new computers. Software which emulates the essential functions of the machine must carry out tasks common to all applications softwares. The first generation of OS for micro-computers was Digital Research's CP/M, dethroned by Microsoft's MS/DOS. But the software designers proposed integrated applications which simultaneously emulate several programs while each program, increasingly simple for the user, has more and more functions which demand more memories. An OS using MS/DOS can control only 640k of central memory, a capacity which begins to be obsolescent in respect of the requirements of users and the potential of the technology. This lag is even more clearly seen with the widespread use of the Intel 80386 32-bit microprocessor. Although it can simultaneously activate different programs and use considerable amounts of memory this microprocessor has not so far found an OS which optimises its utilisation. With the IBM PS/2 Microsoft has offered the operating system OS/2 so as to maintain the domination of DOS in micro-informatics: in the United States is likely to rise from 68% in 1986 to 84% by 1990.

14. By contrast in other fields of informatics the search for an international standard and the transportability of applications software has led increasing numbers of manufacturers to adopt the UNIX OS, developed in 1969 by ATT. Initially marketed by the manufacturers of multi-user supermicro-computers, such as Altos Computer or Plexus Computers, UNIX is finding increasing numbers of applications in the flexible workshop, CAD/CAM and super-computers. This is why INTEL has configured its new family of 80X86 microprocessors to work under UNIX. On 17 May 1988 the consensus of manufacturers resulted in an agreement between IBM, DEC, Apollo, HP, Bull, Nixdorf and Siemens to develop a new standard derived from UNIX. Despite its purchase of Sun Microsystems, a company producing work stations, and its desire to control coming developments in this OS, ATT lost control of its software. However ICL, Xerox and Unisys (the result of the Burroughs-Sperry merger) rallied to Sun-ATT. The stakes are high, representing the last chance for ATT to maintain its place on the informatics market. If one computer in a hundred was operating under UNIX in 1981 this market will need to be multiplied by twelve, in Europe, between now and 1991. Apple itself announced a UNIX OS for its MacIntosh II in February 1988.

15. Artificial Intelligence (AI) covers many fields of applications in which specific software loaded into sufficiently powerful machines makes it possible to offer diagnoses, to assist design work, to translate texts, etc. The software used in these expert systems refers to reference bases to "reason" and to arrive at conclusions. This field has been explored for nearly thirty years now, and AI depends more particularly on two languages, LISP (1958) and PROLOG, which make it possible to process symbols as well as numbers, in such a way that they are much faster than other programming languages such as Basic, Cobol or ADA. In 1985 the first "expert" softwares appeared, and most manufacturers have now offered LISP or PROLOG compilers. Many companies have been created and governments are multiplying their financing facilities. In this ferment of activities it is difficult to evaluate the market. In 1985 it was estimated at US$ 200m in the US: it should reach US$ 4b to 10b in 1990 and US$ 30-40b by 1995, taking hardware and software together. The software (natural and AI languages) would have represented US$ 60 in 1985, but the market should increase by more than 60%. Table V-3 sets out the lower hypotheses.

Table V-3 : **THE NORTH AMERICAN MARKET FOR ARTIFICIAL INTELLIGENCE (US$ millions)**

Millions de dollars	1986	(%)	1990	(%)	Δ(%)
Systèmes Experts	145	11,5%	810	18,3%	53,7%
Languages Naturels	125	9,9%	650	14,7%	51,0%
Reconnaissance visuelle	260	20,6%	840	19,0%	34,1%
Reconnaissance vocale	40	3,2%	250	5,6%	58,1%
Langages IA	35	2,8%	105	2,4%	31,6%
Ordinateurs IA	510	40,3%	1570	35,5%	32,5%
Contrats Fédéraux	150	11,9%	200	4,5%	7,5%
TOTAL	1265	100,0%	4425	100,0%	36,8%

Source : SESSI d'après Electronic Business.

4. <u>TELECOMMUNICATIONS : COMPRESSION AGAINST ISDN</u>

16. <u>The telecommunications industry</u> is, above all, characterised by its convergence with informatics. In ten years the fusion of the two fields has been completed with the development of services such as speech mailboxes, electronic mail and video-conferencing. Simultaneously new opportunities have emerged such as private networks, smart buildings and Local Area Networks (LAN). From this ferment has resulted the disappearance of the frontier between private and public networks, and in the same way it has become difficult to distinguish between switching and transmission. However analysts are agreed in considering that certain segments of the market will stagnate or decrease in the United States and in Europe between now and the start of the nineties (Tables V-4 and V-5). Public exchanges will form a stagnant market, and the same will apply to PBXs as long as the ISDN (Integrated Services Digital Networks) have not been completed. However large firms, whose telecommunications budgets are considerable by reason of the large quantities of data they transfer, are forced to bypass the public networks and to replace them with their own network. This growing trend should offer an interesting outlet for the producers of cellular equipment (Motorola, NEC, Matra and Siemens) and high speed multiplexers. The growth of these segments of the market should fall off in the middle of the nineties with the installations of ISDN in the industrialised countries. Digital networks offer users attractive services at reasonable cost, so dissuading them from bypassing the public networks. The global prospects for the market makes it possible to envisage the increased sophistication of equipment intended for the users which will result, with the ISDN, in the installation of videophones or other futuristic communications equipment. Simultaneously one must expect a reduction in transmission costs as a result of the multiplication of wideband fibre optics networks and signal compression-decompression techniques (CODEC) which will make it possible to increase the number of data handled by the network. This will affect the market for packet transmission which will begin to fall off from 1993 onwards in the United States, after having increased by 25% between 1987 and 1991.

Table V-4 : FORECASTS OF THE EUROPEAN TELECOMMUNICATIONS EQUIPMENT MARKET (US$ millions)

Millions de dollars	1986	(%)	1991	(%)	(%)
Terminaux	3565	28,1%	4583	27,0%	5,15%
Commutation publique	3032	23,9%	2733	16,1%	-2,06%
Commutation privée	2829	22,3%	2903	17,1%	0,52%
Transmission	1535	12,1%	2122	12,5%	6,69%
Transmission de données	1421	11,2%	3293	19,4%	18.30%
Communications cellulaires	266	2,1%	968	5,7%	29,48%
Autres Equipements	38	0,3%	373	2,2%	57,90%
Total	12687	100,0%	16975	100.0%	5,99%

Source : GERDIC d'après Electronique Hebdo. 7/05/1987.

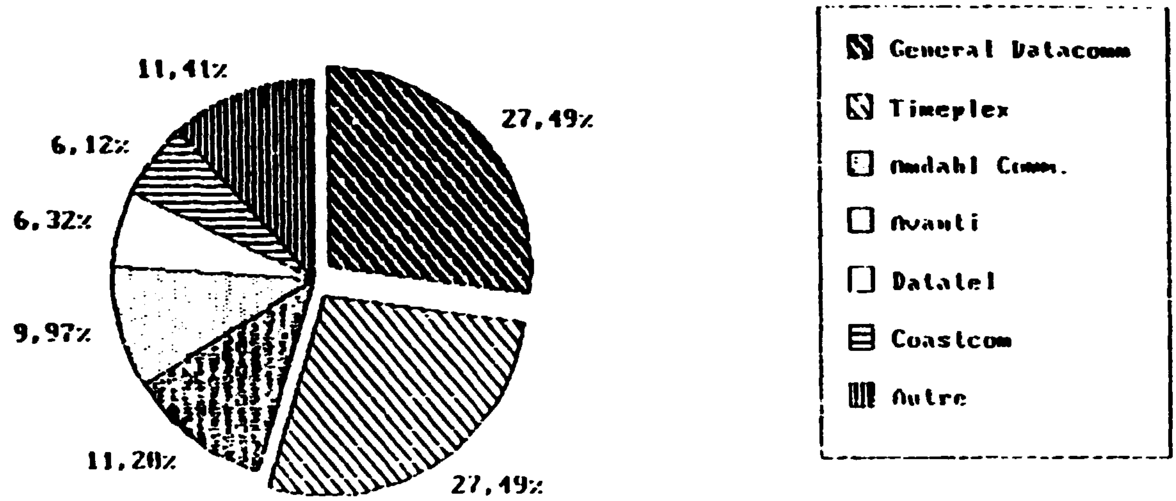
Table V-5 : FORECASTS OF THE NORTH AMERICAN TELECOMMUNICATIONS EQUIPMENT MARKET (US$ millions)

Millions de dollars	1985	(%)	1990	(%)	(%)
Terminaux	1243	5,54%	2018	6,63%	10,2%
Commutation Publique	6005	26,76%	5100	18,92%	-3,2%
Commutation Privée	5247	23,38%	4072	15,11%	-4,9%
Transmission	4532	20,19%	7420	27,53%	10,4%
Fibres Optiques	725	3,23%	1838	6,82%	20,4%
T-1 Multiplexeur	145	0,65%	562	2,09%	31,1%
Communications Cellulaires	528	2,35%	920	3,41%	11,7%
Datacom	1992	8,88%	6136	22,77%	25,2%
Bypass cellulaires	228	1,02%	556	2,06%	19,5%
Autres	1799	8,02%	1811	6.72%	0,1%
Total	22444	100,00%	30433	100,00%	6,3%

Source : GERDIC d'après Electronic Business, données de Dataquest

17. The most dynamic segment of the transmissions market involves the T-1 multiplexers (MUX), the name of which comes from the technical specifications for this equipment which is able to transmit digitised data at a rate of 1.5 Megabits/second, that is to say the equivalent of 24 telephone conversations, using a single channel. Companies which have constructed some dozens of local networks can use them for long-distance communications using the T-1 MUX. Finally the T-1 allows the fusion of digitised telephone conversations and data. The price of such equipment, US$ 50,000 to US$ 100,000, can be amortised over four to six months from the resultant economies.

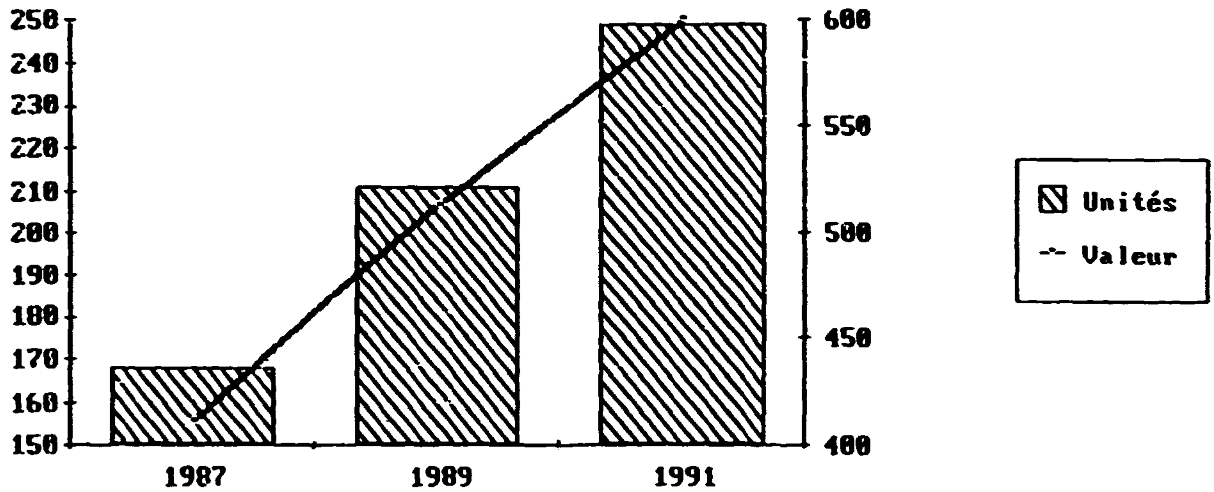
Figure V-13
MANUFACTURERS ON THE WORLD MARKET FOR T-1 MUX IN 1985



Source :GERDIC d'après Electronic Business, données d'IDC.

18. The increased power of micro-computers and the speed of signal processing requires increasingly rapid units for connection to the telephone network (modulator/demodulators or MODEMs). The standard now requires a minimum speed of 9600 bits/second. The V.32 standard, as defined by the CCITT, has not been adopted by all manufacturers, and the price of the units remains high at US$ 2000 each. This is why sales still remain limited to applications where cost is secondary in relation to performance. On the hypothesis of a fall in prices it is certain that this market will develop very rapidly. However price reductions are difficult to operate as long as the complex CCITT standard increases the cost price. This is why certain companies, like Telebit, have opted for their own protocol which the CCITT seems prepared to accept as a world standard for the bottom of the range of high-speed modems.

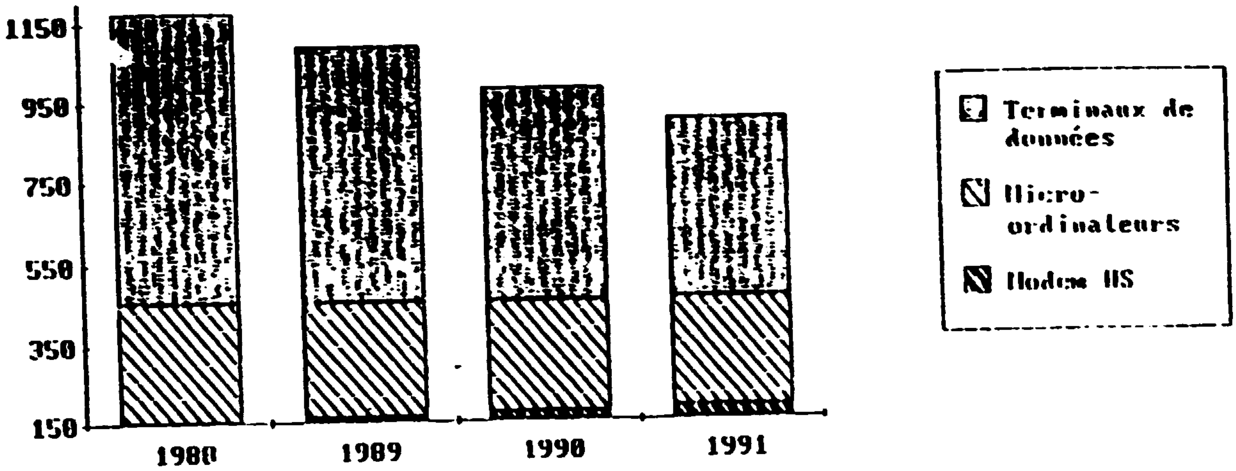
Figure V-14
TURNOVER ON 9600 bps MODEMS FROM AMERICAN MANUFACTURERS



Source : GERDIC d'après IDC.

19. The increasing volume of digital data passing through the telecommunications network has led to several upsets. The T-1 MUX represent one of the aspects of this change, but data compression and fibre optics have also caused a technical break-point. Data compression provides considerable transmission economies since speech can be transmitted at 16 kbits/second and images (video-conferencing) at 64 kbits/second instead of the 144 kbps which is the ISDN standard. This technique partly reduces the attraction of fibre optics since transmission requirements can be reduced. It upsets the modem market since it makes it possible to double or treble speeds, so reducing the interest in the 9600 bits/second modems (cf. 18). The absence of a single standard for the latter risks favouring the 2400 bps modem which, equipped for data compression, can provide 7200 bps for a price which is much lower than that of a high-speed modem. Furthermore the rest of the modem market consists of those integrated with microcomputers so that the only remaining outlet for modems is the OEM market, but PCs are increasingly integrating modems. This is why the growth of the market in terms of volume should be 11.4% per year in the United States between 1988 and 1991 for high-speed modems and 16.7% for modems integrated into a PC. By contrast the market for the other varieties of modems should decrease by 2.5% per year. Figure V-15 shows the evolutions in terms of value. Despite annual deliveries rising from 2.2m to 3m units the falling prices will result in a reduction of 8.5% in the value of the United States market.

Figure V-15
THE NORTH AMERICAN MARKET FOR MODEMS (US$ millions)



Source : GERDIC d'après Dataquest.

20. The most numerous applications for fibre optics cables and components are not in the national telecommunications networks but rather in users' equipment and local networks. Two factors have operated in this direction. Firstly the price of the active components has fallen considerably, with the opto-electronics for a fibre optics transmitter falling from US$ 2000 to US$ 500-600 in 1987, with an expected price of US$ 100 in the near future. Finally standards have been defined for local fibre optics networks, the Fibre Distributed Data Interface (FDDI). Fibre optics networks to the FSSI standard could transmit data at 100 Megabits/second. Many semiconductor manufacturers are trying to supply integrated circuits to the FDDI standards. Marketed initially at US$ 100 each these components will be integrated into PCs, particularly in CAD/CAM work stations. Traditionally dominated by telecommunications the market for fibre optics (cables and components) should be progressively dominated by data communications which, in the United States, is likely to represent a third of the market by 1992 (Table V-6).

Table V-6
UNITED STATES MARKET FOR FIBRE OPTICS (US$ millions)

Millions de dollars	1986	(%)	1992	(%)	(%)
Marché Fibres Optiques	875	100,00%	2700	100,00%	20,66%
dont optoélectronique	638	72,91%	2200	81,48%	22,91%
dont Datacom	137	15,66%	812	30,07%	34,53%
dont Connecteurs	52	5,94%	145	5,37%	18,63%

Source : GERDIC d'apres Electronic Business.

5. MECHATRONICS : THE GREAT EXPANSION

21. Automation calls on practically all sectors of electronics: computers, controllers, semiconductors, artificial intelligence, etc., all of which form the brain of the Factory of the Future. The muscles are the robots, the programmable machine-tools and the automatic handling equipment. Finally the senses consist of the probes and sensors which evaluate the temperature or detect vibrations. Finally it also incorporates the various forms of Computer Aided Design (CAD) and automatic testing. According to work by the BIPE the world market was estimated at US$ 15 billion in 1983 and should reach US$ 85b by 1990, with an annual increase varying between 20% and 25%. Mechatronics touches all the sectors, whether involving continuous processes (energy, chemicals) or batch processes (automobiles, electro-electronics industry, etc.). The energy industry alone represents 25% of the market. Furthermore automation is spreading progressively into small and medium sized companies, since all functions are found to be automatable. Table V-7 shows the expected growth of this market in the United States by the various observable segments.

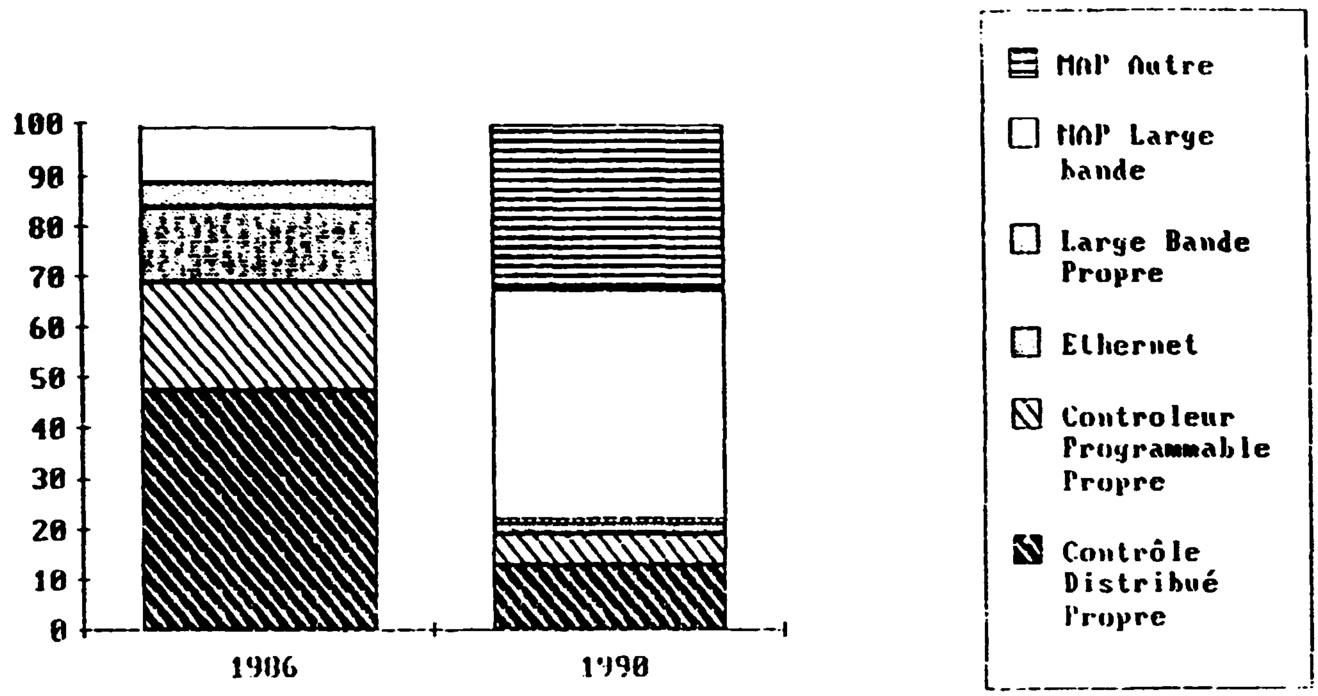
Table V-7
UNITED STATES MECHATRONICS MARKET (US$ millions)

Millions de dollars	1985	(%)	1990	(%)	1995	(%)	(%)
Machines Outils	5300	20,87%	9700	18,51%	1800	18,31%	13,0%
Manutention Automatisee	5000	19,69%	8900	16,98%	15000	15,26%	11,6%
Contrôle et Communications	3800	14,96%	8400	16,03%	14500	14,75%	14,3%
Contrôles de Procedes	3100	12,20%	5500	10,50%	10000	10,17%	12,4%
Test & Inspection Automatique	3000	11,81%	7200	13,74%	12000	12,21%	14,9%
Senseurs/Palpeurs	2400	9,45%	4700	8,97%	9300	9,46%	14,5%
CAO/DAO	1700	6,69%	4500	8,59%	12000	12,21%	21,6%
Controleurs Programmables	700	2,76%	1400	2,67%	3000	3,05%	15,7%
Robots	400	1,57%	2100	4,01%	4500	4,58%	27,4%
TOTAL	25400	100,00%	52400	100,00%	98300	100,00%	14,5%

Source : GERDIC d'après Electronic Business

22. The first problem is that of orchestrating machines of all types so that they produce a symphony rather than a cacophony. It has therefore been necessary to develop a standard communications protocol which will allow many machines to communicate with each other. The local networks proposed are of different types and, initially, protocols will differ from one producer to another. However General Motors seems to have imposed a de facto standard with its Manufacturing Automation Protocol (MAP). Taken over by the major producers of local networks such as Ungerman-Bass Inc. this protocol will probably dominate the market in the nineties at the expense of the LANs derived from the informatics industry such as Ethernet (Figure V-16), and could account for 78% of the applications. The success of this protocol is due to the fact that it depends on the Open Systems Interconnection (OSI) standards approved by the Internatioal Standards Organization. In the United States this market should reach US$ 500 million in 1990 with an annual rate of growth of 30%.

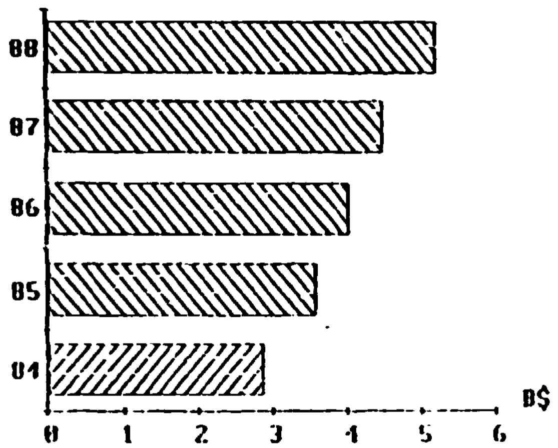
Figure V-16
CHANGES IN THE INDUSTRIAL LAN MARKET BY MARKET SEGMENTS



Source : GERDIC d'après les données de Venture Development.

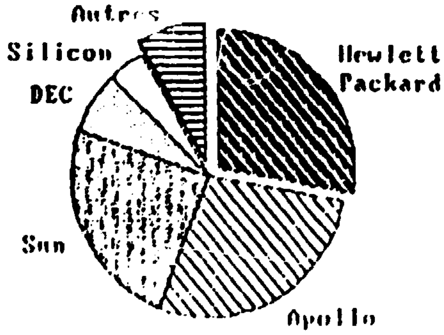
23. One of the most promising segments of the automatic market is that of Computer Aided Design and Computer Aided Manufacture (CAD/CAM) and the work stations which are linked with these activities. Very dependent on business cycles this market should grow by 12% in 1988. But industry is subject to an unprecedented consolidation, many firms being bought up or disappearing. Thus in the United States MENTOR Graphics has merged with CAEDENT Corp. and INTEGRATED Measurement Systems, whilst TERADYNE has bought AIDA Corp. The most spectacular rapprochement remains the 20% shareholding taken out by ATT in SUN Microsystems: these two firms are cooperating in developing a new RISC microprocessor (cf. V.6) and enlarging its applications under UNIX (cf. V.4). Simultaneous with and contributing towards these restructurings are the raging price wars. In the United States work stations at the bottom of the range were being sold at US$ 5000 in March 1988 as against US$ 40,000 in 1985. Furthermore conventional work stations are now meeting competition from the 32-bit PCs built round the 80386 microprocessor: these latter can run under UNIX. But the market remains lively. The global turnover of North American constructors was US$ 4.9 billion in 1988 for CAD/CAM systems in general and US$ 2.9b (60%) for work stations alone. Its growth in the coming years will be between 15% and 20% (Figure V-17).

Figure V-17
WORLD SALES OF CAD/CAM SYSTEMS FROM
NORTH AMERICAN PRODUCERS



Source : Daratech Inc.

THE PRINCIPAL NORTH AMERICAN SELLERS IN 1986



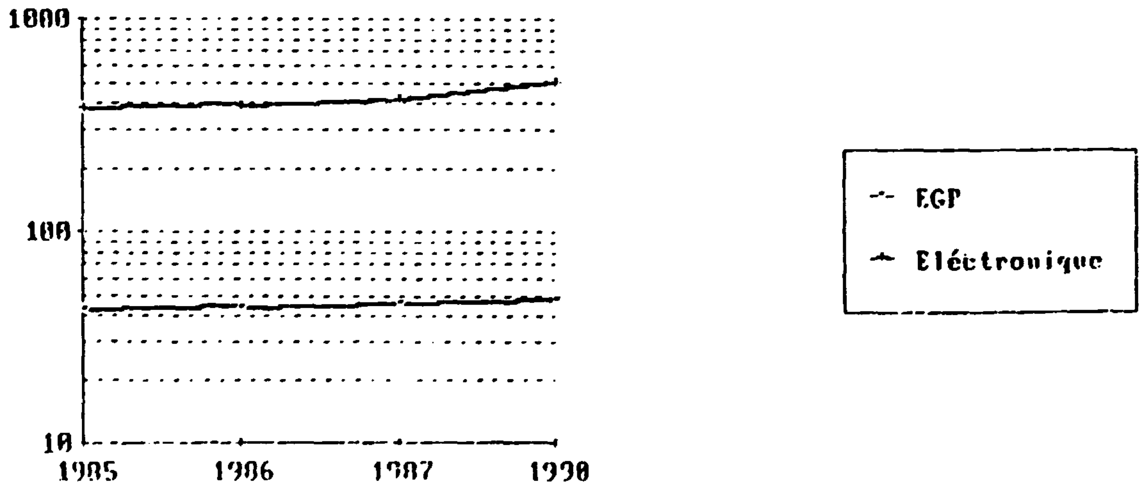
Source : IDC

6. MASS CONSUMER ELECTRONICS : THE LAST GASP?

24. More than half of the electronics products sold to the public in 1986 did not even exist ten years earlier: video-recorders, laser discs, personal computers and electronic watches. The movement will continue, but most of the industrialists in the sector believe that introductions of radically different products are likely to be less numerous in the nineties. Essentially it will be a case of the existing or announced products being reduced in size and falling in price. The problem will be one of maintaining the interest of the consumer in these improved products: this is why analysts forecast a reduction in the margins of the industry.

25. Price wars run the risk of penalising the growth of the market, and the BEP statistics show a world MCE market of US$ 45.2 billions in 1987 and US$ 47.1b in 1990, an annual increase in value of 1.4%. Mass consumer electronics will thus fall from 11% of the world electronics market to 9.5% in 1990 (Figure V-18), with a downward movement in terms of relative value which began after the Second World War. However major modifications in the structure of the MCE market are forecast with High Definition TV, laser discs or the introduction of electronics components into domestic electrical appliances.

Figure V-18
FORECASTS FOR THE WORLD MCE MARKET (US$ billions)



Source : GERDIC d'après les données de B.E.P.

