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INFORMATION TECHNOLOGY IN DEVELOPING COUNTRIES

S.C. BHATNAGAR
N. BJØRN-ANDERSEN
Editors



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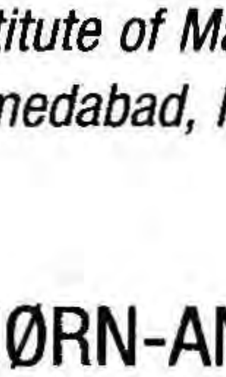
INFORMATION TECHNOLOGY IN DEVELOPING COUNTRIES

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New Delhi, India, 24–26 November, 1988

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PREFACE

Many developing countries are now waking up to the potential of information technology and the role it plays in accelerating the pace of development. In an effort to bridge the gap that exists between them and developed societies, many developing countries resort to hurried actions and formulate policies which may not have the desired impact. Recognising the importance of making considered choices in the use of information technology in developing countries, IFIP TC8 and TC9 decided to set up task forces which will focus on the primary concerns of the developing countries. The conference on the Impact of Information Systems on Developing Countries was the first major activity of the two working groups.

The idea of a conference on the impact of information systems on developing countries was born in the annual IFIP TC9 (Computers and Society) meeting and the conference on Human Choice and Computers (HCC3) in Stockholm in 1984. Amongst the national presentations in HCC3 there was only one from developing countries. The presentation on impact of computers on Indian Society was very different from the rest of the presentations. It talked about a low impact, relatively poor access to computers, large untapped potential of using computers for accelerating development, and socio-cultural factors that inhibit the use of computers. Later in the working group session of HCC3, a working group on developing countries proposed that TC9 form a task force to focus on the impact of computers on developing societies. There was strong support for the task force.

In the same summer TC8 started a similar initiative. It was a chance meeting of Subhash Bhatnagar and Niels Bjørn-Andersen (respective chairmen of the task forces established by TC9 and TC8) in Senegal in another conference that promoted the joint conference proposal.

The theme of the conference Impact of Information Systems on Developing Countries was defined to reflect interest of TC8 and TC9. The objectives of the conference were:

1) Compile and publish an authentic document on the status of information technology in developing countries and its impact on the society.

2) Expose participants from developing countries to innovative applications through presentations by experts from developed and developing countries.

3) Identify especially useful strategies, methodologies, and procedures for the application of computers in developing countries.

4) Identify the major problems in relation to the development and use of information systems in developing countries.

5) Establish a work plan for the proposed working group in developing countries for TC8 and TC9.

The conference was attended by 40 delegates of which 15 were from India and the remaining 25 were from 11 other countries covering both developing and industrialized nations. Twenty three papers had been accepted for presentations of which twenty were presented. The papers covered Country Reports from 5 countries; papers on framework for information systems development; DSS applications in developing countries; informatics policy; and MIS applications.

The inaugural talk by Dr. N. Sheshagiri, Director General of the national Informatics Centre, Government of India was a technical presentation on the computer network being installed at various levels in the Government to collect data for planning and monitoring of key developmental

programs. In the regular sessions an author's presentation of 30 minutes was followed by a discussion for 15 minutes. Many presentations highlighted the special economic and socio-cultural context of developing countries and the need to design culturally adapted systems. Examples of such systems were presented. The country papers presented the status of informatics in their country and detailed the role of governments in shaping informatics applications. The need for government interventions and the areas to which intervention should be restricted were some of the issues that were discussed.

One of the sessions discussed the future course of action including the formation of a working group on developing countries. Future joint conferences by TC8/TC9 were endorsed and many ideas on themes and venues were generated. Prof. Bhatnagar (TC9) and Prof. Bjørn-Andersen (TC8) were to follow these ideas through in their TC's. In the concluding session a summary of the conference was presented.

The proceedings are organised in three sections. The first section includes six papers which discuss a theoretical framework for developing and implementing information systems in a developing country context. The next section of five papers presents the country reports covering many aspects of computerisation in these countries. The third section includes five papers which present a regional/comparative status of computer use in selected countries, three papers that deal with framework/specific applications in some sectors, and finally two papers focusing on software industry and ergonomics.

Many organisations lent support for the conference to happen. One of the biggest obstacles was the travel funds required for the authors of country papers to come to New Delhi to present their papers. Most organisations in developing countries can not afford to spend the travel funds for their employees participating in such conferences because the cost represents nearly 30-80% of the annual salaries of such employees, and hard currency is involved.

The Commonwealth Secretariate provided a generous grant to cover expenses for participants from Ghana, Zimbabwe, Nigeria, Sri Lanka, and Bangladesh. Dr. Mohan Kaul, Director Management Division helped identify the participants from African countries and provided inputs for shaping the design of the conference. He was to present an overview of two conferences that he had organised in East Africa and South East Asia on the status of computer use in the countries of these regions. He had to cancel his participation at the last minute.

UNESCO also provided support for travel of participants from developing countries. A few Indian organisations whose names appear in appendix 2, contributed towards meeting organising expenses. Prof. Sachdeva (Chairman Organising Committee) and Brig. Choudhary (Co-chairman Organising Committee) did an excellent job in making all the arrangements in New Delhi.

Putting together a volume like this requires a lot of effort from a large group of people. Unfortunately they cannot all be duly recognized here. We should like to mention Sal Belardo, Pam Mayhew and Trevor Wood-Harper who have provided valuable assistance in the editing process. But there is one person who deserves special mention, and that is Henriette Hansen who has very conscientiously scanned, retyped, and edited the many articles into this consolidated volume. She has done an excellent job, and whatever mistakes still to be found in the text are to be blamed on

Subhash C. Bhatnagar

Niels Bjørn-Andersen

INTRODUCTION

Computers in Developing Countries
S.C. Bhatnagar

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COMPUTERS IN DEVELOPING COUNTRIES

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There is wide spread acceptance of the fact that the impact of information technology on different countries has been quite different. Yet, many professionals argue that there is no need to focus on any group of countries because basic principles of information systems design would not be different in case of different countries. This paper attempts to show the wide differences among countries on several dimensions which influence the use of computers and highlight the differential impact of such usage. First some data is analyzed to get a quantitative index of the difference in usage amongst different countries. Differences are also analyzed on the use of computers within different sectors and types of applications within these sectors. For the purpose of this analysis the paper draws upon the reports of two conferences organized by the Commonwealth Secretariat [1,2]. These conferences had discussed information technology in Government in some countries in the African, Asian and the Pacific region. Finally, the paper identifies some issues which are important in the context of impact of information systems in developing countries.

1. INTRODUCTION

The impact of computers in industrialized societies has been well documented [3]. Almost every aspect of a citizens work and social life is in some ways influenced by the 'chip' [4]. On the other hand the impact of electronics on the life of most rural dwellers in many developing countries is insignificant. Only 10-15% of the population In developing countries have any contact with a product/service which is an output of a computerized process. The number of people who may have seen a computer at close quarters or touched a key board will perhaps be less than one per cent.

The reasons for low impact on developing societies are three fold.

1) The number of computers in use are limited in comparison to the size of the economy.

2) The type of sectors in which computers are used and the nature of applications are such that the life of an average citizen is unaffected.

3) Poor communication infrastructure prevents a quick explosion of information use.

2. DIFFERENCES IN NUMBER OF COMPUTER BEING USED

Table 1 attempts to compare some countries on the extent of computer use in their economies. It presents data on 18 selected countries representing a broad spectrum of degree of Industrialisation [5].

The data on GNP reflects the level of economic activities in these countries. The data on Phones and TV indicates the extent of development in communication infrastructure. The data on computers indicates the extent of computer usage. Traditionally the differences in computer usage has been measured through indicators relating total computing power to total population i.e., on a per capita basis. Measured on such an indicator there is a thousand fold difference

Table 1

INSTALLED COMPUTER POWER IN SELECTED COUNTRIES

COUNTRY	SIZE K SQ. MILES	POP MILL 87	GNP $B 86	PHONES M 87	TV M 87	COMP. M 87	MIPS K 87	MIPS/ COMP.	KMIPS/ B$ GNP
USA	3623	244	4206	238	217	40.73	22812	.560	5.53
IRELAND	27	3.6	22	1.1	1	0.24	115.3	.480	5.24
UK	94	57	555	31.4	28.5	5.42	2591	.478	4.76
NEWZEALAND	104	3.3	25	2.2	1	0.18	86.5	.481	3.89
SINGAPORE	0.24	2.6	19	1.2	0.6	0.17	64.3	.378	3.42
PORTUGAL	36	10	27	2	1.8	0.19	74.3	.391	3.02
AUSTRALIA	2978	16.07	155	9.2	7.6	0.74	356.8	.482	2.40
S. KOREA	38	42	107	10.1	9.2	0.51	195.5	.383	2.12
JAPAN	144	122	1994	72	74.4	8.63	4088	.474	2.11
W.GERMANY	96	61	902	40.9	24.4	3.31	1567	.473	1.77
PHILLIPINES	116	62	45	1.2	1.9	0.14	53.1	.379	1.62
BRAZIL	3287	147	290	14.7	29.4	0.51	250.9	.492	0.99
MEXICO	762	82	170	9.1	9.8	0.26	102	.392	0.67
SAUDIARABIA	830	14.8	115	3.7	4.6	0.15	58.2	.388	0.52
INDIA	1269	800	230	4.8	5.6	0.2	73.1	.366	0.46
CHINA	3705	1074	480	8.6	11.8	0.34	125.3	.369	0.39
INDONESIA	783	180	105	5	10.8	0.07	25.6	.366	0.32
USSR	8649	284	2270	34.1	93.7	0.18	80.9	.449	0.04
WORLD	52426	5055	16795	710	725	80.25	41334	.515	2.46

between USA and India on the extent of usage of computers. Perhaps, a better indicator of the extent of usage can be obtained if the computer power in Kilo MIPS is related to the non-agricultural GNP of different countries. The GNP on account of agriculture is being ignored because of the traditional nature of agriculture in many developing countries where there is hardly any usage of computers. On the other hand, in most of the industrialized countries, agriculture in any case represents less than 10 per cent of the total GNP. The final measure defined as Kilo MIPS per million dollar of nonagricultural GNP reflects the penetration of computers in the sectors of these economies. Measured on this indicator the difference between USA and India is ten fold. Last column in Table 1 shows this indicator for selected countries. In fact, different countries can be classified on the basis of this measure into groups such as industrialised countries, newly industrialized countries, countries on the threshold of industrialization and countries which have yet to develop their industrial economy.

Clearly, the difference amongst various groups of countries are still large because even a two fold difference indicates that the number of computers will have to double for a country for it to catch up with another country in the higher group.

There is likely to be significant growth in the number of computers being used in most of the countries but for countries such as India and China which have an initial low base, the percentage growth in the next few years will look very high.

Some of the variations in KMIPS/B$ of GNP amongst different countries may be explained by the differences in utilisation of computer equipment. Since computers are relatively expensive in countries like India there utilisation tends to be higher. In fact, many PCs in India tend to get used not as Personal Computer but as departmental computers (shared Computers). Considering the fact that 80 per cent of the MIPS shown in Table 1 are accounted by PCs, the utilisation of a PC is an important factor

2.1 Factors responsible for low usage

The low use of computers in developing countries can be analyzed in the context of the following questions that a prospective user is likely to ask.

Do we need Computers?

Can we afford Computers?

Can we implement applications?

2.1.1. The felt need for computers is low because:

Computer literacy amongst managers/technocrats is low.

Lack of competitiveness in the industry results in low motivation to improve performance.

Computers are perceived as being useful for transaction processing. Since the size of operations is generally small, need for automation is not strong.

Poor communication infrastructure keeps many types of computer applications beyond the realm of feasibility for these enterprises which otherwise use computers significantly.

2.1.2. The following factors lead many prospective users to conclude that they can not afford computers.

- Cost of hardware and software is 3 times the international price whereas cost of clerical labour is almost 10 times less. This makes computers 30 times more expensive in relation to the clerical labour they intend to replace. Their primary function is perceived as labour

replacement.

- For a given level of turnover, the number of transactions are large and value per transaction is small. For example, cash withdrawals at a bank counter would range from $3 - $200 and the average amount may be $30. The use of computers for processing such transaction appears to be uneconomic.

2.1.3 In cases where a need is felt and computer use can be justified economically, the following factors may prevent its usage.

- Fear of break down and poor facilities for maintenance. This is particularly true of countries where computers are imported because there is no indigenous assembly manufacturing.

- In many areas the electric supply is erratic and the quality of power is poor. Consequently heavy investments in generators, voltage stabilizers, uninterrupted power supplies make economic feasibility that much more elusive.

- Poor computer literacy amongst clerical workers, particularly poor key board skills results in resistance from such workers.

2.2. Social factors responsible for low usage

Most of the above factors can be traced to poor economic infrastructure or lack of training. There are also some social factors which inhibit the use of computers.

The use of languages other than English in local administration. In fact in countries like India and China there is a multiplicity of scripts and dialects. This restricts access to software, training material etc.

Computers tend to formalise procedures, record transactions and therefore make petty corruption that much more difficult. There is resistance to computer use because it may expose such corruption.

Most important is the societal attitude to computers. In many countries with large unemployed populations, use of data processing is seen as labour replacing. Organized labour has therefore resisted the introduction of computers in several service industries like banking and insurance.

There is lack of awareness amongst union leaders and a lack of successful implementation of planning and decision oriented applications which could help to change these attitudes rapidly.

3. COMPUTER APPLICATIONS

Other factor that lead to differential impact of information technology is the nature of applications. Computer applications can be broadly discussed in the context of the following three sectors:

Public Administration

Enterprises and

Education and R & D.

3.1. Public Administration

The dominant impression that emerges from a review of IT application in the government in the Asian and African region is that there is preponderance of applications concerned with routine statistical data processing [2]. Such data is largely meant for long term planning. However, the

Table 2
Illustrations of development impact of applications in Asis and Pacific countries

Country/Application	Year of Installation	Development impact
1. China Technology Transfer Project Management (TTPM) Subsystem of the state Economic Information System (SEIS)	1986	Control of technology transfer agreements.
2. India a. Karwar rural development information system	1984	Monitoring of rual development program, reduction in delays and scope for petty corruption. Led to nationwide replicate system in other districts.
b. Dharampur Sub-District infrastructure planning for development	1977	Cost optimization for infrastructure. Clarification of objectives in locational decision. Provided benchmark to limit extent of departure from optimal.
3. Malaysia Integrated Development Project Information System (SETIA)	1984	Monitoring financial and physical progress of projects at national level.
4. Philippines a. Remote sensing of natural resources.	1977	Updated and accurate natural resources inventory
b. Settlers' Accounts Management Information Systems	Under Install.	Monitoring of progress of settlement program, reduction in delays and improvement in record-keeping
5. Sinagapore a. Housing Development Board Information Centre Development	1982	Flexible retrieval and reporting for planning and control
b. Housing Development Board offica automation	1985	Enhanced clerical productivity and faster routing of mail
6. Sri Lanka a. District/Village information system for decentralized planning at district.	1984	Project monitoring and control. Fast processing of pensions.
b. Central Bank's Information system	1982	Clerical productivity, faster processing of data
c. Company Data Base System	1978	Retrieval of data of performance
7. Thailand a. SIAM4 Economy-wide Engery Model	1984	Demand projection of energy under different energy pricing policies
b. Water Resources Information Systems (WRIST)	1984	Access to water resoruces data for several govemment agencies.

Source: Mohal Kaul et al., New Information Technology applications for local development in Asian and Pacific Countries, Information Technology for development, Vol. 4, 1989.

time lag between collection and reporting is still very large (2-3 years) for the data to be meaningfully used. In recent years operational information systems have been designed. Many of these have been developed on micros were end user driven, and have created an immediate impact on productivity of operations at the local level. In some experiments in decentralized computing, monitoring systems were designed to improve effectiveness of rural development programs. In general monitoring systems have been poorly designed - there is lack of managerial purpose in the indicators that are reported, and all too often there are too many indicators resulting in a lack of focus. It is only after a few years that planning and monitoring systems will mature to a level where they can improve administration of developmental programs and social services. The impact on rural society is therefore still a long way off. Tables 2 and 3 provide some illustrations of the type of applications developed in these regions.

3.2. Enterprise Sector

In the enterprise sector, experience of developing countries has not been documented. Considering the Indian example, transaction processing applications seem to be wide spread in medium and large (by local standards) enterprises. Some companies have developed an MIS on the basis of transaction data bases. Computerisation is also moving down from corporate level to branch offices in most large companies.

There is new found emphasis on CAD/CAM, but actual impact is marginal. DSS and EIS applications are only beginning to emerge. There is a significant trend towards end user computing. Data base software and word processing are the most common application. Surprisingly spreadsheet use is still very limited. Overall, the impact of computers on productivity or decisionmaking seems to be less compared to industrialised countries.

Table 3

ILLUSTRATIONS OF IMPACTS OF IT APPLICATIONS IN GOVERNMENT

APPLICATION (YEAR IMPLEMENTED)	IMPACT
Botswana Fuel Control System (1983)	Tracking government vehicle movements and efficient resource allocation
Gambia National Population & Housing Survey System (1983)	Production of more accurate and timely demographic and other statistics
Gambia Foreign Trade Statistics System (1983)	Faster processing of foreign trade date and facilitating department coordination
Ghana Expenditure Monitoring System (1972)	Streamline government expenditure processing
Kenya Wagon Control System (1971)	Better fleet control and congestion reduction
Malawi Foreign Trade Statistics System (1966)	Monitoring status of external trade
Mauritius Sales Tax System (1983)	Fast processing of sales tax data and efficient revenue collection
Nigeria Computerized Road Safety & Planning System (1984)	Effective traffic assignment and control, and better planning of road network development

Table 3 (Cont'd)

ILLUSTRATIONS OF IMPACTS OF IT APPLICATIONS IN GOVERNMENT IN AFRICAN COUNTRIES

APPLICATION (YEAR IMPLEMENTED)	IMPACT
Sierra Leone National Population Agricultural Census System (1963)	Fast processing of census data and generation of information for sectoral planning
Tanzania Government Household Budget Survey System (1975)	Fast processing of nation-wide survey data.
Zambia Grade Vll Examination System (1969)	Fast processing of examination results and streamlining secondary school candidate selection
Zimbabwe Voters Registration system	Clean voters roll and elimination of multiple registration

Source: Information Technology in Government - The African Experience, Commonwealth Secretariat, 1988.

3.3. Education and R & D sector

In the Education and R & D sectors access to computers is much better relative to other sectors. In countries like India and China which have large populations, the access to computers is available to university students, but is very limited for school going children. Compared to industrialized countries, the per capita population of computers in the education sector is very low. For example in USA there are 1.2 million computers in schools and 2.27 million in universities. All the developing countries put together are unlikely to reach a total installed base of that many computers in the foreseeable future.

4 . IMPACT ON SOCIETY - SOME ISSUES OF IMPORTANCE

4.1 Need for computer support in rural development

Whatever limited impact computers have created in developing countries have been confined to the urban areas.

For impacting the lives of 70-80% of the population which live in rural areas (See urban population figures reported in [6]), computers will have to be used for increasing the effectiveness and efficiency of rural development programs. In many countries like India, planning is elaborate, but many failures can be traced to tardy implementation. Computers will therefore have to be used at the field level for operational planning and monitoring. This will also improve the quality of data that is reported for central planning. There is need to share experiences of successful use of decentralized computing.

4.2. Need for Indigenous approach to MIS development.

In the enterprise sector, the emphasis of computer applications must shift from clerical application to effective utilisation of investment is plant, machinery, rolling stock etc. This would require that more DSS applications be developed.

Indigenous approaches to MIS development which recognize the following difference between industrial and developing economies must evolve.

- In terms of technology, several generations must coexist because the cost of relacement of hardware is 3-7 times that of industrial countries and therefore economic life is much longer.
- There is a large domestic demand. However competition in domestic market is weak, since markets are sheltered and only a few enterprises are solely dependent on exports. Strategic applications would therefore have to be built not in marketing but in cost control, and improved utilisation of productive capacity, which will increase productivity.

