Occasional Paper No. 56

Induction of Computers in India

Parthasarathi Banerjee

March 1983

Centre for Studies in Social Sciences, Calcutta
10, Lake Terrace
Calcutta-700 029

Acknowledgement

I have been associated with the research project "Foreign Collaboration, Transfer of Technology and Development of Indigenous Technology in Indian Industries," under the supervision of Amiya Kumar Bagchi, Professor of Economics, Centre for Studies in Social Sciences, Calcutta. In this project I have concentrated on the study of the information technology sector. This paper is part of my project work. I am grateful to Professor Amiya Kumar Bagchi for the invaluable corrections made on the earlier drafts of the paper. I am also grateful to Mrs. Nirmala Banerjee for her kind criticisms on an earlier draft of the paper. I am indebted to my friend and colleague in this same project, Uttam Bhattacharya, and to my friends Surajit Bhattacharya, Chandan Jana, et al. I am also indebted to my teacher, Kalyan Roy and to Alok Ghosh, N.K. Roy of Bata India Ltd., Subrata Das Gupta, of Louisiana State University and Siddhartha Bose of IDM for their invaluable suggestions and assistance in course of my work. The paper was presented at the seminar on "Frontier Technologies In The Third World : Towards A Strategy For Self-Reliance" held at the Indian National Science Academy, New Delhi from 15-18 December, 1982. I am indebted to the participants for their valuable comments.

Parthasarathi Banerjee
November, 1982

Introduction

Information has always been essential to any form of economic organisation. With the advances in their complexities, economic organisations have had to devise better and better metho[ds] of gathering and using information.

Continually sustained innovations in information technolog[y] have been induced by this growing demand for information. The lands of giant corporations, through successful innovations have become the primary beneficiary of revolutions in information technology. India being a laggard in the scale of world economic development has naturally been served rather weakly by this tremendous growth in the information technology sector.

This technology is highly research and development (R & D) intensive; it is fast changing and requires a large infrastructure of industry. Since all this involves a large investment, information technology requires for its sustenance, a large and expanding market. Furthermore, government planning, control and assistance have played a very important role in building up such a technology base in other countries. For India, the role of government appear[s] ever larger because the nature or size of the market here has not been conducive to the growth of such a sector.

Some tentative hypotheses have been put forward here, in order better to understand what happened in India since the first computer was supposed to have been built here.

Briefly speaking, since the initial stimulus was entirely academic in origin, and since it could not find a resonating medium in a favourable market environment, further development of the prototypes on an endogenous basis was almost foredoomed from the beginning.

Section I

Early attempts at designing computer

1.1. With the installation of the first digital computer, a HEC-2M, in India at the Indian Statistical Institute, Calcutta (ISI) in April, 1956, the long travail of computerisation made a start in this country. This first computer was purchased from the U.K. This same institute housed the Computing Machines and Electronics Laboratory (CMEL) started on a small scale in 1950, for the advancement of learning relating to computation and computing machines. P. C. Mahalanobis and some other scholars at that institute, were interested in analogue computation facilities; and in 1953 an analogue computer for solving simultaneous linear equations was "designed and built" "mostly out of war surplus materials."[1] The ISI reports also the installation in February, 1959, of a Soviet built computer URAL-1. A computer, in the 1950s, was a marvel, even to the western institutions. Much experimentation and theorisation of computing science and technology were in progress in the developed countries. And at such an early period mounting elements to the final integral - an operable computer, however basic be that, clearly qualifies the state of science and technology in India potentially conducive to the indigenous growth of computing technology. These pieces of early evidence suggest that Indian scientists were (i) informed, (ii) had a certain expertise, and (iii) had the need to use modern technology.

1.2. A study conducted by the Administrative Staff College of India[2] reports (but this is not corroborated by C.R. Rao) that attempts to develop and build a computer was started in 1954 at the Tata Institute of Fundamental Research (TIFR), and a general purpose computer named TIFRAC was completed in 1956. This computer was said to be in operation until in June, 1964, an American computer CDC-3600-160A was installed at this institute. This later computer was 'large' and 'modern'.

Then came the onslaught of the major TNC in the field, viz., the IBM, which more or less conditioned the market to suit its own needs. Governmental planning never matched up to the massive marketing drive of the IBM and other TNCs in the field and in fact played into their hand. Any future success in the way of achieving a greater degree of self-reliance in the information technology sector would be dependent on a proper evaluation of our experience so far. This paper is a tentative attempt at the beginning of this process of evaluation.

1.3. The Indian Statistical Institute and the Tata Institute of Fundamental Research represented, in the fifties, a kindred spirit. They were the advocates of modern technology, basic research, science and technology (S & T) for development. Vikram Sarabhai dreamed about space programmes, remote sensing, flood control ... Mahalanobis was enthusiastic about the use of computers in controlling flood, irrigation systems ... some of their associates-scientists -- and planners tried to translate this vision into reality.

Scientific vision to reality

1.4. Translating scientific vision into reality, requires the presence of a wide variety of knowledge links with individual firms.[3] Technological innovation is known to be a complex and uncertain process. A large body of literature exists regarding the role of vision, the role of science (or basic research), role of government research establishments and research associations[4], etc., but for the developed countries only. For such developed countries a large amount of econometric literature exists concerning the social and private rates of return from industrial innovations, the nature of the development process, the relationship between innovation, development and size of firm, etc.[5] Transformation of scientific vision into real innovation requires the activity of a mix of direct government involvement and market mechanisms. This is the experience of the developed countries in particular.

1.5. As yet for the developing countries, the literature concerning the roles of government research establishments, basic research and developmental research, or the difference between the social and private rates of return from industrial innovations, etc., or research and development in specific industry is very scanty. Scientific vision has to be largely equated with researc and developmental work, especially when this vision relates to a research -- intensive, fast-changing modern technology dependent vastly on a large and growing market such as the computer-information technology industry. The first step in vision transformation would be the organisation of research and development and engineering (R & D & E) either by government planning or through market mechanisms/as utilised by large corporations or a mix of both. The objective of such organisation is successful innovatio In a country such as India which is short in investible resources t organisation of R & D & E in such a sector as computer or information technology needs to be supported by various other structur linkages, viz., administrative measures, financial assistance, and overall planning. At any rate, the role of government looms large. Most of the available studies suggest that dynamic linkages between different parts of the research establishment and the government policies/administrative frameworks are weak. Our enquiry is focussed in a tentative fashion on the nature and magnitude of such linkages in the case of electronics, especially in the area of computer development in India.

Lack of Government Planning

1.6. In the early part of the sixties, no government policy was in existence, neither was there-any institutional set-up to look after, co-ordinate, plan and direct the 'electronics' leave alone the computers. The first committee set up to look into the question of "meaningful national goals" in electronics was the Bhabha Committee. Its report prepared in late 1964 and early 1965 could not deal with the computer issue deftly because the picture of Indian computer-scene was ill defined.[6] However, the report laid great emphasis on R & D activities, recommended the setting up of powerful design and development groups in every plan producing electronic equipment.

However ill-defined, the Bhabha Committee Report was the only thesis available around which the protagonists and antagonists of national self-reliance drew their lines.[7] In the late sixties, two attempts were made at the governmental level to update the projections made by the Bhabha Committee. The first was a committee on 'Computer Development in India' constituted by the Chairman of the Atomic Energy Commission as a compact group of four scientists; P. V. S. Rao was the convener, This report was circulated amongst a few top administrators only. The second, a "Study Group on Computers" was formed by the Electronics Committee, with a somewhat wider representation. The second of these two updated reports, which had somewhat wider circulation and had come to be known as Working Group Report, was submitted to the Electronics Committee in December, 1968. Its Chairman was R. Narasimhan.[8] The recommendations of these committees were ill-fated. The Bhabha Committee report had a bearing on discussions or symposia related to the development of electronics, while the other two had but little impact. Till the early 1970s, these reports were seldom used for planning, probably because of the fact that planning as such was not appreciably present. The Electronics Committee, in the late 1960s, was only an advisory body. There was no apex body to monitor and control the growth of electronics industry in India.[9]

Ad-hocism perpetuating discreteness

1.7. Decisions, when required, were taken on an *ad-hoc* basis, regarding only the procurement, allocation and installation of computers to be installed in various government departments. In 1966, the Department of Statistics, Government of India, started functioning as an apex body to co-ordinate the disbursement of ten Honeywell computers amongst various government departments.[10]

Some people were sent abroad to get trained in data-processing. In 1967 a Computer Centre was formed in the same department to look after the maintenance needs of the Honeywell systems, the software need and the need for software consultancy, if required by other government departments. The Electronics Committee, form in 1966, was empowered only to take account of urgent needs, to keep track of the research being done in design and development, etc. The Department of Electronics was set up as a separate department in the later half of 1971. In succession came the Electonics Commission in 1971, Technology Development Council (under the Electronics Commission) Information, Planning and Analysis Group (under the Electronics Commission) etc. The Department of Electronics was initially charged with the responsi bility for the development of electronics industry. But even aft the formation of this department, the co-ordination work relating to the acquisition of computers etc. by government departments was assigned to the Department of Statistics. The Department of Electronics (DOE) was only concerned with the import of computers

The Computer Society of India, a body of computer professionals, was formed in 1964.[12] It was a society of professionals, formed in the interest of the professionals and in the interest of the expansion of data processing. Its formation prior to the formation of any such body by the government, reflec the commercialisation of computing-interests to a great extent.