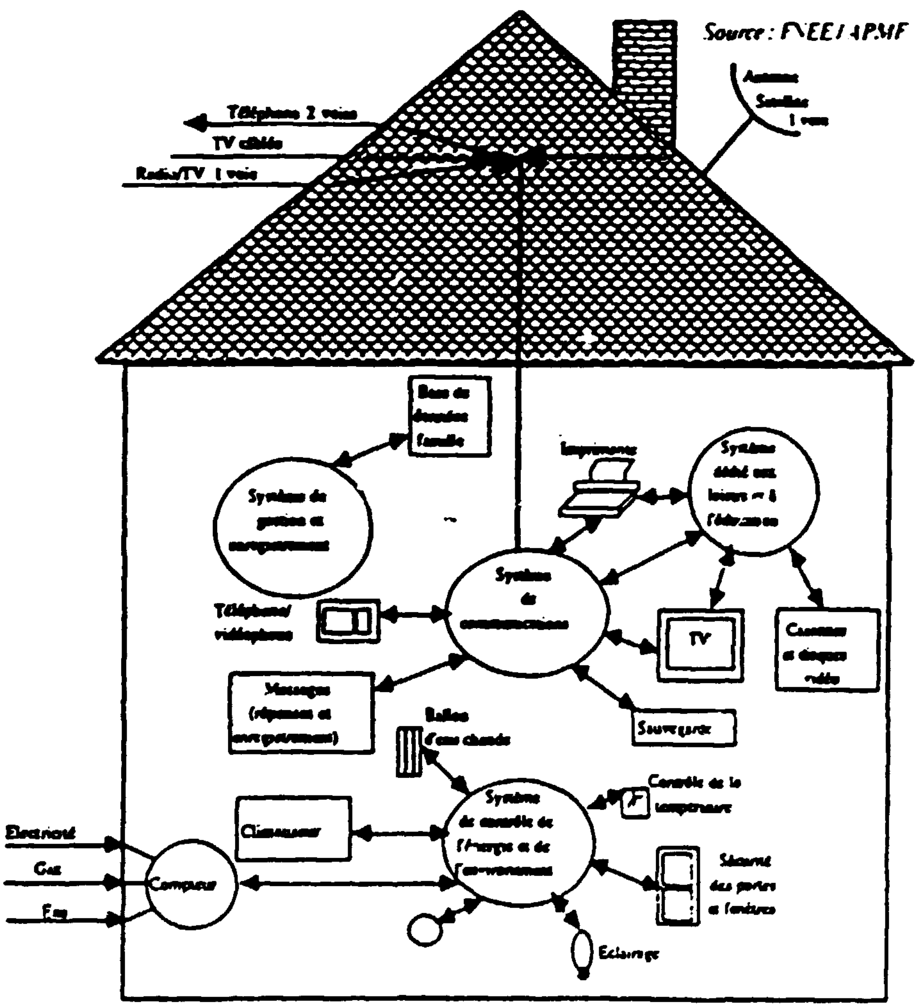
Table V-8 : THE MCE MARKET IN THE MAJOR INDUSTRIALISED COUNTRIES BETWEEN 1974 AND 1984 (US$ millions)

Millions de dollars	1984	(%)	1979	(%)	1974	(%)
Etats Unis Total	19190,6	100,0%	11848,8	100,0%	6908,2	100,0%
TV	5684,1	29,6%	4091,3	34,5%	3378,6	48,9%
Magnétoscopes	2789,5	14,5%	477,7	4,0%	5	0,1%
Radios	2646,4	13,8%	956,3	8,1%	669,5	12,6%
Phonographes	628,1	3,3%	725	6,1%	319,6	4,6%
Magnetophones	593,4	3,1%	778	6,6%	700,7	10,1%
Hi-Fi	1864,6	9,7%	905	7,6%	542,5	7,9%
Video Disk Player	119,4	0,6%		0,0%		0,0%
Horlogerie	767,6	4,0%	639	5,4%	115	1,7%
Autres	4097,5	21,4%	3276,5	27,7%	977,3	14,1%
Europe Total	15822,9	100,0%	13025,6	100,0%	6222	100,0%
TV	5236,1	33,1%	6533,7	50,2%	3830,3	61,6%
Magnétoscopes	3260,7	20,6%	437	3,4%	23,8	0,4%
Radios	2168,8	13,7%	2053,1	15,8%	928,4	14,9%
Phonographes	317,7	2,0%	518,2	4,0%	355,8	5,7%
Magnetophones	750,4	4,7%	648,7	5,0%	517,6	8,3%
Hi-Fi	2250,8	14,2%	1715,4	13,2%	535,8	8,6%
Video Disk Player	114,1	0,7%		0,0%		0,0%
Horlogerie	563,5	3,6%	512,3	3,9%		0,0%
Autres	1160,8	7,3%	607,2	4,7%	30,3	0,5%
Japon Total	11219,3	100,0%	6903,9	100,0%	4136,9	100,0%
TV	2387,1	21,3%	2335,5	33,8%	1666,6	40,3%
Magnétoscopes	2469,2	22,0%	515,1	7,5%	55	1,3%
Radios	732,1	6,5%	949,1	13,7%	572,1	13,8%
Phonographes	23,6	0,2%	185,3	2,7%	376,3	9,1%
Magnetophones	843,2	7,5%	706,5	10,2%	439,7	10,6%
Hi-Fi	824,1	7,3%	784,1	11,4%	332,7	8,0%
Video Disk Player	91,5	0,8%		0,0%		0,0%
Horlogerie	965,5	8,6%	563,4	8,2%	70	1,7%
Autres	2883	25,7%	864,9	12,5%	624,5	15,1%
Grand Total	46232,8	100,0%	31778,3	100,0%	17267,1	100,0%
TV	13307,3	28,8%	12960,5	40,8%	8875,5	51,4%
Magnétoscopes	8519,4	18,4%	1429,8	4,5%	83,8	0,5%
Radios	5547,3	12,0%	3958,5	12,5%	2370	13,7%
Phonographes	969,4	2,1%	1428,5	4,5%	1051,7	6,1%
Magnetophones	2187	4,7%	2133,2	6,7%	1658	9,6%
Hi-Fi	4939,5	10,7%	3404,5	10,7%	1411	8,2%
Video Disk Player	325	0,7%	0	0,0%	0	0,0%
Horlogerie	2296,6	5,0%	1714,7	5,4%	185	1,1%
Autres	8141,3	17,6%	4748,6	14,9%	1632,1	9,5%

Source : GERDIC d'apres les données d'Electronics

26. One of the challenges to be met by manufacturers is the design and promotion of the intelligent home, that is to say a domestic environment which includes, under a single control system, all tasks as diverse as heating or air conditioning, security, leisure activities, cooking, etc. In the United States the movement has been put forward by the National Association of Homebuilders who claim to have under construction about 1000 intelligent houses, forecasting that all building firms will offer this type of product round about 1995. The simplest solution is that which involves the integration of domestic networks into new dwellings by means of the precabling technique, the cost of which varies between 2% and 8% of that of the house; subsequently various systems of home informatics ("domotique") could be proposed (Diagram V-1), but those in the industry must also envisage the possibility of inserting them into existing dwellings. This is why they must work towards the standardisation of communications protocols on the carrying currents and also on systems not using wires.

Diagram V-1 : THE INTELLIGENT HOME

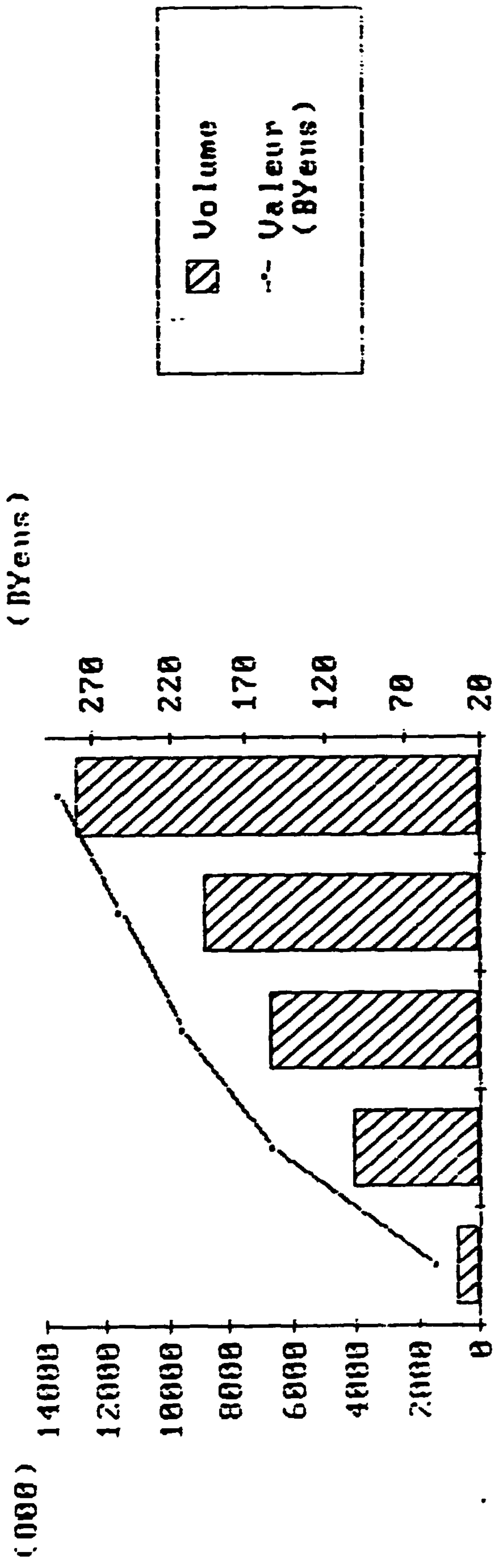


Source : La lettre de la F.I.E.E., n° 24, janvier 1988, p. 3.

27. Evolution in the existing products will mainly involve video applications, that is to say the digitisation of TV and of video-recorders and camcorders which will become smaller and lighter. The market which would seem to be the most promising is that of High Definition TV with an image resolution of 1025 lines as compared with the existing 625 lines. The American Electronics Association evaluates the world market for High Definition TV in the nineties at more than US$ 100 billion if transmission equipment, integrated video-recorders, etc. are included. The stakes are all the greater since this market will exert a powerful demand on the integrated circuits industry. But as in the sixties, when North American and European producers opposed each other when defining the world standard for TV, one finds the European AMC (Analog Multiplexing of Components) in opposition to the Japanese MUSE (Multiple Sub-Nyquist Encoding). Companies are therefore moving prudently when defining this promising market, which nevertheless demands very considerable investments, the results from which are not likely to be seen for about ten years.

28. New technologies for laser disc readers have relaunched the growth of the audio-electronics market. Laser units will carry the greater part of this growth, since Japanese production should increase by 25% a year in volume and 14% in value between 1985 and 1990 (Figure V-19). Introduced in 1983 and seen as the leading innovation in audio since the tape recorder in the sixties the laser unit and, subsequently, the Digital Audio Tape (DAT) will represent a factor for the renaissance of this segment of the market by encouraging the replacement of existing loudspeakers or amplifiers. Taken overall the market should move towards the top of the range, a movement which is alreeay perceptible in the United States where companies obtaining their turnover from this segment of the market were realising margins of 32% in 1986, whereas these margins were only 18% to 25% for products situated lower down the product range.

Figure V-19
FORECASTS OF THE PRODUCTION OF LASER DISC READERS IN JAPAN



Source : GERDIC d'après les données de B.E.P.

29. A considerable potential market, encouraged by home informatics, is that for domestic electrical appliances. In fact scarcely 10% of domestic electrical appliances incorporate electronic components. Those in the industry feel that the insertion of electronic control mechanisms in refrigerators, washing machines or other electrical dryers is inevitable. Most domestic electrical appliances in the industrialised countries are bought as replacements for existing appliances. This is often reflected in the buyer moving up the range, so that products at the top of the range could represent 20% of the market by 1990 as against 10% today. Estimates of the value of the electronic components in the appliances vary from US$ 50 to US% 100 for a refrigerator and from US$ 60 to US$ 120 for a washing machine. This allows us to evaluate the potential for these two products alone as US$ 250m to US$ 500m in the United States of Japan for refrigerators and as US$ 400-800m in the United States and US$ 300-600 in Japan for washing machines. Although it is more difficult at a global level a low estimate would envisage a market of the order of US$ 5 billion.

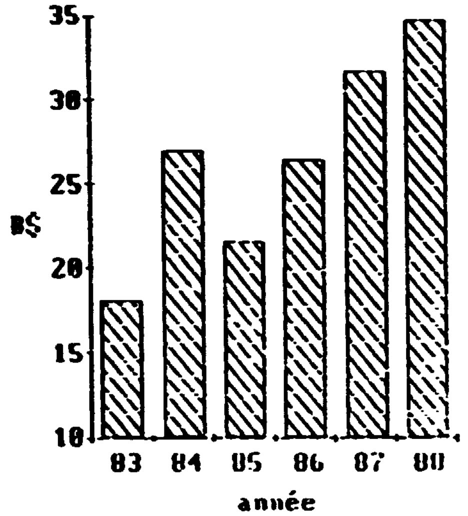
7. Semiconductors : the highs and the lows

30. After 1984, when world production of semiconductors increased by 50%, industrialists were brought back to the harsh reality of an eminently cyclic industry (Figure V-21). After a catastrophic year in 1985 world sales recovered their upward trend in 1987 :

	1986-87	1987-88
United States	18.8%	11.1%
Europe	13.0%	5.5%
Japan	15.5%	8.4%
Rest of world	64.2%	20.1%
WORLD TOTAL	21.8%	17.9%

After the Stock Market crash of October 1987 the year 1988 is likely to augur a halt in the recovery. These erratic movements contribute towards a cleaning up of the market, the structure of which seems to be tending towards a restricted oligopoly and to be encouraging companies to multiply their strategic alliances so as to share the financial and technical burden imposed by the world market. The technological paths are becoming more complex and the future of the smaller firms seems to be seriously compromised. However those of them which want to continue will have to develop product niches, that is to say on this market the complex logics components which will be as integrated as, for example, the existing dynamic memories. Furthermore they must accept the trend towards falling prices, knowing that a megabit of memory which cost US$ 200,000 in 1975 had come down to US$ 100 in 1985 and would cost US$ 5 in 1995.

WORLD MARKET FOR SEMICONDUCTORS



Source : GERDIC d'après E.B.

GEOGRAPHICAL BREAKDOWN OF THE MARKETS IN 1988

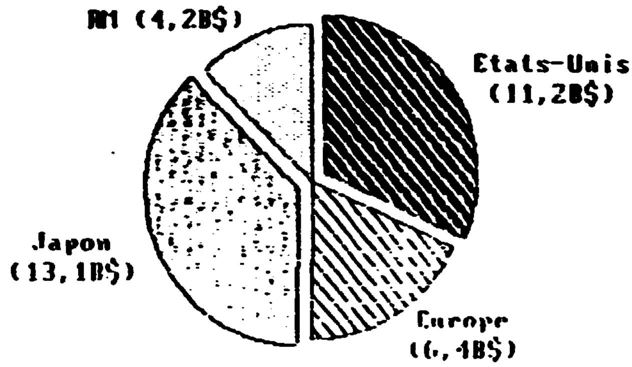
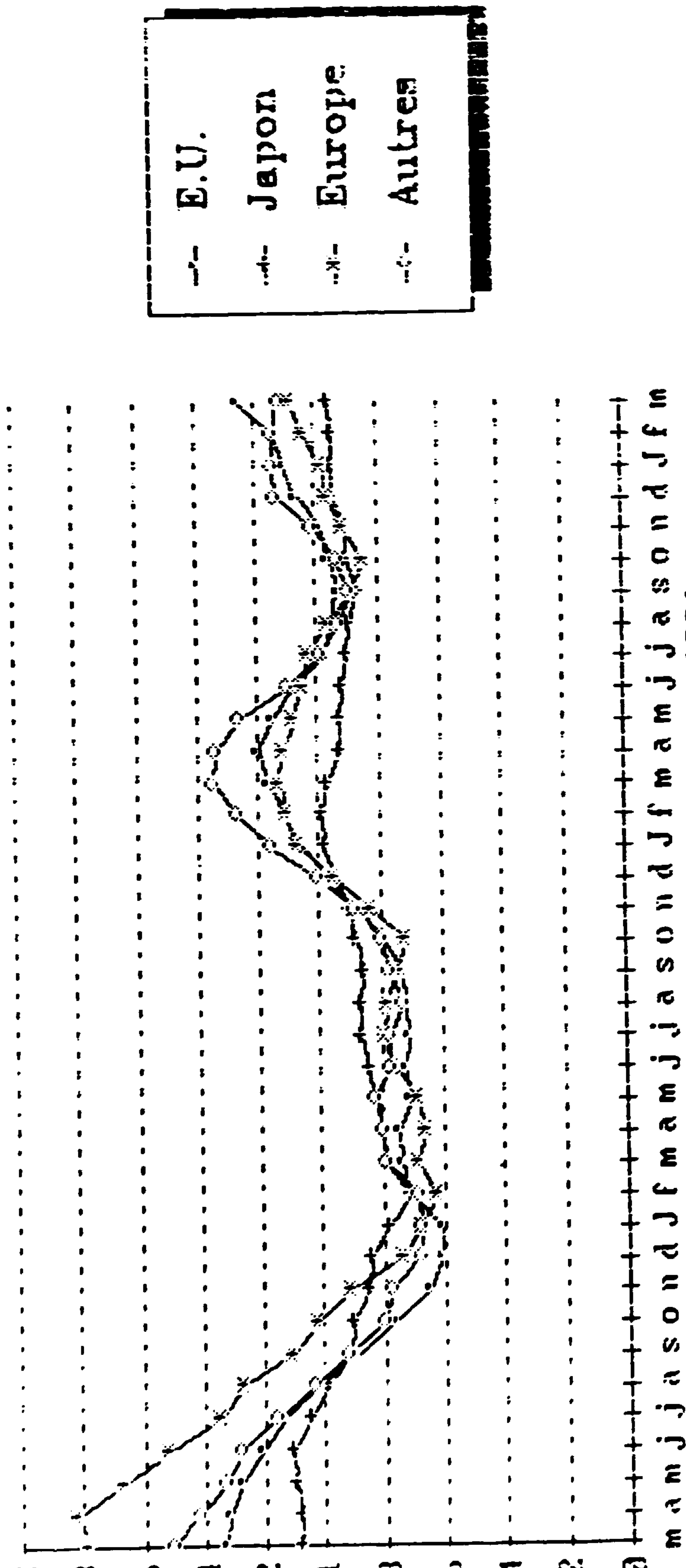


Figure V-21
BOOK TO BILL RATIO : INTEGRATED CIRCUITS



Source : GERDIC

31. The market for Application Specific Integrated Circuits (ASIC) forms one of the product niches mentioned above. In the United States 30% of the new firms in the semiconductor industry have entered this market. Although relatively marginal up to 1983, when it represented 8.6% of the world market for semiconductors, the ASIC market has now risen to over 13%, and is likely to become a quarter of the world market by 1992. Whether customised or pre-diffused the ASIC make it possible to reduce the cost price of a component very considerably by using, for example, standard functions already integrated into the chip with those functions specifically requested by the client. More than a hundred companies are fighting it out on this market, but in 1986 nine of them accounted for 70% of the market. The difficulties encountered by the producers on the standard components market have led some of them to penetrate this profitable sector. Competition has now hardened on this market with resultant reductions in prices leading to about fifteen of the small and medium sized firms withdrawing from the market. As a result the development and engineering of components has become less profitable, and it is now the foundry activity which allows the producers to achieve margins. On the gate array market the Japanese groups are trying to maintain low prices to increase their market shares. Companies can make profits with only 5% of this top of the range market, but the technology in this segment of the market is very sophisticated. The density of a top of the range ASIC is 25 times greater than that of other ASICs. This means that high value added circuits have 100,000 gates, whilst the remaining 5% have only 4000. Thus it is very difficult for small and medium sized companies to obtain access to this segment of the market.

Table V-9 : FORECASTS FOR THE ASIC MARKET (US$ millions)

(Millions de dollars)	1985	(%)	1987	(%)	1990	%	1992	%	%
Gate Arrays	[illegible]	40,[illegible]%	2406,6	39,9%	4851,2	45,5%	[illegible]	[illegible]	[illegible]
CI Logiques programmables	84	3,6%	416	6,9%	[illegible]	[illegible]	1160,2	[illegible]	[illegible]
TOTAL CI Semicustom	1074	43,9%	2822,6	46,8%	57[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CI Cell-based	235	10,0%	919,4	15,3%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
CI Full-Custom	1089	46,2%	2283,6	37,9%	2148,1	21,5%	2057,6	14,2%	-1,6%
TOTAL CI Custom	1324	56,1%	3203	53,2%	4236,6	[illegible]	[illegible]	[illegible]	[illegible]
Grand Total ASIC	[illegible]	100,0%	6025,6	100,0%	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

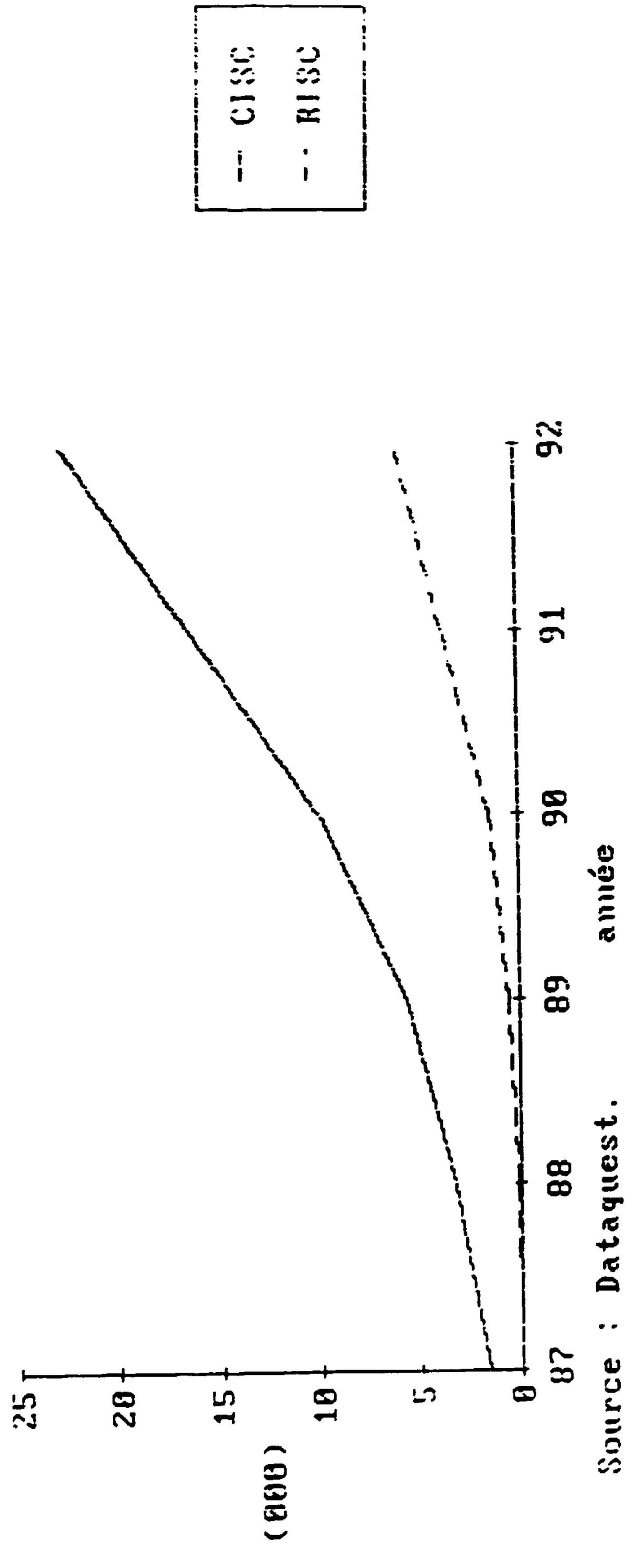
Source : [illegible] d'apres Electronic Business et Dataquest, [illegible].

32. The development of home informatics will permit the development of the market for "smart power" semiconductors". These products make it possible to effect, simultaneously, logic control and power switching. They can find applications in a large number of products from printers to domestic electrical appliances and including automobiles. They can cover powers ranging from 1 to 1000 Watts and can have up to 400 gates for logic circuits. Their primary interest lies in reducing the cost and size of the equipment into which they are incorporated. One component can operate an electric lamp or it can check and identify a short-circuit and shut off the energy supply. Thus a single component is sufficient between the microprocessor, which controls the diagnosis made by the chip, and the engine of a vehicle. It makes it possible to replace about fifty mechanical or discrete components and so also allows a reduction in consumption. About forty firms supply the world market which was estimated at US$ 180m in 1986 but which should reach US$ 650m by 1991, an annual increase of 29%.

33. With a degree of complexity greater than that of the semiconductor, and halfway between a chip and a system, microprocessors are at the heart of the ongoing technological revolution which is upsetting the electronics industry. The industry is now at a crossroads for two reasons. Firstly the standard has moved from the 16-bit to the 32-bit microprocessor; secondly new architectures are envisaged, in particular for vectorial processors (cf 2.). A new generation of microprocessors came out in 1985 with the MOTOROLA 68020 and the INTEL 80386. On this small market (US$ 450m in 1986) the giants, MOTOROLA, NEC, INTEL and ZILOG, are fighting for the dominant position. The market is fairly exclusive, since the technology and the means for production are extremely complex. Furthermore since 1987 new producers, such as Sun Microsystems and Intergraph, have defined a microprocessor using a sophisticated language. In this way they have built Reduced Instruction Set Computers (RISC) which are coming into conflict with the traditional microprocessors, the Complex Instruction Set Computers (CISC). In the first case the microprocessor incorporates a very limited set of instructions, and these are the software which carry out those functions which are only used infrequently by the operator. In this way one obtains microprocessors which are more powerful and more rapid; these naturally find applications in work stations (60%) or in informatics (15%). The market prospects are encouraging and, according to Dataquest, it should represent 20% of the market for 32-bit microprocessors in 1992 (cf. Figure V-22). Some consultants, such as ICE, go so far as to predict that they will account for 35% of the total market. However this type of equipment makes it necessary to remodel the software, which becomes even larger, consuming at the same time the central memory. It is therefore necessary for the user to strike a balance between the compatibility offered by the CISC microprocessors or the speed of the RISCs.

Figure V-22

EXPECTED EVOLUTION OF THE WORLD MARKET FOR 32-BIT MICROPROCESSORS ACCORDING TO THEIR PROGRAMMING LANGUAGE (thousands)



8. CONCLUSIONS

34. This very rapid overview of the technological pathways of the electronics industry does not claim to be in any way exhaustive. It shows that, in many fields, the industry is subject today to intense restructuring dictated by the technology. Such a movement makes it very difficult to attempt forecasts. However we have gathered together in Annex A-8 those forecasts made by consultants for the particularly dynamic segments of the market. These data merely amplify the contrast which is immediately apparent in this industry which is subject to an incessant process of creative destruction.

CHAPTER VI

OBSTACLES AND POSSIBILITIES FOR PROMOTING ELECTRONICS PRODUCTION IN THE THIRD WORLD NATIONS

1. TOO RESTRICTED A PARTICIPATION IN WORLD ELECTRONICS PRODUCTION

1. Although the electronics industry is a recent industry the Third World nations have been producers and even exporters of the products of the electronics industry for the last fifteen years. This is a remarkable fact, since it was necessary to wait for a hundred and fifty years and until after the Second World War before several non-industrialised countries became exporters of textile products, and yet they were producing certain electronics products in a far shorter period of time, less than a decade in fact for some components. Today most of the Latin American, Asian and North African countries are producers of electronics goods; only the countries of Sub-Saharan Africa form a large group of non-producers of electronics goods. In fact this young industry is no sanctuary reserved for the most industrialised countries, and it is certainly possible to verify the fact that, above a fairly low threshold value of the ratio of the manufacturing value added to the Gross National Product, practically all countries are producers. Electronics production is not therefore impossible, and to seek to promote it is relevant to one consideration: that of increasing the too restricted participation of the Third World nations in global electronics production.

1.1. The multinationals relocate to lower wages : jobs and foreign currency

1.1.1 The New International Division of Work

2. During the seventies analysts believed that they could identify a lasting dynamic of relocation. The crisis in the countries of the North being reflected in a fall in the profitability of capital the largest companies, the multinationals (or "transnationals"), effected a massive relocation of their productions by installing themselves in the countries of the South with their low wages, so that they could make profits on products which were then re-exported to the countries of the north. According to F. GROEBEL (1977) a new international division of labour was thus instituted, principally illustrated by what could be observed in the textiles and electronics industries. This new scheme gave the multinationals a dominant role to exploit to their own advantage the incomes (and the markets) of the North and the low wages of the South, leaving no space or freedom to either the North or the South.

1.1.2 The "offshore" installations of the multinationals

3. Low wages allowed the firms to reduce their costs to a considerable extent, since wages were rarely even 10% of those in their home territories; confronted with problems of profitability it can be understood why they examined the immediate solution which was offered to them: to shut their factories and to build them further away in quieter countries with no strikes or union agitators. This was the reason for the multiplication of the so-called "offshore" installations, particularly of course in the highly labour-intensive industries. This was the case in the electronics industry, and particularly in semiconductors: "In 1976, for example, semiconductor products required 54 man-years of labour per million Dollars of product, which is the highest intensity of labour in all North American industries with the exception of pottery, lace and kitchen utensils" (J.L. PERRAULT, R. FROUVILLE, 1986).

4. In the electronics industry the first "offshore" installation was that of Fairchild in Hong Kong in 1962 (cf Chapter III, 1.1). By 1974 there were 47 American esablishments in operation. The Japanese had started with sub-contracting agreements with independent firms in Korea and Hong Kong at the beginning of the seventies. According to our evaluations by 1985 more than a third of all jobs in American semiconductor firms were to be found "offshore": this proportion was actually more than a half in the case of unskilled jobs. In the same way more than a fifth of employees in Japanese electronics firms were to be found outside Japan (this includes their subsidiaries in the United States and in Europe). This very marked movement by firms towards offshore installations was not entirely of their own doing: it partly resulted from public measures taken both by the industrialised and the Third World nations.

1.1.3 Public encouragement : export free zones and special import tariffs

5. In the United States their relations with Mexico were at the origin of the creation of a bonded or duty-free production zone on Mexican territory, near the frontier, where the so-called "make-up" or "maquiladora" enterprises converted and re-exported North American products. The "Bracero" programme made it possible, up to the beginning of the sixties in the United States , to call on Mexican labour for farms in the south of the country. The halting of this programme posed a delicate frontier problem, with very numerous clandestine crossings and undeclared employment in the United States. The solution consisted of partly regulating the problem of the employment of Mexicans by offering non-immigrant industrial labour to American firms and hence labour which could be paid, without contravening the law, at the Mexican rate of pay, that is to say remuneration of the order of a tenth of remuneration in the United States. The two public powers found this to be of advantage, and a large number of "maquiladoras" were established at the end of the sixties in textiles and clothing; up to 1973 at least 50% of the capital in these was Mexican. The rapid growth of the electronics industry led to the utilisation of this zone of activities for certain steps in the process of production, for example the assembling of the components or of television receivers so as to meet Japanese competition. This was facilitated both by the Mexican legislation on the zone and also by the North American customs regime (Tariffs 806/807) which only taxes the value added on products of North American origin. The Mexican bonded production and exporting zone was itself copied from the zones of South-East Asia already used by American and Japanese firms.

6. In the field of semiconductors (cf Table VI-1) three-quarters of North American imports came in under Tariffs 806/807. This tariff is the origin of the production of electronics goods in the Third World countries which are competitive on the American semiconductors market. The Mexican share, which was 28% in 1971, had fallen to 5% by 1978: in that same year the share of Malaysia was 30%, of Singapore 20%, of Korea 15% and then the Philippines appeared with 8%. In 1982 Mexico and Malaysia were at the same level, the Philippines had risen to 18%, whilst Korea and Singapore had fallen back to 10% and 17% respectively. If we take into account the very large increase in the value of imports, for example those from Mexico, whilst imports had fallen they had not collapsed: from US% 36 million in 1971 it had risen to US$ 72m by 1978 and US$ 185m by 1982. However it would be necessary to carry out a much more detailed analysis in order to evaluate the profit extracted by each of the countries of the South participating in such zones. Mexico has practically no electronics exports apart from those passing through these zones and, as far asthe rest of its industry is concerned, the domination of the North American multinationals is patently obvious. This is also the case, it would seem, in Singapore, Malaysia or Taiwan where the percentage of jobs in the electronics industry attributable to American or Japanese firms is, respectively, 90%, 63% and 45%. The strategies of the firms also seem to have been accompanied by the encouragement given by tariffs and free zones.

Table VI-1 : NORTH AMERICAN TRADING IN SEMICONDUCTORS AND TARIFFS 806.30 and 807.00 (1966-1983)

VI-1.1. Global evolution (1966-1983)

Year	807 imports (millions of dollars)	806/807 imports (millions of dollars)	Total U.S. imports (millions of dollars)	806/807 imports as percent of total[b]	806/807 imports (millions of 1967 dollars)[c]	Percent increase in 806/807 imports in 1967 dollars	Price index of SCDs
1966	31	n.a.	50	62	n.a.	n.a.	n.a.
1967	36	n.a.	50	72	n.a.	n.a.	100.0
1968	67	n.a.	86	78	n.a.	n.a.	96.5
1969	106	127	134	95	130	n.a.	96.6
1970	127	160	168	95	167	28	95.7
1971	130	178	187	95	190	14	93.6
1972	162	254	329	77	277	46	91.8
1973	223	413	611	68	447	61	92.4
1974	346	684	953	72	688	54	99.4
1975	312	617	802	77	605	−12	102.0
1976	556	879	1,098	80	909	50	96.7
1977	864	1,120	1,358	82	1,231	35	91.0
1978	1,329	1,478	1,775	83	1,733	41	85.3
1979	1,852	1,916	2,427	79	2,267	31	84.8
1980	2,451	2,506	3,326	75	2,763	22	90.7
1981	2,798	2,825	3,553	80	3,111	13	90.8
1982	3,106	3,131	4,128	76	3,510	13	89.2
1983	3,368	3,383	4,851	69	3,726	6	90.8

Note The older data are those which the Customs have subsequently revised.
n.a. = not available
b : 807 only for 1966-1968
The calculation in 1967 Dollars has been made by using the index for semiconductors.