- There is a certain lack of performance orientation in the managers because of high job security and a perpetual shortage of professionally trained manpower. In the people, the lack of performance orientation is due to lack of training and low aspiration levels.

- Level of computer literacy are low at all levels in the organisation.

- The capacity to evolve original approaches professionals is limited because for decades there has been a strong dependence on western industrial nations in terms of management concepts and approaches, hardware, software technologies, computer education, and even applications.

4.3. Need for overcoming the handicap of poor communications

On both per capita telephones and telephones per square mile, large countries like India and China are way behind the industrialized countries. In many of these countries, TV as a communication medium receives higher priority and therefore any significant expansion of the communication infrastructure is unlikely. For example in India, currently efforts are afoot to improve quality of transmission and achieve very modest expansion. There are a few computer networks connecting government users (NICNET), education institution (EDUNET), and industrial users in a few major cities (INDONET). These networks are based on circuits leased from the only telecommunication agency which is run by the government. There are no packet switched public data networks and very limited use of remote terminals (airline reservation is of one of the successful uses). The rail reservation system for example is localized to trains departing and arriving from a few major cities and is available to users in these cities.

Much of the social impact of computers in industrialized countries eg. altering work environment; cash less transactions; access to public information have taken place because of good communication infrastructure. In fact computer networks have allowed enterprises to compress time and overcome geographic restrictions to gain strategic advantages.

For most of the developing countries these applications are beyond the technical feasibility. Indigenous approaches will need to be developed to circumvent the disadvantage of a poor communication infrastructure.

4.4. Role of Government

Unlike many industrialized countries the role of government in many developing countries is all pervasive. For example the yearly budget of federal and state governments in India is almost 30% of the yearly GNP. In relation to computerization, governments has to play a supportive role.

Many countries have recognized the potential of electronics/computers as a growth sector in the economy, and have designed policies to promote indigenous industry. However not enough has been done to promote computer applications because the role of computers as a catalyst for the development process has not been recognized. The largest contribution of the government can be made in the field of creating awareness and providing training opportunities. Lack of appropriately trained manpower has been responsible for poor quality of applications. Some areas of government interventions are listed below:

- Promoting computerisation in public administration.
- Application software development suited to developmental needs and local condition.
- In defining policies to augment supply, reduce prices, increase indigenous availability.
- Selective imports and adaptation of technology
- Create training opportunities and public awareness.
- Develop communication infrastructure.
- Develop a computer maintenance infrastructure.

4.5 Misuse of Information

Some of the societal concerns which have become important in countries which have extensive computerisation are also beginning to emerge in the developing countries. With increasing use of computers, several issues of privacy, security of data, abuse of data will become important. For example in India the income tax department has used computerised list of car buyers, and new telephone connection to investigate possible tax evasion. Such uses of data on private citizens available with commercial agencies may seem to serve a good public cause but legal safeguards will have to be built to ensure that such data is not misused.

5. CONCLUSIONS

An attempt has been made to identify differences in the extent of use and the nature of computers applications amongst developing and industrialized countries. Some issues which significantly affect the way computers will be used, and consequently their ability to create an impact on society, are mentioned.

Some of these issues are addressed by various papers in this volume, and others may be topics of future conferences. On most of these issues an interaction of professionals from developing countries and professionals from developed countries who have experience of working in problems of development will be of great value. In exploiting IT for a social impact there is some part of technology that developing countries can borrow rather than reinvent (for example sophisticated hardware and low level software), and some aspects of technology which must be adapted to local cultural environment (for example methodology and approach to MIS design) and a significant part that must be creatively developed entirely indigenously (For example priority application areas, design of applications).

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SECTION 1

FRAMEWORKS FOR DEVELOPING INFORMATION SYSTEMS IN DEVELOPING COUNTRIES

Information Technology in Developing Countries
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A CONTINGENCY APPROACH TO MANAGING INFORMATION TECHNOLOGY IN DEVELOPING NATIONS: BENEFITTING FROM LESSONS LEARNED IN DEVELOPED NATIONS

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Information Technology (IT) is a key resource that should be exploited by developing nations so that they can become more competitive in today's dynamic world economy. The evidence to date, however, suggests the contrary. The focus of most IT applications has been limited to structured data processing tasks which are justifiable by a rather narrow cost-benefit analysis. The potential of IT for the less structured applications that support management in strategic level problem-solving and decision-making activities has hence not been tapped. Further, the implementation strategy must be attuned to organizational and environmental factors. The paper presents a set of propositions for effective management of IT and illustrates their relevance with a case study of a leading Indian company.

1. INTRODUCTION

In today's competitive global economy, industries and nations must manage their human, capital and material resources efficiently and effectively if they are to survive and prosper. Since information lies at the heart of any management process, Information Technology (IT) is an equally important resource for improving productivity and performance in both the private and public sectors. In recent years, organizations in developed nations have also used IT to help them change the way they do business so as to give them a strategic advantage in their operations (e.g., the use of automated teller machines in banks to improve customer service.)

The Information Revolution of the Eighties has spread to developing nations as well, and they are naturally anxious to avail themselves of the benefits of this new technology. The scope for using IT is undoubtedly vast in these nations and many have already made significant investments in IT from their scarce economic resources. However, the return from these investments has fallen short of the potential. In our view, there are two major reasons for this: (a) inappropriate choice of applications; and (b) inadequate consideration of the organizational and environmental factors in the formulation and implementation of the IT strategy. In many developing countries, computers are being used mostly for automating large-scale clerical work, whereas the real payoff comes from using IT for applications of strategic importance. An example of the latter is the use of satellite-linked computer networks in Indonesia to eradicate illiteracy.

There is no best model for managing IT since it depends on external forces such as social, economic, political, and cultural factors that vary from one nation to another, as well as on internal forces such as organization culture and people skills that vary from one organization to another even within the same industry in the same nation. Our paper presents a contingency approach for managing IT in developing nations through a set of propositions drawn from academic research and the practical experience of developed nations. The relevance of these

propositions is illustrated by a recent case study of IT implementation in a leading firm in India.

2. OUR BASIC PREMISES

Manufacturers and vendors of Information Technology and Information Systems tend to focus on technical issues for solving the "information" problems of developing nations. In reality, the most urgent problems are not technical, they deal with the management of this technology.

Information Technology is often confused with computer applications that are designed to improve efficiency by automating manual systems and are justified by savings from replacement of human labor. Since many developing nations are "labor-rich", any technology that adversely affects the already high unemployment rate or results in dislocations in the labor force will be viewed as a politically unwise investment. Our focus, however, is on computer-based information systems to support managers in their problem-solving and decision-making tasks. Such systems are crucial for leveraging critical resources like energy, scarce raw materials, capital, and foreign exchange. Indeed, given the shortage of qualified managers, especially in developing nations, these systems, if properly designed, and implemented, will also increase managerial productivity.

Our approach for managing IT is based on several premises. First, we believe that all developing nations, irrespective of their political philosophy, have to successfully compete in the world economy in order to increase the standard of living for their peoples. This implies they have to manage better their limited resources. In our view, information and its associated technology must be recognized as a valuable resource for improving the management process of any organization, whether it be in the private or public sector. The benefits of IT will not, however, be realized unless this technology is managed with a strategic perspective that takes cognizance of environmental factors, both external and organizational, which affect successful implementation. Finally, we suggest that organizations in developing nations learn from the experience of developed nations so that they can avoid the pitfalls that result from ill-planned technology transfer.

3. THE EVOLUTION OF INFORMATION SYSTEMS: IMPLICATIONS FOR IT STRATEGY

The evolution of information systems in the West provides a useful framework for thinking about what might be the right IT strategy for developing nations. We can trace three "eras" of computer applications in the West as shown in Exhibit 1. Early computer systems were installed to automate clerical functions such as payroll and general ledger, and were justified by greater accuracy, faster processing and lower cost. These Era I systems focused on highly structured, well-understood problems, and were concerned with historical data. In the second era, the focus shifted from accounting-oriented systems to systems that aided operational personnel such as on-line order entry systems and manufacturing control systems. These systems not only automated clerical tasks but generated additional benefits in terms of more up-to-date information, better customer service and improved utilization of assets (e.g., working capital tied up in inventory). The third era has been labeled "Information Support" to signify the shift in emphasis to applications that are solely concerned with providing information to help decision-makers do their jobs better. The prime benefit of Era III systems is the ability of managers to better analyze, plan and control their operations. The initial Era III applications were called Decision Support Systems (DSS) to distinguish them from the traditional MIS application of Eras I and II. Subsequent applications include Executive Support Systems (ESS), Expert Systems (ES) and Group Decision Support Systems (GDSS), the different labels reflecting the focus of the applications. More recently, organizations have begun to view information as a valuable resource to be managed at the highest levels of the organization to gain a competitive advantage or improve organizational effectiveness.

A significant lesson for developing nations lies in the paradoxical state of affairs in the West wherein, despite all the advances in IT, most organizations are less than satisfied with their

information systems. Managers feel that they receive too many reports but too little useful information. Often information is so dispersed throughout the organization that great effort is needed to locate simple facts. Managers also complain that important information arrives too late to be useful or in a form that leaves no idea as to its accuracy. Finally, long lead times for system development and inflexible systems hinder the ability to meet management's changing needs for information in a competitive environment.

A Decision Support System, simply stated, is a responsive system which provides managers with actionable information in a timely manner. Given the urgent need for developing countries to become more competitive in the world economy, we believe the potential value of DSS in these nations is as great as in developed nations. Despite their late start, developing nations do not have to lag behind developed nations and can leap-frog into Era III. A strategic plan for IT should be drawn by each organization in line with its business objectives which will define the portfolio of information systems to be developed and their priorities. This portfolio could span all three eras of the evolution depending upon the business objectives and should ensure that the "data-rich but information-poor" problem experienced in the West is avoided. This approach would also help to avoid the "data gap" problem encountered in the West where the original Era I systems captured only the data required by the narrow accounting functions for which they were designed. When Era III applications were built years later using the Era I data bases, serious gaps were discovered. This problem arose because of the sequential manner in which computer systems evolved in organizations with no forethought about the future use of Era I data bases for Era III systems.

With regard to the evolution of hardware, developing nations should capitalize on the wonderful opportunity to benefit from the latest microcomputer technology without being saddled by the expensive and relatively obsolete mainframe technology that is available in these nations. The tremendous advances in the Personal Computer (PC) in terms of increased capacity, auxiliary storage, speed and performance make the PC an extremely cost-effective alternative to mainframes. In addition, the PC gives the user total ownership and control of the system and helps facilitate the trend toward decentralization in large organizations. Equally important, the software tools that have been developed for the PC using 4GL (fourth generation language) technology are not only easy to use but are significantly less expensive than comparable tools for the mainframe.

Finally, let us examine the evolution of system development methodology. Era I and Era II methods are based on the premise that the system can and should be fully specified before being designed, and fully designed before being implemented. The standard System Development Life Cycle (SDLC) method used for Era I and Era II applications is a sequential procedure consisting essentially of four stages: analysis of system requirements, system design, programming and installation, in that order. This sequential procedure will not, however, work for Era III applications since it is difficult for managers to specify at the outset what they want from the system to support their planning and control activities. Their information requirements are ill-defined and fuzzy, which in turn make it difficult to specify the data requirements for the system.

In the circumstances, a different methodology has to be employed for Era III systems. The key idea of this methodology is to build a prototype or test version and expand it incrementally on the basis of user feedback. The system evolves through a series of iterations in short cycles, each of which encompasses all the four stages of the sequential approach and results in usable versions of the system. Also, the user has to be involved in a significant way during the system development process to ensure that the system which is implemented is indeed what he wants and can use. This also implies that the type of MIS professional required for Era III systems is quite different from that for Era I and II systems. Computer skills alone will not be adequate. A strong business orientation is necessary for appreciating user needs and for effective communication with them during the entire process.

4. IMPACT OF EXTERNAL AND ORGANIZATIONAL FACTORS ON USE OF IT

The effective utilization of IT is dependent on a number of factors which can be broadly divided into two major categories: Environmental (e.g., Social/Political/Cultural factors) and Organizational (e.g., Management Style). These factors influence the management process of an organization or the way in which the organization conducts its business. To the extent that the management process is driven by information, these factors affect the use of IT by the organization. A brief commentary on these effects follows.

4.1 Environmental Factors

The environmental factors have been classified under Economic/Market/Financial, Technological, Societal/Infrastructural, and Social/Political/Cultural factors.

Economic/Market/Financial: Organizations in developing nations do not generally have access to the financial markets that their counterparts in the West have. In addition, because of the shortage of foreign exchange, duties are often imposed that add considerably to the price of IT. As a result some types of IT may be prohibitive in cost. Moreover, conventional wisdom would suggest that the potential for using technology is low for nations in the lower rungs of the ladder of economic development. However, this general truism may not apply to IT since it is a technology that enables any organization to leverage its limited resources so as to operate more effectively and gain competitive advantage. Market factors have a direct effect on management processes. This is best illustrated by the contrast between a free market philosophy and the doctrine of central planning. The appropriate IT strategy will not be the same for the two environments.

Societal/Infrastructural: One of the most acute problems facing developing nations is the paucity of well-educated and trained middle managers. As such, management education becomes a higher priority since there is no point in making investments in IT until a managerial cadre who can use IT is developed. Another problem is the lack of "Information Awareness" that permeates society in many developing nations [1]. As an example, a careless attitude prevails about the need for maintenance, whether it be for a high-speed elevator in an expensive tourist hotel or for computer hardware. People lose sight of the serious consequences of this negligence on the anticipated payoff from the investment made in the hotel or the hardware.

Social/Political/Cultural: Many of the problems faced by businesses in all nations are complex and require the management process to encourage broad participation, cooperation among interested constituencies and unfettered sharing of information. On the other hand, rigid hierarchical orientations prohibit the free flow and exchange of ideas necessary for the development of creative solutions [2].

Technological: The technological maturity of a nation is a key influence on the choice of the type of IT that can be productively utilized in that nation. Specifically, if computers are introduced in a relatively immature technological environment, it may result in increased dependence on foreign personnel for providing the necessary support services for hardware and software. Many nations are carried away by the low prices of the PC without realizing that the PC by itself is unproductive and requires software support personnel to put the PC into productive use.

4.2 Organizational Factors

The organizational factors are adapted from the work by Harold Leavitt [3] who postulated that management must maintain a dynamic equilibrium among the four components: tasks that the organization had to accomplish, which we call its strategy, the organization structure and the corporate culture, the people in the organization and their skills, and the Information Technology that is employed.

IT/Strategy: Information is essential for effective implementation of corporate strategy. But strategy must first be conceptualized, and made explicit, so that pertinent issues can be raised,

and the underlying assumptions tested [4]. Often it is difficult to align IT with corporate strategy, and, in too many instances, IT policy and implementation are decoupled from strategy. One way to ensure that IT strategy is in line with, and supports, corporate strategy is to use the Critical Success Factor (CSF) methodology. The CSF approach helps firms articulate those "limited number of areas in which satisfactory results will ensure successful competitive performance" [5]. The methodology enables the decision-makers to identify the CSFs, namely, the specific factors most responsible for the organization to achieve its corporate goals. The CSFs are then examined to identify the measures which best track the behavior of each factor, leading ultimately to the determination of the portfolio of information systems to be developed and their priorities.

IT/Structure: The IT strategy should also fit the current organization structure. The new range of information technologies have opened up new ways to manage an organization. For example, the mainframe technologies of the Seventies did not facilitate decentralization as much as the more recent technologies that permit distributed and departmental processing of data. The organization structure should not, however, be looked at without the important dimension of corporate culture which gives life to the structure. This is the element that makes some organizations successful while others in the same industry and even with the same structure do not do so well in comparison. For example, a results-oriented culture would motivate managers to use Era III systems to improve performance while a "business as usual" type of culture would not be a fertile ground for introducing Era III systems.

IT/People: Effective utilization of IT in an organization is a direct function of the skills of the people using this technology. Since Era III systems are by their nature designed to support management in their planning and control functions, these systems will not serve any purpose if the management style is "seat-of-the-pants" rather than analytical and information-oriented. Moreover, if the managerial cadre is not well- trained, Era III systems would be premature since the users would not know how they fit into the management process. Also, Era III systems require MIS professionals with business skills to facilitate effective interaction with users in the design of these systems. Such business-oriented MIS professionals are scarce even in the developed nations where external consultants with expertise in Era III system are brought in for designing and implementing such systems in the short run.

5. PROPOSITIONS FOR MANAGING INFORMATION TECHNOLOGY

The previous sections laid the groundwork for the propositions which are presented now under three major headings dealing with: (a) Portfolio of IT Applications; (b) Implementation Strategy; and (c) Selection of Hardware/Software Technology.

5.1 Portfolio of IT Applications

The first question that needs to be addressed by a model for managing IT is: Where should IT be applied? The following set of propositions delineate the linkages between the portfolio of IT applications and external factors as well as organizational factors including the role of top management.

Proposition 1(a): The real payoff of investments in IT is realized only when this technology is utilized for applications of strategic importance. The focus of these strategic systems is to enable any organization, whether it be in the private sector or public sector, to leverage its limited resources to operate more efficiently and effectively. Such systems are essential for developing nations if they are to compete successfully in today's world economy. Developing nations should hence take advantage of the opportunity to leap-frog into Era III systems, despite their late start in using IT, because of the contribution these systems can make to their economic growth.

Proposition 1(b): The portfolio of IT applications must be in line with corporate strategy. The Critical Success Factors methodology is a useful tool for identifying applications that are needed to support the management of the factors most responsible for the organization to achieve its corporate goals.

Proposition 1(c): Corporate culture is an important factor to be considered in determining the IT

strategy. Unless the organization is results-oriented, it would be futile to introduce Era III applications whose objective is to improve operational efficiency and organizational effectiveness.
Proposition l(d): Management style is an equally important factor that influences IT strategy. Era III systems can play a useful role only if the managers they are designed to support are analytical and information- oriented.
Proposition l(e): The top management of the organization must provide the executive leadership to ensure that IT is used to its fullest potential to achieve corporate goals and not bogged down in labor-saving applications. IT must be recognized as a valuable corporate resource since it is at the heart of the management process and, hence, it should be managed at the highest levels of the organization.

5.2 Implementation Strategy.

The next set of propositions discuss implementation requirements.
Proposition 2(a): An important prerequisite for successful implementation is the creation of awareness in top management about the value of Era III systems to support corporate strategy. Unless senior managers exercise their leadership in bringing about organizational change, these new tools will not be used. A one-day seminar which includes a live demonstration of an Era III system that has been implemented elsewhere has been found to be effective in educating senior management about the potential of Era III systems.
Proposition 2(b): Implementation of Era III systems requires an educated and well-trained managerial cadre who have the capability to use these new tools. Otherwise, the investment in Era III applications will be premature and will not generate the anticipated benefits.
Proposition 2(c): Since Era III systems are new in concept and the only proof of their value is in actual usage, it is recommended that the initial applications be selected with a short development time period. There are enough examples in developed nations of projects with long development periods ending up in disaster. Experience suggests that a one-year time-frame for development would be a useful criterion in selecting the initial Era III applications.
Proposition 2(d): The methodology to be used for system development is totally different for Era III systems in comparison to the traditional MIS procedures which work well for the structured systems of Eras I and II. The prototyping methodology, where the system evolves through an iterative process based on testing the prototype with users and modifying it on the basis of their feedback, is the recommended approach for Era III systems.
Proposition 2(e): Era III systems also require business-oriented MIS professionals who can interact effectively with users to secure their participation in the system development process. If such skills are not available in-house, external consultants will have to be employed for the initial applications and, at the same time, the in-house MIS organization needs to be upgraded to meet Era III needs.
Proposition 2(f): The "data gap" problem encountered by organizations in the developed nations where the initial Era I applications do not capture the data needed for subsequent Era III applications should be avoided. A "tunnel-vision" approach in designing Era I systems will lead to such a data gap problem. Management must realize that even though Era I applications are only automating clerical processes, they generate in many cases the basic data for Era III applications.