1.8. As is evident from such ad-hocism,[13] computers were thoug of, by the government, as a mere tool to increase office-efficien as a mere capital-good to be imported like many other capital goo And that to manufacture it and the related items, the government is required to have a wide and closely interwoven electronic industrial base, was not recognised at all. So that the policy centred around the acquisition and the disbursement of computers and not around the development of 'research and development and engineering' (R & D & E) activities, etc. Before the inception of DOE and Electronics Commission in 1971, there really was no government/agency concerned with the deployment of electronics in any integrated way. This industry was handled by the Department of Defence Supplies for some period of time. It was also handled for some time by the Department of Technical Development, in the Ministry of Industry.[14]

1.9. A computer is certainly a computer, but it is also something more than that. A Computer is not a discrete electronic piece of apparantus; it has got technology associated with it. A Policy that assumes the technology to be a discrete item to be chosen or discarded as a separate element is bound to misfire. The primary evidence put forth in previous sections support this conjecture which is to be tested in some more details.

Discrete Technology and Disconnected Organisation

1.10. Some literature exists concerning the choice of technique and the relevant political economy.[15]

Organic growth presupposes the existence of various sectors and sub-sectors of industry and linkages as interactive network between those various sectors and sub-sectors. Arguments have been put forth regarding the existence of "the linkages between the electronics sector and other sectors of the economy as a whole."[16]

There are other potential linkages which are no less important. This concerns the network of knowledge between various R & D & E institutions, between government policy directives and financial assistance, tariffs, licensing etc., between the R & D & E institutions and other institutions or firms, etc. This is because, while invention is inherently non-organisational, innovation is inherently organisational.[17] These linkages may b sufficient conditions, but are sine qua non for the growt of a dynamic organisation. If there are potential linkages whic are not acutalised, then they leads to limping growth.[18] But linkages do not come about automatically. They have to be induc by market mechanisms and/or planned. When the industry concerne is computer manufacture, the roles of large corporations and the government become crucial. In India, since no large private sector organization was big enough, it was the government which would have had to plan and build the linkages, and this it faile to do, except by fits and starts.

1.11. While discreteness of adoption is a problem in itself, i also lends itself to the second problem. Alienated technology generates disconnected organisation, i.e., one is accentuated by the other.

This problem has been identified in connection with technology transfer and technology development.[19] In the inducti of computers, how these problems are intertwined has to be teste

1.12. It may be plainsibly assumed that in designing an analogu computer at ISI, the scientist-engineers had developed a certain expertise. And since the computer was designed and built mostly out of war-surplus materials, it was very probably made out of electr tubes or of the electro-mechanical elements. Electron tube expertise belongs to the first generation computer expertise (excluding the analogue character of the facility). Expertise in the same first generation technology had been garnered by the TIFR scientist-engineers (TIFRAC dates back to 1954-1956, when second generation technology did not appear even in the develope countries) also.

No information exists regarding any communication, whatsoever, either between these two institutes or amongst a number of institutes in this country. Even C.R. Rao of the ISI does not acknowledge the designing of TIFRAC at TIFR.

No other design with electron tubes is reported to have been attempted.

Developed Countries' Experience

1.13. Electron tubes were invented early in this century. Commercial production began in 1920, in the U.S.A., R & D & E activities have since produced a variety of different types and models. For many years it was the only significant active component available in the developed countries, not to speak of the developing countries. The Second World War gave a tremendous impetus to the developmental efforts; the war needed increased reliability, ruggedness, and easy application of the technology. Consequently a major effort was made to improve and perfect the electron tube, in the U.S.A., Japan, U.K., France etc.

The war needed computing facilities.[20] Computers were innovated using electron tube technology. A huge literature grew up, innovators sought after a market. Initially, in the early 1950s, even such large corporations as Lockheed were hesitant to buy such a piece of apparatus. But this new instrument found a good market quickly, so that at the end of the 1950s, the computer population of the U.S.A. stood at 5500, that of Western Europe at 1500, and of Japan at 400 (see Table 1).

Military need, computing need and the management need were there to organise R & D & E and the innovation, activities of research institutes, industrial firms, the buyers and the federal fund had a productive confluence.[21]

1.14. Electron tubes had many important and inherent limitatio
To overcome these limitations, development efforts were centred
around discrete semiconductors. Research was stepped up during
war, and in 1948 the invention of transistors by Bell Laboratori
was announced. Three years later, Western Electric, an affiliate
Bell Laboratories, began commercial production. "These developments stimulated interest in semiconductor technology and induce
substantial R & D expenditures throughout the world"[22] and produ
a multitude of new and improved devices.

With the advent of transistors, more reliable, less cost
transistorised versions of computer could replace fast the old
1st generation computers (see figs. 1.2. and 1.3). IBM 1400
series of computers, meant exclusively for data processing, were
introduced in 1959. The first in line was 1401.[23] The IBM
announced other faster computers also for defence laboratories.[2
The computer population soared to a new high. Hundreds of
thousands, even millions, of transistors in a single product pos
serious problems. Research efforts to overcome such difficulty
resulted in the invention of the monolithic integrated circuit,
by Texas Instruments in 1958. Commercial production began three
years later. Its initial high cost restricted its use in missil
with the improvement in production process a great many number o
integrated circuits diffused into many products, computers inclu
This new computer was a third generation computer (for example,
IBM system/360) with a very high performance, higher reliability

The product computer benefited not only from the innovations in components, but also from the innovations in peripheral
from developments in software and architecture. In fact, the IB
system/360 and later system/370 set the standard for the compute
industry. Development took place in an integrated manner, embracing the entirety of the technology and the organisation.[25]

Islands of Learning : Lack of Organisation

1.15. In India experience gained in the electromechanical/electron tube technology application into computer-building, was not diffused into secondary institutions or firms. A large number of educational institutions also were either ignorant of or were indifferent to, it.

Dissemination of information through research papers/publications was, probalby, the only recourse available. Any other interactive method, such as, symposia, joint research project or active governmental intervention was absent from the scenario. A study of the growth of research journals in India [26] shows that in the period 1940-70, the growth rate of journals (in engineering, general, pure and applied sciences) was exponential. And, it is most probable, thus, that some of the Indian scientists/engineers shared their knowledge concerning computation, computing technology and the components. But use of information, does not[27] (and it did not do so in Indian environment) lead to the growth of organisation on its own. Lack of organisation is again reflected in that, for some or other reasons, these pioneering institutions, never again tried to design any new computation facilities. Instead the ISI, for example, received a medium sized Soviet computer as a gift in 1959, then again rented an IBM 1401 in 1964, and after that got one Honeywell H-400 in the late 1960s.

Instead of the dissemination of knowledge and expertise gained at the ISI and TIFR, there appeared the start of a diffusion process of computing practices gained through imported sets. It is reported that many other scientific organisations[28] used the computing fecilities available at ISI and the TIFR.

1.16. A study on trends of research in electronics engineering[29] has thrown up some interesting points. This study made a broad analysis of the trends of research in electronics engineering on the basis of publications by Indian authors, by scanning the author indices of Electrical Engineering Abstracts for 1961 to 1965, an inventory of papers published by Indian authors was made. The international trend was studied by analysing a 10 per cent random sample of abstracts published in Electrical Engineering Abstracts (January and July-December 1964).