VI-1.2. Evolution of market shares of various countries under tariffs 807 and 806.30 (a)

Percent

Region and country	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Western Hemisphere	25	26	30	22	20	24	20	15	11	10	10	11	11	11	14
Canada	2	1	2	*	1	*	*	*	*	*	3	4	4	2	4
Mexico	22	26	28	21	19	20	18	11	6	5	5	5	5	5	5
El Salvador	0	0	0	0	0	*	1	3	3	3	2	2	2	2	2
Haiti	0	0	0	*	*	1	*	*	1	1	*	*	*	*	*
Barbados	*	0	*	0	*	*	*	*	*	*	*	*	*	2	3
Netherlands Antilles	1	*	*	1	*	1	*	*	0	0	0	0	0	0	*
Brazil	0	*	*	0	0	*	1	1	1	1	*	*	*	*	*
Western Europe	14	15	15	11	7	4	2	2	1	*	1	*	*	*	*
United Kingdom	*	*	6	2	0	0	0	0	*	0	0	*	*	*	*
Ireland	12	11	4	7	4	3	2	2	1	*	1	*	*	*	*
Portugal	2	4	5	4	3	1	*	*	*	*	0	0	0	0	0
Asia	61	56	55	67	72	70	76	82	87	88	87	88	87	89	85
Hong Kong	30	25	18	17	15	12	9	9	7	6	4	4	3	3	1
Korea	14	13	17	18	17	16	13	17	19	15	12	9	5	10	14
Taiwan	9	5	7	7	9	9	6	6	8	5	4	4	4	4	4
Singapore	6	10	13	25	24	16	20	23	21	20	20	22	20	17	11
Malaysia	*	*	*	*	6	15	23	21	24	30	29	30	30	32	31
Japan	2	3	*	*	*	*	1	*	*	*	4	*	*	*	*
Thailand	0	0	0	0	0	*	0	*	1	3	2	3	4	3	4
Indonesia	0	*	*	0	0	*	*	*	1	1	2	2	2	2	2
Philippines	0	0	0	0	1	2	4	6	6	8	10	14	16	18	18

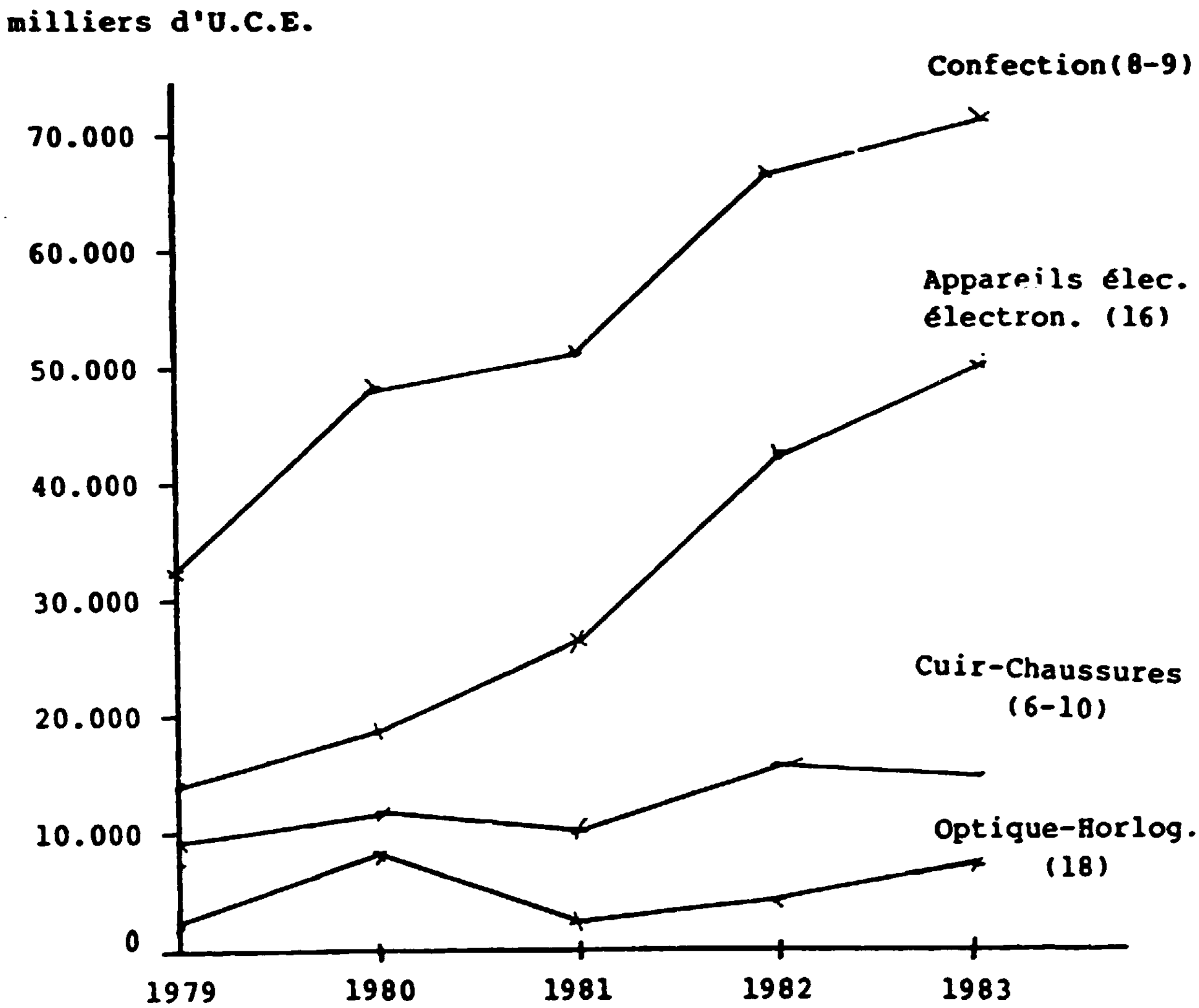
(a) : 807 only for 1969-1971
* = less than 1 %

Data extracted from J.GRUNWALD and K.FLAMM, The Brookings Institute, Washington, pp,74-75 (1985).

7. The relocation movement of the multinationals mainly concerned the United States, Japan and a score of countries in the South. Europe was not entirely absent and, within the framework of the EEC, a passive advantage tariff was implemented, similar to the North American system even if it involved a lower level of customs relief (cf. BERTHOMIEU, 1985). However this system is much less used than that of the United States. Of imports from the developing countries only 13% of those entering France and 22% of those entering West Germany come under this tariff. France and West Germany in particular operate it for few products and countries, although electrical and electronic appliances occupy a relatively important place in those countries (cf. Figure VI-2). For the South-East Asian countries this trading under the passive advantage tariff represents only a very small part of their exports to France (less than 5%), including those from the Philippines (5.12%), even if in the electronics industry this percentage is high (34%; see Table VI-3). The figures are slightly higher in the case of Germany but remain modest (less than 8%, except for Singapore where more than 17% of all exports to West Germany come under the passive advantage regime). Table VI-3 shows all these data and also makes it possible to appreciate the overall position of the trade balance of France and West Germany in relation to these countries. Whilst for Morocco and Tunisia, which represent more than half the French imports under this regime, French exports are more than six times larger than the imports from these countries, the same does not apply in the case of Asian countries. In the case of this group of countries total French imports are three times larger than exports. The situation of West Germany is of the same type: it exports considerable quantities of goods to Mexico and Brazil when compared with its imports from them, but it imports twice as much from the Asian countries as it exports to them. There is however one difference: Germany imports from Asia three times as much, in this field and under the passive advantage system, as France, and for all trading in this sector it exports four times as much as France. Obviously these respective positions, and more generally those of Europe, when compared with the North American and Japanese positions, result from two intimately linked factors: the place of these States and their firms in the dynamic of the field of activity, and the degree of engagement of each of them in the countries concerned in the South.

8. Taken overall one may nevertheless consider that a movement of international redeployment was, during the seventies, one of the sources of the not unimportant participation of a number of Third World countries in world electronics production.

Figure VI-2 : EVOLUTION OF IMPORTS INTO FRANCE FROM THE DEVELOPING COUNTRIES AFTER PASSIVE ADVANTAGE



Source : C. BERTHOMIEU (1985, op. cit., p. 147).

Table VI-3 : TRADING IN ELECTRICAL AND ELECTRONIC APPLIANCES IN 1983 AFTER PASSIVE ADVANTAGE - FRANCE AND FEDERAL REPUBLIC OF GERMANY

PAYS PARTENAIRES	FRANCE				R.F.A.			
	Importations au titre du perfectionnement passif		Echanges totaux		Importations au titre du perfectionnement passif		Echanges totaux	
	Montants milliers d'ECU	En % de (1)	Importations (1)	Exportations	Montants milliers d'ECU	En % de (2)	Importations (2)	Exportations
Afrique								
MAROC	16 735	81,79	20 461	79 784				
TUNISIE	9 836	73,25	13 428	125 394				
EGYPTE	16	2,94	544	100 000				
AFRIQUE DU SUD					24	7,14	336	272 000
Amérique								
MEXIQUE					707	33,10	2 136	55 714
BRESIL					6 264	40,61	15 425	102 553
Asie								
THAILANDE	4 299	81,48	5 275	8 831				
MALAISIE	344	1,01	34 059	55 000	34 949	24,22	144 298	130 255
SINGAPOUR	5 139	3,74	137 406	35 027	60 902	31,19	195 261	119 159
PHILIPPINES	7 100	33,59	21 137	25 226	29 141	74,12	39 316	87 535
COREE DU SUD	265	0,92	28 804	4 444	1 888	2,21	85 430	50 000
TAIWAN	5 264	12,95	43 429	19 820	52 347	25,99	201 412	43 447
HONGKONG	3	0,01	30 000	14 986	2 632	1,62	162 469	53 097
TOTAL	49 654				188 856			

Source : Calculs d'après BERTHOMIEU (1985).

Les échanges totaux ne sont mentionnés que lorsqu'existe un courant d'importation au titre du perfectionnement passif.

1.2. Intensification of the recourse to electronics products: to purchase or to manufacture?

1.2.1 The spontaneously increasing consumption of electronics eats into foreign currency

9. It is possible to see in particular three fields with a growing consumption of electronics goods which, when there is no local production, are therefore imported and very rapidly exert a considerable weight on the balance of payments. These fields are television receivers, telecommunications equipment and computers. Those countries with a not unimportant and growing domestic market are therefore led to ask the question: is it necessary to purchase and be satisfied to remain a user, or is it not time to produce?

10. Whilst during the fifties the phenomena of television broadcasting and, more broadly, that of interactive telecommunications remained relatively limited, even in the industrialised countries, they have now become largely planetary. Gradually all the countries of the globe have installed a television broadcasting system, today often connected in real or deferred time to international broadcasts: similarly automatic telephone exchanges have been installed in all the capitals and large towns of the whole world, with which it is possible to converse directly. In 1950 television was rare, even in the industrialised countries; now at a time of seeing global events, and with satellite retransmission which avoid the cost of radio networks, television sets are becoming generalised at lower levels of real incomes, the more so since the price of sets has been considerably reduced. Table VI-4 shows the very considerable increase in the level of equipment for all the major zones of the world between 1965 and 1982 together with some specific data for certain countries. We can see for example that for South America the rate has risen from 19 television sets for 1000 inhabitants in 1965 to 203 sets by 1987. Even if they have not been entirely manufactured locally a high proportion of these sets have been at least assembled in South American countries.

11. Television sets, and also cassette-radios, digital watches, calculators, games and even hi-fi and tape recorders, proliferate everywhere as soon as the fields are opened up, whilst smuggling and fraud are, in general, very significant. In all countries where a not unimportant proportion of the population are able to feed themselves one can see a frenzy of consumption in leisure electronics. In the past photographs of an abundance of television sets in some shanty towns seemed somehow astonishing, but this is no longer so today. Only a few countries have so far resisted the change from black and white television to colour.

Table VI-4 : EVOLUTION OF THE RATE OF EQUIPMENT WITH TELEVISION RECEIVERS (per 1000 inhabitants)

	1965	1975	1982
Afrique	1,5	6	17
Amérique du Nord	254	408	458
U.S.A.	370	581	652
Canada	279	438	471
Mexique	28	87	111
Amérique du Sud	19	66	203
Asie	10	16	53
Japon	180	238	818
Chine	0	1	6
Inde	0	0,5	3
Corée (Sud)	1	36	120
Europe	126	293	428
Est	86	202	237
Ouest	138	319	486
Océanie	136	254	302
U.R.S.S.	80	264	368

Source : Annuaire statistique de l'UNESCO, New-York, 1984 (cf. Annexe C).

12. Whilst the consumption of mass consumer electronics goods lies in the hands of private individuals the public authorities can obviously limit its growth by restrictions on imports and by customs duties. However since in most cases they have a monopoly on television broadcasting as soon as they install a system (generally in the capital) they have started on a process of progressive access to the largest number who can receive these broadcasts. Public authorities are further encouraged to do this by the fact that it is generally recognised that television is not simply a means of information and communication but is also a means of imposing beliefs which governments like to use in order to reinforce their authority over the people.

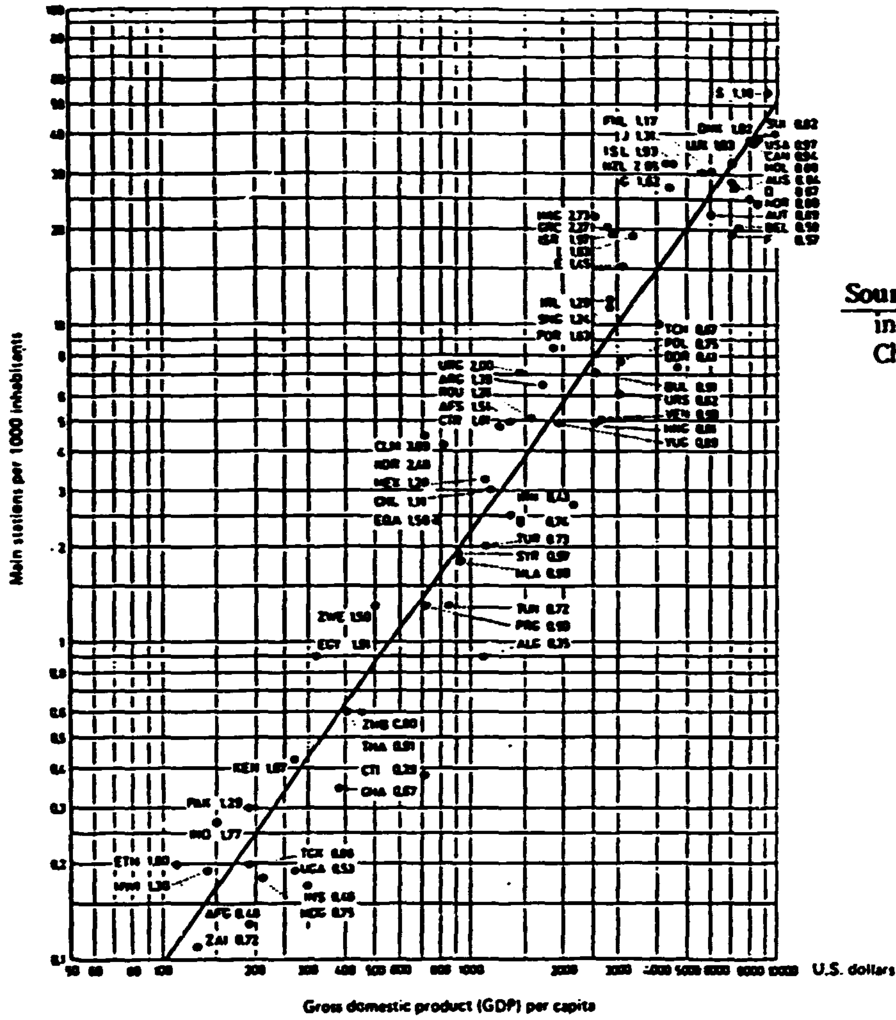
13. There are also reasons of a general kind rather than those of individual satisfaction which encourage the public authorities in a country to provide it with a telecommunications infrastructure linked to the rest of the world. This seems to reinforce national unity, sometimes not very firmly bonded, by allowing inter-person communication between different parts of the country. It also facilitates the conduct of business and, more generally, of the economy. It seems generally to be a necessary political option that this network should be connected to a regional infrastructure, whilst economic imperatives demand connection to the international network by the most efficacious means, which involves satellites. Whilst terrestrial installations remain relatively costly links via satellites are constantly becoming cheaper. When countries are vast and the needs for telecommunications is felt, but is becoming more expensive, it has to be met by increasingly complex industrial electronics systems. The decision to equip often leads to importing, and in many

cases even to calling on a foreign enterprise to organise the telecommunications services.

14. Until now the need to communicate by telephone seems to have increased at the rate of the per capita product (cf. Figure VI-5); however technical progress intensifies this need, as in the case of television, and most of the non-industrialised countries have launched very ambitious equipment plans. This opens up very large market prospects for telecommunications equipment and for subscribers' terminals in the Third World countries.

15. Prudent public administrations have needed censuses since the beginning of time, involving processing simple data. With the development of the needs of administrative management, including the implementation of "strategies", there are vaster quantities of information to be processed, from political administration to social and economic administration, and so the State has recourse to the electronics infrastructure of information processing so as to affirm and confirm its national autonomy. Administrations in the Third World are not exempt from this rule and are even encouraged to undertake information processing. The various international organisations wish to obtain from each of the countries of the South extensive and reliable information to rationalise their actions, in particular in favour of economic and social development. To this end they impose "informatisation", even offering missions from experts and various facilities so that the local public administrations can have computers with which to process the data from population, agricultural, industrial, health and other surveys. The IMF and UNCTAD are particularly interested in facilitating the collection and management through informatics of customs and fiscal statistics. To this end UNCTAD has developed the ASYCUDA system (cf. Note VI-6). The United Nations organisations and the International Bureau for Informatics (IBI) offer technical assistance in developing the employment of informatics in administrations.

Figure VI-5 : RELATIONSHIP BETWEEN THE NUMBER OF TELEPHONES PER 1000 INHABITANTS AND THE PER CAPITA GDP (in US Dollars) FOR 1978



Source : "The Telecommunication industry...", 1987, op. cit., Chap.I, Tableau 13, p. 157-158.

Légende des pays :

AFG	Afghanistan	ISR	Israel
AFS	South Africa	J	Japan
ALG	Algeria	JMC	Jamaica
ARG	Argentina	KEN	Kenya
AUS	Australia	KOR	Republic of Korea
AUT	Austria	KWT	Kuwait
B	Brazil	LBY	Libyan Arab Jamahiriya
BEL	Belgium	LUX	Luxembourg
BRM	Burma	MDG	Madagascar
BUL	Bulgaria	MEX	Mexico
CAN	Canada	MLA	Malaysia
CHL	Chile	MLT	Malta
CLM	Colombia	MWI	Malawi
CTI	Ivory Coast	NOR	Norway
CTR	Costa Rica	NZL	New Zealand
CYP	Cyprus	PAK	Pakistan
D	Germany (Federal Republic of)	PHL	Philippines
DDR	German Democratic Republic	POL	Poland
DNK	Denmark	POR	Portugal
E	Spain	PRG	Paraguay
EGY	Egypt	ROU	Roumania
EQA	Ecuador	S	Sweden
ETH	Ethiopia	SNG	Singapore
F	France	SUI	Switzerland
FJI	Fiji	SYR	Syria
FNL	Finland	TCH	Czechoslovakia
G	United Kingdom	TZA	United Republic of Tanzania
GHA	Ghana	THA	Thailand
GRC	Greece	TUN	Tunisia
HKG	Hongkong	TUR	Turkey
HNG	Hungary	UGA	Uganda
HOL	Netherlands	URG	Uruguay
HVO	Burkina Faso	URS	USSR
I	Italy	USA	United States
IND	India	VEN	Venezuela
INS	Indonesia	YUG	Yugoslavia
IRL	Ireland	ZAI	Zaire
IRN	Iran	ZMB	Zambia
IRQ	Iraq	ZWE	Zimbabwe
ISL	Iceland		

Note VI-6 : UNCTAD's ASYCUDA SYSTEM

Le Système automatique de saisie, de contrôle et de gestion des données douanières (ASYCUDA) a été créé et mis au point par des experts de la CNUCED pour être utilisé de diffférentes manières dans un bureau des douanes ainsi qu'aux services douaniers centraux. Le système fonctionne sur un micro-ordinateur capable de recevoir des extensions, notamment pour ce qui concerne la mémoire et le nombre de postes de travail et de communication. Il peut fonctionner de façon automatique ou sous le contrôle d'un ordinateur central.

Récemment, le logiciel ASYCUDA a été adapté par des experts de la CNUCED/CEAO pour assurer, d'après des codifications et des documents douaniers normalisés, la collecte, la saisie et le contrôle des informations dont ont besoin les pays membres de la CEAO pour calculer les compensations et établir des statistiques commerciales. Les droits de douane perçus sur les échanges au sein de la CEAO alimentent un fonds commun destiné à indemniser les pays importateurs qui ont négocié des droits inférieurs sur des marchandises, et cela pour les deux tiers de la différence entre ces taux inférieurs et les taux pleins.

Compte tenu des obligations mutuelles des membres de la communauté, le système peut traiter toutes les données nationales, selon les exigences de chaque pays. Le système assure aussi une homogénéité des informations, de sorte que la communauté elle-même et ses pays membres individuels puissent être assurés de l'exactitude et de l'authenticité des données collectées. Sa flexibilité permet aussi la mise en place de procédures spécifiques à la demande de la communauté.

Source : Finances et Développement, septembre 1985, p. 47.

16. As in the case of the ASYCUDA system informatics projects have today moved on to microcomputers. According to the Statistical Office of the United Nations the microcomputer is the tool which is increasingly being proposed to governments to help them implement and process their censuses, and this tool gives satisfaction (statement by G. SADOWSKY to R. LAWSON, High Technology and the Third World - Micros move South: in Development Forum, October 1985, p.8).

17. Despite the need for ancillary equipment in tropical zones, or when the electricity supply is of imperfect quality, microcomputers are much less expensive and, in particular, much more robust than the general run of computers. These qualities allow them to proliferate not only in public administration but also in the private sector for sales or accounts management. Here again it is an item of expenditure which has increased considerably wherever importing is possible, particularly since the world-wide expansion of the standard IBM-PC or its clones.

18. Mass consumer electronics with television sets, telecommunications equipment, informatics equipment and, principally, the microcomputers thus constitute three items of rapidly increasing consumption which can lead to

very severe haemorrhages of foreign currency if it is not possible to produce them locally.

19. Furthermore, and faced with the question as to whether one should buy or make, it has to be asked if it is effectively possible to be a good user without being a producer. The question is not crucial in the case of mass consumer electronics, at least up to the present time when its pilot product, the television set, can still be repaired by technicians who import and replace the defective components. One can almost say the same today about microcomputers. But it is very different in the case of telecommunications equipment and large informatics systems.

20. More generally in the case of informatics equipment the problem of good usage is more delicate. With general equipment there is extremely frequent under-utilisation and very inadequate maintenance which means that a number of computers remain inoperative for long periods, principally in administrations and universities. Within a central administration it is not unusual to find many disparate items of equipment which make any effort towards rationalisation of maintenance very difficult. Many countries have nevertheless been tempted to achieve rationalisation, and this has also been done at regional level as in Latin America with the first Latin-American conference of governmental authorities on informatics (LALAI). This involves at least implementing a coherent buying policy and the harmonisation of services. The future of intelligent administration buildings can only reinforce the question of the dependence of the administration on a private and foreign informatics system. Inasfar as production is extremely difficult modular solutions with operation which can be disconnected from a central computer and the local utilisation of a large number of microcomputers represent sub-optimal situations in regard to sovereignty and security. It further reinforces the encouragement to promote the manufacture of microcomputers.

21. Whether one manufactures or not utilisation cannot be undertaken in a satisfactory manner without the possession of minimal technical and industrial know-how. In the absence of productive activities this know-how is only available at an academic level or by expatriates. It is evidently necessary to regroup some of those possessing it so as to establish one's own evaluation structure which can illuminate the decisions to be taken, even if this is done after receiving reports from international technical assistance organisations or private consultancy companies.

22. Even in some countries where very advanced technical know-how is available one can encounter problems if public decision makers do not organise their purchases in a completely rational manner. C.J. HAMELINK (1987) reports a case in telecommunications. In general the markets involved are extremely large and the administrations proceed by way of international calls for tenders and employ teams of consultants to study the replies. According to Hamelink it is difficult to understand how such a situation could have led Mexico to entrust to Hughes the execution of the MORELOS satellite project which was seen to be manifestly very incomplete, in particular since everything concerning the terrestrial stations had been neither provided for, nor had these evidently been the subject of a study. Whether this diagnosis is arguable or not the lesson which has to be drawn from it is the need for meticulous consultations and the absolute necessity of associating competent experts with the deciders of policy, together with subsequent clear explanations of the technical and economic choices and their implications.

23. The telecommunications infrastructure which is installed cannot be allowed to suffer from breakdowns which would be difficult to accept even in the case of isolated informatics equipment. As a consequence purchases of exchanges and other telecommunications equipment must be accompanied by maintenance services and, as far as is possible, the training of local personnel, which is the general case. In countries having sufficient potential a major equipment purchasing plan could be accompanied by the creation of a subsidiary or a joint venture to assemble and install the various systems. In those countries where the forecast scale of equipment buying is particularly vast, and which already have considerable national technico-industrial potential, the local production of a certain number of components could be envisaged. Thus the size of the domestic market for telecommunications can facilitate the growth of electronics production. The maintenance and hence the efficient usage of the equipment will thus be obviously facilitated.

1.2.2 An emerging wish to transform technology by way of electronics

24. On the one side the public powers find themselves confronted by increasing expenditure which loads the balance of payments and which has to be rationalised for this reason and also to extract the greatest benefit, and for which they would like to substitute products which have at least been assembled locally so as to reduce the outflow of currency. On the other side governments can also find reasons to promote the utilisation of electronics so as to succeed in a technological transformation which is favourable towards, if not indispensable for, industrialisation.

25. In the middle of the seventies UNCTAD (1978) considered that electronics constitute a technique which is indispensable for any industrialisation strategy. The ILO has also considered the problem, going rather beyond the single question of employment (J. RADA, 1980) and UNIDO is beginning to interest itself in the problems posed by the progress of electronics in the process of industrialisation (UNIDO, 1981).

26. What is involved is an implicit understanding of the passage of the world to the age of electronics, as we have described it here in Chapter I. The question is then posed of knowing whether one is to accept or reject the "modern technology" developed principally by the industrialised countries. There are many options: analysts (such as F. STEWART, 1985) end by abandoning the illusion that one can preserve oneself from it, and the debate on alternative or "soft" technologies is now very much limited. Technological pluralism has been accepted with, according to the local possibilities, the prospect of an acceptance of a technological change embellished with some modifications which relate more to the process of production than to the characteristics of the products (apart from any "add-ons" necessary for their utilisation under particular local conditions).

27. The UNCTAD Group of 77 has adopted a clear position within the Committee on Transfer of Technology (UNCTAD, 1986), and issued at the time of this preparatory phase an explicit document (from which note VI-7 is taken) stating that: "The application of newly emerging technologies needs to be mastered both in the modern and traditional sectors in order to exploit comparative advtanage and accelerate industrialisation." This is a document presented by Tanzania in the name of the States members of the Group of 77 (TD/B/C.6/L.73). On this occasion industrialisation appears as clearly contributory towards a process of technico-industrial transformation which finds its support on the state of the art in technical matters and hence on the "frontier technologies" and consequently on electronics as a "frontier technology".

28. Under these conditions it is not a question of replacing imports, constrained by consumer needs and costly in currency, by a local production starting with assembly, but rather of renovating the industrial apparatus, of proceding as in the industrialised countries to a kind of restructuring of the existing industrial activities, to a modernisation of the productive activities. The problem is therefore, and in particular, that of "productique", to use the French word, that is to say that of extending micro-electronics into equipment, in the production process and, where necessary, in the existing products. The object is to achieve at the same time an improvement in productivity and also in the quality of the products. This would seem to be essential in the case of those products which it is wished to place on the world market and also essential for semi-products if it is hoped that the local integration of components, parts or assemblies will not produce negative results. These would result from finished products which could not be placed on the world market or which would provide inadequate service on the national market. Furthermore it is necessary to ensure that these semi-products will be used, otherwise users will not fail to obtain their supplies by importing. Inasfar as all activities are touched by the impact of the electronics industry the danger of a downgrading of the products, and that of the pressure to import with an outflow of currency, will in fact affect all activities.

29. This therefore constitutes a formidable pressure to employ electronics as much as is possible, in all those activities which give rise to easily tradable products. Is it possible, in regard to electronics for industry, to be an efficient and judicious user, without being a producer? This would seem to be a total illusion. It is not possible to install a productive apparatus in any country in the age of electronics without also producing the electronics.

30. Under these conditions it is the actual pursuit of an effective industrialisation strategy which makes it necessary for Third World countries to participate in an extended manner in world electronics production. It is therefore necessary to go beyond simple assembly activities which limit import costs, and it is not clear that the world movement towards relocation as described above will be sufficient to achieve this production requirement.

Note VI-7 : Extract from "PRELIMINARY OUTLINE OF THE STRATEGY FOR THE TECHNOLOGICAL TRANSFORMATION OF DEVELOPING COUNTRIES" Document of the Group of 77 (TD/B/C.6/L.73)

D. — Recherche-développement et innovation technologique

17. Les leçons de l'expérience acquise en matière de production permettront d'affermir la base technologique. Les importations de technologie pourraient être un facteur de progrès. Toutefois, c'est l'esprit d'innovation et d'invention qui est l'élément moteur de tout changement technologique. Les activités de recherche-développement dans un pays sont l'une des principales sources de changement technologique. Les pays en développement doivent élaborer des stratégies et des politiques à long terme afin de renforcer leur capacité d'entreprendre des activités de recherche-développement, en particulier dans les secteurs clés du développement. A court et moyen terme, étant donné les ressources limitées que la plupart des pays en développement peuvent affecter à ces activités, le secteur national de la recherche-développement devrait concentrer les efforts sur des objectifs bien définis, par exemple l'adaptation des améliorations apportées aux techniques et la modernisation de la technologie déjà en service. Il serait nécessaire de renforcer le secteur de la recherche-développement afin qu'il puisse suivre le développement des technologies naissantes et des techniques de pointe, en évaluer les incidences ainsi que les possibilités d'application au développement technologique national, et en faciliter l'assimilation. Il faudrait augmenter les ressources financières et humaines.

18. Concernant l'élaboration d'une politique de recherche-développement, une attention particulière devrait être accordée à l'exploitation efficace des résultats des travaux de recherche-développement. A cette fin, il faut renforcer les politiques et les mécanismes qui visent à améliorer les courants de technologie et les échanges d'information entre le secteur de la recherche-développement (laboratoires de recherche, instituts et universités) et les secteurs productifs.

19. Les centres de recherche-développement du secteur industriel offrent des possibilités de coordination souhaitable et essentielle entre les activités des instituts de recherche et celles du secteur productif. Des engagements fermes devraient être pris visant à garantir des investissements suffisants dans la recherche-développement en vue de l'absorption, de l'adaptation et de l'amélioration des techniques, qu'elles soient mises au point au niveau local ou importées. Il faudrait accorder une attention particulière à la prospective technologique et aux possibilités de découpage des apports technologiques. Les systèmes de recherche-développement devront viser à contribuer à un transfert technologique efficace de connaissances de base (savoir-faire) et à faciliter de nouveaux progrès. Les organismes d'études, d'ingénierie et d'ingénieurs-conseils contribuent de façon capitale à transformer les innovations technologiques en techniques viables.

c) *Technologies de pointe*

36. L'application de technologies nouvelles doit être maîtrisée à la fois dans les secteurs modernes et traditionnels, pour exploiter l'avantage comparatif et accélérer l'industrialisation. Il faut agir sans tarder pour instaurer une collaboration dès le stade de la recherche-développement, pour faire concorder les points de vue des utilisateurs éventuels et de ceux qui actuellement mettent au point les technologies. Une assistance devrait être offerte aux entreprises nationales pour les aider à participer à cette collaboration, qui leur permettra de négocier dans de bonnes conditions et d'accroître leur pouvoir de décision en acquérant, sur le marché international, les éléments, plans, installations et connaissances techniques que ces technologies requièrent. Les pays en développement devraient bénéficier d'un traitement différencié et spécial quant à l'accès aux technologies de pointe sur le marché international de ces technologies.