5.3 Selection of Hardware/Software Technology

The final set of propositions deal with the type of IT to employ which clearly depends on the type of applications selected. Since this paper strongly advocates the use of IT for Era III systems which have strategic significance, the propositions are relevant for these types of applications.
Proposition 3(a): Microcomputers are an extremely cost-effective alternative for implementing Era III systems. Further, they have the added advantage of giving the users total ownership and control of the system which facilitates successful implementation of these systems.
Proposition 3(b): Software tools that are employed for Era III systems have to enable quick prototyping and should have the flexibility to permit system changes on the basis of user feedback. Here again the higher level languages that are available for the PC are several orders of magnitude lower in cost vis-a-vis comparable tools for the mainframe, another compelling

reason for using the PC for Era III systems.

6. A CASE STUDY OF IT IMPLEMENTATION IN AN INDIAN MANUFACTURING FIRM

The case study of implementing IT in Delhi Cloth Mills (DCM), a leading company in India, provides an illustrative example of the applicability of the propositions presented in the preceding section.

DCM is a conglomerate involved in a diverse range of businesses, including textiles, fertilizers, sugar, computers and consumer durables. This case is based on the implementation of a PC-based Decision Support System in the Sugar Division of the company and illustrates the potential of such systems for other organizations in developing nations.

The DCM Sugar Division is a leading manufacturer of sugar in India. The sugar industry is highly controlled by the government at both the front end (sales) and back end (raw material procurement). The selling prices are fixed by the government as are the markets where DCM can sell the sugar. Raw material production is controlled in terms of the acreage of sugarcane and prices paid to the farmers. In addition, the sugar business is highly vulnerable to the vagaries of the monsoon, an uncontrollable and unpredictable factor. Both the quantity and quality of the cane harvested depend on the right amount of rainfall at the right time in the growth cycle of the crop.

Since DCM has no control over selling prices, the only avenue open to make profits (and avoid losses) is cost control. The two major critical success factors for the sugar business are: management of cane purchases and control of manufacturing operations. Between the two, cane management was in the view of management, more complex since it involved several external factors, other than the weather that affect the availability of cane at the buying centres. They felt they had a better handle on the manufacturing control CSF since it involved only internal factors and the problem was relatively more structured.

Cane management was hence selected as the first priority for a strategic DSS to support operational management at the plants and top management at corporate headquarters. The system was visualized as a comprehensive DSS to support both the planning and control tasks involved in cane management. The planning component of the DSS would support the on-going analysis of crop estimates as well as the development of the fortnightly purchase plan on the basis of the current balance crop available and estimated future diversion of cane to other sources of demand. The control component will focus on the day-to-day operational control of the purchases made at the centers. For this purpose, the daily purchases at the centers and the despatches to the plants will be monitored along with information on the number of trucks/carts used and who was the centre-in-charge. The system includes a number of exception reports to identify "problem centres."

The project was initiated by top management after attending a one-day DSS seminar. The proposed system was conceived as a strategic DSS to meet the corporate objective of cost control. The company already possessed the necessary management infrastructure, an analytical management style, and a tradition of measurement for providing data -- all of which are essential preconditions for successful introduction of DSS.

The implementation strategy had the following noteworthy features:

(a) Securing the involvement and commitment of the plant management by having at the start of the project a DSS overview presentation to all of the senior and middle managers accompanied by a Workshop to examine the potential applications of DSS in the sugar business.

(b) In view of the severe demands of operating pressures on management's time, participation of users in the design of the system was minimized. Brainstorming sessions were held, rather than individual interviews, to arrive at system requirements.

(c) Prototyping was employed as part of the design strategy to help in firming up system requirements. Live data was used in the prototype system, which was a key factor in stimulating management to react to the outputs of the system.

(d) The system was developed as a PC-based system using Foxbase Plus.

(e) The entire system was completed in 18 months. The prototype system with live data was demonstrated two months after the project was initiated. The initial version of the system was reviewed by users four months later and the first version of the system was installed within a year of the project's initiation. Based on users' feedback, the system has been modified and expanded in two subsequent iterations.

7. CONCLUSION

The case illustrates how IT can be utilized in developing nations to help organizations operate more efficiently and effectively. The Cane Management System is an example of an Era III system that was developed for DCM as a strategic application of the highest priority. It demonstrates the need to involve senior management and how the CSF methodology can be used to help these managers articulate strategy and participate in identifying systems that support strategy. The DCM experience also demonstrates that microcomputer technology can be used to implement strategic systems that leverage critical resources such as senior and middle managers without any detriment to employment at the operational level.

In sum, the paper examines the contingent nature of IT problems that are faced by developing nations and suggests that these problems must be dealt with from a strategic and organizational perspective.

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INFORMATION SYSTEMS DEVELOPMENT FOR DEVELOPING COUNTRIES

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The paper reviews progress in the development of appropriate information system methodologies for use in Developing Countries. The experiences of two cases studies is used to develop the theme of a changing methodology in changing situations.

1. INTRODUCTION

For some years information technology (IT) has been quietly seeping into the Developing Countries (DCs) through direct purchase and donor assistance. The purpose of this paper is to review some of the problems which arise with IT adoption in two African examples and to propose a methodology which might encompass the range of issues which arise. The work is based on previous papers [4][41] and attempts to link and integrate the current thinking in IT methodology with practical constraints which arise in DC adoption.

1.1. Computerisation in Africa

In this section we give a brief background to the history of computerisation in Africa. Since the mid 1950's there has been a steady trickle of computing facilities into Africa and developing countries (DCs) as a whole[1]. In the early years the majority of computing facilities imported to the DCs were large and cumbersome mainframe systems often inappropriate to the needs of the receiving institution in terms of size, capacity, power supply, effect on local labour, etc[2]. In more recent years with the advent of the microcomputer this trickle has increased to a steady flow[3]. In the 1970s companies such as Apple Corp and Osborne were in evidence with their small "8 bit" micros. In the late '70s and early '80s some of the large multinational computer mainframe corporations, often previously uninterested in the use of microcomputers, moved into the centre stage. IBM (International Business Machines) most notably have been increasing their market share at a rapid rate [4].

The uptake in systems has often been matched by a lack of real understanding as to *what* technology, advised by *whom* and for *which* reasons, is being used *where* and by *whom* to do *what*? Bell[5] has pointed out this lack of basic information on in-country uses and, therefore, the difficulty for aid donor agencies to know the answers to such questions as:-

What information technology (IT) is available?
What can be supplied in country X?
What are the environmental limitations?
What local support is available?
What degree of training is necessary?

Without this information there is little possibility of understanding the degree of IT adoption which is useful or possible in DCs as a whole[6]. The work which has been carried out so far in this field (notably the books by the Ad Hoc Panel and Damachi, Souder and Damachi[7]) suffers from either a lack of real developmental detail from case studies or resort to generalisation. Nevertheless the lack of relevant information has not halted aid and donor agencies putting more and more technology with little apparent interest in the specific local situations prevalent.

1.2. The Focus

One of the key areas which has arisen from the limited studies which have been carried out to date is that any new system has to be developed in terms of the requirements and aptitudes of the resident user community. A study which we carried out in East Africa in 1985 showed quite clearly that if the user community does not have much interest or knowledge of the type of system being discussed then there will be little chance of a positive uptake. Therefore there might be a need for an evaluation of current techniques involved in assessing user groups, their technology requirements and the potential of the user environment to support technically sound systems.

2. COMPUTING SYSTEMS EVALUATION AND ADOPTION FOR USERS IN DCs

The following section covers the broad area of IT adoption and deals in particular with:

- Background to the kind of issues which are involved in such an enterprise (both technical and other).
- A simple set of technical points to note.
- A revised set of guidelines produced in the light of experience.

Others [5][13][17] have already given overviews of the possible applications of IT in general and computers in particular in DCs. Gotsch deals in particular with the main areas of microcomputer use and the requirements in terms of training levels and the hardware and software required. In a second study we looked at some of the problems encountered by professionals working with the new technology in DCs and the importance of good training.

The attempt made here is to provide a simple and usable set of criteria by which systems can be realistically evaluated. There are a number of such criteria in existence but some of them were thought to be too detailed in terms of the wider developmental issues involved in the transfer and, therefore, installation of new technology [16]. Eres provides a wide-ranging listing of factors operating in the local environment (e.g., Eres recognises that local needs have to be analysed in the light of the technological appropriateness of the systems which might be advocated and the prevailing socio-economic conditions). Eres provides a list of factors and under the headings of Economics, Manpower, Physioecological, Cultural, Demographics and Social, Political and existing information structure factors, underlines the conditions in DCs. Eres is dealing with the problems which information technology encounters in a holistic fashion but could this list of factors be easily adopted in full as a set of practical guidelines to planners who are intent on introducing new systems? Given limited resources it is possible that research teams would not carry out research elements which were thought to be non-technical (i.e., not relating directly to the process of making a computer system work). This is not to say that such an evaluation is not important. Of course new technology and technology transfer does have dramatic implications on local societies and economies. Elsewhere we have covered a wide range of such problems, e.g., in terms of the cultural adaptation which is required in the society into which micro-technology is being installed [7], or the problem of DCs becoming net exporters of raw data and net importers of technology and media products as well as western 'information' [35]. However, the rate at which computing, and particularly the microcomputing technology is now being adopted [26] requires a degree of computer installation planning which at worst should be a set of rules of thumb which will be widely applicable to a variety of systems and can be easily carried out.
The necessity of guidelines is to reduce the frequency with which electronic information systems are installed only to be found to be of considerably less value than hoped, or to be unable to perform essential tasks in hostile environments. This issue is related to "appropriate technology" and the need for any particular system to be developed by and for the end users.

The following paper begins by outlining the details of earlier work which made use of one set of general software purchase guidelines and compared them to the actual particular experience of working on information technology projects in East and West Africa. Secondly, we come to up-to-date by outlining the more recent methodological advances made by Wood-Harper et al

and Wood-Harper and Corder with the web model and Multiview. Working from these guidelines we re-work the models developed from the African field experience and suggest a more flexible, holistic system.

3. THE ORIGINAL ANALYSIS METHODOLOGY

Our central theme was always the problem of devising a clear and user-sensitive methodological approach to determining user requirements in relation to computer acquisition. The problems which were encountered in the East and West African cases (hereafter case 1 and case 2) were in some way typical of IT adoption in many DCs ie:

- Patchy understanding of the computing involved by the potential users
- Very wide range of requirements
- Awkward environmental factors involved in potential siting of sophisticated systems
- High cost training and staffing implications

What made this more surprising was the fact that in case 1. the organisation we were dealing with was an international research institution with global links and this might have been expected to improve the possibility of fairly smooth and successful implementation of a potential Geographic Information System (GIS). The remainder of this section shows the type of difficulties which were encountered and highlights the range of problems which were met.

Various agencies and individuals have drawn up what are specifically designed to be clear and concise guidelines on procedures to follow in the adoption of computing technology (e.g., the UNESCO guidelines, 1984 for GIS in particular and the factors which Eres outlines in her 1981 paper for information technology in general). The problem which the adoption of these two systems produced in the context of case 1. was that the UNESCO guidelines required a degree of understanding of technical factors involved in operation, running and output on the part of the potential users (and the researchers) which was not realistic given the complex and diverse nature of the systems and the state of rapid development of the technology. In the case of the Eres list of factors, these required a social survey of the area and looked to produce a political-economy type analysis of the issue of technology adoption. Like many consultancies before us we found that we did not have the time or resources to be so full in our approach, nor did we feel in this case (and by implication in many others) that this type of analysis was necessary. It appears to rest on an assumption that technology will generally radiate negative effects on the surrounding user community and that, therefore, the forces and effects of this development should be understood prior to installation. The assumption was thought to be more relevant in more remote areas with little or no previous experience of computing. We did, however, wish to make as full an analysis as possible (not wishing to fall foul of the "piecemeal approach" problems which Sprague has outlined) and, therefore, made efforts to include as many specifically 'local' factors as possible. What we needed was a set of theoretical guidelines for systems analysis which would meet our requirements for understanding the technology on the one hand and the constraints in the local environment on the other. In the following review of the DataPro system we will compare theoretical guidelines with working practice and draw on the experience of case 1 and 2 to outline problems which were encountered in using the method.

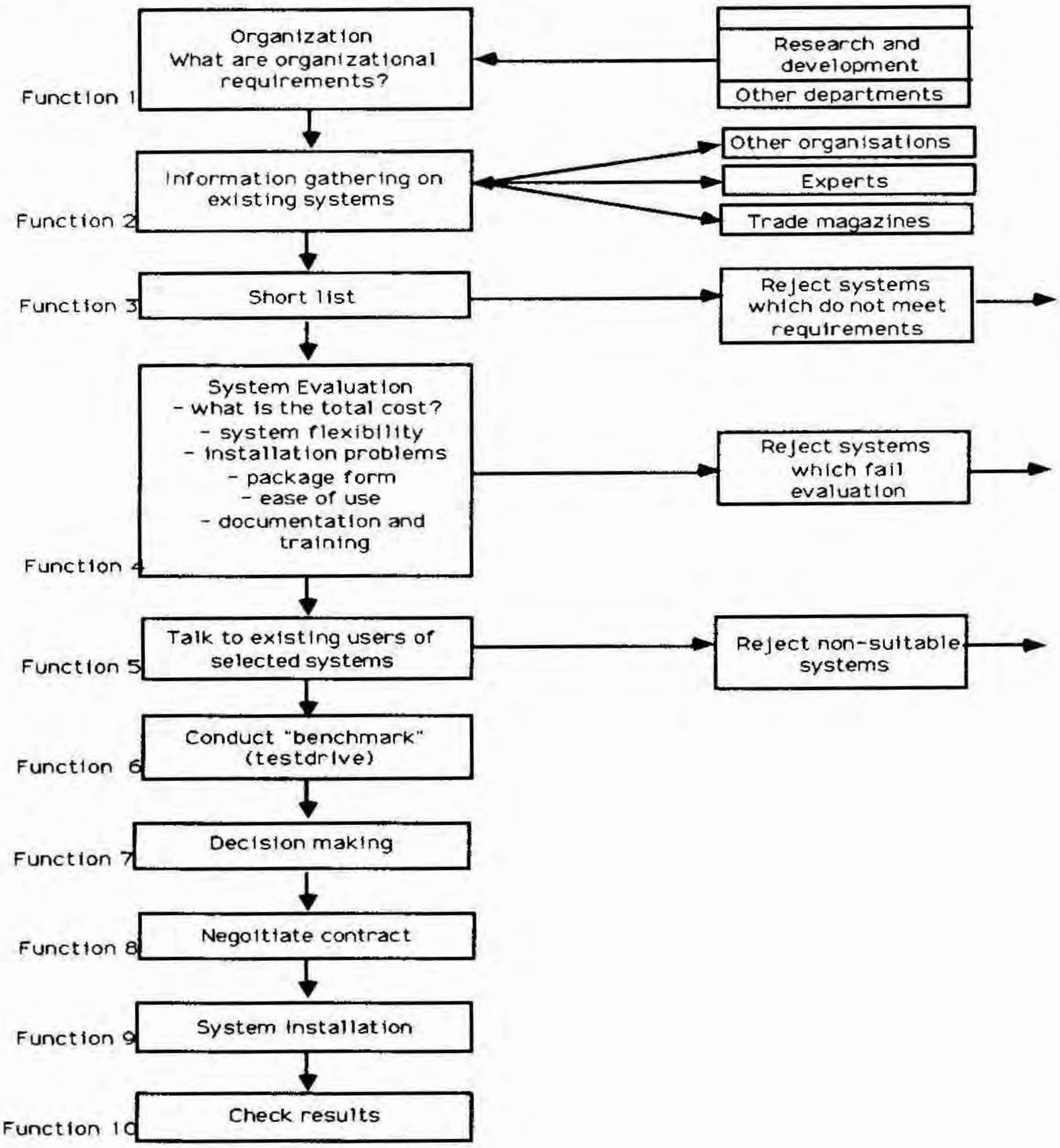
(Note: Although the DataPro guidelines are specifically intended for software selection only, we attempted to adapt them to cover the entire range of elements which comprise a computing system). The DataPro system argues that there are essentially ten logical steps to selecting software for any given system (be it micro, mini or mainframe) these are as follows:

- Determine the requirements.
- Gather information on existing systems.
- Draw up a short list.
- Perform a detailed evaluation.
- Review previous users experience.
- Conduct benchmark (i.e., test drive short listed systems).

- Make final decision.
- Negotiate contract - look into support considerations, consider software and hardware warranties, consider maintenance support.
- Install the package.
- Check the results.

(These factors have been represented diagrammatically in figure 1.) In the following we will look at how each of these steps can be adapted to guide decision making not only in terms of an environment where the only real constraint on acquisition is financial (as is the case in most of Europe and the USA), but also with the problems and constraints arising in developing countries.

Figure 1 Computing Systems Selection



4. RESULTS OF USING THE METHODOLOGY

4.1. Factor 1 Determine the Requirements

A systems analysis of computer requirements in the relatively sophisticated environment of western society requires the analyst to understand the often poorly presented range of operations and limiting factors which are perceived by the client as being of primary importance

and to integrate these into a model of what is technically possible. The same procedure in remote environments (in terms of access to hardware, software, maintenance, etc) raises a range of problems which call into question some assumptions which underlie the above. The major assumption is that the host organisation is going to have a clearly defined idea of where the computer is to go and what it is thought it will do.

Firstly "what does it have to do?". There may be some difficulty with this as there is often a knowledge gap between users of existing systems which are to be replaced and the capacity of computers to undertake and alter the work. There may well be a problem in determining the range of functions which are to be performed. Often there is a need to pre-judge the nature of the take, or to be able to stimulate interest by showing what is available in other organisations of a comparable stature. Computing personnel may believe that computers are now a well-known phenomena, and that if a user is expert at their own job they will automatically appreciate the nature of packages which are able to perform specific jobs, relevant to that user. This seems very often not to be the case.

Secondly, we need to consider the following factors:

- Function definition
- Volume determination
- Future requirements

A computer brings with it the capacity to make changes in the way in which jobs are done. A computer brought into any given work environment will tend not only to perform operations as specified in the original brief, but also change existing work relationships and practices. In the first case the staff responses to the section of the questionnaire which dealt with the proposed use of the system were very general and lacking in detail. They ranged from analysis of satellite imagery to plotting statistical graphics. Even following a technical briefing on the potentialities of GIS it was thought that the idea of what the system might do was not clearly understood by most of those who stood to make most use of it. We had attempted to improve understanding an to instigate a discussion but still found the response to the system's capabilities to be poor. This could in part be because the possibilities raised by the computer systems were themselves vague at this early stage and partly because individuals were unwilling to face the full implications of what a system would mean in terms of changed work practices. It was therefore impossible to express clearly how great the volume of usage would be. Possible future requirements were again not given in any detail. The computer system would so revolutionise the way that work is done at present (assuming that the system receives heavy usage in the first place, this is not guaranteed) it is not possible to state clearly what ideas (if any) users have for the future. The key issue arising from this factor is that individuals were not enthusiastic about the capabilities of the new system. The key factors identified as causing this were:

- Lack of time to grasp the system's capabilities.
- Inadequate internal consultation.
- Content with current practice.

The point should be made that a computer system is not just a matter of new technology replacing obviously outmoded equipment. There is a wealth of information available to scientists at all levels without the need to generate still more. The new system is often seen as being just another way to create and/or reproduce clutter. In contrast to the response from case 1, there was a much greater level of understanding in case 2. The system we were discussing was micro-based, but even so, both in both case 1 and case 2 we were suggesting computerisation of functions to existing subject experts. In case 2 the response was positive and detailed, in case 1 it was reluctant and hazy. To the researcher it appeared that at least part of the reason for the positive response from case 2 was that potential users were given initial information about the types of system being offered and that the systems being offered were fairly small-scale and non-intimidating.