The whole subject was divided into twelve major areas (e.g., 'Electronic components, materials and machinery', 'Semi-conductor materials and devices', 'integrated circuits and microcircuits', 'Electronic control and data processing', etc.). Each major area was divided into various subdivisions, e.g., the area 'Electronic control and data processing' was divided into (a) cybernatics, (b) control systems (theory and design), (c)components and circuits for control systems, (d) control systems (applications), (e) telecontrol telemetry, (f) digital computers, (g) analogue and hybrid computers.

It waw found in the study that the pattern of growth of Indian publications was more or less similar to the international trend. In the area-wise analysis, it was found that the area 'Electronic control and data processing' accounted for 19.48% of total publications by Indian authors and occupied the 2nd rank. (compared to international trend of 14.1%, rank 2nd of the same area in the international sample). The sub-division analysis showed that, the sub-division 'digital computers' ranked 3rd (i.e., 12% of the total publications in this area of Indian publications), 'analogue and hybrid computers' ranked 2nd (i.e., 24% of total Indian publications in this area).

The area 'semiconductor materials and devices' accounted for 7.56% of total publications by Indian authors (6th rank). This same area accounted for 10.4% of all publications in the international sample (5th rank in that sample). It should be reckoned that in the period of study i.e., in 1961-64/65, the field of semiconductors/integrated circuits were just emerging, 'Integrated circuits' area ranked 12th in the international sample and received practically no attention from Indian researchers. In spite of the fact that electron tubes were rapidly being replaced by semiconductors at that time, the area 'Electron tubes and devices' occupied first rank in the international sample, and sixth rank in the Indian publications.

The total involvement in electronics research in India, was meagre "both in terms of number of workers involved and their productivity (in terms of number of papers published)."[30] The number of papers by Indian authors was only 2.5% of total publications in this field. Moreover, (of this 2.5%) about 44% of research work was the result of research done abroad by Indian authors.

These data did not reveal any serious gap in learning between the Indian researchers and the international researchers. The relative degrees of importance were somewhat different but the gaps were due to the lack of organisation, direction and planning rather than lack of individual learning.

1.17. Though there was no serious gap in learning, there was a serious gap in the utilisation of that learning. In the areas of learning related to computation, i.e., in electron tubes, semiconductors, digital computers, etc., Indian publications more or less corresponded to the international trend. But, in terms of inventions, applications, and developments in those areas research institutes in India were totally inactive, let alone any innovative activities in Indian firms.

On the contrary, as we have seen, even the ISI, one of the forerunners in India, had to resort to importation of computers in succession. TIFR had to go the same way. In the period, 1955 to 1964, educational institutes/research establishments, imported 13 computers (out of a total number of computers in India at 16).[31]

This same period experienced one notable exception. The ISI and Jadavpur University, in 1961, started working jointly for building up two solid-state, second generation, computers of advanced design.[32] The first computer, the ISIJU-1, was commissioned on April 2, 1966.

1.18. Therefore, the expertise in electron tubes/electro-mechanical elements carried itself over, with the possible help of international standard of learning, to the next generation expertise, i.e., the expertise of building computer with transistors. Ironically, no other institutes (there were some 20 institutions working on electronics)[33] attempted with the design, neither was there any interactive-dissemination or skill/knowledge diffusion.

And since there was no central-level government body, no policy excepting adhocism, the institutes behaved like islands, insulated from the environment. Paradoxically enough the learning achieved in Indian institutions supported with public funds had probably acted as an input to the R & D in developed countries, especially those in the U.S.A.[34] (This is another glaring instance of the socalled 'brain drain' or 'knowledge drain)'.

Computers were taken as a discrete instrument of computation by various research/education institutes. The computer itself (i.e., the electronic-mechanical assemblage), the computational skill, the maintenance skill and the theoretical knowledge (say of design, architecture etc.)- these were not networked together. Very few institutions had such intra-organisational cohesion. Inter-organisationally, they were not connected together, e.g., the theoretical knowledge of one institute seldom combined with, say, the design expertise of another. And naturally a computer appeared in the Indian scene as unique and discrete item of importation.

Section II

Indian Market - Prey to TNCs

2.1. Commercial computerisation started in India in 1961 with the installation of an IBM 1401, by the subsidiary of foreign firm, viz., Esso Standard Eastern Inc., Bombay. In the following three years, 1962-1964, 14 computers were installed, out of which as many as 12 were installed in R & D organisations. As many as 30 commercial installations came into existence during 1965 to 1966. A further increase was registered during the next three years, on an average 20 computers each year.[35] The number of installations rose to over 200 by 1973/74. But this was a very poor show, as compared to international standards (see Table 1) - the Indian market was just emerging.

The maximum number of computers were purchased out of public funds (see Table 5). Various government departments accounted for 10 computers, public-sector undertakings accounted for 39 and R & D organisations, educational institutions accounted for 36 (some of these 36 were obtained either through grant or gift).[36] But the private sector had the largest share of computers. Most of these computers were old (speaking technologically) and second-hand 'As-Ls' machines.[37] IBM 1400 series was specially meant for business data-processing,[38] so also was ICL 1900 series. There were but a few systems installed for scientific purposes.

2.2. The state of information or data regarding computer and th access to it was very poor.

For the professionals, the Computer Society of India was there from 1964 onwards. But it was not a strong body. Its publi cations started appearing irregularly from the late 1960s. It also conducted courses but that was much later.

Consultancy services grew up mainly in the 1970s, such organizations as the Tata Consultancy Services, Engineers India Limited, Administrative Staff College of India, etc., usually offered software (often for export) services. Dissemination of professional knowledge amongst the users or potential buyers was virtually absent till the early part of the 1970s.

As a result potential buyers had to depend on the TNCs (IBM & ICL) for getting the services the computers were designed for. The IBM had four Data Centres at Bombay, Calcutta, Delhi and Madras. These centres offered computer services, and firms with little or no knowledge in computation had to depend on such services. The Cost Accounts Branch of the Ministry of Finance pointed out that 'the working capital employed in activities relating to machine rentals as well as customer jobs in Data Centres is almost negligible'[39] and yet the profits were very high. The majority of potential buyers of computers had to depend for training in their use on IBM or ICL. (see Table 14).

This training was a kind of manufacturer's training--training that would let the customers know only about the IBM and especially only those gadgets that had lately been exported to India. "They provide only that kind of information that is required for them to carry on the business over here ...their training programme is completely geared to their business interests and activities here."[40]

2.3. After planning to go in for a computer, a typical buyer had to wait typically for about two years (see Table 11). This time was required to carry out the necessary feasibility/system study and to train the necessary staff.[41]

Moreover the necessary system/feasibility study was usually designed by the IBM engineers. For example, All India Radio and the Registrar General of India left the task of designing the system almost entirely to the IBM.[42] This not only led the user to continued dependence on the TNCs, but also led to a differently motivated computer-application package. Indian Railways, which had the largest number of computers in any government department, installed the computers without analysing in-depth the real need of computerisation.[43] As a result, the computers were very far from being optimally used.

2.4. The sources of computers to an Indian buyer were principally the IBM and the ICL. The models presented by the IBM were 1401, 1410, 1460, 1440, 1620-I, 1620-II, 1130 and 7044; of which 7044 and 1130 were 3rd generation, 1620-I, 1620-II, 1440 were 2nd generation - and these models were generally meant for scientific work; the rest, viz., 1401, 1410, 1460 were principally for data processing work and were 2nd generation products - almost all of the installations belonged to this last category.

The ICL presented 1300, 1909, 1903, 1902, SIRIUS, 1904, 1901 and 1004 (calculating machines); excepting SIRIUS almost all the computers presented were for business data processing and were 2nd generation equipment.

Other computers, including some installed in the research organisations, were mostly gifts. Government departments imported exclusively for their own use ten Honeywell 400s.

Thus Indian buyers had not the scope of opting for a system that satisfied their own requirements. They had little information concerning the international market,[44] as has been shown earlier.

2.5. It was reported that barring a few departments, all other departments had procured the computing machines without floating any tender.[45] Floating global tenders was never thought of. Firms had to purchase computers in accordance with the guidelines set up by the "spoon-feeding" staff of the selling TNC.

Ignorance of the second-hand computing market,[46] ignorance of the existing international technology, lack of professionals, lack of communication inter-organisationally and the presence of TNCs with a fast-changing technology had all accentuated the dependence on TNCs.