<u>Source</u> : CNUCED, 1986 (op. cit.)

1.3. From comparative advantages to the laws of the World Industrial System

1.3.1 The objective limits to wage cost advantages

31. Analyses in terms of the New International Division of Labour or of International Redeployment depend on a classical and static approach through Comparative Advantages. The existence of cheap labour in the non-industrialised countries does not date from yesterday.... They have always had, in a general sense, the advantage of low wage costs. Rates of exchange have also, in an equally general manner, always reflected this advantage and the cost of the labour in international currencies is clearly much lower in the countries of the South. It is therefore an absolute advantage in the classical sense of the term, and this is confirmed on the market. To remain within this framework it is necessary to extend it to the neoclassical situation and to consider other components of the cost. It may be assumed, for example, that the cost of capital is at a higher level in international currency. This would ensure that this situation could not lead to producing everything in the countries of the South. They would thus have a surplus in their trading balance which would, in its turn by bringing with it a rise in their rate of exchange, re-establish equilibrium. The reality is totally different: there is an obvious industrial deficit. If therefore wage costs in international currencies are low it is still the fact that, within the framework of this neoclassical argument in terms of Comparative Advantages, the other components in the cost are, in international currencies, much higher than in the industrialised countries. If this reasoning is correct the specialisation of the countries of the South must be found in activities using relatively more labour since these will be the first to see their overall costs in international currencies fall below world costs, when their rates of exchange have fallen to a sufficiently low level.

32. It was on the basis of this simple, or even simplistic, analysis that the IMF, facing the problems of deficits in trading balances, advised countries to compress wage levels and to devalue their currencies, and this gave short-term results which were not negligible. But this same analysis can suggest entirely different solutions. If a country wishes, in the long term, to increase its participation in the fruits of world expansion, it must raise its wage levels in international currencies. It must therefore attack other components of the overall cost to become industries which are "competitive" on the international market. Remaining within this same analytical framework then as long as cost components other than wages remain, on average, at a higher level then these industries will remain those which are relatively more intensive in terms of labour.

33. However to view the problem in this way is to open up a fundamental breach, since it transfers the reasoning from the field of costs to that of productivity. Whatever the other components of the cost may be do not the industrialised countries have apparently specific advantages in productivity? Manifestly the industrialised countries have a great advantage in the cost of putting physical capital into production, and even more in their mastery of production know-how together with its industrial transformation.

34. The relocation of multinationals towards low wages, provided that these are sufficiently low, can continue to be operated for those industries which are most labour-intensive, and can offer employment and currency for the beneficiary countries. The other condition for its

continuance is linked to two kinds of constraints. Those operators which are multinationals must not be shackled by the closing of plants in their countries of origin if it is to be relocation in the strict sense; it must also be possible to supply the markets for which the products are intended from the new sites of production.

35. Obviously since the end of the seventies the development of micro-electronics is directed towards an increasing automation which is continuing, and will go on continuing to the point where the electronics industry will no longer be a highly labour-intensive industry, even if it is far from being this now. It must also be added that the impact of micro-electronics has, for all industries and globally, considerably reduced the contribution of the cost of unskilled labour in all industrial productions. In order to effect a modification of the comparative advantages, within the framework of this type of analysis, it is necessary that the scale on which industries are classified as a function of their labour intensiveness be also modified. If this is the case then the international relocation movement, under the conditions set out in paragraph 34, will apply to those industries which have newly become more labour-intensive, and also provided that there has been no modification of the other components in the overall cost.

36. The wage costs advantage therefore comes up against the fact that it promotes not any particular industry but those industries which are most labour-intensive. If the electronics industry is a high technology industry, relatively less labour-intensive when compared with other industries, it should not, according to the scheme of the multinationals' relocation towards low wages, continue to develop in the Third World nations.

37. In order to attract foreign investment in electronics production it is therefore necessary to offer something other than low wages, in such a way that production is competitive, at least to the point where it is possible to believe that the operator can relocate with his costs for components other than labour at the level of global competitiveness. Many empirical observations have led to a recent report from the United Nations Centre on Transnational Corporations delivering a judgement which is in every respect concordant with the analysis that we have set out. According to this report : "... only those developing countries or areas would be selected by transnational corporations for high technology investments which already possess certain characterstics, namely, a relatively well developed network of capital goods and intermediate industries; a well developed financial, transportation and communications infrastructure; a highly skilled labour force of engineers and technicians; and substantial government commitment to research and development." (UNCTC, 1986, p.440). This means in fact that electronics production will be relocated taking account not just of low costs, other than the cost of unskilled labour, but because of the existence of specific productivity advantages (cf paragraph 33 above) which are necessary for carrying out the production of high technology electronics.

38. Is a return to the North of those industries which had been relocated in the South to be regarded as probable? Remaining within the strict framework of the classical argument in terms of Comparative Advantages, and hence of wage costs, the single fact that electronics production was no longer one of the labour intensive activities would inevitably lead to a return of electronics factories to the industrialised countries. If on the other hand one leaves the classical static argument to consider that

the older establishments have been accompanied, in terms of dynamics, by the progressive creation of specific productivity advantages then the question of their return must obviously be posed in a very different manner. It also has to be posed differently if there are local constraints of the type of those cited in paragraph 34 and, in particular, those related to productions destined for domestic markets where proximity is a very important specific commercial advantage.

39. An empirical analysis of cases of relocation shows in effect the creation of dynamic effects which could endow the receiving country with specific advantages. Thus for C. BERTHOMIEU (1985, op. cit.) the sub-contracting of manufacture to an independent enterprise can advance local industrial capabilities. One would certainly consider that joint ventures can very often have certain characterstics of independence, at least when assimilating technological transfers. It is in this respect that the Korean industry seems to have succeeded, where in 1984 foreign subsidiaries only employed 16% of the manpower in the electronics industry. Finally it should also be noted that in the case of the data on North American imports (Tariff 806-807) an analysis as detailed as that set out in Table VI-6 above shows changes in the proportion of the offshore value added in the imported value. For Korea and Singapore this has increased considerably, but this is not the case in Malaysia and the Philippines and so is evidently the index of an extension of converting activities: a larger number of stages in production, adding more value to the product, are carried out locally. This indicates very clearly the skill content of the work carried out offshore and, as a consequence, an improvement in the level of local industrial competence. Such competence, relevant to a specific field but which is not only found within the relocated subsidiaries but is held collectively, constitutes a specific advantage which goes beyond classical and neoclassical analyses in terms of comparative advantages.

40. One can give by way of an example two empirical elements which illustrate this analysis perfectly. The first is taken from R. CHAPONNIERE and R. TIBERGHIEN (UNIDO study : "The electronics industry in the ASEAN countries", June 1988, p.11 of French version): "the study of the electronics industry in the ASEAN countries underlines, however, a paradox: it is the country with the highest wage levels which receives the largest number of investors. As one can see this divergence has always existed, wages in Singapore being traditionally the highest in Asia." The second takes us to Mexico and the assembly firms; we may quote the headline of a recent article in Electronic Business : "Robots in Mexico? Automation where many are jobless? Sure - US electronics firms are automating their plants south of the border. The push for high quality is just one reason why." (15 February 1988, p.110). Quality and speed are good reasons for automating, but if it is automated why continue to come to this area? In this article the average structure of costs in the United States is evaluated as being 15% for labour, 65% for materials and 20% for general overheads. In Mexico the cost of labour is at least eight times smaller than in the United States so the replacement of a few workers by an automatic machine cannot be justified in terms of costs. The machine, or more generally automation, does not in fact replace workers in order to do the same work; it does something that they cannot do. This is the case, for example, with the Surface Mounted Devices (SMD) technique. The reality is that, even within this zone which, has often been seen exclusively as an enclave where Mexicans sold their labour at a low price, specific advantages have developed. The article cited above emphasizes that engineers and technicians trained, more or less well, in Mexico are now being employed and sent by the American firms for further training in the United States; the level of technico-industrial capabilities must be sufficiently high for Zenith to establish a Research and Development team working on television tuners in its Matamoros unit (op. cit, p.116).

41. All this shows clearly the need for an analysis which takes into account the functioning of the industry, that is to say the world industrial system, within which is seen the global technico-industrial evolution which we described in Chapter I. It is here that the laws which make it possible or impossible to participate in an increasing manner in world production are defined. Whilst they may show certain facilities they also indicate major difficulties.

1.3.2 Difficulties in mastering a high-technology global industry

42. The electronics industry has been progressively transformed into a high-technology industry in all its components; recently it was the turn of telecommunications, then came mass consumer electronics, whilst the production of discrete components and printed circuits is also seeing its recourse to unskilled labour greatly reduced. Research and Development activities increase everywhere, and also as a percentage of turnover, being engaged in greater depth and calling increasingly on fundamental research work.

43. Electronics production needs highly skilled labour and machines which are capable of meeting the demands of precision and quality which can only be achieved when they are automatic. In many cases these machines are under numerical control, and it is generally necessary to have recourse to the development of software suited to the production to be carried out.

44. The first two factors form an extremely high barrier to entry into production since it consists of specific know-how to which access is difficult and also of academic training which then has to be supplemented by experience in the laboratories and workshops of operational plants. The system of technical evolution is also so rapid that this know-how is of a highly evolving and cumulative nature, so constantly raising the height of this barrier against entry.

45. The pervasiveness of electronics has recently been expressed in an increasing manner which multiplies the technico-industrial interactions between all the branches, firstly of electronics and then of the increasing number of different activities which are concerned by the impact of electronics. This makes it necessary, in the case of any electronics production of an international level, to be able to call on a well developed industrial fabric which few Third World nations can offer.

46. The amount of the necessary investments, and the scales of production which are imposed by the need to make them profitable, constitute a considerable technico-financial and commercial barrier. In most cases the electronics industry is very capital-intensive and must be assured of a very large market. For any given country, where the domestic market is restricted, this implies the need to export, and this cannot be done very easily in fields where clients are very concerned with reputations, particularly in regard to quality. It is also necessary either to master, or to introduce oneself into, very specific production channels, whether these involve telephone terminals or components.

47. Finally this field is an extremely desirable one. A real "technological war" rages between the industrialised countries who are increasingly conscious of any penetration of their markets, these being always the markets which are most susceptible of offering those outlets which the Third World countries do not have locally.

48. To enter into electronics production, with its high technology, with the objective of an industrialisation strategy seeking to bring the territorial production apparatus into the age of electronics, thus presents major difficulties. It may therefore be tempting, initially, to look at it from the side of those facilities which the operation of this global industry can offer.

1.3.3 The facilities for dependent insertion by way of assembling or copying

49. Sheltered on a protected domestic market it is certainly possible, with a delay of some years, to proceed to local production after dissecting and copying many electronics products. In a large number of countries having some electronics production it is possible to decipher the procedure for the production and testing of a board, for example for disc readers, to purchase the components on the international market and to produce them at a cost which is lower than the price of the imported product (with higher or lower taxes).

50. The electronics assembling industry remains possible, even with automation at a high level, within the framework of sub-contracting as OEM or as second source, provided that the necessary equipment and components can be imported and that there is an adequate domestic market.

51. For countries which already have some technico-industrial competence the efforts being made by certain actors in world industry in regard to international standardisation may, from certain aspects, present a favourable character. Standardisation does allow some technical transparency, increases the size of markets and raises competition. The standard compatible PC has allowed a number of countries to start production of microcomputers, something which would not have been thinkable in another situation. The ISO, RNIS and other standards can play the same role. From another side national specifications for this or that item of equipment can shelter local industry from exterior competition and allow the development of know-how without being immediately at international competition level. This can only be operated in the case of those countries which have an appreciable domestic market, since such a specification excludes any possibility of exporting.

52. All these facilities for insertion into world electronics production are operations where the local actors are in fact led to try and follow those who possess mastery, and thus they are in some way dependent. However it may be imagined that this is also an occasion to improve the levels of the existing capabilities which were inadequate. Nevertheless using these facilities alone will not suffice to transform the production apparatus and to become industrialised. It is therefore necessary to envisage a real strategy for entry into electronics in the more or less immediate future.

2. TOWARDS AN INDUSTRIAL STRATEGY FOR ENTRY INTO ELECTRONICS

2.1. What point(s) of entry?

2.1.1 A critical examination of simplistic responses : softwares and ASICs

53. One often hears it said that Third World countries would have a comparative advantage in software production. Without going back to what has already been explained in paragraphs 31 to 41 concerning the argument from Comparative Advantages it should however be emphasized how this is in fact a simplistic or misleading response to the question concerning the point of entry.

54. The basis of the argument rests on the low cost of abundant skilled labour and on the fact that it would be possible to develop software in a way which is quite independent of the production of the hardware. This leads to the idea that Third World countries should launch themselves into software and occupy a significant place on the international software market.

55. In fact relatively skilled, and sometimes very skilled, manpower does exist in practically all Third World countries, and whilst it is always cheaper manpower than that of the industrialised countries it is not abundant. Furthermore the production of software independently from the hardware relates only to applications software, and always requires access to the hardware on which it is to run.

56. This has two consequences. Even a populous country like India with considerable resources of highly skilled manpower can only expect, despite ambitious objectives, very modest prospects in this field. If the projected plan is achieved India will export software to a value of some US$ 300 million in 1990 (Datamation, 1 September 1987). This is a very mediocre exporting resource when it is realised that one software package for the PC microcomputer can achieve sales of US$ 1 billion. All this is despite the fact that electronics is one of the many fields in which India has real capabilities. However, amongst its most remarkable results is not the fact that the excellent team at TATA Consultancy Services has been able to produce this or that software for one or another of the North American or European firms, but rather the fact that a team of eighty Indian computer scientists are able to start up in software design of integrated circuits as a result of the investment made in Bougalore by Texas Instruments.

57. This easy entry, by way of dependence on a world leader, is necessary since in the production of software the barriers against entry are very significant. Hardware know-how is essential for keeping abreast of the frenetic rate of technical progress in basic software. In regard to applications software other serious barriers are raised in respect of credibility, a reputation for customised software, publicity and distribution channels.

58. In particular one can see that the field of software for PC micro-computers follows an inverse innovation cycle rather similar to that shown by R. BARRAS (1986) for services. After an initial phase when all software proliferated a large number of firms found their own niches. During the second phase firms in every country of the world could sell their applications software. Finally in the third phase there appeared new and more all-embracing software concepts, and this allowed a small number of firms to become leaders and to cause the many small niches to disappear. At the present time the launching of a new product requires considerable expenditure on development and, particularly, on publicity and consequently demands a very considerable market.

59. Thus to enter electronics through software would seem to be a difficult option. If this is true for India it is all the more so for any country which does not have a comparable potential of highly skilled manpower. Furthermore it is far from obvious that this is an optimal point of entry to carry out an industrial strategy which necessarily remains centred on material production. This criticism does not apply to the "ASICs" option.

60. Another option which is proposed for entry into electronics is the production of high technology integrated circuits. Since it would appear that a silicon foundry and the design of completely original circuits form a field which is probably reserved for highly industrialised countries with an adequate domestic or export market one may turn towards a simpler version, that of the design of ASICs: a definition of these may be found in Chapter I, paragraph 61.

61. Even in the simplest versions the sums that need to be invested remain considerable, and the levels of training to be achieved are very high (cf. O. MANCK, 1987). In the European countries there are only a limited number of teams which are fully up-to-date and capable, if needed, to train engineers after academic training, so that they could then attempt to carry out this extremely delicate operation.

62. Here again the idea of separating the software activity from the design activity seems totally unrealistic. Interaction between these two activities has to become all the greater as technical progress speeds up. Most careful studies confirm this judgement, which is shared by J. SIGURDSON (1986) : "It is not yet obvious to what extent the design phase can be separated from productions of ICs considering the very high rate of development of IC manufacturing."

63. Under these conditions to launch Third World countries into the production of software or into that of ASICs is mainfestly to adopt an extremely simplistic approach to a very difficult question.

2.1.2 Focalisation-articulation requirements

64. The very strong interconnection of the various branches of the electronics industry makes the problem of choosing a point of entry an extremely delicate one. Reasoning which is too exclusively guided by "technique", that is to say the reasoning of an engineer, cannot provide a satisfactory solution. Within such a framework the solution is to be present everywhere since it is not possible to locate oneself concretely in one place without profiting from the multiple technico-industrial interactions. Such an option was unsuccessfully attempted by France within the framework of the "plan d'action filiere electronique" (cf. Chapter IV), and most Third World countries are much less well equipped to attempt it in their turn. This does not mean that one should not produce some of every kind of goods, even with a low degree of mastery and integration, when this is possible. However the dissipation of efforts runs the risk of considerably lengthening the time needed to master any one product.

65. Using this same reasoning the limited solution consists of attacking, since one cannot do everything, the micro-electronics foundation, the basic bricks. This is a withdrawal when compared with the extensive investments which would have to be made but, as was pointed out above, the production of integrated circuits - and even just their design - cannot be carried out without technico-industrial interaction with clients' activities and very extensive know-how. It is not therefore a real answer. In the same way the "software" solution evades the problem without solving it.

66. Taking the technico-industrial situation of the world electronics industry into account it is necessary to adopt a strategic attitude and to seek a weak link, taking its specific advantages into account and to apply

all one's weight to this by devoting large private and public resources to it. The magnitude of the tangible and intangible investments needed, and the size of the market for profitability in most of the fields, imposes on any strategy of entry, with the ambition of future mastery, this requirement of focalisation.

67. Simultaneously this focalisation raises the requirement of articulation. That is to say the chosen entry activity will gradually extend its advantages to one of the numerous linkages in the inter-connections which characterise the whole of the electronics complex. In particular, and as soon as one begins to master the initially focalised production, the production of certain of its components or constituent parts will be found to be perfectly justified and feasable while to produce a more complete assembly could pose problems by reason of another requirement, that of its level of complexity.

2.1.3 Complexity level requirements

68. Entry into a field of high technology can be effected, when a weak link has been identified, without necessarily choosing a point which is less complex than others. In order to achieve mastery at this point it is first of all necessary to be capable of implementing state-of-the-art production techniques: to acquire the equipments and to commission them. Then, and after the capability to utilise the production technique, it is necessary to pass from technique to technology (cf. Chapter I, paragraph 15), that is to say to acquire an overall understanding of the processes to be utilised. Finally it is only this understanding which makes it possible to make improvements in various aspects of these processes or to modify the product in some way so as to meet the wishes of certain clients or changes in the demand. This third step shows true technological mastery and may take a longer or shorter time; in an industry where progress is rapid this may mean in fact several generations of products.

69. Progressive mastery of tl field of entry shows the obvious temptation to progress towards vertical integration, since the overall understanding of the process to be utilised will be found to be improved. This is in fact the way in which a number of large informatics firms arrived, a long while ago now, at the stage of manufacturing their own integrated circuits, and it is also the way which Goldstar has recently followed in Korea. Onto this choice is also grafted that of the nature of the resources to be utilised, and this will depend on national characteristics: the formation of a large and increasingly integrated enterprise or specialised enterprises, the relations between then resulting from the market where an intermediate price will duly appear.

70. This being the case the relationships with clients can also facilitate a prior understanding of a field where elaborated products enter as constituent parts. In certain cases an understanding specific to a constituent part and the availability on the market of other constituent parts of the same level of complexity may require only an easily accessible supplementary technico-industrial capability in order to construct a system which links them into one machine which processes or transforms information.

71. It is clear that all depends on the level of complexity for both extension and for integration. We can take as a point of departure the production of printed circuit boards by small firms, with an agreement with other client firms, these circuits carrying out a specific function and consisting of various components. Mastery of one circuit corresponding to one function can confer the ability to master circuits corresponding to other functions, and hence to generate a potential to master partially the production of the equipment which links together these different board-functions. By contrast it is perhaps, if not certainly, more difficult to consider that the building of one or other integrated circuit on these boards could mean progress in a significant manner towards the capacity to produce them. This does not mean, on the contrary, that it is impossible to envisage progressing towards complexity by integration as well as by extension: the printed circuit board certainly includes other components which are easier to produce than integrated circuits. Furthermore it is equally possible to progress in complexity laterally. Electronics is a constructional industry, a technico-industrial complex, and cannot be seen as a chain or thread linking together activities which interlock from upstream to downstream and which, from the chip to the super-large system, become increasingly complete. Laterally increasing complexity may correspond to more sophisticated boards, at several levels, necessitating more sophisticated equipment: the spectrum is extremely broad here, as in all segments of the electronics industry.

72. The existence of a gradation in levels of complexity therefore makes it necessary to choose a relatively less complex point of departure, in a place which will not prevent the achievement of the expected results, with the excess costs inherent in the inadequacy of mastery which will necessarily characterise the start of any activity. It is not possible here to go into a detailed study of the increasing complexities through which all the activities in the electronics industry pass. It is however possible to illustrate this gradation in a very simplistic manner by the variation in the degrees of complexity "revealed" by the international hierarchies concerned with the major traditional branches of the electronics industry. Japan started with relatively simple components and then dominated the world market in mass consumer electronics, with radios and then with television receivers, when they utilised relatively few very complex components other than the tube. It is only recently that Japan has been able to become an important manufacturer in integrated circuit memories. Its world position remains somewhat backward when compared with American domination in small, medium and large informatics systems, fields in which Europe remains powerful as also in the case of telecommunications where, once again, the power of the Japanese is more recent. It should be added that it is only from today that one can date the birth of a microprocessor of Japanese design. This presentation of the revealed levels of complexity during the course of history shows numerous correctives: above all it is necessary to point out that within Mass Consumer Electronics (MCE) one finds a fairly wide spectrum of levels of complexity with a particularly high complexity in present and future television receivers.

73. However this very general sketch makes it possible to direct ideas towards this very important concept of gradation which can be illustrated by an example of a more recent and current progression, that of South Korea. This country manufactures and sells on the world market television sets and electronic chips; however although it also sells compatible microcomputers it is today seeking to integrate a number of components - obviously all the microcomputers manufactured in the Third World operate not only with imported microprocessors but also with numerous other components. Furthermore, and even by purchasing the components, South Korea cannot manufacture super-minis, that is to say rather more complex informatics systems, and has to be content with buying them in kit form and hoping gradually, by dissecting them, to acquire a little mastery. According to Kil-Nam CHUN of the Korean Advanced Institute of Science and Technology (KAIST) although Korea has hundreds of computer scientists they are not at the present time capable of designing a diagnostic system for a CPU which can identify defective boards (DATAMATION, 1 June 1987, p.68-2). One could cite other examples such as attempts by Korea, India and Brazil to produce telephone exchanges of a certain size.

74. This gradation also poses the problem of the possibilities for maintenance. These are directly linked with the level of complexity of the equipment to be maintained and also the level of complexity of the equipment which needs to be used in carrying out this maintenance. It is obviously not possible to go into detail, but here again these comments should guide considerations and, above all, prevent adopting any position until after highly detailed consultation. Table VI-8 sets out an attempt at a very broad evaluation of levels of complexity and their accessibility by the generally accepted categories of Third World countries (J. SIGURDSON, 1986, op. cit., p.76): "A more detailed distinction, linked with an evaluation of the scientific and technico-industrial potentials, would obviously be preferable, and then it would be necessary to link this with an equally detailed scale of complexity."

Table VI-8 : EVALUATION OF THE LEVELS OF COMPLEXITY AND OF ACCESSIBILITY OF ELECTRONICS PRODUCTION ACCORDING TO THE LEVELS OF DEVELOPMENT OF COUNTRIES

"Stage of national development"	Use of professional electronic equipment	Manufacture of electronic equipment	Manufacture of semiconductor components	Manufacture of complex electronic systems
Developing countries at the early stages of development	severely constrained	generally not possible	impossible	impossible
Developing countries	possible with certain constraints	only possible through collaboration	not possible	not possible
Newly industrialized countries (NICs)	without constraints	possible but in the main limited to consumer electronics	independent possibility impossible for the time being	only possible through collaboration
Industrialized developing countries (India & China)	without constraints	general capability possible	independent capability constrained and at high costs	independent capability severely constrained and at high costs
Industrialized countries (e.g. Sweden, USA)	without constraints	general capability possible but economies of scale requires specialization	general capability only possible for a few countries	possible only for a few big countries or smaller ones with viable international companies

Source : J. SIGURDSON (1986), p. 76.

2.2. What tactics?

75. The theme of the endogenous creation of an appropriately adapted technology has for many years been the burden of a number of specialists in the theory of development. One saying has now become international: there is no point in re-inventing the wheel: the wheel, the hammer and many other objects are saturated but neverless indispensable techniques. One can understand the heuristic value of re-inventing the steam engine or the foot lathe and so on, but it is certainly possible to discover just as much heuristic value in the least complex technical elements in those technico-industrial wholes which make it effectively possible to generate an industrial strategy for the age of electronics. Under these conditions the principal tactics to follow are recourse to foreign technology and the search for a level of global competitiveness.

2.2.1 Recourse to foreign technology

76. The commissioning of any new production activity will necessarily involve the purchase of imported equipment and hence the implementation of a production process which has been defined abroad. Frequently this is in fact accompanied by the purchased authorisation to produce some product, often limited by market restrictions,. Must one be offended by this and cry after technological independence? Certainly one may regret that the techniques, with their rational mastery which constitutes technology, are not provided free of charge but are in part at least sellable and appropriable. In these days the activity of all firms is founded on this reality, and the operating rules of world industry do not always encourage them to hand over what constitutes one of their specific advantages, on the nature of which the so-called International Division of Labour is established (cf. point 1.3. above). At the present time and in many fields firms in the industrialised countries are relatively more reticent than in the past to hand over their technologies. Nevertheless attempts should be made to purchase them, even if this is to recognise to some extent what is, when all is taken into account a very real technological dependence. There is nothing ignominious in this dependence, and doctrinal judgements on the matter must be expunged in the face of pragmatic analysis. If we look at international trade in licences it is possible to emphasize generally the enormous deficit which characterises the technological dependence of the Third World nations. Undoubtedly true. But using this yardstick the country which is most technologically dependent is Japan! In 1983 (CPE Bulletin, No.29, Paris, pp.45-46) the rate of coverage of imports of licences was 10 for the United States: their export receipts are ten times greater than their import expenditure. The corresponding figure for Great Britain is 1.3, for Germany 0.7, for France 0.6 and for Japan 0.285! Taking the 1982-1983 average Japan, according the the OECD, had an external deficit of more than US$ 10 billion: what a level of dependence!

77. Recourse to foreign technology must be effected without any doctrinal preoccupations concerning dependence, but partly with the logic of the competition of the world industrial system and partly with that of international private or State cooperation.

78. The competitive logic in the acquisition of foreign technologies must not be limited to the consideration that "technologies" are available on the market. Firstly there is, in fact, a considerable quantity of knowledge concerning techniques and even on their utilisation which is practically free. It is necessary to visit exhibitions and to subscribe to data banks: this cannot be done entirely free of charge but it is possible to find in them data which one needs and which it would be pointless to purchase at a much higher price by means of an agreement with a foreign firm.

79. Before buying technology it is necessary to define the field of technico-industrial knowledge which one is seeking to acquire, and to target a technological lookout which should make it possible to obtain, at very low cost, a quantity of information and knowledge which does not have to be purchased. Such knowledge will make it possible to target more effectively those operators who hold what is really indispensable and which must necessarily be acquired on the market. This also makes it possible to enter into negotiations and to this end to have already acquired a certain level of competence by an examination of technical documents, by visits to plants, by discussion, by inviting foreign engineers and by the competition in certain fields which it is sometimes possible to stir up between various foreign operators. This new level of prior knowledge will make it possible to evaluate with more accuracy exactly what should be the object of the licence, in particular by eliminating a number of facts which one hopes to be able to generate oneself on the basis of the principal acquisition.

80. It is tactics of this type which will make it possible to master a technology progressively and which will harmonise with the requirements set out in paragraphs 64 to 74. They have been successfully employed here and there, obviously in Japan but also in other countries such as Ireland. E. LALOR (1985) reports that the Irish Goods Council marshalls its forces to show what equipment the public authorities import in order to encourage local manufacture. In this way public orders provide an occasion for facilitating this "technological lookout" for companies. In this way an Irish firm was able to dissect a French modem and thus to appropriate it in such a way that, shortly afterwards, not only did the Irish administration give them orders for this product but the Irish firm succeeded in exporting them to France.... The cases can also be cited of Korea which, with its desire to produce super-minis (cf. paragraph 73), simply decided to take a shareholding in an American start-up firm which held this technology, or of the Economic Development Board of Singapore which is established in Silicon Valley, or again the purchase in 1984 of Autonumerics, a manufacturer of electronic machine tools, by China, so as to facilitate their "dissection" by its engineers.

81. This tactic is not always accessible and already demands some technico-industrial capability so it may be necessary to place more faith in the virtues of international cooperation, even if this involves going through the market for a not unimportant part of it. This international cooperation can be established with private firms, despite their essentially merchandising logic, particularly when they have the feeling that the partner is not operating the tactic described in paragraph 79, or when they feel that he does not have the required resources to do so. There are many examples of this and one may, as an example, cite the case of the cooperation in informatics between Data General (United States) and China which was initiated in 1979 and which opened up a route followed by a whole string of firms from Sinclair (with microcomputers) to IBM (installed in 1986) and which, as everywhere else in the world. seek to develop a very close cooperation with universities, starting by supplying them with equipment.

82. International inter-State cooperation is more usual. Very many international agreements including programmes for training and technical assistance are in operation to the benefit of Third World countries. This is also a source for a possible technical lookout tactic. The industrialised countries are starting to be disturbed by the considerable proportion of foreign students whom they are training. In the United States nearly 50% of 11 the PhDs awarded each year go to foreign students. However it must be added that graduate unemployment leads a number of these foreign graduates to remain in the industrialised country of their training. Eventually programmes for the repatriation of such graduates (as is the case today in India and Korea) could facilitate the acquisition of technologies, as in the case of the Indian S. PITRODA, an industrial physicist in the United States, who returned to India and founded CDOT to design small telephone exchanges for country areas (Electronique Hebdo, 4 February 1988, p.5).

83. International cooperation on a South-South regional basis is also the subject of numerous agreements, although the content of these remains very limited. Certainly a number of countries accept foreign students, but this merely reproduces a cooperation of the same type as that between the countries of the North and those of the South. It is therefore a kind of cooperation between intermediary or linked countries and slightly less advanced countries.

84. It is rare to find real cooperative actions which unite, in a convergent manner, the efforts of countries of comparable levels of development, or of regional proximity. There are certainly numerous texts on this: Chapter V of the Lagos Plan of Action on Science and Technology, adopted in 1980 by the Organization of African Unity, the Tokyo Programme on Technique in the Service of Development in the Asian and Pacific Region, adopted in 1984 by the United Nations Economic and Social Commission for Asia and the Pacific, together with various organisations attached to the UN. However concrete applications remain modest. Even in Latin America, which has shown for many years a desire for regional cooperation, the results are of little importance. There is certainly the Latin American Economic System (SELA) which adopted in 1986 a Scientific and Technological Strategy to reinforce the scientific and technological capacity of the region as an indispensable element in promoting general and harmonious economic development in Latin America. And it is in this region that the UNIDO project to create regional networks is the most advanced. However in the most recent version (UNIDO, 1987) the acitons of UNIDO in this matter do not indicate any modifications as compared with the previous versions: it must therefore be concluded that projects of this type are difficult to develop.

2.2.2 Seeking a level of global competitiveness

85. Successful entry into world production is only confirmed when technical capacity to produce is reflected in industrial quality without excess costs over what could be achieved. In other words it is necessary to achieve the level of global competitiveness which means including not just the more technical aspects but also the industrial and commercial elements. This therefore leads to defining the inherent tactical choices which are associated with this search for a level of global competitiveness.