From this stage we concluded that it was very much part of the ongoing research to feed

information back to the users. By providing a formalised user feedback facility the developing understanding of the local user community to new systems would be related more precisely in the system being planned. By this means we would hope to improve current awareness of what is and what is not possible to the community and improve what we might call the "community/electronic information system interface" ie, the grey area between systems potential and user understanding.

4.2. Factor 2 Gather Information Concerning Packages

In the first case it was found to be very hard indeed to restrict our search to anything like a specific set of requirements. As a result our search has to be as wide as possible. The first major problem which arose was in discovering the major producers of such systems and then determining the real capabilities of each system. At the time of research GIS were and still are a very new and fairly experimental area of computing. There are a number of organisations which offer partial systems which appear to provide some compatibility (the main division in simple terms being between systems which are based on image analysis and those which are based on map analysis) but which are not GIS proper.

There are some organisations which claim to offer GIS, but on closer inspection it was found that the term was used fairly loosely to describe any number of very different systems. This again seems to be a problem with the general area of computing. Terminology is often not clearly defined. Because most of the systems on offer are new and some are relatively un-tested there is little practical evidence on which to base a sound evaluation. Eventually we decided to keep our review as wide as possible. This would inevitably lead to wide coverage but by the same measure we felt this would also lead to as comprehensive a listing as possible. It was hoped that Factor 3 would assist us in reducing the list of possibilities. In the second case the range of options was much better understood and the possible alternatives restricted to a negligible number

4.3. Factor 3 The Short List

In the first case it was not a simple task of looking at a system and seeing if it filled a single (or even multiple) function. This idea works well if the system being planned is to conduct a well-defined series of tasks (eg, accounting and ledger work). The problem with our requirements was the multiple nature of the proposed tasks, each of which contain multiple functions. When we had taken this into account we decided that Factor 3 was only appropriate to the project in so far as it eliminated items which were *obviously* unable to perform the required tasks. We decided that we should look not only at total GIS (that is fully integrated packages) but also at a range of partial systems which might not answer all the needs of the organisation, and might not be able to plug directly into other systems, but which would be able to perform given functions and produce output which could then be re-interpreted into a form which other elements of the system could use. Our experience of the image analysis software and hardware in particular led us to believe that such re-interpretation was possible.

4.4. Factor 4 Detailed Evaluation of Packages

This was found to be largely not appropriate to the first case at this stage. We had not been able to shorten our short list of the point where it was possible to start asking detailed questions concerning possible installation. The types of system which we were looking at were based in the UK, Australia and the USA. This in itself was a fairly severe barrier to the free flow of information. We had to content ourselves with a curtailed evaluation which could then be fed back to the original user group to provide further information for them in terms of their developing understanding of their needs. To this end we attempted to discover:

> What are the hardware constraints of the system? What kind of machines will support the package?
>
> What are the software constraints? How much memory does it need, how easy is it to use?

What are the current uses to which each particular system is being put?

We gathered this information for about fifteen different systems, the aim being to keep the information in a non-specialised form which would be easy for potential users of the systems to understand. We saw this as being a necessary pre-requisite to the users being able to specify what it was that they wanted in the first place.

4.5. Factor 5 Talk to current Users

On the whole this factor was thought to be very useful. However, it runs into problems when the packages which are being tested are very new and experimental. There are quite often non-general problems which arise in specific locations and non-transferable solutions to these problems. In situations where information on specific technical issues is often very hard to come by (which is the situation in many DCs) it is often not possible to get this type of detailed information. However if the technology is widely understood (for example as in the second case e.g., micro-computer software and hardware concerned with standard database and spreadsheet facilities), and the environmental constraints have been mapped out in Factors 1 2 and 4, communication with existing users can often provide the essential fine-tuning which will lead to a specific package being chosen or discarded in favour of something else.

We did gain some useful information from users of existing systems but found:

- most present users were defensive.
- unable to contact users of all systems.
- unable (due to 2) to form objective criteria whereby all feedback could be evaluated.

4.6. Factor 6 Conduct the Benchmark (test drive the system)

It is *always* preferable to conduct the benchmark in the location where the system is going to run. However, it is often costly running a bench test. If the site for location is remote then few suppliers will willingly enter into this type of arrangement free of charge. The agency which wishes to test the system will also often incur costs (e.g,. the installation charge).

It will often be the case that this stage is not feasible and that Factor 5 will have to suffice. An alternative which was proposed in the first case was to take sample data sets to present users' sites, buy time on their machines and run the trial data sets. This raises other issues which have to be taken into account e.g.:

The user is not testing the *institutional factors* which may affect successful adoption e.g.,

- quality of in-house technical expertise
- quality of in-house environment
- quality of operator experience
- the isolation factor (being remote from manufacturer)
- user procedural ignorance in application.

The local environments are not being tested e.g.,
- climatic
- economic
- socio-cultural (common language forms, etc).

The eventual recipient users are not being given the chance to add their evaluation.

4.7. Factor 7 and 8 Decision Making and System Purchase

It should be kept in mind that items of cost and contract can alter the purchasing decision. A less than perfect system offering water-tight security will often be preferable to "ideal" systems

with poor contractual support. Organisational requirements should be re-evaluated in the ligh of the final agreement.

4.8. Factor 9 and 10 Installation and Results

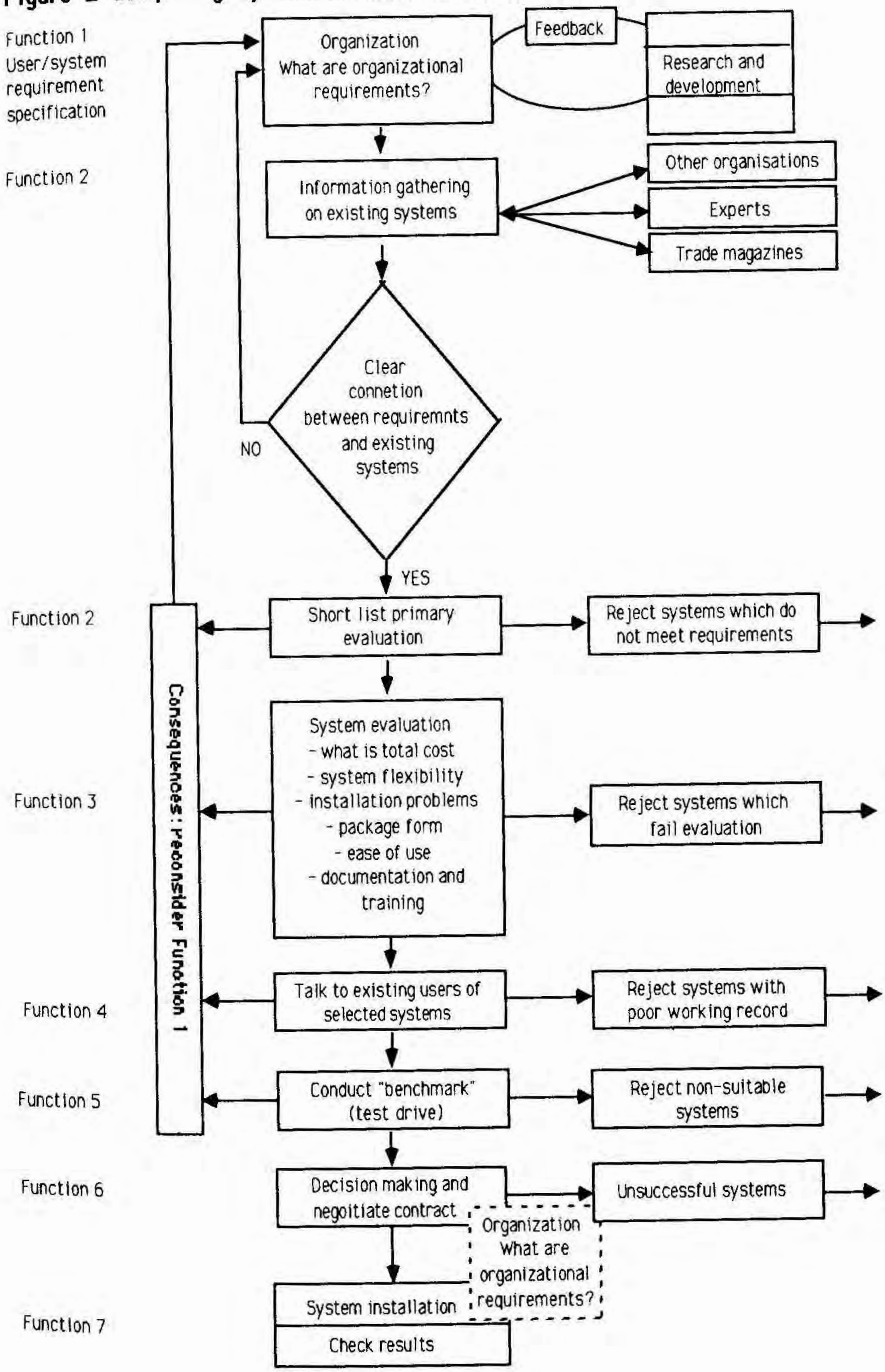
Problems which arise after installation in DCs indicate that previous stages have not beer efficiently carried out. In the same vein we feel that checking the results is generally a essential element of the procedure but that it is too late at this stage to alter decisions (unless very friendly contract has been negotiated or the package is not working at all). The results o stages 9 and 10 are not useful to the immediate purchaser of a package at the time of purchas although they may well be useful when other new systems are being planned. Monitoring an documenting system installation is essential if the benefits which arise from feedback fron current practice are to be taken into account in future planning.

5. MODIFICATIONS TO THE METHODOLOGY

Following on from this analysis of the weaknesses of adopting a standard approach to system analysis in DCs we wished to modify the initial set of procedures to reflect a more realisti approach which although not setting out to be definitive, might well lead to less errors and greater possibility of final system success (see figure 2).

Generally the DataPro approach was useful and has a lot to offer in circumstances of low-leve or standard technology adoption (eg, in general the guidelines might work in the second case but we thought that it could be better adapted to needs in DCs where, as has been see elsewher very specific constraints are in operation. In particular it seemed that more feedback is neede for users. Figure 2 demonstrates that:

Figure 2 Computing Systems Selection: Adapted Model



5.1

Functions 1 and 2 can very often be combined into a general user/system requirement specification. When a particular computer system is specified as being desirable there should be a series of meetings at which users are given details of existing systems and are allowed to re-evaluate their requirements. This will benefit further research in three ways:-

- Users will know more of what is and what is not possible.
- Researchers will know more clearly what users are looking for.
- It should be easier to specify function 2.

This demonstrates increased concern for adapting systems to users rather than users to systems. As we have seen throughout this thesis there is a tendency among information and IT suppliers that "we know best". Technically speaking this is usually true but in terms of the local environment the user is the expert.

5.2.

Functions 2, 3, 4, 5 should be provided with feedback loops allowing re-evaluation of Factor 1 in the light of findings. It is too easy to accept solutions and ignore user-defined priorities. On the technical assessment side first case confirmed that it should not be assumed that only one system should receive a benchmark test. It may well be that researchers are unable to provide a short list of one system. In these cases it might be necessary to run shortened benchmark tests on a number of systems. A point worth making explicit is that users should be consulted on the type of material to be used in dry runs. In this way the system will be made to carry out tasks which are actually relevant to daily practice.

5.3.

Function 6 should occur with an explicit re-appraisal of the previous stages, as shown by the broken lined box. It should never be a decision made in isolation on an assumption that the only adequate system is the one that is chosen for this stage. In so far as feedback throughout has been maintained than the final re-appraisal is less important but, even so, initial aims and requirements when reviewed might indicate overlooked points.

5.4.

Finally, Function 7 indicates that systems should be monitored right into installation and beyond if possible. It is only when the system is actually working that the real problems of day-to-day use will arise [42]. This information could be stored and used in later transactions. This will produce a file of material on the kinds of problems which arise when adopting computer technology and, if widely distributed, will be helpful in revealing the types of institutional lessons which can be learned.

6. GREATER FLEXIBILITY: THE WEB AND MULTIVIEW

Selecting, evaluating and installing computing systems for DCs produces a set of problems which are not always catered for in standard evaluation practices.

It is possible to improve upon these standard practices without making the procedure so lengthy so as to be impractical within limited budgets.

The assumption which we make is that users do not normally know precisely what they want and that systems analysts and manufacturers documentation will not always provide simple answers even where needs can be clearly defined.

There is a need for users to be drawn further into the procurement process and this can be accomplished by developing useful feedback between the researcher and the users. Feedback

should be regular throughout system selection and could be in the form of reports from the research team giving:

- Details of the types of system being reviewed.
- The results of evaluation.
- The responses from present users of suggested systems.
- The results of benchmark tests.
- Testing the most appropriate systems.

There is now a further development within methodological construction which encompasses some of the criticisms of the DataPro type outline. As we have already noted there has been a tendency in the past for the designers of methodologies to be focused on technology and to see systems as static, un-integrated and largely absent of people! Tables 2 and 3, adapted from Kling and Scacchi begin the work of getting the social forces behind technology in perspective. The models are still very "neat" and "functional" but we begin to see the web of forces interacting behind apparent technical "solutions". So what is new here? in the early sections of this paper we discussed this type of "total" model with regards the work of Eres. This we dismissed as being impractical and un-workable in the field. The web model however can be used as a foundation for guidelines to take into account:-

> "... the social, factors external to the formal and social organisation, the interaction of all resources involved in the system, internal as well as external, and the historical background that prepares the stage." [40].

Four Theoretical Perspectives To Examine Social Life

Perspective	*Assumptions*
Formal-Rational	Interested in formal goals, formal procedures; problems are solved through decomposition into its components.
Structural (cybernetic)	Organisations are composed of different task groups, connected by communication channels; procedures are established to offset limited cognitive capability of individuals.
Interactionist (political)	Organisations are composed of groups, with isolated and possibly conflicting views. Negotiation governs the activities between the groups.
Organisational Politics	Organisations are groups with different degrees of power, different interests and shifting alliances Resource control is an important issue.

Table 1 (adapted from Kling and Scacchi)

Comparative Assumptions

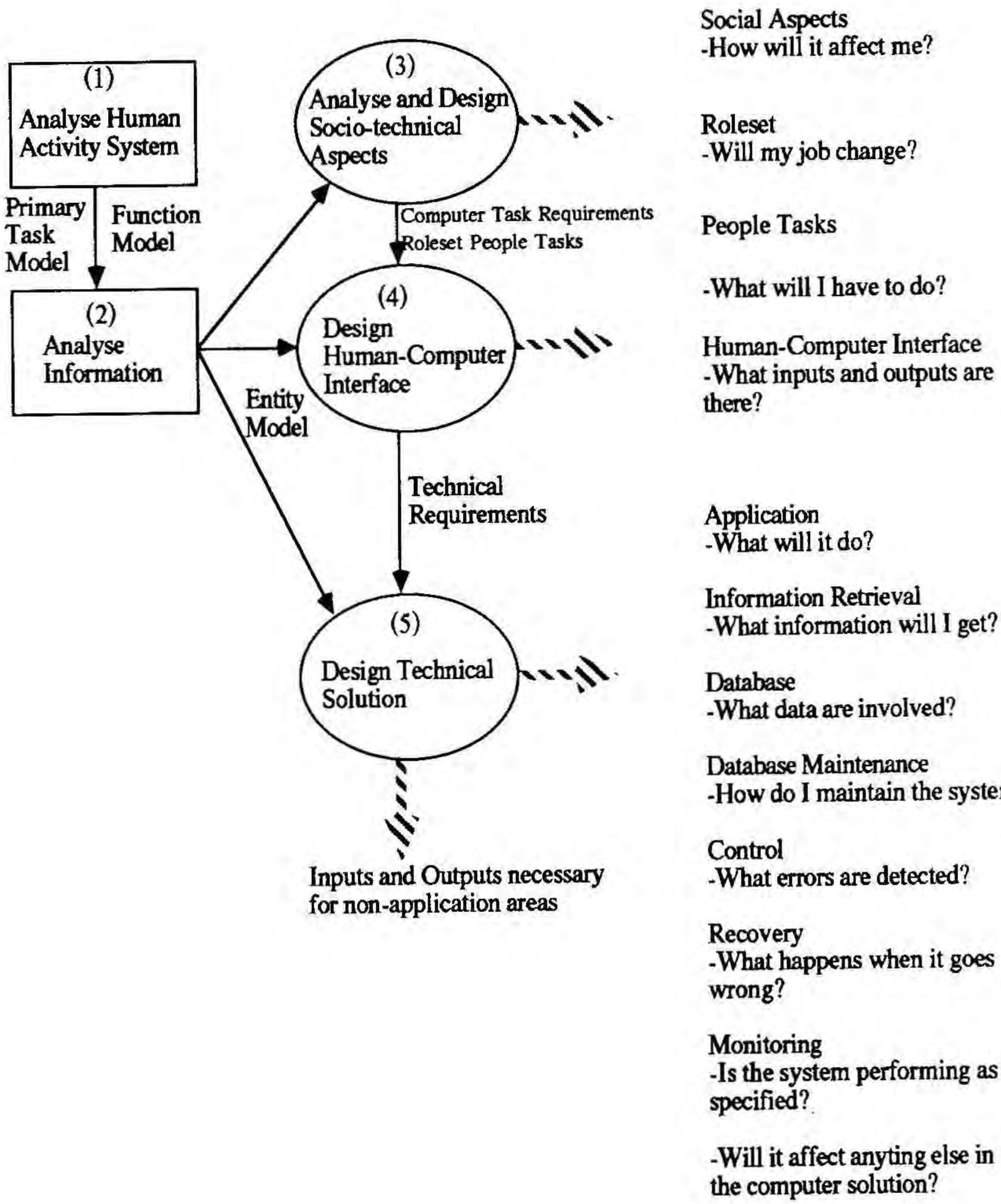
Discrete-Entity v. Web Model

Category	Discrete-Entity	Web Model
Computing Resource	Equipment, application technique with information processing capability, and socially neutral.	The resource or is an specific ensemble of pieces,which can not be completely described separately. Also highly charged with meaning in the social context.
Infrastructure	The human resource is separable from the technical resource. Neutral.	The human resource is NOT separable from the technical resource. NOT neutral.
Control Over Infrastructure	The infrastructure can both supply and support any conceived developments and usage.	The infrastructure can support only a limited number of projects.
Interactions	The computing resource is analysable independent of other computing resources and the social environment.	The computing resource NOT analysable independ-ent of other computing resources and the social environment.
Social Action	Organisations are analysed through formal descriptions and roles. The computing resource is studied through its formal purpose/function.	Formal descriptions are inadequate for describing true boundaries of organisation which are affected by political interest and volatile situations.

Table 2 (adapted from Kling)

Leading from this insight the Multiview methodology attempts to operationalise it. Figure 3 demonstrates the overview of this methodology. The five stages are designed to interact within or out of sequence. The focus is on the user and no simple assumptions are made as to the environment into which the in-coming system will reside.

Figure 3
The multiview Methodology



Stage 1 here the socio-cultural context in which any information system must survive is studied and brought into perspective.

In Stage 2 the process of information analysis occurs. In this process the main functions for the 'information system' are abstracted and linked to the things or entities which we need to hold information about.