2.6. Dependence on TNCs had cost the country in many ways. Some points have already been mentioned. But there are more.

Application of computers in railways had resulted in computerising routine accounting applications, while neglecting many important areas of applications in railway-engineering. A similar developments took place in the case of many other departments. As Table 13 shows, routine accounting applications were the majority applications. The causal links of this dependence are, designing of system by the TNC peoples, the nature of the machine offered,-- specially its small memory --- inhibiting large data-base to be worked on, lack of management-direction and lack of communication, professional skill.

Some warnings had been given, from time to time, about the implication of such applications in a developing economy, with low-wage and surplus labour and with a great need to increase accumulation potential.[47] Moreover, what needs to be probed more is the conditioning of demand-behaviour and future applications (and the generated technology) by such TNC activities.

2.7. Many imported computers were probably second hand machines. Second-hand machines could sometimes be quite useful. But there is an acute dearth of information concerning the international second-hand machine market, and concerned organizations have either not collected such data or not systematized them in any useful way.

Next looking into the question of pricing of computers, it was observed that the IBM had resorted to 'various unfair practices like transfer pricing under the garb of inter-company billing system, misuse of import entitlements, exaggerated claims of drawback, under payment of excise duty, exaggerated claims of depreciation, development rebate, head office expanses, etc. All these practices have enabled them to reaphigh profits.[48]

The Inter-Ministerial Working Group found a prima-facie case for the reduction in rates charged the IBM and the ICL to the extent of 25% to 30%. The revelations about IBM operations point to the fact that drainage of foreign exchange on account of these operations could continue for a long period principally owing to the lack of organisation.

When we come to costs of repair and maintenance, we find that the costs involved in repair and maintenance were high[49], and as has been pointed out,[50] not commensurate with the costs of operation of new systems. New technology had almost swept out the old technology in terms of hardware prices largely. However, those old systems were economically acceptable to its owners.[51] Given the sunk costs, the owners continued topay high charges for repair and maintenance.

The problems of maintenance and spare could be tackled without depending on the TNCs after the IBM's withdrawal with local skills;Computer Maintenance Corporation started indigenising spare parts and maintaining the IBM machines[52] this shows that concerted effort on the part of the government and other organisations could well act as a challenge to TNCs.

Complimentarity of Two Poles

2.8. Lack of policy and/or a discrete approach to technology resulting in disjoint organisation is reflected in the organization of the Indian market.. On the other hand, the TNCs are well-organized and able to take advantage of the fragmented nature of the Indian responses to the new technology. Since the government did not have , any firm policy, any organised activity for interactive communication and any integrated outlook towards technology/the responses only perpetuated dependence on foreign technology and exploitation by TNCs, thus thwarting the development of indigenous development of technology.

Further Research

3.1. Further areas of research, suggested by the present study are :

1) the question of obsolescence in technology.
2) the question of discreteness versus integrity in technology and technology policy.
3) the process of perpetuation of the TNC-conditioned technology-market.

4) the question of organisation design for the optimum use of information resources.

These areas will, however, need further intensive research, and will be taken up in other papers.

REFERENCE

1. C. Radhakrishna Rao : Computers and Future of Human Society (First published 1969, students edition, Statistical Publishing Society) p.58.

2. P. Gopalkrishnan & K.S. Narayanan : Computers in India - An Overview (Bombay, for the Administrative Staff College of India, Hyderabad, Popular Prakashan, 1975) p.58.

3. M. Gibbons and R. Johnston, "The Roles of Science in Technological Innovation", Research Policy 3 (1974) 220.

4. J. Langrish, M. Gibbons, W.G. Evans and F.R. Jevons : Wealth from Knowledge (Macmillan, 1972) p.78.

   R.C.O. Mathews, "The Contribution of Science and Technology to Economic Department", in B. Williams, ed., Science and Technology in Economic Growth (London : Macmillan, 1973).

   C. Freeman, The Economics of Industrial Innovation (Baltimore : Penguin, 1974).

5. Edwin Mansfield, et al, The Production and Application of New Industrial Technology (New York :W.W. Norton & Company, Inc., 1977) p.190.

6. R. Narasimhan, "Meaningful National goals in Computer Development, Production and Use", Electronics : Proceedins of the National Conference on Electronics organised by the Electronics Committee, Government of India, Bombay, 24-28 March, 1970 (Electronics Commission, Government of India, Bombay, 1971).

7. Electronics : Proceedings of the National Conference on Electronics, Bombay, 1970. This conference was attended by administrators, heads of research institutions (including defence), scientists, journalists, et al. Subjects of discussion included licensing policy, import licensing policy research and development policy, computers, tele-communication, etc.

8. R. Narasimhan, "Meaningful National Goals in Computer Development, Production and Use" Electronics : Proceedings of the National Conference on Electronics.

9. A. Parthasarathi, amongst many other, strongly pleaded for a body like National Electronics Development Board (NELDEB). See A. Parthasarathi, Electronics : Proceedings of the National Conference on Electronics.

10. Public Accounts Committee (1975-76), Fifth Lok Sabha, 221st Report : Computerisation in Government-Departments, Department of Electronics; pp.39-40.

11. Computerisation in Government Departments, p.38.

12. It is interesting that in 1964, the total number of computers in India was only 16. Out of this number, a large part of the total number of computers, were in the research institutions and only a few computers were available commercially Naturally, the total number of computer professionals in the country could hardly be above hundred ! Its total membership rose to 8000; reported in Asian Computer Yearbook, 1981-1982 (Computer Publications Limited, Hongkong). In Asia, only the Philippine Computer Society (formed in 1967) and the Singapore Computer Society (formed in 1967) were the other two societies formed in the 1960s. Other Societies, such as those of Indonesia, Malaysia, Thailand were formed in the 1970s (excluding Japan). Reported in the Yearbook.

13. The Secretary, Department of Electronics (DOE) stated in evidence to the Public Accounts Committee : "...the introduction of computers in the past was done in good faith because that is what was available", in Computerisation in Government Departments, pp.32-33.

14. Computerisation in Government Departments pp.41-42.

15. A.K. Bagchi, "On the Political Economy of Technological Choice and Development" Cambridge Journal of Economics, June 1978.

Dieter Ernst "The New International Division of Labour and Global Patterns of Technological Dominence/Technological Dependence : in Dieter Ernst (ed.) : The New International Division of Labour, Technology and Underdevelopment, Consequences for the Third World (Frankfurt, Campus Verlag, 1980).

A.K.N. Reddy, "An Alternative Pattern of Indian Industrialisation" Change and Choice in Indian Industries Ed. A.K. Bagchi and N.Banerjee, (K.P.Bagchi & Co., Calcutta, 1981).

16. A. Parthasarathi : Electronics in Developing Countries : Issues in Transfer and Development of Technology, (Trade and Development Board, UNCTAD, Distribution General No.TD/B/c.6/34, 12 October 1978) p. vii.

According to Parthasarathi, in India "Close external linkage with the rest of the industrial economy also exist." But Parthasarathi bases his argument on the experience gained ti mid-1970, the time by which some of the observations based on 1960s could have become insufficientor wrong.

However, he also notes in that volume, that "...lack of internal linkages between the different sub-sectors of an electronics industry in a developing country primarily due to ownership structure (dominance of TNCs) and its market orientation (exports), is also reflected in the lack of exte nal linkages..."(p.28). Here, however he does not recognise the difference between technology developed indigenously and the technology borrowed from without. A technology, to be developed indigenously, requires close linkages between firm R & D establishments, government institutions. And this is the history of that technology. Linkages are thus not only determined by the market, but are also determined by the history-specific.

17. John A. Czepiol, "Communications Networks and Innovation in Industrial Communities", in Michael J. Baker (ed.) Industri Innovation, Technology, Policy, Diffusion (The Macmillan Press Ltd., London & Basingstoke, 1979).

Evan, William N., "The Organisation Set : Toward a Theory of Organisational Relations", in J.D. Thompson (ed.), Approache to Organisational Design (Pittsburgh : University of Pittsburgh Press, 1966).

18. Ernst, "The New International Division of Labour and Global Patterns of Technological Dominance/Technological Dependence" ...Ernst discusses the importance of the development of technology from within, and its importance to linkages.

19. D. Banerjee, "Role of R & D in Transfer of Technology" in International Seminar on Technology Transfer, Seminar Papers, 11-13 December, 1972, NewDelhi (Council of Scientific and Industrial Research, New Delhi). Banerjee stresses the Importance of development for the continuity of R & D. And he says "Organisations have to be conveyed for this purpose." (p.7.4).