86. This search for a level of global competitiveness guides first of all the choice of the product as a function of its level of complexity and links up with the mode of recourse to foreign technology. However it is preferable, even for a simple component, to verify its level of competitiveness rather than to try, by lowering the price of the product by a possible public subsidy, to place it on foreign markets or, by means of customs' protection, to impose it on local users (national or foreign). Such standards can only be temporary if the stages for reaching the required level are clearly defined.

87. This tactic poses the specific problem of the choice of the operators and, where necessary, their number. Small firms, an existing or potential division of a large firm, an existing or future enterprise in the public sector....the choice here will obviously depend on the specific local context, but in particular one must be guided by this search for competitiveness where clearly the concept of competition which it includes tends, a priori, to favour a multiplicity of actors of small size. Whereas technical mastery sometimes seems to be more accessible to large firms the stimulants to competitiveness seem to operate better with firms of medium size, and more so in the private sector than in the public sector. The problem is even more complicated when, for reasons of recourse to foreign technology, it is necessary to call on foreign investment or a joint venture which then excludes the small enterprises and often leads to a public shareholding. Each or almost every case is obviously a special case which requires an in-depth examination.

88. The number of possible operators is clearly linked with the potential of the existing resources and the forecast market for the goods to be produced. If in the initial stage it is only the domestic market, of relatively modest size, which is to be supplied, then the number of possible operators, if scale economies and the desired profitability of the investments are to be achieved, will need to be limited, whether these operators are local or foreign. Thus in telecommunications whilst some markets may make it possible to require foreign manufacturers to install a production and assembly activity for some components, from which it is possible to derive a raising of local industrial capacities, it is very exceptional (as in India or China) for the potential market to make it possible to envisage these activities being operated with several operators at a level of world competitiveness. Conversely on the Brazilian market, which is reserved for local operators, the unlimited number of operators has deprived each of them of the scale economies and the curves of experience which could rapidly improve their competitiveness, leading to a long and hazardous process by the local market to arrive at this point.

89. The importance of being at the level of world competitiveness is demanding but essential for transmitting positive rather than negative effects to a unity where, as has often been pointed out, interconnections are very numerous. Even better this can reinforce the occasions for increasing participation in world electronics production by giving specific advantages to the country. Knowing that one can have locally this or that type of component, constitutents or intermediate goods of world competitiveness level a firm elsewhere in the world could find it of interest to establish here, rather than elsewhere, an investment on which it had decided for the purpose of supplying the regional market (cf. Chapter III, 1.2.). It is this which explains why many investments have been made in Singapore where wages are higher than anywhere else in Asia other than Japan.

90. When exporting is involved it is essential to follow a tactic of global competitiveness. It is true that in certain cases it is possible to sell certain products abroad by using a foreign firm and an exchange involving access for more sophisticated products to the domestic market, the latter including a certain level of integration of the former products. These are doubtful successes, without any future, and on which there is no point in dwelling. To export in a lasting manner, possibly in a more autonomous manner, is much more difficult and, in particular, requires major expenditure on publicity, even for intermediate goods (in the trade papers). Furthermore in many cases it is necessary to identify and to master the export and distribution channels, which are rarely simple. Here again one finds a form of know-how which demands a difficult and progressive apprenticeship.

91. In the case of each product raising it to the level of global competitiveness should make it possible to achieve a not unimportant position on the world market, and in certain cases the successes are spectacular. One cannot close without citing the case of the Korean mass consumer electronics industry which exported goods to a value of US$ 3 billion in 1987 and which has today arrived at the stage of relocation to the most industrialised countries as can be seen from Table VI-9.

Table VI-9 : FOREIGN INVESTMENTS BY THE KOREAN MASS CONSUMER ELECTRONICS INDUSTRY

ENTREPRISE	USINE A L'ETRANGER	CAPITAL	INVESTISSEMENT	PRODUITS	REMARQUES
Goldstar Co	GSAI : E.U. GSEG : Allemagne F. GSV	2,5 millions de $ 1,4 million de $	Possédée en totalité 2,6 millions de $ Joint venture (25 %)	TV couleur et fours à micro-ondes Fours à micro-ondes	TV couleur et VTRS 10 % du marché E.U. 400 000 VTR/an, 300 000 TV/an
Cie Samsung Electronics	SIL E-U. SET : Portugal SEMUK : G.B.	2 millions de $ 500 000 $ 1,5 million de $	Possédée en totalité Joint venture (56 %) Possédée en totalité	TV couleur TV couleur Fours à micro-ondes	600 000 TV/an
Sunkyong Chemical	America (inauguration en 1988)	1,5 million de $	Possédée en totalité	Bandes magnétiques	200 000/an
Saehan	Ireland (inauguration en 1988)	-	Possédée en totalité	Bandes magnétiques	
Daewoo	Longwy : F.	?	Possédée en totalité	Fours à micro-ondes	30 000/an

<u>Note</u> : EU = Etats-Unis ; GB = Grande Bretagne ; F = France

<u>Source</u> : Electronique Hebdo, n° 57, 28 janvier 1988, p. 4.

2.3 What problems?

92. The previous paragraphs have clearly shown that <u>neither the choice of the point of entry nor the tactical decisions can be taken on an a priori basis</u> for every country or even for every category of countries. It is not therefore possible to go further into this matter; however it is possible to <u>specify an approach to the problem</u> involved in developing an industrial strategy for entry into the electronics industry. This approach to the problem is based on work which we have recently published under the title "<u>Les strategies d'industrialisation dans l'electronique</u>" (Strategies for industrialisation in electronics) and in which we have analysed the strategies of about fifteen Third World countries (HUMBERT, 1988).

2.3.1. Rejecting miserable dependence and sordid independence.

93. The approach which one must employ when defining a national strategy for entry into the electronics industry must, in particular, endeavour to escape from the traditional cleavages which have been induced in the past by theories of development each of which has opposed sterile doctrinal objections to the other.

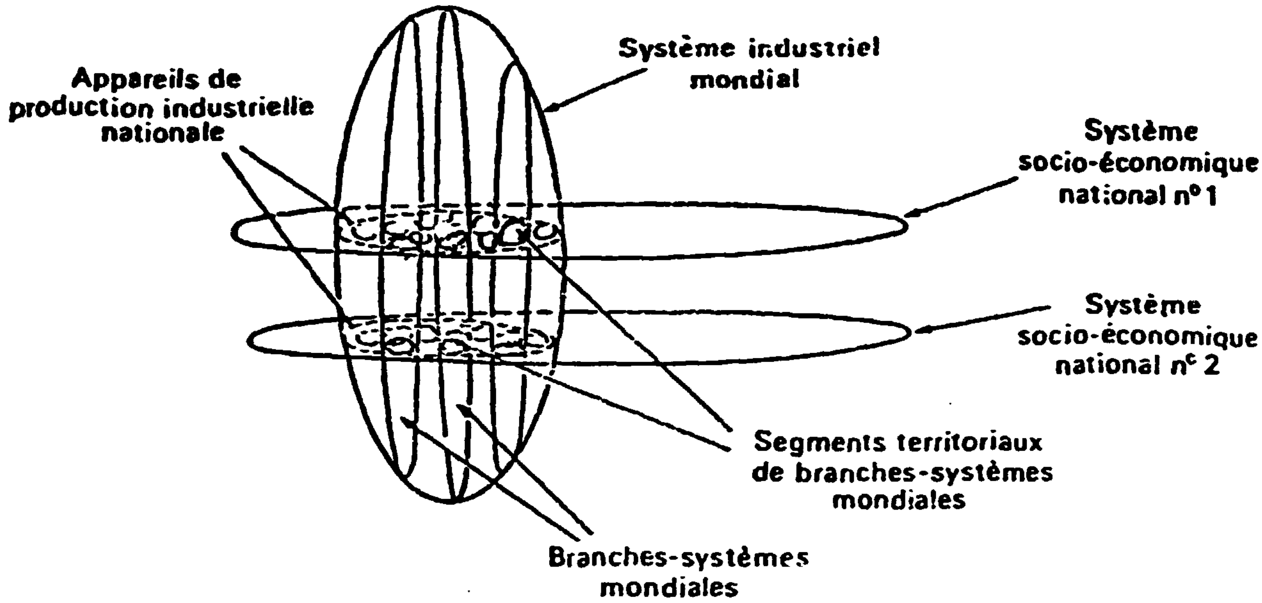
94. For one theory it is a matter of opening up to the rest of the world, in some way to the operation of the world industrial system; to do this as well as possible it is necessary to attract or to favour, without any distinctions, any foreign investment and to promote in this way, with eyes fully or nearly closed, all exporting. In order to facilitate this one operates on the "comparative advantages" by trying to exert pressure to hold down wages and to devalue the currency.

95. For the other theory it is a matter of escaping from the domination exercised by the International Division of Labour on national economies. Those who do not close their frontiers suffer despoliation and disarticulation, and their dependence forces them to be just an enclave in the service of the multinationals. Caricaturing the first theory leads one to question a situation of miserable dependence, and to accept the counter-risk of arriving at a sordid independence.

96. To close oneself off from the rest of the world and to fall back on a domestic market which will always be too small leads to a squandering of resources on local oligopolies or a bureaucratic public sector, sheltered from any economic calculation of profitability; without external stimulation the technological level progresses even more slowly than in the past and the lag with respect to the rest of the world grows ever greater. Independence is safeguarded, and possibly such a situation could favour greater equality between the citizens of the same nation, but probably with a considerable reduction in the average standard of living. All in all this would just be a sordid independence.

97. A simple graphical representation (cf Figure VI-10) makes it possible to understand how necessary it is to escape from this cleavage, each of the theories giving precedence to effective realities which must nevertheless be combined. The world industrial system consists of various world branch-systems where the world technico-industrial logic traverses the various economic spaces. This vertical logic cares little for the social wellbeing of this or that nation, and one would be very wrong to entrust the improvement of one's wellbeing to it. By contrast the national economies which wish to take charge of this organise their own socio-economic system and for them, and for their public authorities, production is only a means of improving the collective wellbeing and its distribution. The universal technico-industrial evolution does not, of itself, constitute their objective. To a certain extent their horizontal logic could very well pass through this.

Table VI-10 : THE ORTHOGONALITY OF THE WORLD INDUSTRIAL SYSTEM AND THE NATIONAL SOCIO-ECONOMIC SYSTEMS



Source : M. HUMBERT, Revue Tiers-Monde, *"La socio-dynammique industrialisante"*, septembre 1986, p. 549.

98. The orthogonality of the logics is such that to adhere to one leads to miserable dependence, whilst to fall back on the other safeguards a sordid independence. Clearly what needs to be sought is some articulation.

2.3.2 Linking a social dynamic to the World Industrial System

99. Any successful strategy carries both a national mark, that of its national socio-economic system, and a date, corresponding to the state of the world industrial system at that point in time. It is the judicious application of a national scientific, technical and industrial potential to the instantaneous state of the world industrial system. Such a strategy cannot thus result from the strict copying of a model but perhaps of an approach to the problem, and must be specific to the country concerned as well as to the moment at which it is defined, that is to say to the state of the world industrial system.

100. As an industrialisation strategy the various choices may be judged by the criterion of their impact on the progressive technico-industrial transformation of the national potential: it is necessary to raise the technico-industrial capacity to the largest number. As a national strategy it must be based on the national system and to be found therefore, by its nature, to be a social strategy. It is necessary, and this is a particularly delicate point, that it engages with an endogenous social dynamic. It is this which leads to industrialisation, not the electronics.

101. With the electronics industry playing an essential role in the functioning of the world industrial system the strategy for industrialisation, which must reduce the orthogonality of the logics by placing the local production apparatus more in phase with world industry, chooses in a totally pertinent manner to seek to enter into the electronics industry. However if miserable dependence is to be avoided it is necessary to restrict the choice even further and, in a general way, to organise a relative and modulated opening-up to a judiciously chosen target so that this opening-up effectively serves as a lever to industrial growth rather than merely allowing access to a rather destructive wind.

102. However, and whatever precautions are taken, this opening-up will shake the socio-economic system, and various accompanying measures will be absolutely essential to ensure the permanance of a social cohesion, which is in any case not always perfect. The process of the technico-industrial catching-up with the world electronics industry, and more generally of a rapidly evolving world industral system, together with the progressive raising of national capacities, is the ferment for major social transformations, the difficult management of which falls into the fields of disciplines other than ours. However enthralling these may be we will not say anything more concerning them.

LITERATURE REFERENCES TO CHAPTER VI

(In the order in which they are cited)

FROEBEL F., HEINRICHS J., KREYE O., (1977)	The new international division of labour. English edition, Cambridge University Press, 1980.
FROUVILLE R., PERRAULT J.L. (1986)	Bilan et perspectives des strategies d'insertion dans l'industrie electronique mondiale: le cas des nouveaux pays industrialises Revue Tiers-Monde, Vol. XXVII, No.107, July-September 1986, pp.669-686.
BERTHOMIEU C. et al. (1985)	L'insertion de la France dans la segmentation internationale des processus productifs par la sous-traitance internationale Report to the Commissariat General du Plan, October 1985, Vol.1, 353pp, Vol.2. Annexes (c. 200pp.).
HAMELINK C.J. (1987)	Les technologies de l'information dans le Tiers-Monde. Revue Tiers-Monde, Vol XXVIII, July-September 1987.
UNCTAD (1978)	Electronics in developing countries: Issues in transfer and development of technology. United Nations, TD/B/C.6/334.
RADA J. (1980)	The impacts of micro-electronics ILO-BIT, Geneva, 116pp.
UNIDO (1981)	Implications of micro-electronics for developing countries. A preliminary overview of issues. UNIDO/IS/246, Vienna, 1981.
STEWART F. (1985)	El cambio tecnico en el Norte. Algunas consecuencias para las opciones del sur. Comercio Exterior, Vol.35, No.1, Mexico, January 1985, pp.37-47.
UNCTAD (1986)	Further elaboration and implementation of a strategy for the technological transformation of developing countries. Status of negotiations and presentation of proposals by the regional groups and China. Note by the UNCTAD secretariat. TD/B/C.6/135, 22 July 1986.
UNCTC (1986)	(United Nations Centre on Transnational Corporations) Transnational operations in the international semiconductor industry. New York, 1986, ST/CTC/39, 471pp.

BARRAS K. (1986) — Towards a theory of innovation in services. Research Policy, 15, 1986, pp.161-173.

MANCK O. (1987) — Some considerations for the establishment of silicon foundries and design centres. UNIDO, IPCT-45(SPEC), 6 November 1987, 41pp.

SIGURDSON J. (1986) — Selected aspects of microelectronics technology and applications: custom and semi-custom integrated circuits. UNIDO IS 631, 26 May 1986, 101pp.

LALOR E. (1985) — The use of public purchasing as a tool to develop technological competence in micro-electronics. UNIDO IDWG 440/1, April 1985, 52pp.

UNIDO (1987) — The UNIDO programme of technological advances: microelectronics. IPCT 29 (SPEC), 3 July 1987.

HUMBERT M. (Ed.) (1988) — Les strategies d'industrialisation dans l'electronique. GERDIC, Rennes (7, place Hoche), 1988, 364pp.

STATISTICAL ANNEXES

ANNEX A

GEOGRAPHICAL DISTRIBUTION OF THE MARKETS

Tables

A1-A3 World production

A4-A6 World markets

A7 Trading balances by zones

A8 A historical retrospect : 1957-1986

A9 Prospects for some market segments in the United States and in the world

Source : Calculations by GERDIC from data contained in the Mackintosh Yearbook, Electronics Data 1987. Vol.1: "West Europe", 226pp; Vol.2: "America, Japan, Asia, Pacific", 224pp. Benn Electronics, Luton, 1987.

Note : The trading balances are calculated "ex-post" from the differences between production and the market.

Annex 3

Table A.1 - 1986 production (US$ millions)

PRODUCTION 1986 (Millions de $)

	Info.	Bureau.	Contr. Instr.	Milit. Commu.	Telé comm.	Médic.	Indust.	EGP	Comp. Pass.	Comp. Act.	TOTAL	Emploi 1985	Nombre Firmes
Allemagne Federale	6742	735	4342	1193	3548	668	395	2361	3590	1332	24906	422000	1200
Benelux	694	22	240	99	598	32	27	401	379	9	2501	33000	100
Danemark	116	23	354	146	99	138	10	88	168	4	1166	25000	225
Espagne	1029	14	76	160	571	31	21	412	219	98	2631	54000	140
France	4129	125	1471	3534	3258	222	160	797	1926	1245	16867	249970	699
Irlande	1669	26	178	51	177	17	18	21	368	223	2746	14500	300
Italie	3615	213	1033	1074	1683	213	164	545	805	464	9829	200000	630
Pays Bas	1491	370	693	420	452	349	55	220	646	572	5268	110000	70
Royaume Uni	5461	274	2587	2930	2309	261	384	956	2109	1015	18287	372167	250
Total CEE	24946	1802	10974	9607	12695	1931	1234	5801	10230	4983	84203	1480637	3614
Autriche	143	20	165	23	229	37	18	262	261	89	1247	75000	350
Finlande	281		153	92	189	35	16	166	135	10	1077	34000	50
Norvege	337		146	92	226	9	20	11	47		888	13000	100
Suède	592	28	465	380	1331	152	35	126	420	56	3585	90000	250
Suisse	218	94	944	171	290	90	84	1078	374	98	3441	50000	
TOTAL Eur. Occidentale	26517	1944	12847	10365	14960	2254	1407	7444	11467	5236	94441	1742637	4364
Canada	1153	135	540	818	1387	135	64	329	441	380	5382	85000	847
Etats-Unis	42620	7100	21270	40940	16600	4592	1745	6106	18194	14900	174067	1529200	18832
TOTAL Amerique du Nord	43773	7235	21810	41758	17987	4727	1809	6435	18635	15280	179449	1914200	19679
Japon	17620	4555	3820	4552	6251	1741	674	20402	15139	12770	89524	1190000	17092
TOTAL Pays Industrialisés	89910	13734	38477	56675	39198	8722	3890	34281	45241	33286	363414	4646837	41135
Corée du Sud	900	76	145	140	880	9	48	2436	1294	1905	7829	293115	1112
Hong Kong	693	163	56	308	334	2	51	1428	542	300	3897	107939	2511
Singapour	1409	112	105	27	73	8	10	877	1298	1679	5598	67500	250
Taiwan	977	134	38	203	506	23	57	1667	1623	941	6369	289245	2600
TOTAL Nains Geants	3979	507	344	678	1793	42	166	6402	4957	4825	23693	757799	6473
Indonésie	50	19	35	30	100		8	115	112	186	675	25000	200
Malaisie	69	2	25	77	85	4	8	231	160	1544	2205	64350	73
Philippines	12	5	16	30	63	5	4	68	72	1103	1383	50000	350
Thaïlande	74	8	17	38	11	7	1	159	24	426	765	12500	134
TOTAL ASEAN (hors Sing.)	205	37	93	195	261	16	21	573	368	3259	5028	151850	757
Afrique du Sud	59	6	21	31	249	11	22	86	57	4	546	48000	600
Australie	102	13	151	187	366	34	20	141	108	7	1129	19500	313
Bresil	1400	120	118	194	760	59	22	1162	892	418	5145		380
Inde	185	23	347	131	432	23	44	936	308	155	2584		2600
Israel	100	4	56	350	180	210	35	21	218	10	1164	40000	184
TOTAL Autres	1846	166	693	893	1987	337	143	2346	1567	594	10586	107500	4077
TOTAL	95940	14444	39607	58441	43239	9117	4220	43602	52149	41964	402723	5863986	52442

Annex 4

Table A.2 - 1986 production as % of TOTAL

PRODUCTION 1986 (%)	Info.	Bureau.	Contr. Instr.	Milit. Commu.	Télé comm.	Médic.	Indust.	EGP	Comp. Pass.	Comp. Act.	TOTAL
Allemagne Féderale	7,03%	5,09%	10,96%	2,04%	8,21%	7,33%	9,36%	5,41%	6,88%	3,17%	6,18%
Benelux	0,72%	0,15%	0,61%	0,17%	1,38%	0,35%	0,64%	0,92%	0,73%	0,02%	0,62%
Danemark	0,12%	0,16%	0,89%	0,25%	0,23%	1.51%	0.24%	0,20%	0,36%	0.01%	0.29%
Espagne	1,07%	0,10%	0,19%	0,27%	1,32%	0,34%	0,50%	0,94%	0,42%	0,23%	0,65%
France	4,30%	0,87%	3,71%	6,05%	7,53%	2,44%	3,79%	1,83%	3,69%	2,97%	4,19%
Irelande	1,74%	0,18%	0,45%	0,09%	0,41%	0,19%	0,43%	0,05%	0,71%	0,53%	0,68%
Italie	3,77%	1,47%	2,61%	1,84%	3,89%	2,34%	3,89%	1,25%	1,54%	1,15%	2,44%
Pays Bas	1,55%	2,56%	1,75%	0,72%	1,05%	3,83%	1,30%	0,50%	1,24%	1,36%	1,31%
Royaume Uni	5,69%	1,90%	6,53%	5,01%	5,34%	2,86%	9,10%	2,19%	4,04%	2,42%	4,54%
Total CEE	26,00%	12,48%	27,71%	16,44%	29,36%	21,16%	29,24%	13,30%	19,62%	11,87%	20,91%
Autriche	0,15%	0,14%	0,42%	0,04%	0,53%	0,41%	0,43%	0,60%	0,50%	0,21%	0.31%
Finlande	0,29%	0.00%	0,39%	0.16%	0,44%	0,38%	0,38%	0.38%	0,26%	0,02%	0,27%
Norvege	0,35%	0,00%	0,37%	0.16%	0,52%	0,10%	0,47%	0,03%	0,09%	0,00%	0,22%
Suède	0,62%	0,19%	1,17%	0,65%	3,08%	1,67%	0,83%	0,29%	0,81%	0,13%	0,89%
Suisse	0,23%	0,65%	2,38%	0,29%	0,67%	0,99%	1,99%	2,47%	0,72%	0,23%	0,85%
TOTAL Eur. Occidentale	27,64%	13,46%	32,44%	17,74%	34,60%	24,72%	33,34%	17,07%	21,99%	12,48%	23,45%
Canada	1,20%	0,93%	1,36%	1,40%	3,21%	1,48%	1,52%	0,75%	0,85%	0,91%	1,34%
Etats-Unis	44,42%	49,16%	53,70%	70,05%	38.39%	50,37%	41,35%	14,00%	34,89%	35,51%	43,22%
TOTAL Amérique du Nord	45,63%	50,09%	55.07%	71,45%	41,60%	51.85%	42,87%	14,76%	35,73%	36,41%	44,56%
Japon	20,45%	31,54%	9.64%	7,79%	14,46%	19,10%	15,97%	46,79%	29,03%	30,43%	22,23%
TOTAL Pays Industrialisés	93,71%	95,08%	97,15%	96,98%	90,65%	95,67%	92,18%	78,62%	86,75%	79,32%	90.24%
Coree du Sud	0,94%	0,54%	0.37%	0,24%	2,04%	0.10%	1,14%	5,57%	2,48%	4,54%	1.94%
Hong kong	0,72%	1,27%	0,14%	0,53%	0,77%	0,02%	1,21%	3,29%	1,04%	0,71%	0,97%
Singapour	1,47%	0,78%	0,27%	0,05%	0,17%	0,09%	0,24%	2,01%	2,49%	4,00%	1,39%
Taiwan	1,02%	0,93%	0,10%	0,35%	1,17%	0,25%	1,35%	3,82%	3,50%	2.24%	1,58%
TOTAL Nains Géants	4.15%	3,51%	0,87%	1,16%	4.15%	0,46%	3,93%	14,68%	9,51%	11,50%	5,88%
Indonesie	0,05%	0,13%	0,[illegible]9%	0.09%	0,23%	0,00%	0,19%	0,26%	0,21%	0,44%	0,17%
Malaisie	0,07%	0,01%	0.06%	0,13%	0,20%	0,04%	0,19%	0,53%	0,31%	3,68%	0,55%
Philippines	0,01%	0,06%	0,04%	0,05%	0,15%	0,05%	0,09%	0,16%	0,14%	2,63%	0,34%
Thailande	0,08%	0,06%	0,04%	0,07%	0,03%	0,08%	0,02%	0,36%	0,05%	1,02%	0,19%
TOTAL ASEAN (hors Sing.)	0,21%	0,26%	0,23%	0,33%	0,60%	0,18%	0,50%	1,31%	0,71%	7,77%	1,25%
Afrique du Sud	0,06%	0,04%	0,05%	0,05%	0,58%	0,12%	0,52%	0,20%	0,11%	0,01%	0,14%
Australie	0,11%	0,09%	0,38%	0,32%	0,85%	0,37%	0,47%	0,32%	0,21%	0,02%	0,28%
Bresil	1,46%	0,83%	0,30%	0,33%	1,76%	0,65%	0,52%	2,67%	1,71%	1,00%	1,28%
Inde	0,19%	0,16%	0,88%	0,22%	1,00%	0,25%	1,04%	2,15%	0,59%	0,37%	0,64%
Israél	0,10%	0,03%	0,14%	0,60%	0,42%	2,30%	0,83%	0,05%	0,42%	0,02%	0,29%
TOTAL Autres	1,92%	1,15%	1,75%	1,53%	4.60%	3,70%	3,39%	5,38%	3,04%	1,42%	2,63%
TOTAL	100,00%	100,00%	100,00%	100,00%	100.00%	100,00%	100,00%	100,00%	100.00%	100,00%	100,00%

Annex 5

Table A.3 - 1986 production as % by countries and zones

PRODUCTION 1986 (%) II	Info.	Bureau.	Contr. Instr.	Milit. Commu.	Télé comm.	Médic.	Indust.	EGP	Comp. Fass.	Comp. Act.	TOTAL
Allemagne Fédérale	27,07%	2,95%	17,43%	4,79%	14,25%	2,68%	1,59%	9,48%	14,41%	5,35%	100,00%
Benelux	27,75%	0,88%	9,60%	3,96%	23,91%	1,28%	1,08%	16,03%	15,15%	0,36%	100,00%
Danemark	9,95%	1,97%	30,36%	12,52%	8,49%	11,84%	0,86%	7,55%	16,12%	0,34%	100,00%
Espagne	39,11%	0,53%	2,89%	6,08%	21,70%	1,18%	0,80%	15,66%	6,32%	3,72%	100,00%
France	24,48%	0,74%	8,72%	20,95%	19,32%	1,32%	0,95%	4,73%	11,42%	7,36%	100,00%
Irelande	60,74%	0,95%	6,48%	1,86%	6,44%	0,62%	0,66%	0,76%	13,39%	8,11%	100,00%
Italie	36,78%	2,17%	10,51%	10,93%	17,12%	2,17%	1,67%	5,54%	8,19%	4,92%	100,00%
Pays Bas	28,30%	7,02%	13,15%	7,97%	8,58%	6,62%	1,04%	4,18%	12,26%	10,86%	100,00%
Royaume Uni	29,86%	1,50%	14,15%	16,02%	12,63%	1,43%	2,10%	5,23%	11,53%	5,56%	100,00%
Total CEE	29,63%	2,14%	13,03%	11,41%	15,06%	2,29%	1,47%	6,89%	12,15%	5,92%	100,00%
Autriche	11,47%	1,60%	13,23%	1,84%	18,36%	2,97%	1,44%	21,01%	20,93%	7,14%	100,00%
Finlande	26,09%	0,00%	14,21%	8,54%	17,55%	3,25%	1,49%	15,41%	12,53%	0,93%	100,00%
Norvege	37,95%	0,00%	16,44%	10,36%	25,45%	1,01%	2,25%	1,24%	5,29%	0,00%	100,00%
Suede	16,51%	0,78%	12,97%	10,60%	37,13%	4,24%	0,98%	3,51%	11,72%	1,56%	100,00%
Suisse	6,34%	2,73%	27,43%	4,97%	8,43%	2,62%	2,44%	31,33%	10,87%	2,85%	100,00%
TOTAL Eur. Occidentale	28,08%	2,06%	13,60%	10,98%	15,84%	2,39%	1,49%	7,88%	12,14%	5,54%	100,00%
Canada	21,42%	2,51%	10,03%	15,20%	25,77%	2,51%	1,19%	6,11%	8,19%	7,06%	100,00%
Etats-Unis	24,48%	4,08%	12,22%	23,52%	9,54%	2,64%	1,00%	3,51%	10,45%	8,56%	100,00%
TOTAL Amerique du Nord	24,39%	4,03%	12,15%	23,27%	10,02%	2,63%	1,01%	3,59%	10,38%	8,51%	100,00%
Japon	21,92%	5,09%	4,27%	5,08%	6,98%	1,94%	0,75%	22,79%	16,91%	14,26%	100,00%
TOTAL Pays Industrialises	24,74%	3,78%	10,59%	15,60%	10,79%	2,40%	1,07%	9,43%	12,45%	9,16%	100,00%
Coree du Sud	11,50%	1,00%	1,85%	1,79%	11,24%	0,11%	0,61%	31,04%	16,53%	24,33%	100,00%
Hong Kong	17,78%	4,70%	1,44%	7,90%	8,57%	0,05%	1,31%	36,64%	13,91%	7,70%	100,00%
Singapour	25,17%	2,00%	1,88%	0,48%	1,30%	0,14%	0,18%	15,67%	23,19%	29,99%	100,00%
Taiwan	15,34%	2,10%	0,60%	3,19%	7,94%	0,36%	0,89%	26,17%	28,62%	14,77%	100,00%
TOTAL Nains Geants	16,79%	2,14%	1,45%	2,86%	7,57%	0,18%	0,70%	27,02%	20,92%	20,36%	100,00%
Indonésie	7,41%	2,81%	5,19%	7,41%	14,81%	0,00%	1,19%	17,04%	16,59%	27,56%	100,00%
Malaisie	3,13%	0,09%	1,13%	3,49%	3,85%	0,18%	0,36%	10,48%	7,26%	70,02%	100,00%
Philippines	0,87%	0,58%	1,16%	2,17%	4,70%	0,36%	0,29%	4,92%	5,21%	79,75%	100,00%
Thailande	9,67%	1,05%	2,22%	4,97%	1,44%	0,92%	0,13%	20,78%	3,14%	55,69%	100,00%
TOTAL ASEAN (hors Sing.)	4,08%	0,74%	1,85%	3,88%	5,19%	0,32%	0,42%	11,40%	7,32%	64,82%	100,00%
Afrique du Sud	10,81%	1,10%	3,85%	5,68%	45,60%	2,01%	4,03%	15,75%	10,44%	0,73%	100,00%
Australie	9,03%	1,15%	13,37%	16,56%	32,42%	3,01%	1,77%	12,49%	9,57%	0,62%	100,00%
Bresil	27,21%	2,33%	2,29%	3,77%	14,77%	1,15%	0,43%	22,59%	17,34%	8,12%	100,00%
Inde	7,16%	0,89%	12,43%	5,07%	16,72%	0,59%	1,70%	36,22%	11,92%	6,90%	100,00%
Israël	8,45%	0,34%	4,73%	29,56%	15,20%	17,74%	2,96%	1,77%	18,41%	0,64%	100,00%
TOTAL Autres	17,43%	1,57%	6,55%	8,43%	18,77%	3,16%	1,33%	22,16%	14,95%	5,61%	100,00%
TOTAL	22,82%	3,59%	9,83%	14,31%	10,74%	2,26%	1,05%	10,83%	12,95%	10,42%	100,00%

Annex 6

Table A.4 - 1986 markets (US$ millions)

MARCHES 1986 (Millions $)