Stage 3 encourages users and system designers to interact. The participation in the design

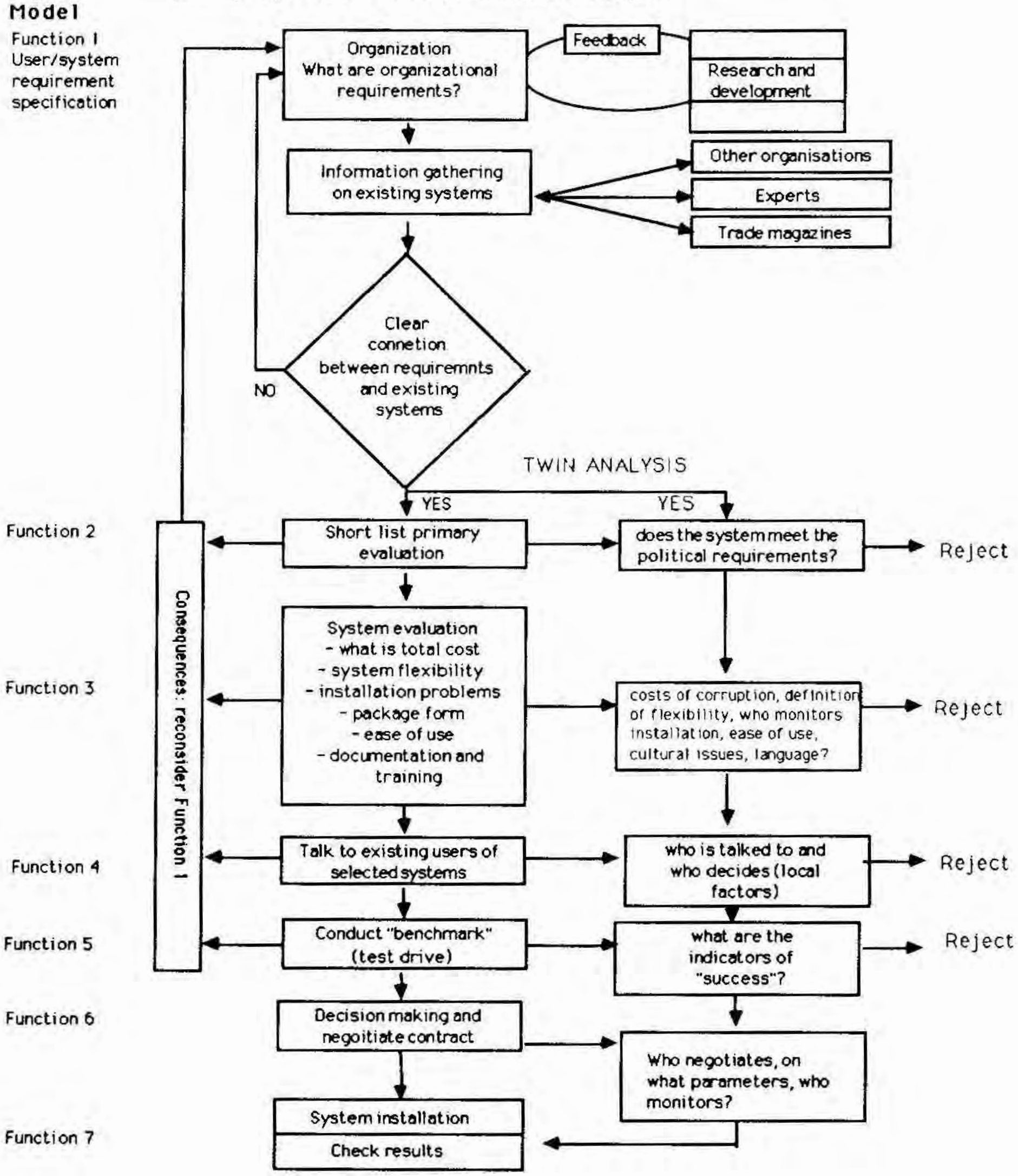
process should encourage "an optimal or acceptable fit between the social objectives and the technical objectives" [40].

Stage 4 really deals with the ergonomics of the computer solution. Here the problems which technical options impose on the human participants can be considered.

Finally, stage 5, the imposition of a technical solution occurs within the bounds set out by all previous stages.

As a methodology Multiview encourages the analyst to cover all the socio, politico/cultural aspects as developed in our adapted DataPro model (Figure 2) but encourages a non-linear approach to analysis. In a sense we still need to hold onto the DataPro checklist as adapted in Figure 2 and further developed in Figure 4. Multiview does not prescribe the limits of our analysis, rather it sets a context in which meaningful analysis can take place.

Figure 4 Computing Systems Selection: Second Adapted Model



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IMPLEMENTING INFORMATION SYSTEMS IN DEVELOPING COUNTRIES: ORGANIZATIONAL AND CULTURAL CONSIDERATIONS

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Multinational corporations (MNCs) face a number of potential obstacles in their efforts to implement computer-based information systems in developing countries. The lower level of technical sophistication manifest in most developing countries is one obstacle, but not necessarily the most important. Cultural barriers to implementation present more difficult problems because they provide the social context within which information systems are interpreted and given meaning. This paper describes one MNC's efforts to implement an automated accounting system in two of its Latin American subsidiaries. Problems experienced in one country led the company to adjust its implementation strategy by involving members of the company's international division in a redesign effort. Subsequent efforts to implement the same system in the second country succeeded easily due to the management of the implementation process.

1. INTRODUCTION

Technology is rightfully recognized as an important ingredient in the economic development of a country. Paradoxically, however, successful adoption and use of technology is dependent on the existence of a technological infrastructure in a developing country. Jones [7] regarded a country's capacity to exploit modern technology as dependent on the number of trained scientists and technicians available. Effective use of imported technology requires an understanding of how such technology may be put to use and improved. Where an enterprise has qualified manpower, the imported technologies will be quickly put to full use and will generate new ideas and further improvements. Where such an infrastructure is not available, resistance to new technologies may retard ultimate development.

The national policies of developing countries often encourage importing appropriate technology as the basis for establishing the country's own scientific and technological capabilities. For example, The National Committee on Science and technology in India [9] concluded:

> "It is imperative that a developing country should have an indigenous science and technology capacity of its own.... Furthermore, the terms and conditions under which foreign technology is available to a recipient country depend upon its own scientific and technological capacity. In the real world, the bargaining power of a country in the international technology market is directly related to the extent of its indigenous capability in science and technology."

The transfer of most commercial technology is accomplished through multinational corporations (MNCs). MNCs aid economic development directly through the import of technology, and economic development in turn has cultural and socioeconomic ramifications [5]. MNCs often experience difficulty in the implementation of new technologies, including computer-based information systems, into their subsidiaries in those countries. The management of the implementation process must carefully consider the technological readiness of the new site and the social and political factors affecting implementation.

This paper reports the efforts of a MNC in the transportation industry to automate certain accounting functions and to transfer this information technology to two developing countries in Latin America. The results indicate that social factors and technological "readiness" both affect the success of implementing information technology, but that social factors are more important. Specifically, social factors relevant to the organization and management of the implementation process, rather than national culture, are most relevant.

2. TECHNOLOGY TRANSFER AND SOCIAL CONTEXT

Technology transfer, in this paper, is considered the application of technology to a new use or user. Appropriate technology transfer depends on both the country's technological and scientific capabilities, and the economic and socio-cultural context into which the chosen technology will be integrated [6]. Considerable research has been devoted to the measurement of a country's technological capability and its capacity to absorb and assimilate new technology. For example, Gousty, Pigeyre, and Thieblemont [3] proposed a method for evaluating the capacity of a developing country to absorb and assimilate foreign technology. Haq [4] has also presented a method to measure the technological capability of a country. However, the literature on the technical, developmental, economic, and political aspects of technology transfer (contractor and Sagafi-Nejad, 1981) contains few articles that deal specifically with the implementation issues.

A number of socio-cultural factors may impede or enhance the implementation process. These may include language, cultural attitudes toward speed and time, the protection of cultural identity, the meaning of authority. People may resist new technology because it brings about many social changes, creating new social gaps and class structures. Fear of the unknown and the more practical possibility of losing one's job are two potentially important reasons for resisting new technology.

For the implementation process to be successful, the managers in developing countries must understand and analyze these factors before the process of implementation begins. Gee [2] has pointed out that in order for the implementation of new technology to be effective, managers must be sensitive to the environment, understand the users' needs, communicate effectively, identify individuals committed to expediting the new technology, and generate organization-wide support for the particular new technology.

Related research on the implementation of operations research/management science techniques in developing countries supports the importance of socio-cultural factors to implementation success. Vertinsky [11,12] examined the diffusion of management science in Colombia, South America by focusing on the process of legitimizing new approaches to analyzing problems in traditional cultures. In later work, Vertinsky, Barth, and Mitchell [13] treated implementation as a process of social change, shifting their focus to the social dynamics of introducing technical changes into organizations. They concluded (1) that technical solutions often mobilize counter forces aimed at reversing significant social changes, (2) changes in management approaches generate conflict between management styles, and (3) management's quantitative aptitude increases the likelihood of successful technical change.

Studies of implementation should also recognize that technology is received differently in different cultural settings because it carries different social meanings in different settings. Culture, at either the national or organizational level, has become a useful construct to explain the meaning of technology and other artifacts (Robey, 1988). Since cultural meaning is part of an emergent process of organizational change (Markus and Robey, 1988), the same technology may have different social consequences in different social settings. The implementation and consequences of information technology, therefore, are best explained by tracing the history of technology development and implementation. The case study remains the most viable research method for tracing these processes.

3. CASE STUDY

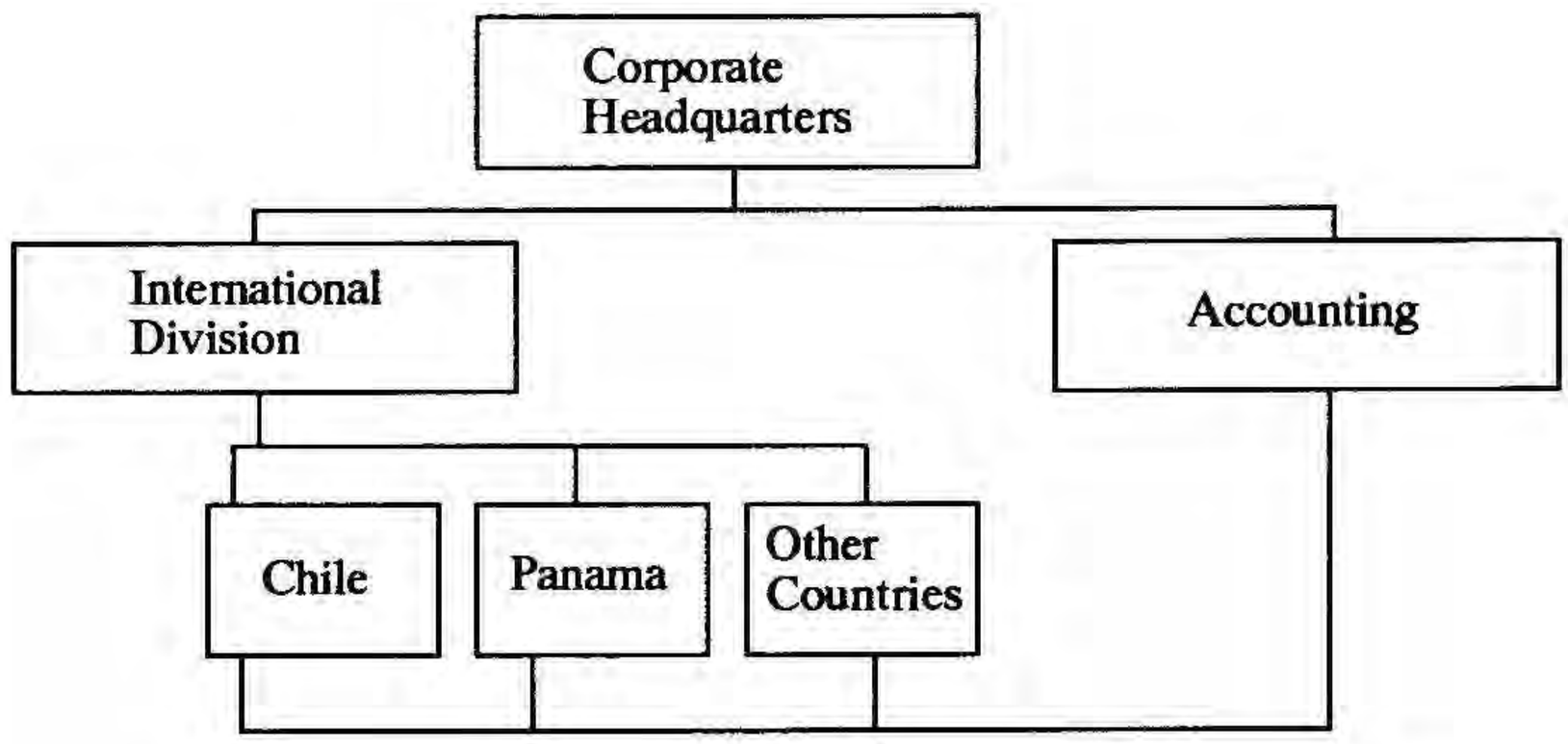
3.1. Corporate Setting

The corporation described in this paper is a major U.S. airline company, operating subsidiary sales offices in various parts of the world. With deregulation of the U.S. airline industry, the company exerienced severe financial problems due to competition from newer, low-cost carriers. With a mature work force of both pilots and flight attendants, the company found it difficult to cut its labor costs to remain competitive. The role of computer-based information systems in reducing costs was important in this environment.

The company operated nine subsidiaries in Latin America, each located in a city on the airline's route system. Figure 1 shows the relationships among corporate headquarters, corporate accounting, the international division, and the Latin American subsidiaries. The function of the international division was to exercise financial control over sales offices.

Figure 1

Partial Organizational Chart of the Airline
and its Latin American Subsidiaries



Before automation of the sales offices, passenger coupons were collected by each subsidiary and mailed to the corporate accounting office in the U.S. to be entered into a centralized accounting system. Reports on the performance of each office were routed back through the international division and on to the subsidiary's management. Local managers typically enjoyed high status within their countries, which enabled them to interact frequently with financial and governmental figures in those countries. As in many developing countries, these relationships were important in conducting daily business.

3.2. Objectives of the Automation Project

Several problems experienced by the airline led to a proposal to automate the processing of sales data in the subsidiaries' accounting offices. First, the corporation was attempting to integrate the accounting functions of its newly acquired international operations with the established corporate accounting practices. An automated accounting system would provide consistency in the reporting methods of the South American subsidiaries by imposing common data formats on tapes sent to corporate headquarters.

Second, the cost of data entry would be reduced by redistributing the operation to locations in Latin America with lower labor costs. Data entry in the U.S. was much more costly, especially when the fringe benefits of U.S. workers were taken into account. The individuals in corporate

accounting who were currently responsible for processing the data from the South American stations could be either eliminated by attrition or reassigned to perform other tasks.

Third, local management would receive more timely information for making decisions. A computer-based system would also assist them by providing electronic spreadsheets, word processing, and other office automation products.

The project was approved in early 1984 on a one-year payback criterion, which was necessary during this period due to the ongoing financial problems of the airline. Corporate management believed the savings gained from reduction of personnel alone would provide the necessary cost justification. The additional benefits gained from utilizing a common, corporate-wide accounting practice and assisting local management were considered "icing on the cake."

3.3. System Design and Development

System development consisted of writing programs to allow the local clerical staff to record sales and make journal entries. Data were to be entered by operators at the terminal, keying in the data as they read the passenger coupons. The system prompted input, signaled errors, and prompted corrections that were detected. Data input would be controlled by a system of tables that validated input and controlled important items such as exchange rates, customer account numbers, and so on. History files would be updated each day, and weekly tapes would be generated and sent to corporate headquarters. The new system's outputs would have to match the formats expected by the host corporate computer.

Hardware for the local system consisted of a Motorola 68020 based Unix operating system capable of supporting up to eight CRT terminals and two line printers per device. Storage consisted of 80 megabytes of direct access disk storage and unlimited offline tape capacity. Application programs were written in COBOL and in C. The system contained some dial-up communications, used mainly in supporting trouble-shooting efforts directed from corporate headquarters in the U.S.

The project was initiated in March, 1984 by the corporate accounting department. The accountants viewed the system as their own because they had the responsibility for receiving and entering the data for the South American countries. The historical relationship between corporate accounting and the subsidiaries was abrasive. Corporate accounting thought they had all the information and authority necessary to make any decision that had to do with implementing systems, and local management resented the fact that corporate headquarters imposed certain rulings on them without requesting their input. Corporate management was concerned with the immediate reduction of costs and was not really interested in obtaining input from the South American countries. The extent of the subsidiaries' involvement in the design stage was headquarters' circulation of a copy of the final design specifications with a request for input from local management. The inputs from local management, if ever provided, never found their way back to corporate management. Further, corporate accounting dealt directly with the local management without involving the assistance of the international division, which was the department formally in charge of South American operations.

Once the project was approved, the location for pilot implementation was considered. Corporate management selected the subsidiary located in Santiago, Chile because it had low enough volume to provide a safe test, but Chile also provided enough data to perform an adequate evaluation. Selection was made at corporate headquarters without soliciting input from the local management of any of the potential sites.

The system was developed by the corporate computer services department. The development schedule experienced minor setbacks due to a transfer and replacement of one member of the computer services staff. Acceptance testing was still underway a week before the scheduled implementation, and the first hands-on user testing in Chile had to occur approximately two weeks before implementation, and that testing could only last two days.

3.4. Implementation in Chile

3.4.1. Hardware shipping and installation

The transportation of the system hardware from the test area to the final destination took about 60 days, including the delays due to export requirements and customs clearance in Chile. The implementation schedule slipped by about two weeks due to missing or improper documentation required to remove the equipment from customs in Santiago. Had the paperwork not been readily available in the U.S. the schedule would have been severely delayed because the required paperwork usually took a few weeks to prepare. In order to expedite importation proceedings, the services of a customs broker were used in Santiago.

Once the equipment was cleared through customs and arrived at the office in Santiago, the boxes were stored in a room designated to house the new system. The manager responsible for the local accounting department ordered that the boxes and crates remained sealed and that access to the room was forbidden.

After its arrival, the computer services team set up the system unit, an expansion unit, a printer, and three terminals. While they were setting up the equipment, they overheard comments from some of the clerical workers expressing feelings of fear and concerns about the time required to learn this new machine. Some wondered whether they could avoid having to work on the machine. Since all these comments were spoken in Spanish, only one of the individuals on the implementation team (who was bilingual) understood what was being said.

After discussing the potential problem of operator resistance, the implementation team made a decision to remove the strict security associated with the computer room. The clerical staff was given a hands-on demonstration intended to relieve their anxieties. Some assurances were made regarding job security and the role of the machine in helping them and the company. After this brief introduction the atmosphere in the office seemed less anxious.

3.4.2. Selection and training of system administrators

The computer services team then turned to the selection and training of candidates for the job of system administrator. This supervisory position was required by the local management because this person would train the clerical staff in the operation of the system. Candidates were selected through a joint effort from all the parties involved, including local management, computer services, and corporate accounting. Three candidates were selected, each of whom currently supervised one of the three functional areas in the local accounting department. Each was respected by his or her peers and understood the current accounting procedures well.

The team's corporate accounting representative trained all three of the candidates on the new accounting procedures first; then the two computer services representatives trained them in the operation of the system. Because the new procedures changed the chart of accounts, all users would have to learn new account numbers for making journal and ledger entries. In addition, training was confused by the manager of the accounting department's discovery of several areas where new accounts had to be created in order to handle some intricacies of Chilean business.

The responsibility for these unexpected specifications belonged to both the local and corporate personnel. Local management had received copies of the new chart of accounts in advance but had not responded to corporate headquarters.

Headquarters had provided the chart of accounts and the accompanying documentation in English with no real effort to ensure that the local office understood the changes. While all of the candidates knew some English, their proficiency was quite low. The adjustments to the chart of accounts were handled by telephone conversations between the team and headquarters in the weeks that followed.