John A. Czepiel, "Patterns of Inter-organisational Communications and the Diffusion of a Major Technological Innovation in a Competitive Industrial Community" Academy of Management Journal Vol.18 (1975).

20. The first computing machines using electro-mechanical elements were developed during the last years of 2nd World War. But in fact, the first one, the Z-3, was developed by Zuse in Berlin between 1936 and 1941. Z-3 and Z-4 were both electro-mechanical, so also was the first Harvard-IBM computer, the Automatic Sequence Controlled Calculator (ASCC) which was under construction from 1937 to 1944.

The first electronic computer was the ENIAC, Electronic Numerical Integrator and Computer (1945). In quick succession, several other systems were designed and built (for example, at the Institute of Advanced Study, Princeton). Mark III (1950), mark IV (1952), UNIVAC-I (1951), HEC - 2M (1953) etc. based on the same electron tube technology followed during the early fifties.

21. There are many examples. In the 1950s the computing power available at a computer was very small. But demands, especially of millitary, werefor higher computing speed and larger memory. On the other hand, when such computing power was not available, many other methods were developed to tackle the problems. Out of one such problem arose Delphi method. 'Project Delphi' was the name given to an Air Force sponsored Rand Corporation study, starting in the early 1950s to obtain "expert opinion to the selection, from the point of view of a Soviet strategic planner, of an optimal U.S. industrial target system and to the estimation of the number of A-bombs required to reduçe the munitions output by a prescribed amount." M.A. Linstons, M. Turoff (eds.) The Delphi Method : Techniques and Applications (Addison-Wesley Publishing Company Advanced Book Programme, Reading; Mass: 1975) p.10.

Another interesting example : is IBM's computer - 'Stretch'; in its time the World's fastest. First shipment was in May, 1961 and was some five years in gestation. It had many new features, such as, an oil-cooled core memory system, selectric typewriter as a console printer, 64-bit words plus eight bits of hamming code to form a 72-bit word in memory, etc. Many of these new features were later to appear in the famous system/360s. It had 169,100 transistors, mounted on two types of boards or cards. There were 18,747 so called single cards and 4,025 so-called double cards. It had more than 100 K words of memory, versus something like 32 K for the 704 system (of IBM) then in vogue, 'Stretch' was to achieve an imporvement in performance over the 704 by a factor of 100. Atomic Energy Commission, (AEC) which was to be the first customer, demanded a performance up time of at least 90% and the 'Stretch' afforded a performance up time in the low 90s. Original price was set at $ 13.5 million. The 'Stretch' project was partly government funded. In the midst of the project the federal government issued an RFP for a solid-state computer system to be used in the ballistic missile early warning system (BMEWS), part of the nation's defense set-up. IBM proposed a transistorized version of the 709 computer. The new computer, called 7090, inherited its system design from the 709 and its hardware from the 'Stretch'. National Security Agency (of U.S.) needed more computing power than was available, and such power could not be developed at an affordable price by using electron tubes, and yet it was obvious that an enormous investment would be required to develop the infant transistor technology. IBM had the proposal and NSA agreed to it. And the World's the then fastest computer was designed.. From <u>Datamation</u>, January 1982, pp.34-47.

22. John E. Tilton : <u>International Diffusion of Technology : The Case of Semi-conductors</u>, (Washington D.C. : The Brooklings Institution, 1971) p.11. Within the transistor class is a large variety of different types, each meant specifically for a set of characteristics; and one cannot substitute the other. Continued process innovation to improve reliability to reduce cost and to increase applicability and applications over the 1950s and the 1960s resulted in modern low-cost, highly reliable mass-produced transistors (of great many variety). ~~3oxxxfxgx. xhxk~~ These have greatly stimulated product innovations in computers, radios, control systems, TVs etc.

During the period 1952-68, patents awarded to various United State firms on semi-conductor alone was 5,128. Maximum rush for patents was in the period 1958-1967/68. Of these total, Bell laboratories accounted for 835 patents, IBM 521 patents, RCA 668 patents, General Electric 580, and so on. Another important point to note, that new firms (such as IBM, Fairchild, Honeywell ...) accounted for more than 50% (2240 in number) of the total patents.

The large TNC, AT & T with Bell Laboratories, its research ar and Western Electric, its manufacturing arm accounted for 56% of the total process innovation, and 29% of total product innovations. General Electric 22%, Taxas Instruments 0% and IBM 0% of total process innovations and 13%, 17% and 8% respectively of total product innovations.

R & D expenditures were high indeed. Patents per $ 1 million of R & D expenditures were 2.4 for the Bell Laboratories and the receiving tube firms, and 2.7 for the new firms. Also "R & D expenditures are significantly related at over the 99 percent probability level to the number of patents a firm obtains." (John E. Tilton, p.63). Significant is the contribution made by the millitary need (See Table-7 and Table-8) to the development of new components. In both transistor and integrated circuit production, defence market constitutes a high percentage. So that firms can get themselves crossed over the high-cost barrier.

Table-9 and Table-10 pertains to a glimpse of the government assistance in R & D, in two ways, First, by funding a portion of the R & D work undertaken by private firms. Second, by maintaining and operating their own laboratories. These tables also indicate the relatively higher importance of government fund for the firms in Europe than in the U.S. A very pertinent observation :

"Yet, for several reasons, government sponsored R & D apparently is less productive, or at least has less commercial pay-off, in these two European countries than in the United States. First, about half of the available public funds are absorbed by government and university laboratories, where commercial considerations are not as important in shaping the focus of and direction of R & D activity as in company laboratories. Many projects carried out at the government and university laboratories involve basic research. Findings are generally published, which facilitates their quick dissemination throughout the world. This research becomes an imput into the R & D efforts of foreign as well as domestic firms. (Indeed, American firms pushing on the frontiers of semiconductor technology may well benefit the most). When public laboratories do produce new developments with direct commercial productions, problems of organisation and communication may retard their transfer to firms for introduction into the market". (Tilton, p.130).

In the case of Japan, control over foreign trade and over the importation of capital and technology give the government considerable power to control and direct the affairs of industry. In the initial years, government funding in R & D efforts of the firms were low, which increased over the years. However, government funding is principally in the nature of assisting basic research, the results of which get quickly disseminated throughout the entire cross section of the industry and laboratories. (See : Mick Mclean : Technical Change and Economic Policy : Sector Report : The Electronic Industry, OECD, Paris, 1980).

23. Anthony Ralston (ed.) Encyclopaedia of Computer Science First eition (Van Nostrand Reinhold Company, 1976). This system enjoyed widespread use until 3rd generation appeared in the mid-1960s. It was a fully transistorised machine with magnetic core memory having original capacity options of 1-4K, 2K and 4K characters, with later options of 8K, 12K and 16K characters.

24. There are many instances, e.g., the one mentioned in Datamation, January 1982.

25. Tilton. International Diffusion of Technology.

26. A. Rahaman, et al, Scientific Journals in India : A Study of Their Characteristics (New Delhi : Research Survey & Planning Organisation, CSIR, April 1907) Survey Report No.10.

27. K.J. Arrow : Limits to Organisation

28. C.R. Rao : Computers and Future of Himan Society, p.58.

29. P.S. Nagpal, J.R. Bhatia, A. Rahman, and R.M. Bhargava : Trends of Research in Electronics Engineering - an analysis of publications by Indian Authors (New Delhi : CSIR, December 1966).

    This study is based on the analysis of publications by Indian authors in relevant field in the period 1961 to 1964/65.

30. Nagpal, Bhatia, Rahman & Bhargava : Trends of research, p.8

31. Om Vikash, "Indigenous development of computer systems," CSI communications, January 1979, p.11.

32. Gopalkrishnan and Narayanan : Computers in India, p.81.

    Rao : Computers and Future of Human Society, p.59.

33. Nagpal, Bhatia, Rahman, and Bhargava : Trends of Research, p.8.

34. Tilton, International Diffusion of Technology.

35. Public Accounts Committee (1975-76) Fifth Lok Sabha, 221st Report: Computerisation in Government Departments (New Delhi : Lok Sabha Secretariat) pp.12-4.

Government of India, Ministry of Labour & Rehabilitation: Report of the Committee on Automation, 1972.

See Table - 4.