	Info.	Bureau.	Contr. Instr.	Milit. Commu.	Télé comm.	Médic.	Indust.	EGP	Comp. Pass.	Comp. Act.	TOTAL
Allemagne Fédérale	7452	827	3401	1022	2932	399	303	2490	3181	2103	24110
Benelux	1237	82	374	109	515	48	32	290	345	221	3253
Danemark	550	66	216	100	119	26	12	176	249	102	1616
Espagne	1670	112	285	224	556	53	29	734	404	221	4286
France	5362	440	1427	2502	2765	264	203	1617	1811	1350	17741
Irelande	632	29	140	64	129	24	19	71	353	229	1690
Italie	4086	364	1456	885	1708	271	122	1179	1010	890	11971
Pays Bas	2169	218	662	420	512	175	62	640	605	540	6003
Royaume Uni	6369	590	2373	2702	2430	205	313	2306	2787	1559	21634
Total CEE	29527	2728	10334	8028	11666	1465	1095	9503	10745	7215	92306
Autriche	594	65	264	50	248	44	24	240	281	78	1888
Finlande	513	47	178	106	188	29	22	186	195	159	1625
Norvege	790	66	223	170	306	24	24	162	1510	162	3437
Suède	910	97	502	414	507	124	33	334	576	428	3925
Suisse	1049	202	517	171	290	91	36	381	493	219	3449
TOTAL Eur. Occidentale	33383	3205	12018	8939	13205	1777	1234	10808	13800	8261	106630
Canada	2518	474	1073	617	985	245	117	1211	891	734	8865
Etats-Unis	37520	9035	17920	39460	18650	4493	2120	19300	22275	15346	186119
TOTAL Amérique du Nord	40038	9509	18993	40077	19635	4738	2237	20511	23166	16080	194984
Japon	14861	1108	3791	2348	4624	1267	464	6615	9993	10020	55091
TOTAL Pays Industrialisés	68282	13822	34802	51364	37464	7782	3935	37934	46959	34361	356705
Coree du Sud	670	79	320	138	825	68	45	722	1116	856	4839
Hong Kong	321	45	50	54	230	7	21	401	699	544	2372
Singapour	741	71	264	71	68	20	21	485	932	269	2942
Taiwan	238	40	135	72	401	46	42	564	1151	1021	3730
TOTAL Mains Géants	1970	235	769	335	1524	141	129	2192	3898	2690	13883
Indonésie	80	28	70	120	180	10	22	203	123	71	907
Malaisie	165	16	117	83	282	11	11	200	257	87	1229
Philippines	36	9	29	28	90	5	4	59	73	29	362
Thailande	199	17	76	59	81	17	4	182	58	66	759
TOTAL ASEAN (hors Sing.)	480	70	292	290	633	43	41	644	511	253	3257
Afrique du Sud	502	51	144	82	452	48	41	152	141	73	1686
Australie	786	130	303	359	535	87	44	583	328	139	3304
Brésil	1360	128	133	235	746	60	45	1113	800	494	5648
Inde	[illegible]	29	298	129	452	33	44	778	377	299	2657
Israël	390	21	138	210	145	130	15	38	206	119	1432
TOTAL Autres	3404	359	1016	1015	2324	346	189	2664	1864	1124	14327
TOTAL	74136	14486	36679	53004	41945	[illegible]	4294	43434	53232	38428	388172

Annex 7

Table A.5 - 1986 markets as % of TOTAL

MARCHES 1986 (%)	Info.	Bureau.	Contr. Instr.	Milit. Commu.	Télé comm.	Médic.	Indust.	EGP	Comp. Pass.	Comp. Act.	TOTAL
All. Fédérale	7,92%	5,71%	9,22%	1,93%	6,99%	4,80%	7,06%	5,73%	5,98%	5,47%	6,21%
Benelux	1,31%	0,57%	1,01%	0.21%	1,23%	0,58%	0,75%	0,67%	0,65%	0,58%	0,84%
Danemark	0,58%	0,46%	0,59%	0,19%	0,28%	0,31%	0,28%	0,41%	0,47%	0,27%	0,42%
Espagne	1,77%	0,77%	0,77%	0,42%	1,33%	0,64%	0,68%	1,69%	0,76%	0,58%	1,10%
France	5,70%	3,04%	3,87%	4,72%	6,59%	3,18%	4,73%	3,72%	3,40%	3,51%	4,57%
Irelande	0,67%	0,20%	0,38%	0.12%	0,31%	0,29%	0,44%	0,16%	0,66%	0,60%	0,44%
Italie	4,34%	2,51%	3,95%	1,67%	4,07%	3,26%	2,84%	2,71%	1,90%	2,32%	3,08%
Pays Bas	2,30%	1,50%	1,80%	0,79%	1,22%	2,10%	1,44%	1,47%	1,14%	1,41%	1,55%
Royaume Uni	6,77%	4,07%	6,43%	5,10%	5,79%	2,47%	7,29%	5,31%	5,24%	4.06%	5,57%
Total CEE	31,37%	18,83%	28,02%	15,15%	27,81%	17,62%	25,50%	21,87%	20,19%	18.78%	23,78%
Autriche	0,63%	0,45%	0,72%	0,09%	0,59%	0,53%	0,56%	0,55%	0,53%	0,20%	0,49%
Finlande	0,54%	0,32%	0,48%	0,20%	0,45%	0,35%	0,51%	0,43%	0,37%	0,41%	0,42%
Norvège	0,84%	0,46%	0,60%	0,32%	0,73%	0,29%	0,56%	0,37%	2,84%	0,42%	0,89%
Suède	0,97%	0,67%	1,36%	0,78%	1,21%	1.49%	0,77%	0,77%	1,08%	1,11%	1,01%
Suisse	1,11%	1,39%	1,40%	0,32%	0,69%	1,09%	0,84%	0,88%	0,93%	0.57%	0,89%
TOTAL Eur. Occidentale	35,46%	22.12%	32,59%	16,86%	31,48%	21,37%	28.74%	24,87%	25,92%	21,50%	27,47%
Canada	2,67%	3,27%	2,91%	1,16%	2,35%	2,95%	2,72%	2,79%	1,67%	1,91%	2,28%
Etats-Unis	39,86%	62,37%	48,59%	74,45%	44,46%	54,04%	49,37%	44,41%	41,85%	39.93%	47,95%
TOTAL Amérique du Nord	42,53%	65,64%	51,50%	75,61%	46,81%	56,99%	52,10%	47,20%	43,52%	41,84%	50,23%
Japon	15,79%	7,65%	10,28%	4,43%	11,02%	15,24%	10,81%	15,22%	18,77%	26,07%	14,19%
TOTAL Pays Industrialisés	93,78%	95,42%	94,37%	96,91%	89,32%	93,60%	91,64%	87,30%	88,22%	89,42%	91,89%
Corée du Sud	0,71%	0,55%	0,87%	0,26%	1,97%	0,82%	1,05%	1,66%	2,10%	2,23%	1,25%
Hong Kong	0,34%	0,31%	0,14%	0,10%	0,55%	0,08%	0,49%	0,92%	1,31%	1,42%	0,61%
Singapour	0,79%	0,49%	0,72%	0,13%	0,16%	0,24%	0,49%	1,12%	1,75%	0,70%	0,76%
Taïwan	0,25%	0,28%	0,37%	0,14%	0,96%	0,55%	0,98%	1,34%	2,16%	2,66%	0,96%
TOTAL Nains Géants	2,09%	1,62%	2,09%	0,63%	3,63%	1,70%	3,00%	5,04%	7,32%	7,00%	3,58%
Indonésie	0,08%	0,19%	0,19%	0,23%	0,43%	0,12%	0,51%	0,47%	0,23%	0,18%	0,23%
Malaisie	0,18%	0,11%	0,32%	0,16%	0,67%	0,13%	0,26%	0,46%	0,48%	0,23%	0,32%
Philippines	0,04%	0,06%	0,08%	0,05%	0,21%	0,06%	0,09%	0,14%	0,14%	0,08%	0,09%
Thaïlande	0,21%	0,12%	0,21%	0,11%	0,19%	0,20%	0,09%	0,42%	0,11%	0.17%	0,20%
TOTAL ASEAN (hors Sing.)	0,51%	0,48%	0,79%	0,55%	1,51%	0,52%	0,95%	1,48%	0,96%	0,66%	0,84%
Afrique du Sud	0,53%	0,35%	0,39%	0,15%	1,08%	0,58%	0,95%	0,35%	0,26%	0,19%	0,43%
Australie	1,05%	0,90%	0,82%	0,68%	1,28%	1,05%	1,02%	1,34%	0,63%	0,36%	0,90%
Brésil	1,38%	0,88%	0,36%	0,44%	1,76%	0,72%	1,05%	2,56%	1,50%	1,29%	1,30%
Inde	0,24%	0,20%	0,81%	0,24%	1,08%	0.28%	1,02%	1,79%	0,71%	0,78%	0,68%
Israël	0,41%	0,14%	0,37%	0,40%	0,35%	1.56%	0,35%	0,13%	0,39%	0,31%	0,37%
TOTAL Autres	3,62%	2,48%	2,75%	1,91%	5,54%	4,19%	4,40%	6,18%	3,50%	2,72%	3,69%
TOTAL	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%

Annex 8

Table A.6 - 1986 markets as % by countries and zones

MARCHES 1986 (%) II	Info.	Bureau.	Contr. Instr.	Milit. Commu.	Télé comm.	Médic.	Indust.	EGP	Comp. Pass.	Comp. Act.	TOTAL
Allemagne Fédérale	30,91%	3,43%	14,11%	4,24%	12,16%	1,65%	1,26%	10,33%	13,19%	8,72%	100,00%
Benelux	38,03%	2,52%	11,50%	3,35%	15,83%	1,48%	0,98%	8,91%	10,61%	6,79%	100,00%
Danemark	34,03%	4,08%	13,37%	6,19%	7,36%	1,61%	0,74%	10,89%	15,41%	6,31%	100,00%
Espagne	38,95%	2,61%	6,65%	5,22%	12,97%	1,24%	0,68%	17,12%	9,42%	5,15%	100,00%
France	30,22%	2,48%	8,04%	14,10%	15,59%	1,49%	1,14%	9,11%	10,21%	7,61%	100,00%
Irelande	37,40%	1,72%	8,28%	3,79%	7,63%	1,42%	1,12%	4,20%	20,89%	13,55%	100,00%
Italie	34,13%	3,04%	12,16%	7,39%	14,27%	2,26%	1,02%	9,85%	8,44%	7,43%	100,00%
Pays Bas	36,13%	3,63%	11,03%	7,00%	8,53%	2,92%	1,03%	10,66%	10,08%	9,00%	100,00%
Royaume Uni	29,44%	2,73%	10,97%	12,49%	11,23%	0,95%	1,45%	10,66%	12,88%	7,21%	100,00%
Total CEE	31,99%	2,96%	11,20%	8,70%	12,64%	1,59%	1,19%	10,30%	11,64%	7,82%	100,00%
Autriche	31,46%	3,44%	13,98%	2,65%	13,14%	2,33%	1,27%	12,71%	14,88%	4,13%	100,00%
Finlande	31,57%	2,89%	10,95%	6,52%	11,57%	1,78%	1,35%	11,57%	12,00%	9,78%	100,00%
Norvege	22,99%	1,92%	6,49%	4,95%	8,90%	0,70%	0,70%	4,71%	43,93%	4,71%	100,00%
Suède	23,18%	2,47%	12,79%	10,55%	12,92%	3,16%	0,84%	8,51%	14,68%	10,90%	100,00%
Suisse	30,41%	5,86%	14,99%	4,96%	8,41%	2,64%	1,04%	11,05%	14,29%	6,35%	100,00%
TOTAL Eur. Occidentale	31,31%	3,01%	11,27%	8,38%	12,38%	1,67%	1,16%	10,14%	12,94%	7,75%	100,00%
Canada	28,40%	5,35%	12,10%	6,96%	11,11%	2,76%	1,32%	13,66%	10,05%	8,28%	100,00%
Etats-Unis	20,16%	4,85%	9,63%	21,20%	10,02%	2,41%	1,14%	10,37%	11,97%	8,25%	100,00%
TOTAL Amérique du Nord	20,53%	4,88%	9,74%	20,55%	10,07%	2,43%	1,15%	10,52%	11,88%	8,25%	100,00%
Japon	26,98%	2,01%	6,88%	4,26%	8,39%	2,30%	0,84%	12,01%	18,14%	18,19%	100,00%
TOTAL Pays Industrialisés	24,75%	3,87%	9,76%	14,40%	10,50%	2,18%	1,10%	10,63%	13,16%	9,63%	100,00%
Corée du Sud	13,85%	1,63%	6,61%	2,85%	17,05%	1,41%	0,93%	14,92%	23,06%	17,69%	100,00%
Hong Kong	13,53%	1,90%	2,11%	2,28%	9,70%	0,30%	0,89%	16,91%	29,47%	22,93%	100,00%
Singapour	25,19%	2,41%	8,97%	2,41%	2,31%	0,68%	0,71%	16,49%	31,68%	9,14%	100,00%
Taiwan	6,38%	1,07%	3,62%	1,93%	10,75%	1,23%	1,13%	15,66%	30,86%	27,37%	100,00%
TOTAL Nains Géants	14,19%	1,69%	5,54%	2,41%	10,98%	1,02%	0,93%	15,79%	28,08%	19,38%	100,00%
Indonésie	8,82%	3,09%	7,72%	13,23%	19,85%	1,10%	2,43%	22,38%	13,56%	7,83%	100,00%
Malaisie	13,43%	1,30%	9,52%	6,75%	22,95%	0,90%	0,90%	16,27%	20,91%	7,08%	100,00%
Philippines	9,94%	2,49%	8,01%	7,73%	24,86%	1,38%	1,10%	16,30%	20,17%	8,01%	100,00%
Thailande	26,22%	2,24%	10,01%	7,77%	10,67%	2,24%	0,53%	23,98%	7,64%	8,70%	100,00%
TOTAL ASEAN (hors Sing.)	14,74%	2,15%	8,97%	8,90%	19,44%	1,32%	1,26%	19,77%	15,69%	7,77%	100,00%
Afrique du Sud	29,77%	3,02%	8,54%	4,86%	26,81%	2,85%	2,43%	9,02%	8,36%	4,33%	100,00%
Australie	28,14%	3,71%	8,65%	10,25%	15,27%	2,48%	1,26%	16,64%	9,65%	3,97%	100,00%
Bresil	25,75%	2,54%	2,63%	4,66%	14,66%	1,19%	0,89%	22,05%	15,85%	9,79%	100,00%
Inde	8,51%	1,09%	11,22%	4,86%	17,01%	0,67%	1,00%	29,28%	14,26%	11,25%	100,00%
Israël	27,23%	1,47%	9,64%	14,66%	10,13%	9,06%	1,05%	4,05%	14,39%	8,31%	100,00%
TOTAL Autres	23,76%	2,51%	7,09%	7,08%	16,22%	2,43%	1,32%	18,73%	13,01%	7,85%	100,00%
TOTAL	24,25%	3,73%	9,50%	13,65%	10,81%	2,14%	1,11%	11,19%	13,71%	9,90%	100,00%

Annex 9

Table A.7 - Trading balances (US$ millions)

Balance Commerciale (Millions de $)

	Info.	Bureau.	Contr. Instr.	Milit. Commu.	Télé comm.	Médic.	Indust.	EGP	Comp. Pass.	Comp. Act.	TOTAL
Allemagne Fédérale	-710	-92	941	171	616	269	92	-129	409	-771	796
Benelux	-543	-60	-134	-10	83	-16	-5	111	34	-212	-752
Danemark	-434	-43	138	46	-20	112	-2	-88	-61	-98	-450
Espagne	-641	-98	-209	-64	15	-22	-9	-322	-185	-123	-1657
France	-1233	-315	44	1032	493	-42	-43	-820	115	-105	-874
Irelande	1037	-3	38	-13	48	-7	-1	-50	15	-6	1058
Italie	-471	-151	-423	189	-25	-58	42	-634	-205	-406	-2142
Pays Bas	-678	152	31	0	-60	174	-7	-420	41	32	-735
Royaume Uni	-908	-316	214	228	-121	56	71	-1350	-678	-543	-3347
Total CEE	-4581	-926	640	1579	1029	466	139	-3702	-515	-2232	-8103
Autriche	-451	-45	-99	-27	-19	-7	-6	22	-20	11	-641
Finlande	-232	-47	-25	-14	1	6	-6	-22	-60	-149	-548
Norvège	-453	-66	-77	-78	-80	-15	-4	-151	-1463	-162	-2549
Suède	-318	-69	-37	-34	824	28	2	-208	-156	-372	-340
Suisse	-831	-108	427	0	0	-1	48	697	-119	-121	-8
TOTAL Eur. Occidentale	-6866	-1261	829	1426	1755	477	173	-3364	-2333	-3025	-12189
Canada	-1365	-339	-533	201	402	-110	-53	-682	-450	-354	-3483
Etats-Unis	5100	-1935	3350	1480	-2050	99	-375	-13194	-4081	-446	-12052
TOTAL Amerique du Nord	3735	-2274	2817	1681	-1648	-11	-428	-14076	-4531	-800	-15535
Japon	4759	3447	29	2204	1627	474	210	13787	5146	2750	34433
TOTAL Pays Industrialisés	1628	-88	3675	5311	1734	940	-45	-3653	-1718	-1075	6709
Corée du Sud	230	-1	-175	2	55	-59	3	1708	178	1049	2990
Hong Kong	372	138	6	254	104	-5	30	1027	-157	-244	1525
Singapour	668	41	-159	-44	5	-12	-11	392	366	1410	2656
Taïwan	739	94	-97	131	105	-23	15	1083	672	-80	2639
TOTAL Nains Géants	2009	272	-425	343	269	-99	37	4210	1059	2135	9810
Indonésie	-30	-9	-35	-70	-80	-10	-14	-88	-11	115	-232
Malaisie	-96	-14	-92	-6	-197	-7	-3	31	-97	1457	976
Philippines	-24	-1	-13	2	-25	0	0	9	-1	1074	1021
Thaïlande	-125	-9	-59	-21	-70	-10	-3	-23	-34	360	6
TOTAL ASEAN (hors Sing.)	-275	-33	-199	-95	-372	-27	-20	-71	-143	3006	1771
Afrique du Sud	-443	-45	-123	-51	-203	-37	-19	-66	-84	-69	-1140
Australie	-884	-117	-152	-172	-169	-53	-24	-442	-230	-132	-2375
Brésil	100	-8	-15	-41	20	-1	-23	49	92	-76	97
Inde	-41	-6	49	2	-20	0	0	158	-71	-144	-73
Israël	-290	-17	-82	140	35	80	20	-37	12	-109	-248
TOTAL Autres	-1558	-193	-323	-122	-337	-11	-46	-376	-281	-570	-3739
TOTAL	1804	-42	2728	5437	1294	803	-74	148	-1083	3536	14551
Reste du Monde	-1804	42	-2728	-5437	-1294	-803	74	-148	1083	-3536	-14551

Annex 10

Table A.8 - Mar'.et for electronics goods (US$m)

Marche de l'electronique (M$)	1957	1962	1967	1975	1981	1986
Etats Unis						
Biens de consommation	1923	1690	3699	6527	11424	20251
Biens d'equipement	7356	10751	17029	35406	71571	135491
Composants	3276	3671	5445	6464	29813	40904
Total	12557	16312	26373	51491	112808	196646
Japon						
Biens de consommation	286	673	1471	4322	5568	10207
Biens d'equipement	132	245	1215	5674	12049	29631
Composants	202	475	1063	3654	9111	20644
Total	622	1599	3969	13510	26168	61062
Royaume-Uni			(1966)			
Biens de consommation	375	278	276	1452	3602	2229
Biens d'equipement	416	476	666	2022	12652	16241
Composants	545	543	656	1018	3151	4634
Total	1336	1297	1598	4492	18652	23204
Allemagne Federale	(1966)					
Biens de consommation	622	567	636	2275	3193	2537
Biens d'equipement	136	227	435	3806	13241	17711
Composants	359	403	487	1961	4249	5722
Total	1117	1197	1558	8049	20683	25970
France						
Biens de consommation	192	321	297	851	2802	1680
Biens d'equipement	245	442	801	2654	12475	14153
Composants	175	282	513	1018	2756	3416
Total	612	1045	1611	4523	18123	19231
TOTAL						
Biens de consommation	3400	3931	6799	15487	25143	37664
Biens d'equipement	8287	12145	20346	52770	122172	213207
Composants	4557	5374	8164	14115	49126	75322
Total	16244	21450	35309	82372	196435	326133
PIB (Millions de $)						
Etats Unis	440500	560500	793700	1531966	3000500	4194560
Japon	36761	59033	123803	498777	1145121	1962971
Royaume Uni	61936	86668	111968	236088	514666	549117
Allemagne Federale	51524	90200	123600	417225	685230	872016
France	58815	73160	114520	338032	577369	773264
Total	643536	863561	1267591	3622802	5915830	8371862
Electronique/PIB						
Etats Unis	2.851%	2.910%	3.323%	3,355%	3,76%	4.688%
Japon	2.622%	2.709%	3.206%	2,796%	2,285%	3.112%
Royaume Uni	2.157%	1.498%	1,606%	1,903%	3,625%	4.226%
Allemagne Federale	2.168%	1.327%	1,261%	1.927%	3,027%	2.911%
France	1,041%	1,428%	1,407%	1,335%	3,166%	2.487%
Total	2.524%	2,484%	2.786%	2.725%	3,321%	3,896%

Annex 11

Table A.9 - US$ millions

Millions de $		1984	1985	1986	1987	1988	1989	1990	1991	1992	1994	1995	Δ(%)
Test de protocole (télécom)	TELECOM	64	135	157	186	222	262	310	366	432	510	602	18,0%
T-1 multiplex	TELECOM		145,5	191	250	326	430	562,4	737	960	1266	1657	31,0%
CAO pour circuits imprimés	MECATRO	367	393	440	560	664	835	960	1197	1462	1785	2179	22,0%
FAO pour circuits imprimés	MECATRO	273	425	535	655	845	1090	1400	1806	2330	3006	3878	29,0%
Correction de logiciels AC	MECATRO	595	560	620	724	845	986	1152	1342	1566	1828	2133	16,7%
Contrôleurs Programmables	MECATRO	600	750	940	1135	1376	1654	2000	2414	2914	3517	4245	20,8%
CIM	MECATRO	28400	33400	40500	47600	57300	67000	73300	79600	93227	109187	127879	17,1%
Stations de Travail	MECATRO	350	713	1425	1860	2185	2340	2556	2772	3725	5006	6728	34,3%
Unités de Disque Laser	INFORM			471	683	951	1438	2086	3030	4397	6380	9257	45,1%
CI semi-custom	COMPACT		1034	1276	2822,6	3746,6	4757,8	5769	7234	8993	11187	13917	24,4%
CI custom	COMPACT		1089	1495	3203	3257,8	4060,6	4238,8	4501,5	5098,9	6366	7111	11,7%
Total ASIC	COMPACT	0	2123	2765	6025,6	7404,4	8844,4	10008	12136	14692	17553	21028	20,3%
Mémoires ASIC	COMPACT			219	313	447	638	911	1300	1856	2650	3784	42,7%
CI CMOS	COMPACT			5500	7572	10424	14351	19757	27200	37446	51552	70972	37,6%
CI NMOS	COMPACT			7200	7272	7357	7436	7516	7600	7682	7765	7849	1,1%
Total MOS	COMPACT	0	0	12700	14850	17781	21787	27273	34800	45128	59317	78821	25,6%
CI Bipolaires	COMPACT			4400	4946	5560	6250	7026	7900	8880	9982	11221	12,4%
Total CI	COMPACT	0	0	17100	19796	23341	28295	34299	42700	54008	72025	90042	23,1%
SC de moyenne puissance	COMPACT			400	468	548	641	750	678	1027	1202	1406	17,0%
SC de haute puissance	COMPACT			500	553	612	677	750	830	919	1017	1125	10,7%
SC de très haute puissance	COMPACT			300	341	387	440	500	568	645	733	833	13,6%
Total SC de puissance	COMPACT	0	0	1200	1362	1547	1775	2000	2276	2591	2980	3364	41,3%
DSP Télécom	COMPACT			174	222	283	361	460	586	747	952	1213	27,4%
DSP Militaire	COMPACT			176	212	252	300	357	424	504	599	712	18,8%
DSP EGP	COMPACT			9	15	24	39	63	103	168	274	446	62,8%
DSP Industriel	COMPACT			109	138	174	220	278	350	442	558	704	26,2%
Total DSP	COMPACT	0	0	470	587	733	918	1158	1463	1861	2468	3075	26,4%
Liquid Crystal Display (LCD)	COMPACT				1157	1542	2055	2740,5	3482	4424	5620	7140	30,1%
Electroluminescence Display (E	COMPACT				29	51	90	159,5	282	498	879	1551	76,5%
Total Ecran Plat	COMPACT	0	0	0	1186	1593	2145	2900	3764	4922	6499	8691	27,4%

Annex 12

ANNEX B

THE ORGANISATION OF TRADING

Tables

B1-B3	Total trading in electronics
B4-B6	Precision, watchmaking, optics
B7	Mass consumer electronics (MCE)
B8-B9	Telecommunications, informatics
B10	Active components

Source : Calculations by GERDIC using data from the CHELEM data bank of CEPII, kindly supplied by Michel FOUQUIN

Notes :

(1) The tables are to be read along the lines for the exporting countries or zones and down the columns for the importing countries or zones.

(2) "Total Asia" does not include Japan.

(3) Passive components, mechatronics and software are not included in these statistics.

Annex 13

Table B.1

TOTAL	E.U.	Canada	Total A.N.	Total Eur.Occ	Total COMECON	Japon	Anzas	Amérique Latine	P.O.	Afrique	Total Asie(1)	MONDE	Export (%)
E.U.	0	5378	5378	13147,3	56,5	2733,5	1517,2	3662,2	751,1	187,4	6508,6	34687,8	15,92%
Canada	2491,7	0	2491,7	508,1	4,8	56	37,9	118,2	38,7	7,1	117,0	3376,5	1,56%
TOTAL A.N.	2491,7	5378	8869,7	13655,4	61,3	2989,5	1575,1	3780,4	782	119,5	6788,4	38084	17,48%
France	713,2	77,5	790,7	6326,0	152,2	91,8	137,9	489,3	767,1	132,2	634,9	9766,9	4,49%
Belgique	126,1	9,6	135,7	2512,7	26,2	21,2	30,4	45,3	49	37	150,7	3010,9	1,38%
RFA	2276,6	186,5	2463,1	15978,7	525,5	354,3	620,1	472,4	576,5	198,5	1192,7	22351,7	10,28%
Italie	792,7	96,2	888,9	4157,5	92,5	43,7	151,3	167,6	709,7	66,6	227,3	6186	2,81%
Pays Bas	607,1	107,6	714,7	5191,0	66,9	39,9	97,2	113,4	106,3	70,5	205,2	6763,9	3,11%
R.U.	1786,2	249,8	2036	10987,2	191,6	241,5	621	178,2	696,5	220,2	680,3	15853	7,29%
P.Scandinaves	636,7	90,6	727,3	4215,6	278,1	114,1	193,3	274,5	205	58,7	350,9	6449,7	2,97%
P.Alpins	811,9	79,4	891,3	4428,7	183,6	195,1	174,9	186,3	364,0	73,2	776,1	7224,5	3,32%
Europe Mérid.	362	18,6	380,6	1633,8	162	23,6	40,8	134,9	83,2	55,9	41,5	2541,9	1,17%
TOTAL Europe	8112,5	915,8	9028,3	55482,8	1670,6	1125,2	2040,9	1995,9	3239,9	1170,0	4345,1	80848,5	36,82%
URSS	0,6	0,9	1,5	189	270	1	0,2	0	5,9	21,7	10,6	423,4	0,19%
Eur. Est	11,5	1,4	12,9	233,8	7070,7	2,4	8,0	6,9	106,1	16,1	20,7	7475,8	3,44%
TOTAL COMECON	12,1	2,3		344,0		3,0	1	6,7	112	37,0			0,00%
Japon	23407,6	1544,5	24952,1	13737,3	254,3	0	1985,0	1756	1365,1	166,7	10848,6	55871,3	25,33%
Anzas	41,6	4,5	46,1	94,9	6,2	9,4	56,3	3,1	5	1,3	81,5	302	0,14%
Am.Latine	2767	119,6	2877,6	234,2	55,4	125,7	51,7	59	3,2	6,9	82,7	3491,4	1,61%
P.Orient	9,1	0,3	9,4	101	5,4	0	0,2	1,2	0	0,7	14,4	211,0	0,10%
Afrique	17	0,5	17,5	52	1,1	0	2,6	0	0,2	0,0	2,9	75,1	0,03%
Indonésie	0,4	0,1	0,5	5,9	0	0,0	0,2	0,2	0	0	143,6	151,2	0,07%
Inde	12,9	0,3	11,2	13,6	28,2	0,2	0,4	0,1	0,4	0,5	20,6	75,2	0,03%
Asie NPI (Géants)	11730,4	699,6	12430	5504,2	18,2	1283,5	477,2	513,2	370,7	21,7	4989,1	25680,1	11,81%
Chine	73,1	3,8	76,9	189,5	31,4	10,0	5,3	1,6	7,2	0,3	875,6	1145,6	0,54%
Autres Asie	2180,4	18,2	2281,6	972,0	4,7	55,7	21,4	0,6	14,4	1,1	1390,4	4665,7	2,15%
TOTAL Asie	14001,2	722	14723,2	6603	94,5	1359	576,5	545,7	420,7	75,6	7364,3	31745,8	14,60%
non ventilés	0	0	0	472,0	0	0	37,7	0	0	0	33,7	569,2	0,26%
MONDE	58559,0	8078,5	59738,3	90960,2	9434,5	5617,2	6195,0	8140,2	5976,1	1526,6	29514,9	217433	100,30%
Import (%)	23,39%	4,60%	27,47%	41,81%	4,36%	2,58%	2,85%	3,75%	2,77%	0,70%	13,57%	100,00%	