The system-related training was provided by the only team representative who was fluent in

both English and Spanish. He had developed part of the system application in the United States as a member of the corporate computer services department. The system-related functions also lacked Spanish-language manuals. The training progressed well considering that the individuals involved had never worked with a computer. The concepts in the English language manuals were all presented in Spanish by the trainer, who covered basic concepts such as temporary work files used during data entry, permanent work files, and history files.

Of the candidates being trained for the role of system administrator, one individual expressed interest far beyond that of the other two candidates. After a few training sessions the interest levels of the other two candidates fell to the point that the implementation team no longer considered them as candidates for the position. They remained in training to provide backup to the primary system administrator. Unfortunately, one of the dropouts was the choice of the manager of the local accounting department to become the system administrator.

Training of the system administrators continued with a detailed explanation of the data flow from the data entry screen to the point where it became part of the history files. The candidates were also trained on the physical functioning of the system (use of floppy diskettes, cartridge tapes, printers, and terminals) and on the data entry and report producing aspects of the clerical job. They were instructed on how to solve problems dealing with data entry, such as batches out of balance and incorrect entries, and other common data entry errors.

Final selection of the system administrator was the source of some conflict between local management and corporate accounting. In effect, the system administrator would become the data processing and accounting representative in the local country, reporting through a direct line to corporate, bypassing the local country's management structure. The system administrator would become responsible for the day to day operation of the system, supply system knowledge to local management, and serve as the corporate representative for the project. In addition, the system administrator would retain all responsibilities held prior to the conversion and perform all of these tasks for no additional compensation.

Creation of a role this influential was controversial, and the U.S. team and Chilean management disagreed on who was the best candidate. There was only one clearly qualified candidate from the implementation team's viewpoint, but this person was viewed as too independent by the local managers. Local management's favored choice was someone with more loyalty, but corporate viewed this person as too much of a "yes man." The corporate team won this contest and established their choice as system administrator over the opposition of the local managers.

3.4.3. Clerical training and testing

The training of the clerical staff also lacked Spanish-language manuals and was complicated by the new account numbers. Most of the clerical staff did not understand English at all. The terms shown on the data entry screens were in Spanish, but not in the local dialect.

The candidates for system administrator assisted in the training of the clerical staff in their respective areas. This allowed the computer services representatives to train advanced individuals from each group on their specific job functions, i.e., sales and accounts receivables. The sales processing portion was the most important from the corporate standpoint, because it would allow them to off-load the sales processing to the local management. The accounts receivables portion was the most important to the local management, because it would allow them to track their receivables more effectively.

Clerical training was conducted during regular office hours in addition to the normal work load and was not compensated with an increase in pay. The stress generated by such intense training produced exhaustion and lowered employee morale. During the training session many clerks feared losing their jobs if they did not complete their work.

Testing was performed in parallel with the current accounting system to validate the information produced from the new system. Testing took a toll on the local clerical staff, which had to process the same information through two separate systems. Parallel testing proceeded for two

months because of system problems and users' misunderstandings of the new accounting procedures. After the second month of parallel testing, the team was satisfied with the validity and integrity of the system and authorized the cut-over to the new system.

3.4.4. Evaluation and redesign

Soon after the cutover, the Chilean managers began to complain to the corporate accounting office about problems with the system. Similar complaints came to corporate accounting laterally through the international division, which had line control over the Latin American subsidiaries (see Figure 1). So far, the international division had not been involved with the project. However, its influence became apparent when a newly appointed director in corporate accounting, whose specific responsibility was to run the South American accounting operation, suggested a new look at the system in Santiago. The vice president of the international division had taken the opportunity to discuss the Chilean problem with the vice president of corporate accounting, exerting pressure on them to "accept help" in getting the system to work better. The essence of the international vice president's message was that accounting lacked the necessary finesse in dealing with local managements in South America.

Based on this advice, corporate accounting took a closer look at the system with thoughts of redesign. Specifically, the system's procedure for making journal entries was much too cumbersome. A streamlined solution was sought that allowed the user to make the same number of entries per screen but to retain the cross-reference necessary to meet both the reporting requirements of corporate headquarters and the Chilean government. The initial design had underestimated the incompatibility between these conflicting reporting requirements.

Redesign efforts lasted from December, 1984 until June, 1985. The international division was given the role to coordinate the relations between corporate accounting and the local management, becoming the primary mediator between them. In an effort to increase the involvement of the Chilean management, the international division proposed that the manager from Chile go to the U.S. and become the representative for all the other Latin American countries for the duration of the redesign process. Several conferences were held that allowed teams from specific countries to understand the new system of accounting procedures that they would soon have to use. These managers also visited Santiago for an on-line demonstration of the system. At each demonstration a U.S. computer services representative participated actively.

Once the redesigned system was accepted by all the parties involved, the development effort commenced at an accelerated pace for another six months. When the redesigned system went into final test in Chile, it was a custom tailored product, complete with full documentation on system and accounting procedures in Spanish which the locals could understand.

3.4.5. Implementation in Panama

The decision to implement the system in a second South American accounting office was a very sensitive issue for corporate headquarters. Corporate accounting wished to continue the project, but the international division insisted that this implementation be free of the problems encountered in Chile. The computer services department in the U.S. agreed to provide the support necessary to bring Panama up on the system, including a pre-delivery site survey and "get acquainted" meeting with the local management and staff.

At this meeting the candidates for system administrator were selected. Selection was made jointly by the data processing department and the local manager. The data processing representatives provided the local manager with a set of qualifications needed for the system administrator position, and the local manager selected three primary candidates. The initial meeting gave local staff the opportunity to meet the implementation team and to receive copies of system documentation printed in both English and Spanish.

Whereas the team in Santiago consisted of one accounting representative and two data processing representatives, one of whom was bilingual, the team for Panama consisted of two

data processing representatives, the system administrator from Chile, and one Chilean clerk. All members of the Panama team were bilingual. No representative from the corporate accounting department participated on the Panama team.

The use of the Chilean system administrator and one member of the Chilean clerical staff in the Panama training sessions proved to be invaluable. These individuals were versed in the daily operation of the system and assisted the staff in Panama with many problems and questions. The data processing personnel conducted the formal training for the system administrators, but the two individuals with practical experience supplied real life examples.

In Chile local management had taken no active part in the training and had opposed the system completely. By contrast, the Panamanian management insisted on participating in every aspect of the training, both clerical and system-related. In Chile the staff's first reactions were anxiety and fear over losing employment; in Panama the initial surge of interest was so large that scheduling was necessary in order to accommodate everyone at a terminal for at least part of the day.

The training of the clerical staff and the system administrators was conducted simultaneously. This was possible because of the assistance from the Chilean clerk who performed a large portion of the clerical training. She showed the clerks how to prepare their work and familiarized them with the new accounting procedures, teaching shortcuts for associating the old account numbers with the new ones.

Parallel testing was performed to ensure that the data tapes sent to the U.S. could be accepted by the corporate host computer. Although the systems in Chile and Panama were identical in function, some of the unique accounting practices accepted by the Panamanian government had to be tested. The result of this parallel test was a fully debugged system except for the items that were considered country-dependent (about 20 percent of the system). Parallel testing lasted one month although the volume of data put through the system almost equaled the amount that Chile processed in its twomonth test.

The system went "live" two months after the initial visit. The system administrators were all of equal knowledge and interest, thereby eliminating the need to single out one individual as primary. The local clerical staff was very pleased with the system and the assistance they received from their Chilean counterparts. The local management was relieved to see the implementation go so well, especially after hearing about the problems in Chile. The international division, corporate accounting, and computer services all acknowledged each other's contributions. The only difficulty was the Chilean managers' objection to the use of their personnel for training in Panama. However, this objection was quickly removed by the international division in a formal public acknowledgement of the Chilean contribution to the successful implementation in Panama.

4. DISCUSSION

The case study presented here affords comparisons between two developing South American countries that experienced different degrees of success in implementing information technology. Obviously the implementation team learned from the problems in Chile and avoided most of them in Panama, implementing the system in far less time and with far greater acceptance. The reasons for this success cannot be traced to differences in the technology because each country implemented basically the same information system. Immediately, therefore, the case renders untenable arguments of a technological imperative. Rather, explanation of the differences between the two settings depends more upon the social context than upon technical differences.

Social context is often operationalized as national culture, and numerous studies of technology transfer have focused on the differences among national systems of beliefs, values, and social traditions. A comparison between Chile and Panama reveals some cultural and political differences, but not of the extent that would explain the drastic differences in implementation

outcomes between the two countries. It is more likely that the immediate, *organizational* cultures of the subsidiaries provided the context within which the meaning of the information system was interpreted. This level of culture focuses less on national issues and more on organizational issues such as job security, managerial power, and work efficiency.

Examining the reactions of the two subsidiaries in this light reveals a distinct contrast. In Chile the system was perceived as a threat to workers and to local management. Workers were concerned with job security from the outset, and managers perceived an erosion of their power base and possibly their stature in the local business community. These reactions were not due the inherent characteristics of the technology but rather to the actions taken by the corporate implementation team. The team did not involve the end users, they did not provide important manuals in Spanish, they bypassed the international division, and they overruled the local management's choice of system administrator. These actions sent the signal that the system was the property of corporate accounting and would be used to control Chilean operations. Obviously, local managers felt that they did not need such controls which were a threat to their normal ways of doing business.

In Panama, the system was eagerly accepted, but not because it was a better or more liberating system. Rather, the actions of the implementation team were adjusted to involve the international division, involve Panamanian management in early discussions and demonstrations, use Chilean clerical workers in the training, avoid the conflict over choosing one system administrator, and communicate in Spanish. The signal conveyed by these implementation tactics was that the system was a South American product. The role of the international division is particularly important in that the international division mediated the relationship between the U.S. team and the South American managers. Because the international division had the trust and respect of the local managers, it could play a credible role in facilitating the integration of the U.S. team into the business environment of Panama. The U.S. staff and the local managers were involved in social gatherings that the U.S. team initially regarded as unimportant and even inefficient. However, the team learned that social functions are an integral part of business in Latin America, and they ultimately benefitted from these activities.

While the case presented in this paper cannot be generalized beyond the specific settings described, it does illustrate a basic point about transferring technology to developing countries. Technology cannot be (and rarely is) just "dumped" into a country. Rather, technology is transferred via the actions of MNCs, whose implementation teams play a key role in the use and consequences of that technology. Through its actions, the implementation team sends signals that affect the meanings of the technology within the host country and organization. These meanings are not inherent in the technology itself; they can only be supplied by human actors. Implementation tactics, such as the printing of technical manuals in English, convey an important social message quite apart from the system's technical features. The result may drastically affect the success of the implementation effort.

The case illustrates that an intermediary such as an international division can aid in raising implementors' awareness of what their actions mean. An international division can also assume responsibility for part of the implementation process, if "only" by providing opportunities for technicians and managers to meet socially outside of the office. To the extent that such meetings enable more effective communication between implementors and local managers, they can be just as important as training, testing, or even fundamental design activities.

The implications for implementors are not simple and straightforward. It is not a simple matter to recommend user involvement, although clearly user involvement was instrumental in the success of the system in Panama. Rather, the main implication for implementors is to become aware of the role they play in creating social change. People whose primary training has been technical may find this role to be difficult. But because their actions are unavoidably interpreted within a national and organizational culture, implementors should try to understand that context and how their actions will be interpreted.

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INFORMATION SYSTEMS AS SOCIAL SYSTEMS: IMPLICATIONS FOR DEVELOPING COUNTRIES

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Computer-based information systems should be conceptualised as social systems in which technology is only one of the dimensions. This broader perspective on information systems offers opportunities for a deeper understanding of their development and use. The social systems approach is illustrated in the paper by two research projects in the UK on the evaluation of information systems and information systems strategy formation. The relevance of the UK research to a developing country context is discussed and it is argued that methodologies which aim to provide an understanding of the organisational, social and political context are highly suitable for organisations in developing countries. A case study of information systems strategy formation in a Kenyan bank is outlined. Some implications are drawn for research methodology, education and training and implementation of information systems in developing countries.

1. INTRODUCTION

Computer-based information systems are often taken to be technical systems and behavioral and organisational issues are relegated to a secondary role or are not considered at all. However, the problems of implementation of information systems are well known, and invariably they concern an interplay of human, organisational and technical factors which cannot be easily separated. In our view, this complex interlinking can best be addressed by conceptualising computer-based information systems as social systems in which technology is only one of the elements. This broader perspective on information systems offers opportunities for deeper understanding of the context for information systems development and implementation.

We will argue in this paper that the social systems paradigm for information systems results in methodologies and approaches which are applicable to different organisations, contexts and cultures. In particular, we believe that the paradigm is highly suitable for organisations in developing countries. The problems of information systems development and use are often more severe in developing countries in terms of factors such as the availability of suitable equipment and infrastructure, lack of financial resources, shortages of trained and experienced personnel, and constraints imposed by the social and political context. The social systems paradigm implies the need to understand such factors and, more generally, the organisational and national context within which information systems are to be implemented.

In the next section of the paper we provide justification for considering information systems as social systems, and a brief critique of alternative paradigms. This is followed by two examples of research on information systems in the UK based on the above paradigm. These examples concern the evaluation of information systems and the formation of information systems strategy. We next consider the relevance of this work in a developing country context and describe a recent case study on information systems strategy, which we have carried out in Kenya. The implications of our approach for information systems in developing countries are then discussed with respect to research methodology, education and training and IS practice. Finally, we give a brief summary of our main conclusions.

2. INFORMATION SYSTEMS AS SOCIAL SYSTEMS

Most work on information systems has focussed on the technology, basing itself on what Kling describes as discrete-entity models [8]. Computing resources are considered to be particular pieces of equipment, applications or techniques which provide specifiable information processing capabilities. The technology is a tool, socially neutral, with costs and skill requirements which are largely identifiable. Supporting infrastructure for the information system, both technical and administrative, is viewed as a neutral and ample resource over which the organisation has full control.

Allied to the discrete-entity model of information systems is the formalrational perspective on organisations, which views them as relatively well-defined machines, best described by formal objectives, procedures and administrative arrangements over which there is assumed to be consensus. This formal concept of organisations is normally linked to the model of economic rationality, with its emphasis on efficiency and effectiveness. Technology is seen as the critical resource and 'human factors' need only be considered where issues such as training, motivation and user acceptance arise.

Discrete-entity models and the formal-rational perspective are inadequate to explain the impacts of information systems in organisations. Discrete-entity models take no account of the social context in which the focal computing resource is used. This context includes the social relations between the set of participants who are concerned with the information system, such as the designers, managers and users of the system and the constraints and opportunities of the wider social and political environment. Infrastructural resources are not in unlimited supply and are not neutral in terms of their use. For example, when a resource is shared by several participants, service will often be differentially provided, and more powerful participants will receive better service. The history of previous commitments made in developing and operating computer-based technologies will have an effect on any new development or use of computing.

The formal-rational perspective is, likewise, too narrow a basis for understanding. The unitary view which attributes corporate goals to an organisation is incorrect - only the people who together constitute the organisation have goals, and a belief in a unique purpose takes no account of the plurality of stakeholder interests. 'Human factors' should not be perceived as an adjunct to technological issues but as central to the development and use of information systems in organisations. The importance of power and political actions in the information systems area has been described by a number of researchers [5,9].

The above critique of traditional approaches to information systems implies the need to view them in a broader social context. Hirschheim considers that 'information systems are not technical systems which have behavioral and social consequences, but are social systems which rely to an increasing extent on information technology for their function' [3]. Information systems development, equally, is a social process which involves the use of information technology as part of that process. We will now illustrate this view of information systems using two examples of research projects carried out on the basis of the social systems paradigm.

3. EXAMPLES FROM CURRENT RESEARCH

3.1 Evaluation of information systems

Some form of evaluation whether de facto or formal, is undertaken in any project to select and implement an information system. Formal post implementation evaluation is less common; when done, it is usually as part of an on-going development process. The evaluation method which is most widely used by practitioners is cost-benefit analysis. This approach relies on the quantification of all costs and benefits related to the project under consideration and their aggregation into a single figure which represents the project's worth. The aim of the approach is generally to choose a project for which the value of all the benefits less all the costs is a

maximum.

The first difficulty which arises with cost-benefit analysis is what limits one sets for the analysis. In theory, all costs and benefits should be included; in practice, this is often infeasible since the benefits, in particular, are highly uncertain, unforeseen and difficult to quantify meaningfully. A second problem with the method is the question of whose values to use in the analysis: the designers, managers and users of particular systems may all have rather different perceptions of value. A third difficulty concerns the numerical assignment of value to costs and benefits. Such numbers are not absolute or objective and the quantification process reflects the assumptions and beliefs of those people supplying the numbers. Further criticisms of cost-benefit analysis include its undue emphasis on financial criteria compared to social and political objectives, and the favoring of projects with a relatively quick return which can tend to be anti-innovatory and harmful to longer term interests.

The method of cost-benefit analysis is in the positivist tradition which assumes a single or unitary view of reality. As an exercise in 'rational management' it is linked to the formal-rational view of organisations which we have criticised earlier and, in its application to information systems, uses an approach based on the philosophy of discrete-entity models. Many of the benefits of information systems are of a qualitative and often intangible nature, and their quantification is highly subjective and uncertain. Cost-benefit analysis applied to information systems is a poverty-stricken framework, reliant on subjective judgments but incapable of handling them in a meaningful way, and making no attempt to understand the nature of evaluation. Evaluation is itself a social process with formal and informal elements and both overt and covert functions. A formal evaluation procedure normally has a hidden agenda; informal evaluation is usually dependent on contacts within and outside the organisation and subject to the power and influence of those involved.

A comprehensive information systems evaluation must thus be significantly broader in scope than methodologies such as cost-benefit analysis and other techniques in the positivist tradition. Information systems, we have argued, are social systems, and an analysis which treats them as distinct from their infrastructure and context will lose correspondingly in richness of understanding. By 'context' we signify not simply organisational context, but the macrostructures of the wider environment such as the economic and political climate and national technology policy. Historical, social and political issues may be of equal or greater importance than the technical and economic dimensions normally given first consideration. Research on social systems needs an interpretive methodology, one which aims at the analysis and description of human behavior by an understanding of the meanings individuals attach to their actions.

In our work on information systems evaluation, we are using an interpretivist approach which is based on the 'soft systems' methodology of Checkland and the 'web models' of Kling [1,7]. The soft systems approach developed by Checkland over a number of years does not prescribe specific tools and techniques but a general approach to the formulation of ill-structured problematic situations. Using 'human activity systems' as an intellectual construct, the methodology allows that any real-world purposeful activity can be described in many different ways within many different world-views or 'Weltanschauungen'. The conceptual models built can be compared with perceived reality as a means of gaining insight into problematic situations in the real world. In an interpretive case study investigating the evaluation of a word processing system carried out by two of the authors, the organising concepts of soft systems methodology proved useful in surfacing the diverse and sometimes conflicting perspectives of different individuals and interest groups.

The basic tenet of web models [7] is that a computer system is best conceptualised as an ensemble of equipment, applications and techniques with identifiable information processing capabilities. Each computing resource has costs and skill requirements which are only partially identifiable; in addition to its functional capabilities as an information processing tool it is a social object which may be highly charged with meaning. There is no especially separable 'human factor' for information systems: the development and routine operations of computer-based technologies hinge on many human judgments and actions, often influenced by political interests, structural constraints, and participants' definition of their situations. The network of

producers and consumers around the focal computing resource is termed the 'production lattice'; the interdependencies in this network form the 'web' from which the model derives its name. The production lattice is a social organisation which is itself embedded in a larger matrix of social and economic relations ('macrostuctures') and is dependent upon a local infrastructure. According to web models, these macrostructures and local infrastructures direct the kind of computer-based service available at each node of the production lattice, and since they evolve over time computing developments are shaped by a set of historical commitments. In short, web models view information systems as 'complex social objects constrained by their context, infrastructure and history' [7].