Computerisation in Government Departments reports that in 1975 computer population in India rose to 235. It was 217 at the end of 1974. Table-4 pertains to the observation that the rate of growth in the number of installation was never high. The trend is more or less less steady onward 1967. IBMWTC (International Business Machines World Trade Corporation) accounted for 66% (143 in number) of the total 217. ICL (International Computers Limited, a U.K. based TNC) supplied 13% (28 in number). Table-6 shows that share of IBM dropped to 34% (154 in number) of the total population of 448 on May, 1978. This was due to government restrictions on IBM activities in India.

In 1974, share of IBM 1401 was 48% of the total (i.e., 104 out of the total 217), share of ICL 1900 seris was 23 (in number). Other systems included IBM 1620 (16 in number), IBM 1130 (8 in number), Honeywell H-400 (10 in number), TDC-12 (made by Electronics Corporation of India Limited) numbered 19, etc. These computers were almost all 2nd generation, small computers. Only large computers, reported to be present, were on CDC-3600-160-A at TIFR and one IBM 7044 at IIT Kanpur. From Table-6 it is seen that, around 1978, this pciture changed somewhat. By that time some large computers (e.g., from Burroughs) were imported, and the share of large computers (3rd generation) increased significantly.

36. Gopalkrishnan and Narayanan : Computers in India, p.34.

37. Public Accounts Committee, Computerisation in Government Departments, p.195.

Gopalkrishnan and Narayanan, p.34, pp.82-84.

Under the "As Is" programme IBM & ICL would lift up used second-hand machines, from abroad more by weight "which would come as a "hulk", then totaly shipped". At the local TNC factory, defective parts of the machines would be replaced, after which the machines would go through the parts-inspection assembly programme "What is perhaps about Rs.10 worth of a hulk might become to be Rs.100 worth of equipment to the users of most of the machines that have been used or are under use in India". (From Computerisation in Government Departments, p.195).

As was pointed out earlier, '1400' seris, '1300' seris, '1900' seris, etc. were all of second generation. Not only that the initial purchase price of a second generation computer would be much higher compared to the price of a 3rd generation system of the same configuration, but also the running cost (viz., processing cost, time cost etc.) would be much higher. See Fig.1-2, Fig.1-3 and the Table-3, An analysis by IPAG (Information, Planning and Analysis Group, under Electronics Commission) has shown that at the time of installing an IBM 1401 or ICL 1901 system, equivalent mini-computers were available with the same capacity at a cost which was half the cost of a 1401 in 1970, 1/3 the cost in 1972, and $\frac{1}{4}$ in 1974. In 1975 a computer slightly more powerful than the 1401 was available at a cost as low as $ 1200 for a 4.K word memory CPU, as compared to the price of a '1401' of equivalent configuration of $ 20,000 or more (From Computerisation in Government Department, p.41).

38. Ralston (ed.) Encyclopaedia of Computer Science.

39. Computerisation in Government Departments pp.178-179. Annual Report of IBM, for 1974 stated : "During the year, IBM continued to expand its efforts with minority agencies in developing and continuing manpower training programmes." (Computerisation in Government Departments, p.285).

Some 2000 personnels were trained by IBM for its some 144 installations by 1974.

40. Secretary, Electronics Commission, resented "Normally the customers training by the equipment supplier does not involve any broadbased training of manpower of what one might call 'national pool of manpower' in the sense that they have given us men here." (Computerisation in Government Departments, p.289 & 290).

41. Report of the Committee on Automation, 1972, p.35. After the introduction of the computer, typically it took the organisation to computerise the desired operations, some three years more, because of the fact that, (1) computerisation require a structured organisation, in spite of the fact that although a large number of users (from some 70 to 100 per cent) had already a structure for data processing, however

primitive in the form of unit record machines (Gopalkrishnan & Narayanan, p.13); (2) Lack of professional skill on the par of users; the user management had a very narrow view regardin computerisation, sometimes they knew not what to computerise and what not; some comments may not be out of place: "In most companies computer has been acquired as a result of pressure from within due to increase in volume of work and not out of the management's foresight and anxiety to benefit from a new management opportunity" [from IIM, Ahmedabad : Computers & Corporate Policy (IIM, Ahmedabad, 1970) pp.18-19]

or, "While taking certain jobs to the computer, cost considerations received considerably low priority as compared to management's desire to introduce modern management control system" [Work Study Team on Automation (office Automation) : Maharashtra State, Report, 1970, p,37]

Or, "It would appear that at least in the initial stages, computers, had been promoted by the companies essentially as business machines and efficiency-improving office-equipment and that in the selection of applications for computerisation and in the choice of a particular system or configuration, there had not been any positive understanding of the objectives sought to be achieved by computerisation or a scientific evaluation of how far a particular system or configuration would subserve the objectives envisaged." [Computerisation in Government Departments, p.48]

42. Computerisation in Government Departments, p.49.

43. Computerisation in Government Departments, p.5.

44. International market suddenly grew very large. Table-1 exhibits that the international market for computer expanded (in terms of number of computers) over 12 times from 1960-1970, and more than doubled during the three years 1970-1973 and the next five years experienced another doubling. The expansion was most noticeable, in terms of number of installations, in the developed countries.

This was made possible by the falling hardware prices, and the consequential falling computer prices. (See Table-3) ~~(see Table-2 and 3),~~ changes in hardware technology also increased enormously the reliability, reduced the downtime, running cost. At the same time mini and micro computers appeared in the market, expanding the market enormously. Innovations in computer peripherals caused a great many designs further helped by the developments in microprocessor

Especially such changes have made the product life-cycle much shorter, number of product-design to multiply and the TNCs to profit on a higher scale. (See Table-12).

Under such circumstances, especially in the U.S., in the 1960s, the market was laden with second hand machines; at first these were 2nd generation like 1400 seris, and later even 3rd generations, like old models of '360' seris. These systems, necessarily, not always had their economic life exhausted. And thus, even in U.S., there was a second-hand computing equipment market. And being second-hand junk, these were available at very low prices.

Many developing countries were presented with computers slowly in the 1960s, more vigorously in the early 1970s and vigorously in the late 1970s. Table-2 and Table-1 presents some facts.

In spite of the fact that there is no known documentation regarding the second-hand equipment market, or of their being thrown in the developing countries; it is known that the developing countries were not always given the second-hand junks. It is evident from Table-1 and from other sources [Mick McLean : The Electronic Industry, 1980; J. Rada : The Impact of Micro-electronics : A Tentative Appraisal of Information Technology (International Labour Office, Geneva, 1980); J. Wilczynski : Technology in COMECON (The Macmillan, 1974) etc.] that the main thrust of computer marketing was always in the developed countries; in the 1960s the developing countries offered little market which grew explosively from mid-1970s on.

Brazil had a "open-door policy vis-a-vis foreign capital together with a large and expanding domestic market" (Georg Koopman "Technological Dependence and Technology Policy - The Brazilian Conception" Dictor Ernst (ed.). The New International Division of Labour, P.404), it had paid during the whole six-year period 1972-77 U.S. $2.4 million for 10,000 technology-transfer contracts, and the computer population rose almost eight times the 1971 number, by (probably) 1976. The computers supplied to Brazil, initially were large IBM computers later replaced by mini-computers (which IBM at that time did not manufacture) of other U.S. make, mainly DEC. [J. Rada The Impact of Microelectronics p. 54]. Some of the S.E. Asian countries also follow an open-door policy, and those countries have imported the most recent and modern computers. [Asian Computer Yearbook 1981-1982, also, A. Parthasarathi : Elctronics in Developing Countries].

Honce, it is probable, that the countries with open-door policy, i.e., the firms having an exposure to changes in product line, get and install the modern computers, not old junks.

45. Computorisation in Government Departments, p.118.

46. Charles Coopar and Raphael Kaplinsky : Second-hand Equipment in A Developing Country (Geneva : International Labour Office, 1974). This study is based on machineries in jute processing, the technology of which is very different from the electronics technology. But certain pertinent observations are consulted : "Machinery which is sold because innovation has made it economically obsolte is often still in good working order. ...the machines may be reliable and economically viable at developing country factor prices ..." (pp.11-12) or "Generally speaking machinery which becomes available because of changes in product markets in the advanced countries is probably the safest kind to buy" (p.12).

It was found that second-hand machines would be operated for longer in countries with higher interest rates and lower wage rates. (p.51). And the important issues were set : (1) the nature of transactions in second-hand machinery and the way prices are determined, (2) the costs of repair and maintenance (3) the problem of spare parts, (4) the efficiency of operation (p.55).