Annex 14

Table B.2

TOTAL	Belgique	France	RFA	Italie	Pays Bas	R.U.	Pays Scand.	Pays Alpins	Europe Mérid.	Total Eur.Occ	URSS	Europe Est	Total COMECON	MONDE	Export (%)
E.U.	279,2	1944,3	2449,5	853	1291,7	3536,1	1125	580,2	988,3	13147,3	22,5	34	56,5	34607,5	15,92%
Canada	6,8	44,9	52,5	26,3	62,1	162,3	36,7	16	150,5	583,1	1,6	3,2	4,8	3396,5	1,56%
TOTAL A.N.	386	1989,2	2502	879,3	1353,8	3678,4	1161,7	596,2	1093,8	13655,4	24,1	37,2	61,3	38004	17,48%
France	410,9	0	1793,5	931,4	515,5	1129,3	493	401,7	644,5	6326,8	88,2	64	152,2	9766,9	4,49%
Belgique	0	343,4	470,5	296,5	563,3	438,2	145,2	136,6	136	2512,7	7,6	19,6	26,2	3018,9	1,38%
RFA	1034	2332,1	0	2211,9	1775,2	2336,1	1641,4	2358,3	1736,2	15990,7	197,3	328,2	525,5	22351,7	10,28%
Italie	154	312,7	1177	0	290,2	469,4	333,1	319,7	631,4	4157,5	51,9	40,6	92,5	6196	2,81%
Pays Bas	751,2	499,2	1275,1	591,6	0	1153,6	351,2	279,5	278,4	5191,8	15,5	50,4	66,9	6763,9	3,11%
R.U.	589,9	1492,4	2614,8	1000,9	1340,9	1345	1143	615,1	767,2	10987,2	94,9	96,7	191,6	15853	7,29%
P.Scandinaves	115,8	351,3	786,8	255,8	349,5	737,7	1223,7	243,8	245,2	4245,6	210,2	59,9	270,1	6449,7	2,97%
P.Alpins	150,9	522,5	1582,4	547,7	262,2	472,1	324,3	282,2	350,4	4428,7	38,9	144,7	183,6	7224,5	3,32%
Europe Mérid.	72,2	278,6	491,1	194,8	183,1	221,5	185,7	81	93,8	1633,9	94,3	67,7	162	2541,9	1,17%
TOTAL Europe	3279,9	7115,2	10136,2	6113,6	5207,9	8544,9	5739,6	4649,4	4935,1	55482,8	799,8	878,9	1678,6	80968,5	36,82%
URSS	0,6	8,9	29,7	3,7	3	17,8	27,4	1,4	16,5	109	0	278	278	423,4	0,19%
Eur. Est	4,3	31,3	41	9,7	15,2	17,5	17,5	11,1	88,2	235,8	5941	1129,7	7070,7	7475,5	3,44%
TOTAL COMECON	4,9	40,2	70,7	13,4	18,2	35,3	44,9	12,5	104,7	344,8	5941	1399,7			0,00%
Japon	425,9	1541,8	4274,8	808,1	915,1	2536,7	1251,9	750,5	1102,5	13757,3	121,6	122,7	254,3	55071,3	25,33%
Antas	2,4	3,7	12,4	1,6	13,9	47,5	4,6	2,8	3	94,9	6	0,2	6,2	302	0,14%
Am.Latine	10,9	24,9	41,6	20,6	22,8	53,9	13,2	18	10,3	234,2	33,1	17,3	50,4	3491,4	1,61%
P.Orient	2,3	26,3	18,9	5,4	7,9	125,4	0,3	5,8	1	181	3,6	1,8	5,4	211,3	0,10%
Afrique	0,9	13	5,1	1,6	9,5	23,2	0,1	1,3	0,3	52	1	0,1	1,1	75,1	0,03%
Indonésie	3	0,2	1,8	0,3	1	1,1	0,6	0,3	8	5,9	0	0	0	151,2	0,07%
Inde	0	0,5	1,8	0,3	1,6	6,6	3,3	0,1	2,4	12,6	18,6	1,6	20,2	75,2	0,03%
Nains Géants	133,9	576,5	1495,9	379,9	448	1276,9	337,7	274,7	491,7	5504,2	6,4	17,3	10,2	23608,1	11,01%
Chine	3,5	26,7	14,9	7,4	3,9	12,3	3,9	2,4	31,5	108,5	7,2	44,2	51,4	1165,6	0,54%
Autres Asie	6,5	190	263,5	28,8	49,8	324,2	23,8	14,5	17,7	972,8	4,3	0,4	4,7	4665,7	2,15%
TOTAL Asie	139,9	914	1697,9	423,7	516,3	1641,1	328,3	342,5	547,3	6485	38,5	44	94,5	31745,8	14,60%
non ventilée	9	331,4	0	171,5	0	0	0	0	7,9	497,8	0	0	0	564,2	0,26%
MONDE	4221,3	12228,2	18721,6	8481,8	8053,4	15958,4	5887,6	6379	7794,9	90980,2	6979,7	2513,8	9494,5	217433	100,30%
Import (%)	1,95%	5,53%	8,61%	3,94%	3,71%	7,32%	4,80%	2,93%	3,58%	41,91%	3,21%	1,16%	4,36%	100,00%	

Table B.3

TOTAL	Indo-nésie	Inde	Corée	HK	Sing.	Taiwan	Chine	Autre Asie	Total Asie(1)	MONDE	Export (%)
E.U.	134,2	107,9	1048,4	646,7	1285,7	700,7	621	2044	6500,6	34607,5	15,92%
Canada	3,8	0	25,1	22,0	15,7	6	20,3	10,1	119,0	3376,5	1,56%
TOTAL A.N.	138	195,9	1073,5	669,5	1221,4	706,7	641,3	2062,1	6708,4	38084	17,48%
France	55,5	118,4	83,6	40,3	44,4	19,9	186,2	139,1	634,4	9766,9	4,49%
Belgique	4,6	4,3	3,1	7,5	8,7	41,5	64,3	16,7	150,7	3010,9	1,38%
RFA	79,7	155,5	89,5	113	132,8	119,2	223,6	279,4	1192,7	22351,7	10,28%
Italie	21,7	14,4	11,9	12,9	61,7	5,7	26,9	72,1	227,3	6106	2,81%
Pays Bas	33,2	41,0	14	31,3	19,2	71	19,7	53	283,2	6763,9	3,11%
R.U.	36,9	109,1	42,0	95,6	63,5	42,3	98,9	199,2	689,3	15853	7,29%
P.Scandinaves	15,0	43,2	55,2	29,6	17	11,1	67,5	111,5	350,7	6419,7	2,77%
P.Alpins	5,3	37,6	23,5	340,7	104,6	41,7	79,2	143,5	776,1	7224,5	3,32%
Europe Mérid.	1,3	2,4	1,1	4	12,2	2,1	8,4	10	41,5	2541,9	1,17%
TOTAL Europe	254	526,7	324,7	682,9	464,[illegible]	354,5	694,7	1043,5	4345,1	80068,5	36,82%
URSS	0	0	0	9,1	0,1	0	1,4	0	10,6	423,4	0,17%
Eur. Est	1,1	0	0	1,7	0,8	0	17,1	0	20,7	7475,5	3,44%
TOTAL COMECON	1,1	0	0	10,8	0,9	0	18,5	0			0,00%
Japon	131,0	257,4	2338,0	2354,6	1639,8	1815,8	1228,9	1001,5	10848,6	55071,3	25,33%
Anzas	3,4	7,7	2	24,3	15,0	1,6	3,0	22,9	81,5	382	0,14%
Am.Latine	9,9	0	19,6	23,1	11,1	13,7	5,3	0	82,7	3491,4	1,61%
P.Orient	0	0	1,9	11,2	0,9	0	0,4	0	14,4	211,0	0,10%
Afrique	0	0	0	2,6	0,1	0	0,2	0	2,9	75,1	0,03%
Indonésie	0	0	2	1,6	139,5	0,3	0	0,2	143,6	151,2	0,07%
Inde	2,6	0	1,8	0,9	22,3	0,1	0,2	0	28,6	75,2	0,03%
Nains Géants	101,5	145,5	235,3	991,6	412,9	260,4	1473,2	1277,7	4908,1	25605,1	11,01%
Chine	3,2	0	0	872	5,5	0	0	14,9	895,6	1163,6	0,54%
Autres Asie	21,6	0	63,7	262,7	740,4	90	2	0	1390,4	4665,7	2,15%
TOTAL Asie	128,9	145,5	304,8	2128,0	1528,6	358,0	1476,1	1274,0	7366,3	31745,0	14,60%
non ventilée	0	0	6,3	0	0	26,6	0	0,8	33,7	564,2	0,26%
MONDE	667,1	1133,2	4871,6	5907,8	4882,7	3277,7	4069,2	5505,6	29514,9	217433	100,00%
Import (%)	0,31%	0,52%	1,87%	2,72%	2,25%	1,51%	1,87%	2,53%	13,57%	100,00%	

Annex 16

Table B.4 - Precision equipment

CHELEM Précision	1986 E.U.	Canada	Total A.N.	Total Eur.Occ	Total COMECON	Japon	Anzas	Amérique Latine	P.O.	Afrique	Total Asie(1)	MONDE	Export (2)
E.U.		1156	1156	3072,9	34,3	863,6	513,9	741,7	216,8	37,9	1056,8	7713,9	22,32%
Canada	479,7		479,7	82,2	0,8	14,5	10,4	39,4	9,5	3,3	24	671,8	1,94%
TOTAL A.N.	479,7	1156	1635,7	3175,1	35,1	878,1	532,3	781,1	226,3	41,2	1080,8	8385,7	24,27%
France	215	26,7	241,7	1085,1	81	26,0	36,7	132	233,7	106,9	177,5	2121,6	6,14%
Belgique	15,3	3	18,3	387,7	15,3	1,7	7	6,4	23	10	8,1	478	1,38%
RFA	1086,4	86,3	1172,7	3958,1	328,5	170,7	240	197,4	226,4	65,1	416,9	6775,8	19,61%
Italie	91,0	12,1	103,9	723,5	47,0	13,9	27	38,1	07,5	10	37,6	1099,6	3,40%
Pays Bas	168,2	27,5	195,7	1104	23,9	18,6	27,0	30,9	58,1	8,7	61,9	1521,6	4,40%
R.U.	660,7	82,9	743,6	1982,5	129,9	99,9	209,3	44,1	286	76,3	260,1	3750.7	10,85%
P.Scandinaves	237,9	37,3	275,2	1111,6	109,9	71,4	75,0	34,5	43,4	18,1	96,5	1835	5,31%
P.Alpins	194,7	23,6	219,3	1416	108,6	54,6	61	42,6	86,9	16,4	137,2	2133,6	6,17%
Europe Mérid.	92,1	8,6	100,7	208,5	49,7	5,2	17,4	57,3	33,9	6,3	11,9	490,1	1,42%
TOTAL Europe	2762,1	308	3070,1	11897	885,6	462,0	701	583,3	1272,9	317,0	1207,7	20206	58,40%
URSS			0	18,0	0	0,4	0,1				0	11,3	0,03%
Eur. Est	4,2	0,5	4,7	65,1	437,3	1,1	0,4	1,4	4,1	1,3	3,1	513,5	1,49%
TOTAL COMECON	4,2	0,5	4,7	75,9	432,3	1,5	0,5	1,4	4,1	1,3	3,1	574,0	1,67%
Japon	1219,2	63,9	1283,1	940,0	63		213,5	137,4	116,6	18,1	1102,5	3947	11,42%
Anzas	20,2	2,4	22,6	37,2	1,5	2,5	25,3	0,9	0,9	0,2	21	112,1	0,32%
Am.Latine	269,5	1,3	270,0	23,9	4,6	0,4	1,1	4,9	0,2	0,6	1,1	307,6	0,09%
P.Orient	1,5	0,1	1,6	82,9	0			1,1			0,5	86,1	0,25%
Afrique	1,8	0,1	1,9	14,2	0,9		0,1		0,1	0,7	0,2	10,1	0,05%
Indonésie	0,1		0,1	0,4	0						2,4	2,9	0,01%
Inde	2,7	0,1	2,0	6,4	1,9		0,3				3,1	14,5	0,04%
Nains Géants	256,3	19,8	276,1	137,4	0,3	40,7	33,1	0,9	14,4	3,9	226,6	713	2,06%
Chine	4,8	0,7	5,5	9,7	7,1	0,7	0,8	0,1	0,2		38,3	54,4	0,16%
Autres Asie	20,2	0,9	29,1	58	2,5	1,4	2,9	0,3	14,4	0,4	10,6	117,6	0,35%
TOTAL Asie	292,1	21,5	313,6	173,9	11,8	42,8	37,1	9,3	29	4,3	281	904,4	2,62%
non ventillée			0	58,9	0		1,7				1,5	62,3	0,10%
MONDE	5050,3	1553,8	6604,1	16479,8	1434,8	1388,1	1512,8	1519,4	1450,1	376,2	3779,4	34554,1	100,00%
Import (2)	14,62%	4,50%	19,11%	47,69%	4,15%	4,02%	4,38%	4,40%	4,20%	1,09%	10,94%	100,00%	

Table B.5 - Watchmaking

Horlogerie	E.U.	Canada	Total A.N.	Total Eur.Occ	Total COMECON	Japon	Anzas	Amérique Latine	P.O.	Afrique	Total Asie(1)	MONDE	Export %
E.U.		32,8	32,8	18,5	0	2,4	4,3	17,1	0,7	0,1	36,7	112,8	1,31
Canada	7		7	0,7	0	0,1	0,3	1			0,9	10	0,12
TOTAL A.N.	7	32,8	39,8	19,2	0	2,5	4,6	18,1	0,7	0,1	37,6	122,8	1,43
France	19,1	1,5	20,6	177	0,9	3,4	3,3	14,2	17,2	20,1	37,3	278	3,46
Belgique	0,3		0,3	20,3	0	0,1	0,1	0,1	0,1	1,4	5,2	28,1	0,33
RFA	85,5	8,2	93,7	390,2	2,8	0,4	11,6	13	15,4	1,3	39,7	576,3	6,69
Italie	13,8	0,7	14,5	99,8	0,1	1,7	0,9	2,0	4,[illegible]	0,1	1,4	126,2	1,47
Pays Bas	2	0,3	2,3	30,1	0,2	0,2	0,3	0,2	0,1	0,1	0,8	34,3	0,40
R.U.	5,5	0,8	6,3	41,6	0,1	0,8	3,7	1,6	10,8	2,3	22,1	89,3	1,04
P.Scandinaves	1,6	0,3	1,9	12,9	0,1	0,1	0,4	0,9	0,2	0,3	0,7	17,7	0,21
P.Alpins	418,7	25,3	444	902,6	0,3	112,4	27,3	114,3	186,8	7,7	518	2321,4	26,95
Europe Mérid.	0,9	0,1	1	12,8	0,4	0,2	0,5	0,7	5,4	0,5	0,4	22,0	0,26
TOTAL Europe	547,6	37,2	584,8	1699,5	12,9	127,3	48,1	147,8	240,8	33,0	678	3514,1	40,81
URSS		0,8	0,8	12	0						9,1	21,9	0,25
Eur. Est	0,8	0,1	0,9	11,8	0	0,1	0,1				1	13,9	0,16
TOTAL COMECON	0,8	0,9	1,7	23,8	0	0,1	0,1	0	0	0	10,1	35,8	0,41
Japon	432,4	32,3	464,7	416,7	0,7		45,4	120,1	164,5	0,9	885,1	2106,1	24,45
Anzas	0,1		0,1	0,5	0	0,2	0,4	,			2,4	3,6	0,04
Am.Latine	10,5	0,7	11,2	3,5	0		0,1	10,1			2,5	27,4	0,32
P.Orient			0	15,9	0		0,1				9,9	25,9	0,30
Afrique			0	14,4	0						2,6	17	0,20
Indonésie			0	0	0						0	0	0,00
Inde	0,1		0,1	0	0,4				0,1		0,1	0,7	0,01
Nains Géants	582,3	53,7	636	682,2	0,3	217	51,5	114,6	150,5	5	490,6	2275,7	26,42
Chine	11,4	0,9	12,3	29,5	31,6	5,2	1,1		5,7		247,7	334,1	3,88
Autre Asie	52		52	52,7	0	1,7	0,3				34,8	141,5	1,64
TOTAL Asie	645,8	54,6	700,4	683,4	32,3	223,9	52,9	114,6	156,3	5	783,2	2752	31,95
non ventilée			0	7	0						0,5	7,5	0,09
MONDE	1644,2	150,5	1802,7	2873,9	45,9	354	151,7	418,7	562,5	37,8	2361,7	8612,7	100,00
Import (%)	19,09%	1,84%	20,93%	33,37%	0,53%	4,11%	1,76%	4,86%	6,53%	0,44%	27,43%	100,00%	

Table B.6 - Optical

Optique	E.U.	Canada	Total A.N.	Total Eur.Occ	Total COMECON	Japon	Anzas	Amérique Latine	P.O.	Afrique	Total Asie(1)	MONDE	Export (%)
E.U.		278,1	278,1	630,2	5,1	115,4	51	138	21,4	2,7	95,4	1681	9,80%
Canada	126,5		126,5	35,1	0	3,9	2,6	1,7	0,4	0,2	2	172,4	1,06%
TOTAL A.N.	126,5	278,1	404,6	665,3	5,1	119,3	53,6	139,7	21,8	2,9	97,4	1773,4	10,86%
France	145,4	18,6	164	463,2	3,8	14,8	16	22,3	36	10,6	14,7	753,7	4,62%
Belgique	4,5	1,7	6,2	111	1,2	0,4	1,4	1,6	2,4	3,2	1,1	128,6	0,79%
RFA	242,9	33,7	276,6	1425,9	46,6	68,9	48,7	36,2	41,9	13,3	85,6	2043,7	12,52%
Italie	139,1	20,6	159,7	261,4	2,5	3,5	14,5	7,8	20,6	2,8	8,6	481,6	2,95%
Pays Bas	162,4	27,5	191,9	720,2	22,4	3,6	29,2	11,9	19,6	7,7	28,3	1026,8	6,29%
R.U.	133,1	18,1	151,2	601,2	8,5	25,5	25,3	6,5	26,7	10,3	31,7	886,5	5,43%
P.Scandinaves	46,3	5,5	51,8	185,1	2,5	9,3	7	3,9	4,8	2,3	8,3	276,6	1,69%
P.Alpins	91,5	10,8	102,3	360,6	16,2	13,8	12,9	5,2	16,3	16,1	41,9	585,3	3,58%
Europe Mérid.	42,3	2,4	44,7	88,8	2,2	2,9	1,6	5,4	3,0	0,0	2,3	146,4	0,90%
TOTAL Europe	1087,5	146,9	1148,4	4209,4	105,9	142,7	156,6	100,8	171,6	75,1	214,7	6329,2	38,76%
URSS		0,1	0,1	22,3	0	0,2	0,1				0,1	22,0	0,14%
Eur. Est	1,4		1,4	24,2	51,2	1,2	0,2	5,4		0,3	3,7	87,6	0,54%
TOTAL COMECON	1,4	0,1	1,5	46,5	51,2	1,4	0,3	5,4	0	0,3	3,0	110,4	0,68%
Japon	2953,4	243,4	3296,8	2243,8	16,7		257,4	110,5	99	7,4	707,1	6651,2	40,73%
Anzas	4,1	0,2	4,3	8,2	0	1,1	5,5	1,8	0,8	0,1	9,5	31,4	0,19%
Am.Latine	29,4	1,2	30,6	3,6	0,6	1,3	0,9	3,6		3,6	5,1	37,3	0,35%
P.Orient	1,4		1,4	4,4	0,3			0,1			0,2	6,4	0,04%
Afrique	3,5	0,2	3,7	3	0		0,5				0	7,2	0,04%
Indonésie	0,1		0,1	1,9	0	0,8		0,2			0,4	3,4	0,02%
Inde	0,1	0,1	0,2	0,6	12,2			0,1		0,4	1,1	14,6	0,09%
Nains Géants	498,4	39,1	527,5	259,2	8,[illegible]	70,5	37,9	16,4	22,9	5,9	257,4	1201,2	7,36%
Chine	1,6	0,4	2	4,3	1,0	1	0,3	1,3			49,3	60	0,37%
Autres Asie	13,1	0,5	13,6	15	2,2	6,1	1,7	0,3		0,7	7,9	49,5	0,30%
TOTAL Asie	583,3	40,1	543,4	281	16,3	78,4	39,5	28,3	22,9	7	318,1	1328,7	8,14%
non ventilée			0	31	0		2,2				1,3	34,5	0,21%
MONDE	4640,5	704,2	5344,7	7491,2	284,1	344,2	516,9	382,2	316,1	96,4	1357,2	16329,7	100,00%
Import (%)	20,42%	4,31%	32,73%	45,91%	1,25%	2,11%	3,17%	2,34%	1,94%	0,59%	8,31%	100,00%	[illegible]

Table B.7 - Mass Consumer Electronics

EGP	E.U.	Canada	Total A.N.	Total Eur.Occi	Total COMECON	Japon	Anzas	Amérique Latine	P.D.	Afrique	Total Asie(1)	MONDE	Export (%)
E.U.		259,9	259,9	63,6	3,1	12,4	7,5	282,5	6,3	6,2	40	681,5	2,15%
Canada	71,3		71,3	8,2	0			0,1	0,1	0,2	1,6	81,5	0,29%
TOTAL A.N.	71,3	259,9	331,2	71,8	3,1	12,4	7,5	282,6	6,4	6,1	41,6	763	2,44%
France	2,6		2,6	224,6	4	0,9	1,1	14,9	17,7	34,6	6,4	306,8	1,10%
Belgique	12,3	1,6	13,9	812,9	0,2	5,3	2,2	0,2	0,2	3,7	4,0	843,6	3,01%
RFA	60,9	2,4	63,3	2108,6	28,9	1,8	12,3	0,1	10,9	7,7	34,6	2284,2	8,16%
Italie	3	0,1	3,1	233,0	1,3	0,1	0,5	3,1	6,5	5,9	0,4	254,0	0,91%
Pays Bas	17,2	2,1	19,3	370,6	4	1,9	2,6	4,5	11,2	10,3	12,1	436,5	1,56%
R.U.	17,4	2,8	20,2	584,2	3,1	1,6	7,3	1,4	9,1	21,6	10,3	659	2,35%
P.Scandinaves	15	1,5	16,5	418,1	4,3	0,6	2	4,3	1,0	2,9	2,3	452,0	1,62%
P.Alpins	16,7	4,3	21	522,1	6,9	2,1	2,5	1,6	1,8	3,6	5,0	567,4	2,03%
Europe Mérid.	1	0,3	1,3	190,6	15,4	0,1	0,1	0,2	13,1	6,6	1	231	0,83%
Total Europe	146,1	15,1	161,2	5465,5	60,1	14,4	30,6	30,3	80,3	96,9	77,7	6036,1	21,56%
URSS			0	20,1	128,9				4	21,1	1,3	175,4	0,63%
Eur. Est			0	42,9	50,7				4,5	7	1,8	106,9	0,38%
TOTAL COMECON	0	0	0	63	179,6	0	0	0	8,5	28,1	3,1	282,3	1,01%
Japon	7452,4	603,4	8055,8	3141,7	100,9		405,8	444,9	547,7	51	1476,9	14232,7	50,83%
Anzas	0,2		0,2	0,3	0		1,5				2,6	4,4	0,02%
Am.Latine	784,9	65,7	850,6	56	0			5,8			0,4	912,8	3,26%
P.Orient	0,7		0,7	7,5	5		0,1			0,2	2,2	15,7	0,06%
Afrique	2,1	0,2	2,3	0,4	0						0	2,7	0,01%
Indonésie	0,1	0,1	0,2	0	0						0,4	0,6	0,00%
Inde			0	0,9	0						0,1	1	0,00%
Mains Dfants	2195	263,4	2458,4	1417,5	5,6	127,6	92,9	226,1	110,9	36,3	418	4728,7	17,57%
Chine	30,2	1,1	31,3	35,9	7,2	6	2,9		0,9	0,3	342,3	426,8	1,52%
Autres Asie	96	8,3	104,3	104,8	0	0,5	9,4				160,1	467,1	1,67%
TOTAL Asie	2321,3	272,9	2594,2	1659,1	12,8	134,1	105,2	226,1	119,8	36,6	928,9	5816,4	20,77%
non ventilée			0	12,5	0						1	13,5	0,05%
MONDE	10779	1217,2	11996,2	16457,8	377,5	160,9	550,5	917,7	762,7	219,2	2534,4	27999,6	100,00%
Import (%)	38,50%	4,35%	42,84%	37,35%	1,35%	0,57%	1,97%	3,28%	2,72%	0,78%	9,05%	100,00%	

Annex 20

Table B.8 - Telecommunications

Télécoms	E.U.	Canada	Total A.N.	Total Eur.Occ	Total COMECON	Japon	Anzas	Amérique Latine	P.O.	Afrique	Total Asie(*)	MONDE	Export (%)
E.U.		577,4	577,4	934,2	4	270	125	743,1	351,9	33,4	529	3560	10,55%
Canada	614,2		614,2	196,5	3,2	6,9	19,3	50,2	13,6	4,4	46,1	754,4	2,03%
TOTAL A.N.	614,2	577,4	1191,6	1130,7	7,2	276,9	144,3	793,3	365,5	37,0	575,1	4522,4	13,41%
France	52,4	4,9	57,3	500,9	12,7	2,6	38,2	137,6	363	178,6	178,2	1469,1	4,36%
Belgique	16,1	1,1	17,2	417,0	4,7	4,6	6,7	34,5	13,7	7	114,9	622,9	1,05%
RFA	83,7	14,3	98	1650,4	27,3	10,2	170	145,1	204,2	47,7	230,9	2599,0	7,71%
Italie	30,6	3,5	34,1	442,1	5,8	4,5	51,0	79,5	149,1	31,4	93,4	891,9	2,64%
Pays Bas	93	35,7	128,7	400	2,9	4,2	9,0	32,0	56,7	10,9	59,6	713,6	2,12%
R.U.	154,9	40,9	195,8	696,1	11,2	22	97,3	78,4	252,7	78,3	131,5	1563,5	4,64%
P.Scandinaves	138,7	18,4	157,1	1097,9	110	5,7	72,3	215,1	142,0	17,9	174	1992,7	5,91%
P.Alpins	20,4	3,6	24	414	12,0	2,9	10,4	16,0	59,2	20,3	39,6	600,5	1,80%
Europe Mérid.	99,1	4,9	104	149,9	73,1	0,3	7,1	39,6	21,0	17,1	10,2	423,1	1,25%
TOTAL Europe	688,9	127,3	816,2	5793,1	260,5	57	471,6	779,4	1263,2	409,1	1032,3	10885,1	32,27%
URSS	0,3		0,3	19,9	38,0	0,1			1,6	0,5	0	61,2	0,18%
Eur. Est	0,7	0,7	1,4	20,3	1421,0				86,0	6,4	0,3	1545	4,58%
TOTAL COMECON	1	0,7	1,7	40,2	1460,6	0,1	0	0	88,4	6,9	0,3	1606,2	4,76%
Japon	4024,0	329	4353,0	2235,3	18,5		444,2	561,7	347,2	91,1	2122,1	10236,6	30,38%
Anzas	4,1	0,8	4,9	16,1	0	0,2	11,6	0,3	1,1	0,8	12,7	47,0	0,14%
Am.Latine	952,5	23,7	976,2	24	10,7	3,0	0,1	18,9	2,7	2,4	2	1040,0	3,09%
P.Orient	1,1		1,1	31,2	0,1						0,0	33,2	0,10%
Afrique	4,7		4,7	0,5	0,2				0,1	0,1	0	13,6	0,04%
Indonésie	0,1		0,1	0,8	0						3,6	4,5	0,01%
Inde	0,5	0,1	0,6	1,6	5,7				0,3	0,1	0,3	8,6	0,03%
Nains Géants	2595,3	164,3	2759,6	409,7	0,3	260,5	65,0	98,3	42,9	15	1135,2	4893	14,51%
Chine	21,2	0,2	21,4	13,3	2,3	4,0	0,1	0,2	0,4		140,1	182,6	0,54%
Autres Asie	121	5,4	126,4	16,5	0	1,7	1,0				77,2	223,6	0,66%
TOTAL Asie	2738,1	170	2908,1	521,9	8,3	267	67,7	98,5	63,6	15,1	1356,4	5312,3	15,75%
non ventilée			0	31,2	0		1,5				1,4	34,1	0,10%
MONDE	9829,4	1228,9	10258,3	9840,2	1766,1	605	1141	2252,1	2131,0	563,3	5183,1	33732,1	100,00%
Import (%)	26,77%	3,64%	30,41%	29,17%	5,24%	1,79%	3,38%	6,68%	6,32%	1,67%	15,13%	100,00%	

Annex 21

Table B.9 - Informatics

MEID	E.U.	Canada	Total A.N.	Total Eur.Occ	Total COMECON	Japon	Anzas	Amérique Latine	F.O.	Afrique	Total Asie(8)	MONDE	Export (%)
E.U.		2512,2	2512,2	7126,7	8,2	1118,8	779,5	1151,9	142,5	27,1	1376,1	14243	21,74%
Canada	922,7		922,7	162,7	0,8	18,4	15	22,6	7,3	1	19,4	1169,9	1,77%
TOTAL A.N.	922,7	2512,2	3434,9	7289,4	9	1137,2	794,5	1174,5	149,8	28,1	1395,5	15412,9	23,53%
France	172,4	16,4	188,8	2325,5	35,3	13,3	56,4	76,7	76,9	73,7	187,4	3456,7	5,28%
Belgique	75,2	2,1	77,3	610,7	1,6	7,8	12,9	1,8	5,5	11	10,2	733,8	1,12%
RFA	605,3	37,2	642,5	5159,4	61,5	54	195,9	32,2	56,7	12,5	130,4	6254,8	9,55%
Italie	472,2	57,6	529,8	1857,5	31,2	17,3	53,7	28,4	32,5	7,8	24,5	2592,7	3,96%
Pays Bas	126,8	8,1	134,9	1916,4	3,6	3,2	20,7	3,6	20,4	3,6	28,9	2127,3	3,25%
R.U.	585,8	86,1	671,9	6959,1	36,4	44,8	260,7	24,4	182,1	27,6	99,9	7326,9	11,19%
P.Scandinaves	189,8	26,9	216,7	1340,1	40,6	21	27,3	21,7	11,2	4,8	16,3	1729,7	2,64%
P.Alpins	62,2	11	73,2	425,4	27,1	7,7	6,8	4,2	6,6	0,8	10,3	562,1	0,86%
Europe Mérid.	103,8	1,9	105,7	803,3	9,3	14,3	13,5	32,2	4,6	1	6,7	992,4	1,52%
TOTAL Europe	2393,5	247,3	2640,8	21007,4	247,6	183,9	557,9	225,6	316,1	144,3	456,8	25781,4	39,36%
URSS			0	14,7	102,3				0,3	0,1	0,1	121	0,18%
Eur. Est	3,7	0,1	3,8	30,9	4566,8		0,1	0,1	8	1,1	4,7	4618,6	7,05%
TOTAL COMECON	3,7	0,1	3,8	45,6	4669,1	0	0,1	0,1	8,3	1,2	4,8	4739,6	7,24%
Japon	5695,3	212,7	5908	3410,4	31,8		475,7	143,7	73,4	4,2	1362,9	11410,3	17,42%
Anzas	11,2	0,6	11,8	27,2	4,7	5,2	11,5	0,1	0,2	0,1	31,5	92,3	0,14%
Am.Latine	335,5	14,6	350,1	68,5	19,3	119,4	49,3	15	0,2	0,3	62,4	684,5	1,04%
P.Orient	4	0,2	4,2	22	9						0,3	26,5	0,04%
Afrique	3,1		3,1	3,3	0						0	6,4	0,01%
Indonésie			0	0,3	0		0,2				0,3	0,8	0,00%
Inde	7,5		7,5	3,1	3	0,2	0,1				18,5	29,4	0,04%
Nains géants	3741	133,6	3874,6	1712,5	5,7	131,3	183	40,3	27,6	4,7	672,8	6710,6	10,24%
Chine	2,8	0,3	3,1	5	1,4	1,1	0,1				67,9	80,6	0,12%
Autres Asie	65,3	0,5	66,3	15,7	0	6	0,6				153,5	243,1	0,37%
TOTAL Asie	3817,1	134,1	3951,5	1737,6	7,1	138,6	184	40,3	27,6	4,7	915	7064,5	10,78%
non ventilée			0	247,9	0		32,1				4,9	234,9	0,43%
MONDE	13186,1	3122,1	16308,2	33853,3	4958,6	1630,3	2105,1	1607,5	575,6	193,4	4234,1	65503,3	100,00%
Export (%)	20,13%	4,77%	24,90%	51,69%	7,52%	2,49%	3,21%	2,45%	0,88%	0,29%	6,46%	100,00%	