Our work on information systems evaluation [14] involves a series of in-depth case studies of the evaluation process in selected organisations. We are using web models to construct a rich picture of the information system, mapping its technical and social architecture, infrastructure, related social processes, and history. The perspectives emerging can be built into conceptual models of the evaluation process, each model 'owned' by an actor or group of actors with a particular 'world-view'. Comparison of these alternative models with real-world evaluation will enable a rich understanding of the evaluation process which we plan to translate into a descriptive framework and normative guidelines.

3.2 Information systems strategy formation

An information systems strategy aims to align information systems with business and organisational goals and, in the commercial context, seeks competitive advantage from information technology. This area has attracted increasing interest in recent years in the industrialised countries such as the USA and the UK and many approaches have been offered as to how to develop and carry out such a strategy. Much of this work is prescriptive and is concerned with the formulation of strategy through a conscious and explicit process. Mintzberg [10] noted from empirical evidence in organisations that strategy often does not arise from such a process but is better conceived of as a consistent pattern in the stream of decisions. He argued that strategy forms gradually, and sometimes unintentionally, and that the term strategy formation is more appropriate for this emergent process. In our work in this area we have been concerned with this descriptive approach to strategy formation and the brief critique of the literature which follows takes this perspective.

Much of the literature on strategy formulation is linked directly to the formal-rational perspective on organisations and derives its approaches from the theoretical underpinnings of rational decision-making processes [13]. Strategy formulation is seen as the outcome of an iterative, multi-level process where decisions are results of rational or boundedly rational debates. It is broadly assumed that goals are known and consistent, that actors are analytically objective, that cause-effect relationships are fairly well understood, and that information is available in sufficient detail to tackle most issues. These assumptions have been criticised as unrepresentative of organisational reality. In addition the formal-rational paradigm overemphasises analytical content at the expense of the contexts in which strategies are formulated and takes little account of the realities of social and political behavior in organisations.

One of the earliest attempts to incorporate behavioral aspects into the area of strategy was to include coalition formation [2]. Coalitions can be viewed as goal-oriented alliances among actors with different interests which are formed to mobilise joint resources so as to influence the outcome of a decision. Coalitions do not necessarily conform to the formal organisational structure but are socially constructed groupings which emerge out of the informal influence processes that are central to organisational politics. Since this early work on coalitions, power-behavioral approaches, particularly of a social and political nature, have been increasingly considered to be important in describing the reality of strategy formation. Within the power conceptualisation of strategy formation, conflict is considered normal. A final decision evolves out of a process of power mobilisation attempted by each party in support of its demands [12]. Strategy can be considered to be emergent out of the sociopolitical process of interaction of different individuals and groups within a changing context.

With respect to strategy formation in the information systems area, the power-behavioral

perspective is a vital addition to formal-rational models. Information systems, being social systems, are often used as sources of influence and power. Kling cites several studies that emphasise the potent role of an organisation's political context in influencing whether computing is adopted, which technologies are selected, how they are developed and whom they are designed to serve [6]. The actors involved in making such decisions will point to 'technical benefits' such as labour reduction, internal efficiencies and increased managerial control in order to rationalise the adoption and use of information systems but other social and political goals often underlie these publicly expressed objectives. When there are conflicts in the hidden goals, information systems will become an arena for organisational politics and the exercise of power and influence.

A research project is currently being carried out on the formation of information systems strategy in organisations in the financial services sector in the UK [15]. These organisations are particularly interesting for study in view of the high strategic importance of information technology in coping with competitive pressure in the rapidly changing financial services environment. The methodology we are using in our case studies is broadly based on the power-behavioral perspective and draws on the work of organisational theorists on strategy and change in organisations [12]. Our approach involves an analysis of decisions and actions and the contexts in which they are taken. We are collecting empirical evidence on the interaction of key actors, their diversity of perceptions, ways in which sources of power and influence are mobilised and exploited, approaches to decision making and conflict resolution and the role of formal mechanisms.

4. APPLICABILITY TO DEVELOPING COUNTRIES

We now wish to turn, in the remainder of the paper, to the subject of information systems in the developing countries. In the next section we will discuss this subject more generally, but in this section we reexamine the examples described above from the perspective of developing countries, to consider whether the same methodologies and paradigms are likely to be applicable in this context and what additional factors may need to be taken into account or emphasised in a modified analysis. We illustrate the applicability of these approaches to developing country situations by a brief account of the use of our methodology to describe and gain understanding of IS strategy formation in a Kenyan bank.

4.1 Evaluation of information systems

Our criticisms of cost-benefit analysis in the previous section centered around the difficulty of including uncertain and unforeseen benefits, the question of whose values to use in the analysis, the subjective nature of the quantification process, the emphasis on financial rather than social or political impacts and the favoring of short term over long term objectives. In the context of the developing countries these criticisms remain valid and, indeed, it can be argued that they apply with even greater force. It has often been noted that uncertainty of information is a major problem in developing countries. The difficulties of alternative sets of values and thus the subjective nature of the quantification process is often more acute; for example, in assessing telephone systems in rural areas it is necessary to make judgments on the benefits of 'rural infrastructure' and more generally 'rural development'. The emphasis of cost-benefit analysis on economic objectives rather than broader social and political objectives will, in general, be even less satisfactory; for example, in a government department of a developing country compared to a commercial organisation in an industrialised country. Finally, development is a long term process and the pursuit of short-term objectives in a narrow fashion is unlikely to be an appropriate approach to the management of development.

The philosophy of our approach to evaluation emphasises the importance of historical, social and political issues in the evaluation process. We believe that this is also vital in a developing country context. The view that evaluation is a social process with both formal and informal elements and both overt and covert functions is clearly transferrable to the often highly politicised context of organisations in developing countries. With respect to our use of web models, the concept of macrostructures as a larger matrix of social and economic relations

within which an information system is embedded provides a framework for the analysis of such factors as cultural aspects and governmental constraints, which are often very important in developing countries. Aspects such as manpower shortages and problems with 'hard' elements such as electrical power can be analysed within the web model concept of local infrastructure. In summary, an interpretive approach to evaluation offers a broader framework for the evaluation process which is capable, in our view, of adaptation to the environments of developing countries.

4.2 Information systems strategy formation

The formal-rational perspective on organisations is based on the assumptions of known and consistent goals, analytically objective actors, well-understood cause-effect relationships and adequate supply of information. It is clear that these assumptions are broadly invalid in the context of both developing and industrialised countries. Overemphasis of analytical content at the expense of context and the ignoring of social and political behavior in organisations, which are features of the formal-rational paradigm, are further evidence of the deficiency of this approach to the description of strategy formation in developing countries.

The power-behavioral perspective, in the context of information systems strategy, stresses the importance of the socio-political context of the organisation in influencing decisions on computer adoption, the selection of technologies, the development of systems and the choice of system users. This emphasis provides a better understanding of the strategy formation process than does the formal-rational perspective and we believe that similar approaches can be used in the context of developing countries. However, they imply the need for researchers who are able to interpret and understand the social, cultural and political environment of the organisation and country within which they are working. This has important implications for information systems personnel which we will discuss in greater detail later in the paper. In order to test our hypothesis concerning the transferability of our approach, we have recently carried out a case study on a financial service sector organisation in Kenya using an adaptation of the methodological framework developed in our work in the UK. In line with our comment on the need for researchers with an understanding of the socio-political context, the research was carried out by one of the authors, who is a Kenyan national, and a second author who worked in Kenya for a number of years. The case illustrates the inadequacy of the formal-rational approach to understanding strategy formation and the importance of an understanding of the social, political and organisational context.

4.3 Kenyan case study

One of the largest Government-owned Kenyan banks was the first commercial bank in Kenya to start computerising its operations in the late 1960s. The Bank installed various systems for account processing, general ledger and personnel but currently is working with obsolete third generation hardware and very limited batch processing software systems. The reasons for the stagnation of the computerisation programme in the early 1980s included a high turnover of top management making a focussed information systems view difficult to achieve, the fact that the political system had publicly associated computerisation with job losses, and the lack of technically qualified personnel in the bank. The large financial investment needed for upgrading hardware and systems was also a contributing factor.

The current Chairman was appointed in late 1983 and, in early 1985, he formed a senior management committee to look at the Bank's computer strategy for the next decade. This move was triggered by a number of factors including the Bank's ageing computer systems which provided poor services, a booming economy after good agricultural output performance, high coffee prices, a change in the political system's attitude towards computers, and computerisation moves by the Bank's major competitors. At the end of 1986, the computer strategy committee made recommendations about the choice of computer systems to the Chairman. The Chairman however found the recommendations unsatisfactory because they had been based on inadequate technical specifications, the chosen system could not cope with the Bank's projected workload and, in addition, certain manufacturers had not been invited to tender. Moreover, the committee members, who were experienced in banking operations, could not defend the

computer strategy they had drawn up and their views differed in certain of the areas of the strategy. Top management therefore decided not to adopt the computer strategy with the associated computer systems recommendations and instead decided to engage an external person with considerable technical qualifications.

In May 1987, an expatriate computer consultant, who had twenty years of working experience in India and Saudi Arabia, was hired on a three year contract to take over the work of the previous computer strategy committee. He formed a senior management working committee, but this was subsequently disbanded by the Chairman and replaced by a committee whose composition was mainly younger, energetic and lower level managers. The Chairman felt that the senior committee may well have repeated the previous history of the 1985 committee. The computer consultant argued that he could not start by building on the work of the previous computer strategy committee because he did not have a clear view of the Bank's objectives. Moreover, the computer strategy recommended by the previous committee had been based on inadequate information requirements. Top management eventually agreed that the consultant should start the whole process afresh.

By the end of 1987, the computer consultant and the committee had defined the process of strategy formulation in the following sequence :

1) Obtain the Bank's strategic objectives by interviewing top and senior managers;
2) Appraise the existing systems and extract the information requirements with the help of functional user sub-committees;
3) Convert the statement of information requirements into a computerbased information systems strategy;
4) Invite proposals from computer manufacturers through a tendering system;
5) Evaluate the proposals against technical criteria;
6) Choose the appropriate computer systems;
7) Implement the chosen systems.

In our case study, we traced the process up to the evaluation stage. All the stages were found to have been characterised by conflict and resistance to change. Different views were held by the senior managers on the Bank's strategic objectives; there was very little co-operation and comprehensive information was not available at the information requirements stage; the manager of the Information Processing Division did not think that the recommendation for an on-line banking system was appropriate given the state of expertise in the Bank and the country; and some senior managers did not agree with the technical evaluation criteria and wanted to be directly involved in subsequent stages to choose and implement the hardware and software systems. These conflicts and difficulties were experienced for a number of reasons: the lack of appreciation of the potential role of computer systems, the lack of strategic focus and communication which encouraged the pursuit of selfinterests, and the fact that the computer strategy had important implications for power and accountability of individuals in the Bank.

By this time, the computer consultant, who had initially taken all major conflicts and instances of resistance to the Chairman or his deputy for resolution, had started taking part in trying to resolve some of the conflicts and to reduce resistance by direct action with those concerned. He had joined the organisation under the illusion that he would only have to use his technical experience, but he now realised that the organisational challenge was a greater problem than the technical one. He had consequently toned down his essentially positivist approach and started to try to incorporate in his proposals for change the complexity of the social, political and organisational context of the information systems development.

5. IMPLICATIONS FOR DEVELOPING COUNTRIES

The main argument in this article is that the social systems paradigm for information systems results in methodologies which are applicable in different organisations, contexts and cultures although, of course, adaptation is needed to the particular aspects of any given organisation and

its context. We have provided some evidence in the previous section that methodologies derived from the paradigm in order to study the formation of information systems strategy are a valuable approach to studying organisations in both the UK and Kenya. In this section, we will describe and discuss some implications of our work for research methodology, education and training and the implementation of information systems in developing countries.

5.1 Research Methodology

The amount of published research addressing the issue of information systems in developing countries is relatively slight although an increasing interest is being shown in the area. Research is needed to develop underlying methodologies and to judge the usefulness of approaches pioneered in the industrialised countries. In-depth case studies of information systems in specific organisations are an important research approach, but in order to be of significant value, in our view, they must address information systems in organisations from the social systems perspective. Thus, serious consideration should be given to the social, organisational and political dimensions of the processes being studied in addition to the more traditional technical aspects of information systems.

The need for a broader perspective on IS in organisations can be illustrated by reference to a book of recently published case studies which describe information technology applications in various government departments and agencies in seven Asian countries [4]. A total of thirteen cases are described and they make an interesting and diverse collection. The case studies are not treated in isolation from their external context since for each country there is a detailed description of various aspects of the national setting including IT infrastructure, procedures for the acquisition of technology, national promotion measures for IT and financial controls such as import duty. The case studies of individual organisations contain some interesting details but organisational aspects are treated in a formal manner and the sociopolitical dimension in the cases is either completely lacking or is only mentioned very briefly. This does not reflect the relative importance of social and political aspects since it is clear from at least some of the cases that they were probably a prime determinant of the processes which were taking place.

For example, one of the cases in the book is concerned with a computer system to assist the Resettlement Program of the Ministry of Agrarian Reform in the Philippines. This is a highly sensitive political area in the Philippines and the collection of up-to-date and accurate data for land reform purposes is an action charged with meaning in the broader national context. Yet this aspect of the case is not analysed explicitly by the researchers who note only that: 'The inability of the Ministry to implement the ... model in all existing settlements could be traced to a lack of budgetary support from the national government, which so far has failed to evolve a consistent policy and manifest a commitment to the adoption of information technology towards improving government service delivery systems'. The lack of government commitment is a key element of the case and reflects the broader political aspects of this particular information system and the links between the evolution of the system and the broader national context. One can speculate that powerful elements in the government may have had a vested interest in blocking land reform and thus 'resisting' the full implementation of the information system. A broader analysis of the case would have discussed these political aspects which seemed vital to the 'success' or 'failure' of the information system.

Similar comments can be made about a number of the other cases in the book. In a study of the use of location packages to optimise rural infrastructure planning in India, the case emphasised that the approach produced 'good' solutions which were not heavily 'politically biased'. There is not enough detail in the case to be able to explain why such 'unbiased' solutions were politically acceptable although there are hints of the views of different interest groups and how they interacted. A fuller analysis of these views and the socio-political processes taking place would have provided a deeper explanation of the reasons why, in the authors' view, the implementation of the location package was reasonably successful.

Another of the case studies describes a project to create a large central government data base of development projects in Malaysia. Insufficient information is provided to assess the political and organisational issues arising from the need to co-ordinate separate information systems

across four government agencies. Neither is the way in which the system evolved into its present state adequately described to permit an assessment of the historical constraints. One of the writers of the case study expressed the view (personal communication with the authors, 1988) that the changing socio-political environment surrounding the management of development projects in Malaysia over the previous thirty years had shaped the information systems which were put in place. Thus whether the performance of the existing system could be easily duplicated in another developing country context cannot be determined from the case description since it would involve the transfer not of a technical solution but of a social system.

The above examples lead on to consideration of a dilemma. Whilst it may be true that the socio-political aspects of a case are often of high relevance to the development, implementation and use of information systems in developing countries, it is sometimes not 'safe' for Third World researchers to spell out these aspects. The extent of this problem varies considerably depending on the particular country and the context of the information system. In cases where it remains a problem, a certain amount can be achieved by outlining the broader political aspects of the case, leaving readers to piece together a more total picture.

5.2 Education and training

There is an opportunity in many developing countries, where computing education is relatively new, to not repeat some of the errors of the industrialised countries in this sphere. It is widely recognised in the industrialised countries that the training of 'computer scientists' is an inadequate provision for individuals wishing to be broad information systems professionals in organisations. Technical skills need to be supplemented with behavioral awareness, concern for human values and, at a higher level, organisational and political skills. Unfortunately, the uniquely technical approach of much computer education is often attractive to individuals who wish to avoid human systems and their complexity, and concentrate on the simpler world of programming or systems in the narrow sense. This self-selection adds to the problem of technical training and results in the production of computer professionals who attempt to divorce themselves from the social and political realities of the organisations for which they work.

Whilst we argue that the training of computer professionals needs to be broader in its focus and to emphasise organisational aspects as well as technical skills, it is self evident that in many developing countries the shortage of technical skills, and relevant IS experience, is a key constraint on IS development. It was clear in the Kenyan case study that no-one in the organisation possessed adequate technical skills and experience prior to the appointment of the external consultant. However it should also be noted that the consultant's weaknesses were not in the technical area but in his initial unwillingness to address the social, organisational and political issues as part of the process of developing an IS strategy. Individuals are required with a mix of technical skills and experience and a knowledge of organisations and how they function, and this is a major challenge in the future for both in-house and external training institutions.

The need for education and training in computers and information systems is not limited to IT professionals in organisations. It can be noted from the Kenyan case study that the senior managers were deficient in their knowledge of computers and their understanding of the relationship between information systems and the functional aspects of banking. There is a strong need for the training of managers and policy makers in developing countries so that they have an appreciation of the technical aspects of IT, allied to an understanding of their use in organisations and their socio-political implications. Suitable case materials derived from real case studies are a valuable training resource and there is a need to generate materials of relevance to developing country contexts, since there is currently very little of such material available.

5.3 Implementation of IS

It is clear from the article so far that we believe that the successful implementation of information systems in organisations in developing countries is not an easy task and requires

personnel, both IS professionals and general management and staff, to be adequately trained and experienced in the use of information systems. In this section, we note a number of further points regarding the IS group, the role of top management and the use of consultants.

Internal information systems groups in organisations should aim to be regarded as an integral part of their organisation and to understand its culture and politics, rather than being regarded solely as a technical department divorced from the main activities of the organisation. It was noticeable in the Kenyan case study that the IS group was a relatively low level function and, until the appointment of the external consultant, was not able to represent itself effectively at the senior management level of the organisation. Even after the appointment of the consultant, the integration of the IS function with the mainstream of the business was not effective since the consultant was an 'outsider'.

The responsibility for the development of an IS function linked to the organisation rests partly with IS management who can use their influence on recruitment and training policy, and their management of on-going projects, to affect the style and approach of the information systems function towards a broader organisational perspective. However, the power of the IS function is often very limited and a more informed attitude is needed on the part of top and senior management, towards treating information systems as an important part of the organisation and attempting to integrate the function into the mainstream of organisational activities. Top management support is very valuable in developing an effective IS function but, as can be seen in the Kenyan case, is by no means a guarantor of success if senior management is resistant.

With reference to information systems consultants, it is essential that they gain a good understanding of the organisational context in which they are going to work. This can be achieved by allocating time to it as part of the consultant's contract. If the consultant on information systems is regarded as solely a 'technical' consultant, no such time will be allocated and only a limited understanding of the organisational context will normally be gained. This may reduce the budget in the short term but will greatly increase the likelihood of dissatisfaction on both sides in the longer run. An alternative approach to the provision of broader based consultancy in information systems, for larger projects, is to have an inter-disciplinary team of consultants including members with an expertise on organisational and socio-political issues.

The above discussion is even more pertinent for the common situation of expatriate consultants in developing countries. In addition to a requirement for them to learn about the organisations in which they are working, they also need to take time to study social aspects of the country and to gain some understanding of the shared but unspoken values which form part of the culture of any country. This view, although fairly obvious, is not widely acted upon at the present time where the expatriate information systems consultant is invariably thought of by all sides as a 'technical expert'. Our work in Kenya has provided a striking illustration of this way of thinking and its limitations.

6. CONCLUSIONS

We have argued in this paper that information systems should not be regarded as technical systems with behavioral implications but are better conceptualised as social systems in which technology is only one of the elements. We have criticised the discrete-entity model of information systems and the associated formal-rational perspective on organisations. As an alternative, we have proposed approaches from the social systems perspective, including the use of web models, which provide a framework for information systems incorporating their context, infrastructure and history. We have outlined an approach to the study of information systems strategy formation based on the power-behavioral perspective on organisations and an analysis of decisions, actions and context in which they are taken.