Another study [A. Parthasarathi : Electronics in Developing Countries] (p.49). It ovserves "... the implications of this "obsolescence" in terms of the use of which the computer is going to be put to solve the kinds of problems which a developing country faces is, on many occasions, marginal." (p.49).

47. Report of the Committee on Automation, 1972, pp.67-69.

"Ten-year Profile for Electronics & Communications" in Electronics, Information & Planning, 1973, 1 (2).

Nrisingha Chakraborty : Computer Menace in Indian Railways (CITU, August 1980).

J. Rada :

Dieter Ernst in Dieter Ernst (ed.).

48. Computerisation in Government Departments, p.255.

IBM & ICL both had factories in India, where they manufacture items for export. For IBM, the export price for inter-company billing was set after fixing 25% profit on the manufacturing cost. These exports were to IBM's related companies. But this bill did not include the relevant head-office cost and New York costs properly allocable to it, thus resulting in loss to IBM, India. As equipments were sold at uniform international prices, and large amount of profit was thus made outside India.

The foreign exchange earned thus, were used by IBM & ICL for import of "As Is" machines (import entitlement was to the tu of 85%), and other peripherals. The prices shown on the inter-company bill were not related to the prices charged by IBM to local customers. In one case, IBM charged Rs. 3712 (U.S. $ 490) each for Disc Packs against the price quoted in the bills of entry at Rs.598 plus customs duty assessed at Rs. 925 each.

It is seen from Table-14 that IBM earned maximum from rental maintenance etc. 127th Report of the 5yh Lok Sabha indicated that the hire charges were exorbitent and bore hardly any relationship to the nominal cost at which the junk machines were imported. The Cost Accountants Branch of the Ministry of Finance revealed that the rates charged by IBM made them astronomically high profits in items - Systems (i.e., 1400 seris etc.), features for expansion of installed systems, electric typewriter parts, printer, disc pack, disc storage etc. Profits remitted to New York during 1970-1974 amounted to Rs.219.40 lakhs, and it remitted on account of Head-office expenses the sum of about $ 6 million during the period 195 to 1971. The total outflow of foreign exchange as a result of IBM activities in India amounted to about Rs.10.83 crores during the period 1969 to 1974. (see Table-14)

The Committee observed : "It is strange that government took no steps to ensure that machines which had been largely brought in on what is called "As Is" basis and being of neglibible value had to be somewhat refurbished could at least be acquired by the users at reasonably lowered prises or were hired on commensurate rentuls ... if ... the rental fixed on a rational basis after taking account the input price, the estimated cost of refurbishing, the life of the machine (with particular reference to the depreciation claimed from Income Tax authorities) and also the fact of reasonable charges having to be made for spares and

52. As an example of indigenisation, the following would suffice : IBM 1403 was the line printer used with IBM 1401 processor; the controller of 1403 was resident in 1401. 1401 processor has become technologically obsolete and costly, while the printer 1403 has not. But 1403 could not act without the controller. And the characteristics of computer industry, at least till recently, was not to manufacture standardised equipments (i.e., OEM option). Surajit Bhattacharya designed separate controller for 1403 so that it could be used with other computers. (Surajit Bhattacharya : Design of a controller for an IBM line Printer, thesis submitted as partial fulfilment of the requirements for M.E. & T.E. degree of Jadavpur University, 1981).

contd. f.n. 48

maintenance, Government departments would have been able to save large amounts of money". (p.242)

It was found that the reasonableness of purchase/hire charges were never questioned, nor even studied in detail. There was no benefit/cost study, no verification of mechine life (with the life claimed at the Income Tax authorities for depreciation), no verification of inter-company bill, etc. Only in 1973, government constituted an Inter-Ministerial Working Group to go into the question of rentals and prices charged by IBM.

Department of Electronics; Information, Planning & Analysis Group, etc. were already formed; expertise of various other research institutes, consultancy services were there by now, at least to the extent that an organised probe could unearth the TNC ramifications.

Railway Board in 1974 and 1975, in pursuance of the recommendations of the Public Accounts Committee, took up the issue of hiring charges with IBM. IBM finally reduced the annual rental by a net amount of Rs.30 lakhs. This points to the fact that bargaining could have become meaningful were there an organised effort by the government backed up by the expertise of various bodies.

49. A list of such charges would make the subject clear. The cost of a medium size machine ranged from Rs.25-30 lakhs and if purchased outright maintenance charges of Rs.1 lakh p.a. was charged. The same, on hire amounted to Rs.6 - 91 lakhs p.a. inclusive of maintenance, additional charge of Rs. 1 - 1.5 lakhs yr. for Unit record axilliaries etc. (from Report of the Committee on Automation, 1972, p.28).

50. Computerisation in Government Departments.

51. In a meeting organised by the Computer Society of India, Madras Chapter, on 2.12. 1978 to discuss the future of UR machines, the users argued that "the installed UR machines have been purchased recently and itis too premature to consider them obsolete. In most cases, they meet adequately the needs of organisations using them" (CSI Communications, April 1979, p.11). computer/ Maintenance Corporation : CMC - A Review p.3) As an example of their saleability, in Indian market, even today, there appeared two advertisements recently. One of the advertiser was Indian Explosives Limited, Gomia, for sale of IBM 447 accounting machine, S14 re-producing punch, 024 Key-punch etc. (The Statesman, Calcutta, dated February 22, 1982 and March 21, 1982).

Geographical distribution of computers and related

Geographical distribution of computers and related equipment, 1960-88 (Number of computers and value of computers and related equipment, in $ '000,000,000)

= (Values in $ 000,000,000)

	1960		1970		1973		1978		1983[1]		1988[1]	
	No	Values*	No	Values*	No	Values*	No	Values*	No	Values*	No	Values*
United States	5500	8.8	65000	92.6	110 000	124.2	200 000	193.6	400 000	302.4	700 000	403.2
Western Europe	1500	2.6	21000	40.5	55 000	62.3	110 000	124.8	225 000	224.0	450 000	320.0
Japan	400	0.5	6000	7.5	19 000	16.8	45 000	33.6	70 000	49.6	140 000	76.0
Others Countries	1600	0.8	18000	9.6	46 000	22.4	95 000	72.0	205 000	128.0	460 000	195.2
Whole World	9000	12.7	110000	150.2	230 000	225.7	450 000	420.0	900 000	704.0	1750 000	994.4

1. Forecasts : Source : Diebold Europe, 1979 quoted in J. Rada[3], p. 52

India**	1	N.A.	124	N.A.	216	N.A.	448***	N.A.	165[2] more over the 1979-'80 level	N.A.	560[2] more over the 1979-'80 level	N.A.

*** upto May, 1978

2 Growth projections made by information, planning & Analysis Group, Dept. of Electronics, Electronics Information & Planning, November, 1980

** Source : Om Vikash "Indigenous development of computer systems", CSI communications, January 1979, p.11.

3. J. Rada : The Impact of Micro-electronics (Geneva, International Labour Office, 1980)

Table 2

Increase in the number of computers in some developing countries in the 1970s.

Country	1971	Most recent information	Annual Growth of GNP per head 1960-76.
Algeria	63	120	1.7
Bolivia	6	64	2.3
Brazil	840	6641	4.8
India	183	420	1.3
Iraq	7	48	3.6
Kuwait	17	35	-3.0
Nigeria	30	50	3.5

Sources : Rada : Impact of Microelectronics, p. 54.

Table 3

Characteristics		A 1955 computer (IBM 650)	A 1978 calculator (TI - 59)
Components		2000 Vacuum tubes	166500 transistor equivalents
Power (KVA)		17.7	0.00018
Volume (cu. ft.)		270	0.017
Weight (lbs)		5650	0.67
Air conditioning (Tons)		5 to 10	None
Memory capacity (bits)	primary	3000	7680
	secondary	100 000	40 000
Execution time (Milliseconds)			
	ADD	0.75	0.070
	Multiply	20.0	4.0
Price (current dollars)		200 000	300

Source : Texas Instruments Inc. Shareholders' meeting report, 1978
quoted Rada : The Impact of Micro-electronics, p.14.

Table 4

Year-wise break-up of computer installation. 1960-1977.

Year	Number (A)	Number (B)	Cumulative (A)
1960	01	X	1
1961	02	2	3
1962	01	1	4
1963	03	2	7
1964	09	8	16
1965	15	12	31
1966	15	16	46
1967	23	22	69
1968	24	20	93
1969	17	21	110
1970	14	11	124
1971	35	33	159
1972	37	14	196
1973	20	16	216
1974	27	11	243
1975	49	Total 189	292
1976	30	28*	322
1977	39	217	361
			378
Total	378		

*28 computers, according to PAC 221, was installed during 1971-74, exact year of installation not known.