Annex 22

Table B.10 - Active components

Comp.Actifs	E.U.	Canada	Total A.N.	Total Eur.Occ	Total COMECON	Japon	Anzas	Amérique Latine	P.D.	Afrique	Total Asie(1)	MONDE	Export (%)
E.U.		761,6	761,6	1701,2	1,0	550,9	36	667,9	11,3	7	3454,6	6767,3	22,04%
Canada	270,3		270,3	22,7	0	12,2	2,3	3,2			25,0	336,5	1,10%
TOTAL A.N.	270,3	761,6	1031,9	1303,9	1,0	563,1	38,3	671,1	11,3	7	3480,4	7103,8	23,14%
France	106,3	9,4	115,7	1040,5	14	30	0,7	11,6	24,6	5,7	110,7	1361	4,43%
Belgique	2,2	0,1	2,3	152,1	3,2	1,3	0,1	0,7	4,1	0,7	6,4	170,9	0,56%
RFA	111,9	4,4	116,3	1298,1	27,7	40,3	23,6	40,4	13,2	0,9	204,4	1817,1	5,92%
Italie	42,2	1,6	43,8	527,4	3,0	2,7	2,9	7,7	6,7	0,6	61,4	659,2	2,15%
Pays Bas	37,5	4,4	41,9	642,5	9,7	0,2	6,0	27,5	20,7	27,2	107,6	903,0	2,94%
R.U.	237,0	10,2	247	1102,5	2,4	46,7	16,4	13,0	9,6	3,0	133,7	1577,1	5,14%
P.Scandinaves	7,4	0,7	8,1	79,9	2,7	6	10,5	14,1	0,0	0,5	22,6	145,2	0,47%
P.Alpins	7,7	0,8	8,5	308	11,7	1,6	4	1,6	7,2	0,3	23,3	446,2	1,45%
Europe Mérid.	22,8	0,4	23,2	187,9	12,4	0,1	0,6	0,9	0,6	1,6	8,0	236,1	0,77%
TOTAL Europe	566,8	40	606,8	5420,9	98	137,1	75,1	120,5	95	47,3	727,9	7316,6	23,83%
URSS	0,3		0,3	9,2	0	0,3					0	7,8	0,03%
Eur. Est	0,7		0,7	32,6	547,9				2,7		6,1	590	1,92%
TOTAL COMECON	1	0	1	41,8	547,9	0,3	0	0	2,7	0	6,1	597,8	1,95%
Japon	1620,1	59,8	1679,9	1368,6	14,7		63,8	229,7	16,7	2	3112	6487,4	21,13%
Anzas	1,7	0,5	2,2	5,4	0	0,2	0,7			0,1	1,8	10,4	0,03%
Am.Latine	384,7	3,4	388,1	54,7	7,2	0,8	0,2	0,7	0,1		9,2	461	1,50%
P.Orient	0,4		0,4	17,1	0						0,3	18	0,06%
Afrique	1,0		1,0	8,2	0						0,1	10,1	0,03%
Indonésie			0	2,5	0						136,5	137	0,45%
Inde			0	1	0						5,4	6,4	0,02%
Mains Géants	1872,1	25,7	1897,8	915,7	5,9	305,9	35	28,6	1,5	0,7	1699,5	4773,7	16,20%
Chine	1,1	0,2	1,3	11,8	0						14	27,1	0,09%
Autres Asie	1810,3	2,6	1812,9	637,1	0	30,3	4,7				920,3	3421,3	11,14%
TOTAL Asie	3683,5	28,5	3712	1568,1	5,9	424,2	39,7	28,6	1,5	0,7	2783,7	8567,5	27,91%
non ventilée			0	104,3	0						23,1	127,4	0,41%
MONDE	6530,3	893,8	7424,1	9893	667,5	1125,7	217,8	1050,6	127,3	40,3	10144,0	30702	100,00%
Import (%)	21,27%	2,91%	24,18%	32,22%	2,17%	3,67%	0,71%	3,42%	0,41%	0,14%	33,04%	100,00%	

ANNEX C

PRODUCTION OF SOME ARTICLES BY VOLUME

Tables

Source : GERDIC, after data in UNO "Yearbook of industrial statistics", 1987

Annex 24

Table C.1 - TV receivers (thousands)

Recepteurs TV (000)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Etats Unis	10219	10801	9190	7524	7945	7863	9309	9534	10320	10883	10218	11506	13357
(%) :	21,2%	20,7%	17,7%	15,5%	14,1%	13,5%	15,3%	14,7%	14,3%	14,2%	14,0%	14,8%	15,2%
Amérique Latine	2211	2757	3394	3077	3463	3729	4062	4444	5294	4612	4047	3138	3110
(%) :	4,6%	5,3%	6,5%	6,3%	6,1%	6,4%	6,7%	6,9%	7,3%	6,0%	5,6%	4,0%	3,5%
Argentine	195	233	279	290	169	254	219	262	454	515	448	335	430
Bresil	1669	1486	1991	1607	1916	2078	2422	2747	3254	2516	2354	1857	1744
Chili	192	125	223	168	103	139	70	88	167	80	35	23	31
Mexique	436	518	547	569	729	699	767	647	964	978	766	479	467
Colombie	64	71	76	83	93	102	137	100	103	120	100	87	80
Japon	13032	12439	11074	10624	15103	14342	13116	13577	15205	14578	12796	13275	15512
(%) :	27,0%	23,8%	21,4%	21,8%	26,7%	24,7%	21,5%	21,0%	21,1%	19,1%	17,6%	17,1%	17,7%
Asie (hors Japon)	991	1654	2544	3136	4311	5753	7805	10652	13409	17790	16255	19049	25021
(%) :	2,0%	3,2%	4,9%	6,4%	7,6%	9,9%	12,8%	16,4%	15,6%	23,3%	22,3%	24,5%	28,5%
Chine				178	230	285	517	1329	2492	5394	5920	6840	10040
Coree du Sud	308	816	1164	1225	2290	2990	4826	5867	6819	7548	6113	7641	9729
Singapour	84	114	195	397	486	560	726	1390	1889	2174	1516	1361	1345
Afrique	385	384	412	543	805	652	620	629	1138	1333	1562	1757	1796
(%) :	0,8%	0,7%	0,8%	1,1%	1,4%	1,1%	1,0%	1,0%	1,6%	1,7%	2,1%	2,3%	2,0%
Algerie	24	43	36	48	54	51	60	69	74	145	174	194	225
Egypte	76	51	71	85	88	151	174	218	306	440	593	819	
Tunisie	25	26	31	35	45	53	69	73	88	95	100	115	124
Afrique du Sud				227	472	246	173	134	338	399	425	337	377
Europe Occidentale	12019	14178	14698	12463	13357	14584	14918	14395	15422	15417	16129	17197	16620
(%) :	24,9%	27,2%	28,4%	25,6%	23,6%	25,1%	24,5%	22,2%	21,4%	20,2%	22,2%	22,1%	19,0%
dont CEE	10239	12004	12159	10009	10808	11569	12035	11333	11711	11487	11400	12361	11607
(%) :	21,2%	23,0%	23,5%	20,6%	19,1%	19,9%	19,7%	17,5%	16,2%	15,0%	15,7%	15,9%	13,2%
Europe de l'Est	8184	8726	9299	9921	10060	9943	10127	10297	10444	11005	10850	11106	11497
(%) :	17,0%	16,7%	17,9%	20,4%	17,8%	17,1%	16,6%	15,9%	14,5%	14,4%	14,9%	14,3%	13,1%
URSS	5980	6271	6569	6960	7063	7073	7165	7271	7528	8190	8345	8578	8998
TOTAL....................	48216	52194	51825	48695	56526	58081	60942	64776	72134	76502	72764	77800	87670

Annex 25

Table C.2 - Radio receivers (thousands)

Radio-recepteurs (000)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Etats Unis	15672	15665	12009	10406	12807	11252	11181	11741	7672	8446	6577	8288	9817
(%) :	12,5%	12,1%	9,8%	8,8%	8,8%	7,5%	8,1%	8,2%	4,2%	4,8%	6,1%	5,4%	6,2%
Amerique Latine	4547	5126	4937	3029	3024	8148	9496	9346	8953	7725	10731	11510	12426
(%) :	3,6%	4,0%	4,0%	2,6%	2,1%	5,4%	6,8%	6,5%	4,9%	4,4%	7,7%	7,5%	7,9%
Bresil	1179	1299	1185	640	759	6027	7367	6956	6769	5639			
Mexique	732	893	931	1030	1135	976	1126	1290	1029	893	663	413	357
Colombie	37	7	1	5	16	10	13	7	3	2	2	0	0
Japon	26833	24484	18026	14263	16770	17308	16278	13910	15343	15196	14318	13336	13569
(%) :	21,4%	18,9%	14,8%	12,1%	11,5%	11,5%	11,7%	9,7%	8,4%	8,7%	10,2%	8,7%	8,6%
Asie (hors Japon)	48590	54118	56477	54258	71541	83220	73221	80404	123458	118172	81968	93993	96115
(%) :	38,8%	41,7%	46,3%	45,9%	49,1%	55,4%	52,8%	56,0%	67,7%	67,5%	58,5%	61,5%	61,1%
Chine				9356	9925	10494	11677	13607	30036	40572	17239	19990	22303
Coree du Sud	1858	3272	3692	4464	6717	6404	4768	4772	3972	5240	5925	6719	7769
Hong Kong	35434	37899	39391	39022	50491	53022	40902	40639	67476	51758	41296	47986	43372
Singapour	7296	8150	8988	7221	10737	9726	11717	16748	17070	16028	13461	15165	18246
Afrique	1020	994	1306	1730	1755	1764	1888	1994	2096	2111	1865	2096	2397
(%) :	0,8%	0,8%	1,1%	1,5%	1,2%	1,2%	1,4%	1,4%	1,1%	1,2%	1,3%	1,4%	1,5%
RSA						467	657	821	861	905	715	895	1161
Egypte	164	148	157	221	117	265	368	223	171	182	204	245	
Maroc	40	43		157	189	134	42	46	47	23	12	7	34
Europe Occidentale	15821	16413	15951	12410	14367	14995	12840	12288	10976	9254	9176	9815	8865
(%) :	12,6%	12,7%	13,1%	10,5%	9,9%	10,0%	9,3%	8,6%	6,0%	5,3%	6,6%	6,4%	5,6%
dont CEE	14332	14761	14046	10864	13036	13407	11223	10976	9767	8164	8202	8683	7835
(%) :	11,4%	11,4%	11,5%	9,2%	8,9%	8,9%	8,1%	7,7%	5,4%	4,7%	5,9%	5,7%	5,0%
Europe de l'Est	11976	11869	12306	12476	13049	13440	4927	8728	13523	13690	13069	13397	13828
(%) :	9,6%	9,2%	10,1%	10,5%	9,0%	8,9%	3,5%	6,1%	7,4%	7,8%	9,3%	8,8%	8,8%
TOTAL	125370	129678	122088	118274	145697	150240	138805	143461	182403	174942	140041	152761	157335

Annex 26

Table C.3 - Sound reproduction (thousands)

Reprod. du son (000)	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Etats Unis	2576	2738	2428	1491	1685	2330	2197	1941	1425	1184	914	487	933
(%) :	12,4%	12,7%	12,6%	9,3%	8,1%	11,5%	10,8%	10,9%	8,2%	6,5%	6,1%	2,9%	5,4%
Amerique Latine	1328	1317	1534	949	934	989	1063	1156	1096	788	675	668	520
(%) :	6,4%	6,1%	7,9%	5,9%	4,5%	4,9%	5,2%	6,5%	6,3%	4,3%	4,5%	3,9%	3,0%
Mexique	476	632	832	751	708	765	779	949	891	592	485	481	333
Colombie	3	3	4		7	17	14	21	0	2	2	1	
Chili		49	98	69	39	43	26	6					
Japon	8700	8839	7348	6071	9706	9724	10686	9420	10672	12072	9211	11566	10961
(%) :	41,9%	41,0%	38,0%	37,8%	46,5%	48,1%	52,7%	53,0%	61,6%	66,0%	61,5%	68,1%	63,5%
Asie (hors Japon)	240	273	256	586	1302	1466	1328	1026	753	892	866	1217	1635
(%) :	1,2%	1,3%	1,3%	3,6%	6,2%	7,2%	6,5%	5,8%	4,3%	4,9%	5,8%	7,2%	9,5%
Coree du Sud	20	63	80	419	1105	1086	949	617	358	532	551	916	1112
Afrique	18	14	18	7	6	6	0	9	31	27	12	26	29
(%) :	0,1%	0,1%	0,1%	0,0%	0,0%	0,0%	0,0%	0,1%	0,2%	0,1%	0,1%	0,2%	0,2%
Algerie	12	9	13	3	3	4	3	9	31	27	12		
Tunisie				4	3	2	3	0	0	0	0	0	0
Europe Occidentale	7156	7660	7096	6331	6517	5317	4679	3834	2949	2971	3084	2814	2961
(%) :	34,6%	35,5%	36,7%	39,4%	31,2%	26,3%	23,1%	21,6%	17,0%	16,3%	20,6%	16,6%	17,1%
dont CEE	6485	6876	6153	5294	5472	4273	4018	3513	2625	2807	2868	2677	2840
(%) :	31,2%	31,9%	31,8%	32,9%	26,2%	21,1%	19,8%	19,8%	15,1%	15,4%	19,2%	15,8%	16,4%
Europe de l Est	571	599	526	536	451	373	300	360	370	312	171	162	198
(%) :	2,7%	2,8%	2,7%	3,3%	2,2%	1,8%	1,5%	2,0%	2,1%	1,7%	1,1%	1,0%	1,1%
TOTAL	20776	21581	19334	16077	20869	20228	20275	17783	17333	18283	14972	16979	17273

Annex 27

Table C.4 - Transistors/semiconductors (millions)

Transistor a SC (millions)

	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Etats Unis	2801	2801	2801	2801	2801	2801	2801	2801	2801	2801	2801	2801	2801
(%) :	30,3%	23,6%	22,9%	38,4%	23,4%	20,6%	19,6%	16,9%	13,8%	10,3%	10,8%	8,5%	5,7%
Amerique Latine	2	2	6	81	100	150	208	264	185	312	325	360	395
(%) :	0,0%	0,0%	0,0%	1,1%	0,8%	1,1%	1,5%	1,6%	0,9%	1,2%	1,3%	1,1%	0,8%
Bresil	2	2	6		100	150	208	264	185	312			
Japon	4670	6380	6071	4574	8409	9892	10567	12281	16328	22661	21555	28077	42406
(%) :	50,6%	53,7%	49,6%	62,7%	70,2%	72,8%	73,9%	74,1%	80,4%	83,6%	83,5%	84,9%	86,7%
Asie (hors Japon)	921	1557	1972	1352	1890	1861	1858	2103	1983	2305	2026	2860	3769
(%) :	10,0%	13,1%	16,1%	18,5%	15,8%	13,7%	13,0%	12,7%	9,8%	8,5%	7,9%	8,6%	7,7%
Coree du Sud	842	1478	1895	1273	1820	1772	1779	2024	1904	2226	1949	2681	3690
Afrique													
(%) :	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%	0,0%
Europe Occidentale	730	1019	1230	1070	1334	1386	1339	1566	1437	1514	1613	1580	1964
(%) :	7,9%	8,6%	10,0%	14,7%	11,1%	10,2%	9,4%	9,4%	7,1%	5,6%	6,2%	4,8%	4.0%
dont CEE	60	806	990	896	1156	1154	1106	1314	1115	1222	1375	1257	1610
(%) :	0,6%	6,8%	8.1%	12,3%	9,7%	8,5%	7,7%	7,9%	5,5%	4,5%	5,3%	3,8%	3,3%
Europe de l Est	87	101	125	183	226	267	310	341	341	280	274	287	343
(%) :	0,9%	0,8%	1,0%	2,5%	1,9%	2,0%	2,2%	2,1%	1,7%	1,0%	1,1%	0,9%	0,7%
TOTAL	9232	11884	12243	7292	11978	13581	14307	16580	20299	27098	25821	33090	48903

Annex 28

ANNEX D

ANALYSIS INTO PRINCIPAL COMPONENTS OF ELECTRONICS (*)

Annex 29

CORRELATION MATRIX

	INFO	BURE	INST	COMM	TELE	MEDI	INDU	EGF	COMP	COMA
INFO	1.00									
BURE	0.07	1.00								
INST	0.01	0.08	1.00							
COMM	-0.02	-0.01	0.24	1.00						
TELE	0.02	-0.30	0.14	0.24	1.00					
MEDI	-0.17	0.03	0.37	0.60	0.06	1.00				
INDU	-0.09	-0.11	0.32	0.37	0.60	0.34	1.00			
EGF	-0.38	0.15	-0.17	-0.50	-0.17	-0.36	-0.05	1.00		
COMP	-0.04	0.21	-0.12	-0.17	-0.19	0.15	-0.08	0.32	1.00	
COMA	-0.41	-0.14	-0.50	-0.36	-0.53	-0.32	-0.54	0.02	-0.25	1.00

ANALYSIS INTO PRINCIPAL COMPONENTS

VARIABLE		MOYENNE	ECART-TYPE
INFO	1	20.13	12.85
BURE	2	1.85	1.61
INST	3	9.24	7.41
COMM	4	8.57	6.91
TELE	5	15.34	10.21
MEDI	6	2.57	3.04
INDU	7	1.27	0.84
EGF	8	14.19	10.45
COMP	9	12.99	5.39
COMA	10	13.84	19.98

(*) The software used is LOGMAD by M. Philippe MICHEL, IUT of RENNES I.

Annex 30

VALEUR FROPRE		% INERTIE	% CUMULE
1	3.0288	30.29	30.29
2	1.6286	16.29	46.57
3	1.4265	14.27	60.84
4	1.3651	13.65	74.49
5	0.8997	9.00	83.49
6	0.7009	7.01	90.50
7	0.3731	3.73	94.23
8	0.3509	3.51	97.74
9	0.2264	2.26	100.00
10	0.0000	0.00	100.00

HISTOGRAMME des VALEURS FROFRES

```
*********!*********!*********!
*********!******
*********!****
*********!***
********
*******
***
***
**
```

VECTEURS FROFRES (EN COLONNES)

-0.0693	0.0646	0.2616	-0.7706	0.1296	-0.0635	0.1656	-0.2757	-0.1425	-0.4223
0.0545	-0.4534	0.3756	-0.0810	-0.3829	0.6233	-0.3027	0.0512	-0.0367	-0.0529
-0.3383	-0.1518	0.1013	0.0269	-0.6277	-0.5667	-0.0658	0.1440	0.2262	-0.2434
-0.4157	0.1295	0.2736	0.2342	0.1534	0.3339	0.5618	0.2849	0.3130	-0.2270
-0.3585	0.1174	-0.5130	-0.1564	0.1054	0.1991	-0.3920	0.4665	-0.1862	-0.3356
-0.3682	-0.1151	0.3247	0.4220	0.2132	-0.1547	-0.1307	-0.1990	-0.0542	-0.1197
-0.4184	-0.0594	-0.3771	0.0936	-0.0406	0.2158	-0.0709	-0.7213	0.2997	-0.0276
0.2722	-0.4636	-0.4262	0.1167	-0.1560	0.0254	0.5286	-0.0655	-0.3057	-0.3433
0.0728	-0.5986	0.0661	0.0201	0.5788	-0.2245	-0.2167	0.1015	0.2968	-0.1773
0.4281	0.3756	0.0931	0.3441	-0.0386	0.0493	-0.2426	-0.1727	0.1577	-0.0566

Annex 31

REPRESENTATION OF THE INDIVIDUALS

Coordonnee de la variable = ligne 1
Cosinus carre avec l'axe = ligne 2
Contribution a l inertie de l axe = ligne 3

VARIABLE	AXE : 1	AXE : 2	AXE : 3	AXE : 4	AXE : 5	AXE : 6	AXE : 7	AXE : 8	AXE : 9	AXE : 10
RFA	-0.57	-0.67	0.45	-0.70	-0.75	-0.65	-0.68	-0.34	0.27	-0.00
	0.11	0.16	0.07	0.17	0.20	0.07	0.16	0.64	0.03	0.00
	0.36	6.93	6.48	1.19	2.09	0.95	4.11	1.09	1.67	0.45
BELG	-0.11	-0.19	-0.62	-1.07	0.43	-0.62	-0.19	0.40	-0.25	-0.00
	0.00	0.01	0.25	0.42	0.07	0.14	0.01	0.06	0.02	0.00
	0.01	0.66	1.58	2.79	6.68	1.81	0.33	1.55	0.96	1.10
DANE	-2.04	-1.07	1.86	1.65	-0.80	-2.14	-0.35	0.51	-0.43	-0.00
	0.24	0.07	0.30	0.16	0.04	0.26	0.01	0.02	0.01	0.00
	4.56	2.25	8.13	6.67	2.66	21.80	1.11	2.50	2.71	0.39
ESPA	0.17	0.99	-0.51	-1.07	0.49	-0.01	0.58	0.05	-0.99	0.00
	0.01	0.17	0.05	0.56	0.04	0.00	0.06	0.00	0.17	0.00
	0.03	2.00	0.60	6.78	0.90	0.00	2.99	0.07	14.42	3.87
FRAN	-1.05	1.18	0.48	-0.25	0.60	0.25	0.66	0.93	0.67	-0.00
	0.21	0.26	0.04	0.01	0.07	0.01	0.14	0.16	0.09	0.00
	1.21	2.87	0.54	0.16	1.32	0.30	6.66	8.16	6.56	3.29
IREL	0.56	0.87	1.39	-3.03	0.79	-0.98	0.01	-0.96	-0.14	-0.00
	0.02	0.05	0.13	0.63	0.04	0.07	0.00	0.06	0.00	0.00
	0.35	1.53	4.48	22.46	2.30	4.58	0.00	8.57	0.30	5.61
ITAL	-1.01	0.75	0.47	-1.25	-0.36	0.37	0.11	-0.48	-0.04	0.00
	0.27	0.15	0.06	0.40	0.03	0.04	0.00	0.06	0.00	0.00
	1.11	1.15	0.52	3.68	0.47	0.65	0.11	2.17	0.02	0.05
PB	-0.41	-1.21	2.59	-0.38	-1.24	1.30	-1.26	-0.28	-0.58	0.00
	0.01	0.11	0.49	0.01	0.11	0.12	0.12	0.01	0.02	0.00
	0.19	3.02	15.72	0.35	5.69	8.05	14.17	0.72	5.04	4.47
RU	-1.38	0.50	0.45	-0.54	-0.21	0.02	0.54	-0.54	1.03	-0.00
	0.44	0.06	0.05	0.07	0.01	0.00	0.07	0.07	0.24	0.00
	2.11	0.51	0.47	0.72	0.16	0.00	2.56	2.81	15.55	1.68
AUTR	0.19	-1.49	-0.85	0.33	0.29	-0.93	-0.68	0.16	0.19	0.00
	0.01	0.48	0.16	0.02	0.02	0.19	0.10	0.01	0.01	0.00
	0.04	4.52	1.70	0.26	0.32	4.14	4.17	0.23	0.51	1.75
FINL	-0.83	0.18	-0.51	-0.39	0.09	-1.08	0.49	-0.11	-0.13	0.00
	0.27	0.01	0.10	0.06	0.00	0.45	0.09	0.01	0.01	0.00
	0.77	0.07	0.61	0.37	0.03	5.55	2.14	0.13	0.24	0.31
NORV	-2.04	1.72	-0.62	-1.55	-0.59	-0.51	0.07	-0.54	0.29	0.00
	0.39	0.27	0.04	0.22	0.03	0.02	0.00	0.03	0.01	0.00
	4.60	6.04	0.69	5.70	1.29	1.25	0.04	2.81	1.27	13.52
SUED	-1.65	0.86	-0.65	-0.16	0.55	-0.32	-0.92	1.44	-0.41	-0.00
	0.38	0.10	0.06	0.00	0.02	0.01	0.12	0.29	0.02	0.00
	3.00	1.52	0.98	0.06	0.41	0.43	7.63	19.73	2.50	4.30
SUIS	-0.65	-1.71	-0.92	0.96	-2.56	-0.89	0.45	-0.74	0.22	-0.00
	0.03	0.22	0.06	0.07	0.49	0.06	0.02	0.04	0.01	0.00
	0.46	5.95	1.98	2.26	24.21	3.75	1.84	5.22	1.52	1.56

Annex 32

CHNA	-1.16	0.87	0.26	-0.28	-0.34	0.66	-0.10	0.89	-0.09	0.00
	0.37	0.19	0.01	0.02	0.03	0.20	0.00	0.19	0.00	0.00
	1.48	1.40	0.09	0.29	0.42	3.52	0.09	6.13	0.11	2.28
EU	-1.05	0.22	2.04	-0.01	-0.55	1.23	0.69	0.62	0.75	0.00
	0.14	0.01	0.46	0.00	0.04	0.18	0.06	0.04	0.07	0.00
	1.29	0.11	9.73	0.00	1.14	7.30	4.31	3.62	6.28	0.04
JAPO	1.44	-1.69	0.88	-0.29	-0.22	1.07	-0.17	-0.01	-0.28	0.00
	0.29	0.40	0.11	0.01	0.01	0.16	0.00	0.00	0.02	0.00
	2.27	5.64	1.82	0.21	0.18	5.40	0.25	0.00	1.18	0.36
CORE	2.21	-0.61	-1.06	0.39	0.55	-0.28	0.45	0.22	-0.29	-0.30
	0.68	0.05	0.15	0.02	0.04	0.01	0.03	0.01	0.01	0.00
	5.23	0.77	2.61	0.37	1.10	0.38	1.60	0.45	1.21	0.11
HONG	-1.45	-1.88	-0.35	-0.09	-0.50	1.68	0.97	-0.18	-0.36	-0.09
	0.21	0.36	0.01	0.00	0.03	0.28	0.09	0.00	0.01	0.00
	2.31	7.25	0.29	0.02	0.93	13.46	6.59	0.72	1.56	0.64
SING	2.60	-0.67	0.83	-0.47	1.27	-0.63	-0.37	-0.16	0.49	-0.00
	0.63	0.97	0.06	0.02	0.15	0.04	0.01	0.00	0.02	0.00
	7.42	1.53	1.62	0.53	5.94	1.87	1.21	0.10	3.58	0.50
TAIW	1.98	-2.24	-0.32	0.08	1.81	-0.25	-0.11	0.11	0.74	0.00
	0.30	0.39	0.01	0.00	0.25	0.00	0.00	0.00	0.04	0.00
	4.33	16.23	0.24	0.02	12.19	0.29	0.10	0.12	8.13	15.16
INDO	1.11	-0.45	-0.31	0.64	0.13	0.66	-0.45	0.31	0.67	-0.00
	0.39	0.07	0.03	0.13	0.01	0.14	0.06	0.03	0.14	0.00
	1.36	0.42	0.23	1.01	0.06	2.08	1.81	0.93	6.70	10.69
MALA	2.86	2.39	0.04	1.61	-0.06	-0.22	-0.26	-0.26	0.20	0.00
	0.49	0.34	0.00	0.15	0.06	0.00	0.00	0.00	0.00	0.00
	9.02	11.70	0.00	6.32	0.01	0.24	0.62	0.63	0.57	14.55
PHIL	3.00	2.89	0.31	1.77	-0.36	0.00	-0.84	-0.28	0.17	-0.00
	0.42	0.39	0.00	0.15	0.01	0.00	0.03	0.00	0.00	0.00
	9.88	17.05	0.23	7.67	0.49	0.00	6.34	0.74	0.41	2.57
THAI	2.74	1.87	0.23	1.17	-0.82	0.13	0.70	-0.20	-0.69	-0.00
	0.57	0.25	0.00	0.10	0.05	0.00	0.03	0.00	0.03	0.00
	8.27	7.12	0.12	3.35	2.50	0.08	4.34	0.38	6.91	1.75
SAFR	-2.19	0.23	-3.52	0.04	0.35	1.42	-1.20	-0.93	0.01	-0.00
	0.22	0.00	0.57	0.00	0.01	0.09	0.07	0.04	0.00	0.00
	5.29	0.11	28.93	0.00	0.46	9.60	12.83	8.29	0.00	2.20
AUST	-1.88	0.54	-1.10	0.57	-0.25	0.40	0.10	1.01	0.10	0.00
	0.53	0.04	0.16	0.05	0.01	0.02	0.00	0.15	0.00	0.00
	3.87	0.59	[illegible]	0.80	0.24	0.74	0.09	9.66	0.16	4.60
MES	1.31	-0.87	-0.07	-0.88	0.74	0.11	0.14	0.43	-0.52	-0.00
	0.40	0.18	0.00	0.18	0.13	0.00	0.00	0.04	0.06	0.00
	1.89	1.55	0.01	1.87	2.05	0.05	0.17	1.74	4.06	2.07
INGE	0.38	-0.93	-1.93	0.66	-0.87	-0.52	0.92	0.01	-0.22	0.00
	0.02	0.12	0.53	0.36	0.11	0.04	0.12	0.00	0.01	0.00
	0.16	1.78	8.77	1.07	2.79	1.28	7.51	0.00	0.71	0.44
USSA	-3.92	-0.12	1.29	3.08	2.69	0.32	0.51	-1.08	-0.45	-0.00
	0.43	0.00	0.05	0.27	0.20	0.00	0.01	0.02	0.01	0.00
	16.95	0.03	3.89	23.12	26.75	0.45	2.34	10.98	2.52	0.10

Annex 33

REPRESENTATION OF THE VARIABLES

Coordonnee de la variable = ligne 1
Cosinus carre avec l axe = ligne 2
Contribution a l'inertie de l'axe = ligne 3

VARIABLE	AXE : 1	AXE : 2	AXE : 3	AXE : 4	AXE : 5	AXE : 6	AXE : 7	AXE : 8	AXE : 9	AXE : 10
INFO	-0.16	0.06	0.31	-0.90	0.12	-0.05	0.10	-0.17	-0.07	-0.06
	0.02	0.01	0.10	0.81	0.02	0.00	0.01	0.03	0.00	0.00
	0.80	0.42	6.85	59.42	1.68	0.40	2.74	7.52	2.03	17.64
BURE	0.09	-0.58	0.45	-0.09	-0.36	0.53	-0.18	0.03	-0.02	-0.06
	0.01	0.33	0.20	0.01	0.13	0.28	0.03	0.00	0.00	0.00
	0.30	26.47	14.10	0.66	14.66	32.98	9.16	0.26	0.13	0.29
INST	-0.59	-0.17	0.12	0.03	-0.60	-0.47	-0.04	0.09	0.11	-0.00
	0.35	0.04	0.01	0.00	0.35	0.23	0.00	0.01	0.01	0.00
	11.44	2.31	1.03	0.07	39.40	32.11	0.43	2.08	5.21	5.93
COMM	-0.72	0.17	0.33	0.27	0.15	0.28	0.34	0.17	0.15	-0.00
	0.52	0.03	0.11	0.07	0.02	0.08	0.12	0.03	0.02	0.00
	17.28	1.66	7.49	5.48	2.35	11.15	31.57	8.12	9.73	5.15
TELE	-0.62	0.15	-0.61	-0.18	0.10	0.17	-0.24	0.28	-0.09	-0.00
	0.39	0.02	0.38	0.03	0.01	0.03	0.06	0.08	0.01	0.00
	12.65	1.38	26.32	2.45	1.11	3.96	15.36	21.76	3.54	11.26
MEDI	-0.64	-0.15	0.39	0.49	0.20	-0.13	-0.08	-0.12	-0.31	-0.00
	0.41	0.02	0.15	0.24	0.04	0.02	0.01	0.01	0.10	0.00
	13.56	1.32	10.52	17.81	4.54	2.39	1.71	3.92	42.65	1.43
INOU	-0.73	-0.13	-0.45	0.11	-0.04	0.18	-0.04	-0.43	0.14	-0.06
	0.53	0.02	0.20	0.01	0.00	0.03	0.00	0.18	0.02	0.00
	17.50	0.99	14.22	0.88	0.16	4.66	0.50	52.02	8.98	0.68
ESP	0.47	-0.59	-0.51	0.14	-0.15	0.02	0.32	-0.00	-0.15	-0.05
	0.22	0.35	0.26	0.02	0.02	0.00	0.10	0.00	0.02	0.00
	7.41	21.50	18.16	1.36	2.43	0.06	27.94	0.00	9.34	11.78
COMP	0.13	-0.76	0.08	0.02	0.55	-0.19	-0.13	0.06	0.19	-0.05
	0.02	0.58	0.01	0.00	0.30	0.04	0.02	0.00	0.04	0.00
	0.53	35.64	0.44	0.04	33.50	5.04	4.70	1.03	15.74	3.14
COPA	0.75	0.48	0.11	0.40	-0.04	0.04	-0.15	-0.10	0.08	-0.00
	0.56	0.23	0.01	0.16	0.00	0.00	0.02	0.01	0.01	0.00
	18.33	14.11	0.87	11.84	0.15	0.24	5.89	2.98	2.49	43.11