Source : A) Om Vikash, "Indigenous development of computer systems" CSI Communications, January, 1979, p.11. for the column (A).

B) Public Accounts committee (1975-76). Fifth Lok Sabha, 221st Report, Computerisation in Government Departments (New Delhi : Lok Sabha Secretariat) p. 3 ... for the column (B).

Note : The exact number of computers installed and the installation year varies according to various estimates.

Table 5

Computers in India (Year-wise & Sector-wise)
(August 1971)

Year of Installation	Government Departments	Public Sector Undertakings	Private Sector Undertakings	R & D Institutes	Total
1961	X	1	1	x	2
1962	x	1	x	1	2
1963	x	x	x	3	3
1964	1	x	x	8	9
1965	1	3	5	5	14
1966	1	6	5	4	16
1967	3	5	11	3	22
1968	x	9	8	3	20
1969	2	5	10	2	19
1970	1	5	4	x	10
1971 (partial)	1	4	11	7	23
Total	10	39	55	36	140

Source : Government of India, Ministry of Labour & Rehabilitation, Report of the Committee on Automation, 1972 (Chairman : Professor V.M. Dandekar) p. 24.

Note : Even this estimates vary according to other sources.

Table 6

Computer system, their number, source and share in the total number of installations as on May, 1978

Source	Name of the system	Number	%share (approximate)of the system in the total
Foreign Make	BURROUGHS	06	1
	CII	04	1
	COMPUTER-AUTOMATION	19	4
	DEC	59	13
	HONEYWELL	12	3
	H.P.	17	4
	IBM	154	34
	ICL	42	10
	INTERDATA	04	1
	REYAD	08	2
	VARIAN	06	1
	Others	18	4
	Total	349	78
Indian Make	ECIL	99	22
	TOTAL	448	100

Source : Om Vikash - "Indigenous Development of Computer Systems", CSI Communications, January, 1979, p.11.

Table 7

U.S. Production of Semiconductors for Defence Requirements, 1955- 68

Year	Total Semiconductor Production (millions of dollars)	Defence Semiconductor Production (millions of dollars)	Defence as a Percentage of total
1955	40	15	38
1956	90	32	36
1957	151	54	36
1958	210	81	39
1959	396	180	45
1960	542	258	48
1961	565	222	39
1962	575	223	39
1963	610	211	35
1964	676	192	28
1965	884	247	28
1966	1123	298	27
1967	1107	303	27
1968	1159	294	25

Source : John E. Tilton. International Diffusion of Technology : The case of semiconductors (Washington D.C. : The Brookings Institution, 1971) p. 90.

Table 8

U.S. Integrated Circuit Production and Prices, and the Importance of the Defence Market, 1962-68.

Year	Total Production (millions of dollars)	Average price per integrated circuit (dollars)	Defence production as a percentage of total Production
1962	4	50.00	100
1963	16	31.60	94
1964	41	18.50	85
1965	71	8.33	72
1966	148	5.05	53
1967	228	3.32	43
1968	312	2.33	37

Source : Tilton, International Diffusion of Technology, p.91

Table = 9 Distribution of Government and Company Research and Development Funds, and Semiconductor Sales in the United States, by Type of Firm, 1959.

	Government R&D funds		Company R&D funds		Semiconductor Sales	
Type of firm	Millions of dollars	percent	Millions of dollars	percent	Millions of dollars	percent
Western Electric & 8 receiving-tube producers	12.7	78	27.2	50	149.5	37
New firms	3.5	22	26.8	50	252.1	63
Total	16.2	100	54.0	100	401.6	100

Source : Tilton, International Diffusion of Technology ..., p. 94

TABLE = 10 Semiconductor Research & Development Expenditures for Great Britain and France, 1968.

	Great Britain		France	
Source of Expenditure	Millions of dollars	percent	Millions of dollars	percent
Firm, self financed	6.4	43	9.9	55
Firm, Government financed	3.5	23	3.6	20
Government Laboratories	4.1	27	4.5	25
Universities	1.0	7	d	d
Total	15.0	100	18.0	100

d - Funds for semiconductor research conducted at French Universities are included in the figures for government laboratories.

Source : Tilton, p. 129

TABLE = 11 Time Taken for Planning And Installation of Computers

No. of firms taking Less than	No. of firms taking 1 - 2 years	No. of firms taking 2 - 3 years	Total No. of firms

Table 12

Employment and Sales Data for some TNCs

Name		1967	1968	1969	1970	1971	1972	1973	1974	1975
USA	thousands E	222	242	259	269	265	262	274	292	289
IBM	$ billion T	5.3	6.9	7.2	7.5	8.3	9.3	11.0	12.7	14.4
	thousands E				5.8	6.2	7.8	13.0	17.6	19.0
DEC	$ billion T				135	147	188	265	422	534
	thousands E	12.2	13.4				17.0	28.0	28.9	30.2
Hewlett Packward	$ billion T	0.23	0.28	0.34	0.36	0.38	0.48	0.66	0.88	0.98
	thousands E	38.7	46.7	59.0	44.8	47.3	55.9	74.4	65.5	56.7
Texas Instruments	$ billion T	0.57	0.67	0.83	0.83	0.76	0.94	1.29	1.57	1.37
Japan	thousands E	.	45.0	48.4	56.3	59.1	55.8	57.0	60.1	57.5
Nippon Electric Co.	$ billion T		0.61	0.80	1.02	1.13	1.18	1.45	1.68	1.77
approx.	thousands E						27.9	30.7	31.4	31.2
Fujitsu	$ billion T						0.64	0.75	0.89	1.03
	thousands E	55.4	60.3	68.1	78.9	80.9	82.7	85.3	88.2	82.9
Matsushita	$ billion T	1.37	1.84	2.40	3.03	3.08	3.55	4.20	4.92	4.70
France	thousands E						25.3	26.2	27.7	29.0
Thompson CSF F Francs	billion T						2.26	2.63	3.20	4.13
Germany	thousands E	242	256	272	307	306	301	303	309	296
Simens DM	billion T	7.9	8.4	9.7	11.8	13.6	15.1	15.5	17.2	18.9
U.K.	thousands E		34.1	34.0	36.3	32.7	27.7	28.8	29.2	28.1
ICL	£ million T		92	105	131	151	154	169	201	240

T = Turnover, E = Employment.

Source : Mick McLean : Technical Change and Economic Policy : Sector Report ; The Electronic Industry (O E C D, Paris, 1980) p. 28.

Table 13

Statement showing important computer applications & the number of organisations which have computerised them.

Applications	Number of Units Public sector	Private sector	Total
Inventory Control/Sales Accounting	16	18	34
Pay Roll Accounting	15	16	31
Financial Accounting	5	18	23
Production Control & Planning	6	10	16
Sales Statistics	2	10	12
Costing	6	5	11
Billing/Invoicing	2	7	9
Management Information System	3	8	11
Traffic/Freight Accounting	9	x	9
R & D inclucing PERT	1	5	6
Wagon Movement	2	x	2
LP	x	2	2
Design Calculations	1	x	1
Reconciliation	1	x	1

Source : Report of the Committee on Automation, 1972 p. 158

Table 14.

Activities of IBM Resulting in Operating Revenues Listed Year-wise

Activity	1974	1973	1972	1971	1970	1969
Machine Rentals	1257.34	1198.84	1088.53	863.33	702.17	612.35
Export Sales	410.61	333.94	93.80	162.78	139.56	149.94
Sales-Cards	251.62	162.43	130.42	112.93	95.81	63.39
Data Processing Changes	226.90	183.32	160.69	139.55	94.06	60.86
Sales Imported Items	70.32	227.36	110.63	92.41	11.16	64.58
Sales Indigenous Equipments	42.19	33.03	44.74	41.70	22.89	8.87
Ribbons, Control Panels, Wires, etc.	31.97	22.68	22.87	29.11	19.17	14.53
Miscellaneous Sales & Services	64.04	52.93	42.38	59.80	32.71	27.39
Total	2354.99	2214.53	1694.06	1495.61	1117.61	1002.28

Source : Public Accounts Committee, (1975-76) 5th Lok Sabha, 221st Report : Computerisation in Government Departments, (New Delhi : Lok Sabha Secretariat, 1976) p. 176.