The second part of our paper has concerned the relevance of the social systems paradigm to work on information systems in developing countries. We believe that the paradigm is highly appropriate and evidence has been given from our work on evaluation and strategy formation in

both the UK and Kenya. We have discussed some implications of the social systems approach for research methodology, education and training and the implementation of information systems. The main theme of the paper has been the need to include analysis of the social, organisational and political context of information systems in developing countries in order to gain a better understanding of their development and use.

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WORLDVIEW BOUNDARIES AND INFORMATION SYSTEMS DEVELOPMENT: CROSS-CULTURAL ISSUES

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The "rationality" of an information systems development methodology is not always obvious. This may lead to problems of a communicative nature between the analyst/designer and the user of such information systems. This is problematical enough where a common language and national culture is shared but can be compounded where such development is trans-national. The intervention of one form of cultural rationality, ie, the Western methodologies, onto another form, ie, the so-called developing countries may lead to a colonial-style enforcement of an inappropriate worldview. This might at best lead to a limitation in the transfer of knowledge and, at worst, a power struggle through the enforcement of established Western frameworks, enabled through issues of communicative competence [16]. This paper attempts to provide a framework through which, it is argued, such areas of possible problems may be expected. Using the Multiview methodology and the argument that there is a minimum of three Weltanschauungen in all information systems design approaches, such possible problem areas are presented. The discussion herein is to illuminate issues rather than to present solutions.

1. INTRODUCTION

1.1. The Definitional Context of 'Information Systems'

The literature on information systems development is taken to be indicative of the field of thought, this field appears to be dominated by a Western "rationality" which is rooted in logical positivist empiricism and Talcott Parson's functionalism. The resultant impression is that an 'information system' is logical, functional, rational, and objective. Alongside this, there is a strong tendency to adopt the view that an 'information system' is also technological, either as a mechanical or electronic object or as a flow of work. The result which follows from this is that development or design of such is chiefly concerned with a rationalisation of functions as automated or programmed flows. Information becomes an epiphenomenon and as such is treated as secondary or irrelevant in relation to designed change. The implication appears to be that structural variations are acceptable because they can be objectively scrutinised, and hence a further implication that information is some form of structural object which can be 'improved' through improving the logic of the design of the flow structure. This seems to be the crux of the confusion between information and data. Any serious attempt to understand the nature of information is seen to be relevant only to the aesthetically curious and therefore childlike and weak, whilst attempts to improve the flow of data are seen as 'right', useful, and therefore adultlike and strong. The rationalist/scientific mode of logical positivism is hence seen to give greater credence to dataflow design that to the understanding of the nature of information.

The work of IFIP WG 8.2 has challenged such assumptions. It is the argument of this paper that such challenges are not only vital to developing a more enlightened view of information systems development but also that allowing such assumptions to go unchallenged may lead to

serious defaults when cross-cultural communication is dealt with. It is necessary to understand and explicate how design procedures from one culture view that object of design, ie, 'information system', and to then ask whether such procedures have an implied view of the world which is culturally dominated. The extent of such domination, and the possible repercussions, then need to be considered, so that the effects of imposing such design procedures upon another culture can be considered. It is possible that the effects could be, at best, the creation of confusion and, at worst, the implementation of a dominance and coercion which could seek to externally enforce a change upon the accepting culture and also enforce an inequitable power structure. This is the cautionary argument made by Habermas in his discussion of his theory of communicative competence [16]. It is also the argument made against the imposition of new sociological systems onto established cultures as made by Evans-Pritchard when arguing against the notion of 'primitive' cultures [14]. As the theme of this volume is 'Informations Systems in Developing Countries', it is important to recognise that the notion of 'developing' implies a superior model of 'that which is developed' and that this may lead to the view that such countries are akin to 'primitive' cultures. The recognition needs to be made that such statements as 'developing' or 'primitive' are relative and can be applied to all societies or cultures. It is also important to recognise that those who use the terms may be implying a notion of superiority. Such a notion must be challenged. To fail to do so may allow for the simple acceptance of such an implying of some form of 'expertise' which is deemed to be universal and hence culturally transferable.

1.2. 'Information Systems' as Communicative Context

Taking the argument given above that the rationalistic objective view of information systems is predominantly concerned with dataflow, this can be seen as the first challengeable point of contention. The second to be pursued in this section is that of equating the notion of information system s with the computer or computing. It is in this area of contention that the writings of IFIP WG 8.2 are most prolific [3,24,4,20], and the members of that working group are also seen to contribute elsewhere to this argument [17,18,22,21,30,13 and many others]. Notably, the British Computing Society is also starting to recognise that information systems may affect more than computing [5], though this is primarily seen as the impact of computing on organisations, rather than information systems as essentially human aspects of organisational life.

Unfortunately, much of the argumentation presented in these works does not seem to transfer to other writers in the information systems field who seem to be dominated by the view that information system = computing, both hardware and software. The general attitude expressed by the latter is that they are dealing with pragmatics and therefore get on with the job of designing 'better' information systems and this notion of 'better' appears to be equated with overcoming the problems of software complexity management and electronic restrictions on software handling. The realm of their puzzle does not immediately include the notion of people and would certainly not accept the view that the problems of information systems do not even need to consider the notion of computing. If people are considered at all, they are seen in two manners. The first is as workers who create flows of data/information and the second is that of intelligent beings to be dissected and understood as model for the development of artificial intelligence. It is only the first view that is of concern in this paper.

The distinction between the two bounded worldviews of these views of information systems is so strong as to appear to be paradigmatic [19]. This implies that they are in danger of non-communication between each other. This is intellectually problematical but is also pragmatically of concern. If one knowledgeably dominant section of the world is to attempt to transfer aspects of that knowledge to a less dominant section of the world, the hidden biases, and paradigmatic differences of the dominant knowledge must be recognised. A framework for analysing the different writers on the topic of information systems is required. A more detailed discussion of this requirement is given in the next section.

2. THEORETICAL PARADIGMS IN INFORMATION SYSTEMS DEVELOPMENT

2.1 The Sociological View of Information Systems

This view is found to dominate the writings of IFIP WG8.2. Some evidence of it is also found in the field of sociology and of other aspects of human communications, particularly in linguistics. However, it is mainly in the IFIP WG 8.2 writings, particularly in the 1980s, that questions of defining the notion of information systems, and relating that to analysis, design and development are predominant. The questioning of what it is that comprises an information system leads to the suggestion that an information system is:

A conceptually holistic set of complexly interrelated notions which effect each other in reciprocal manners; these notions are highly esoteric in that they are necessarily implied in human communication as political, power referential, sentiential, psychologically temporal, sociologically contractual, and culturally symbolic properties of the signs, symptoms, and symbols of purposeful human organisation.

In this particular theoretical paradigm of information system thinking, human action is central to the notion of information. The systemic nature of that information is phenomenological, and hence conceptually, rather than ontologically, holistic. The human interactions are mediated through certain sociological characteristics, as implied in the above definition. It is this mediation process which references the notion of information in a way similar to the notion of linguistic reference of signs, symptoms, and symbols as discussed by Habermas [16] in his theory of communicative action. The intervention issues which arise around the analysis, design, and development of such information systems tend to be concerned with the effects of information, as a phenomenon, on human social action and also how such social action creates such a phenomenon. Computers may or may not be seen as significant symbols in such a framework, but they are only such as artefacts of human social behavior. This means that intervention has to look at the meanings associated with information in the context of concern (eg, the organisation) and how the social life can create and change those meanings hence leading to such concerns as, for example, the way power is mediated through information exchange.

This theoretical framework of 'information systems' is phenomenological, morally aware, sociologically oriented, and looks at information as essentially a mediator of communication.

2.2. The Datalogical View of Information Systems

This view of information systems tends to be the most widely accepted amongst practitioners of information systems analysis and design. It is particularly noted in the structured system analysis techniques but can also be seen to be implied in the functional decomposition approaches of task design. Information is treated as an entity, and any notion of human tends to be as an ergonomic factor in task flow. The notion of information system implied by such a framework is:

An holistic set of complexly interrelated entities which effect each other in connected manners; these entities behave in a functional and purposive manner and thus display a rational and logical process which indicates that the flow of such entities, and their structural forms, constitutes a composite picture of a work task. These may have actual temporalities in the form of life-histories but are usually both time and context free.

This framework is essentially technical in nature, concerned with the technical aspects of work or data flow The notion of system in this definition is ontological rather than conceptual, and so may be taken to be absolute rather than relative, ie, there is one best system. The entity is the information/data component and such entities operate in logical forms towards the fulfillment of goals. This is achieved through the setting of objectives and the setting up of structures which perform separate functions to achieve these objectives. The essential element of information analysis and design in this framework is the logical structure of the optimal, rational system. The indication is that such a system should be developed as a normative prescription for good

information flow. No real consideration is given to the political or sociological elements of the information system and so development is primarily concerned with improving flow, whilst the notion of information is taken for granted. Computing tends to be a central concern of the objectives of design in such a paradigm.

2.3. The Computational View of Information Systems

This is the theoretical framework of information systems most commonly found in writers who are chiefly concerned with computer programming. It is from this concern that a certain implication of the notion of information systems may be made. The implied definition of information systems from this paradigm is:

> *An holistic set of complex interrelated subsets which effect each other in formulated manners; these subsets comprise elements of a problem which have particular structural arrangements which are restricted in expression by the forms of the computational languages being used. The notations of these languages create a certain bounding of the world of the problem which is always a world of pure forms and such pure forms are represented in the notations. In this pure form they constitute information.*

In this theoretical paradigm the world of information is equated with the world of computer programming. The system is ontologically real in that it is the whole of the subsets which the program may be broken down into. The chief concern with construction and control of that whole is with the formulation expressed in the program. This formulation can only be approximately expressed because of the limitations inherent in the various programming languages available. In this way, this framework shares some of the same areas of concern as that of the sociological framework in that the ambiguities of language are seen to mediate the nature of information without being able to represent it transparently. However, the similarities stop where the computing framework displays a belief in pure forms, as ultimately existing, whilst the sociological framework takes a more hermeneutic and hence relativist stance.

In relation to the pragmatics of analysis, design, and development, the computational model of information systems is chiefly concerned with structuring the concept of the problem in such a way that it may be capable of representation and manipulation through the technology of the computer.

Each of these three theoretical paradigms have distinct views on what an information system is and also on how to improve or develop such. In practice this means that three different sets of assumptions for action can be seen and the strength of these assumptions can create implicit rules for action. In this way, each of the three paradigms can be inculcated into the practical field of information systems development as their different cultural worldviews. The effect of this is to produce three bounded communities for consultation and theoretical development, but also three such communities for practice and hence three types of information system problem tackling approaches are likely to be developed. The result may be akin to the group of blindmen touching the elephant and each being convinced that they have the total picture. Anyone entering the field of information systems will then be highly confused as to what exactly the object of reference is. It is necessary to distinguish between different schools of thought in order to begin to tackle this problem issue.

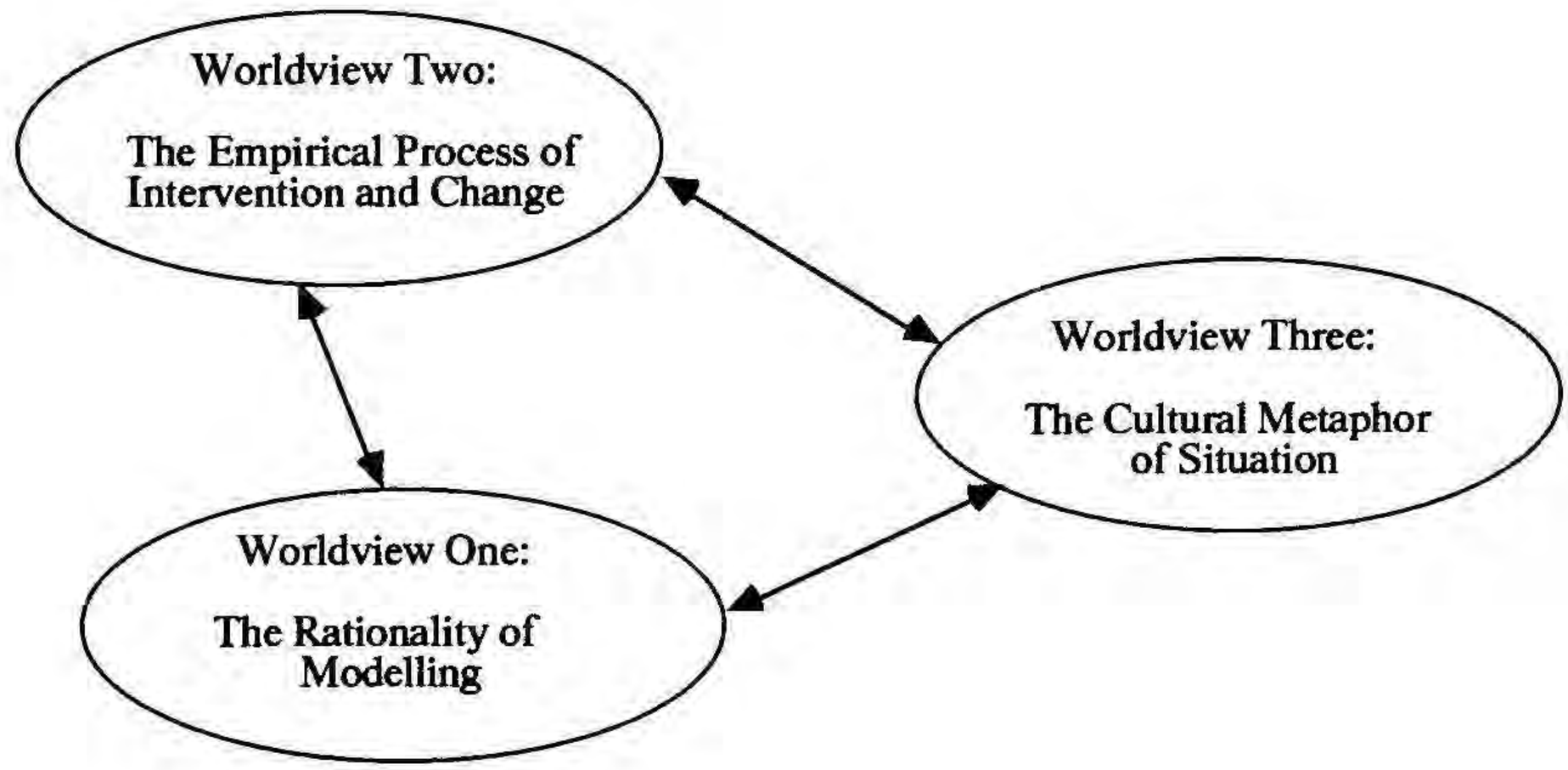
Having categorised some of the distinctions between the three different theoretical frameworks of information systems, the next section will look at methodologies for the analysis, design, and development of information systems. The meta-methodology of Multiview will provide an overview of how certain methodologies work together in the development procedures. To expand Multiview, and to show how the notion of culture may effect the process of development, a framework of three Weltanschauungen will be used to compare the different methodologies presented in Multiview.

3. THE WELTANSCHAUUNGEN OF INFORMATION SYSTEMS METHODOLOGIES

The theoretical framework being taken in this paper is that of the sociological view of information systems development. In this way the process of development is seen to be that of sense-making through human communicative interaction. Methodologies provide a guidance for how to control that process but in doing so they are themselves presenting frameworks for viewing information systems. That is, they create for the user of the methodologies certain presuppositions for action. These presuppositions may be analysed under three different forms. These three forms may be termed worldviews, or Weltanschauungen, in they create paradigms for thinking which may result in culturally closed actions.

These three worldviews were first developed from an analysis of the writings of Checkland on Soft Systems Methodology and have been developed further to show that there are three distinct areas of concern in any organisational intervention situation which is methodologically driven [7,9]. Each of the three worldviews if shown diagrammatically in Figure One and a description of each is given below:

Figure 1
The Three Worldviews



3.1. Worldview One: The Rationality of Modelling

This is the worldview inherent in any modelling. Most methodologies contain a reference to modelling practices and this may range form the modelling of human activity systems to the modelling of program structures. Although this is an idealised world [see 25] there is a theory of information systems implied in the nature of that idealised form. This will be expanded upon later in the next section, when Multivew is used as the framework by which to analyse a set of commonly used information systems' development methodologies.

3.2. Worldview Two: The Empirical Process of Intervention and Change

Any information system's development methodology has be be acted upon, as well as developed through modelling. This action comes in two forms. The first of these is the action of intervention in the situation and it is through this process that the nature of the problem which the information system is being developed for, or in, becomes recognisable. This is the area of analysis. The second form is that of intervening in the problem in order to seek some form of change and it is here that the notion of design becomes paramount. Once again, these

forms may vary tremendously depending upon the theoretical framework of information systems that any methodology implies. The next section shall also analyse this.

3.3. Worldview Three: The Cultural Metaphor of Situation

This last worldview is logically implied by the action nature of methodologies. If methodologies use modelling and intervention procedures then they must be used upon something in order to be actualised. Methodologies have an implied notion of that situation in their development protocols. This is strongly connected to the notion of theoretical paradigm but is more than that. Any practitioner of modelling and intervention will adopt this particular worldview and hence will be able to communicate with fellow practitioners on the nature of that situation. In this way it becomes a cultural metaphor but its point of reference is not just the paradigm for thinking but also the situation which is being intervened upon. This last point is crucial in understanding the implications of information systems development methodologies as that point of reference may or may not align with the points of reference used by the actors in the situation being intervened upon. This can lead to a fundamental mismatch. For example, to view the situation as that of functional task design when it is far more problematical as a political situation may mean the adoption of both an inappropriate notion of information systems and inappropriate methodology for tackling that situation. Alternatively, the practitioner may hold a particular theoretical belief about the nature of the information system and adopt an inappropriate methodology for dealing with it. For example, the situation is highly political and the developer appreciates the appropriate model of the information system as a politically active sociological framework yet seeks to model and intervene upon the situation through the use of a data entity type of methodology. The work is likely to be inflammatory, redundant, or distorting. It is unlikely to be representative or helpful. Because of the importance of this particular worldview, the analyst needs to appreciate the theoretical model of information systems in both the methodology and as implied by the problem or situation.

3.4. The Interaction between the Three Worldviews

Worldview One: The rationality of modelling. This is used as a form of understanding aid which allows for a greater depth of awareness of the situation through its representation in modelling form. It is also used as a template for analysing desirable change, or as an optimal model of the desired end product. It is rational in that it aims to present a logical a.nd abstracted view of some aspects of relevancy to understanding the situation. In this way models are always ideal types, although this distinction is not always clearly expressed in papers presenting such models. In enhancing awareness and implying change, the worldview interacts with that of Worldview Two: The empirical process of intervention and change.

Worldview One also interacts implicitly with Worldview Three: The cultural metaphor of situation. This interaction occurs in two ways. Firstly, the models developed imply a particular theory of the situation, e.g., hermeneutically understood human action or logically implied objects, the behavior of which are expressable in formulae. Secondly, the user of the models is predetermined to see the situation in a particular way because of the implied theory of the situation.

Worldview Two: The empirical process of intervention and change. This is empirical in that it is only actualised through an inquiring process or through purposeful change procedures. It interacts with the modelling worldview in that it indicates the appropriateness of various models and then uses them for structuring change. It also interacts with the situational worldview in that it seeks to understand that situation and to change it. Like the modelling worldview, it also has an implied model of the situation.

Worldview Three: The cultural metaphor of the situation. This is cultural in that it is the implied sense-making process which creates the world of the situation which may be investigated and/or changed. It is also metaphorical in that the situation may be many things but different methodologies, through their intervention and modelling worldviews have implicit understandings of the situation. They are, therefore, initially bounded in their ability to

understand the situation as its complexity is relegated to a particular notion of 'problem'. Each of the different methodologies implies a different notion of 'problem' in their attempts to model desired 'solutions'.

The next section will use the framework of Multiview to relate different information systems development methodologies to the three worldviews, and to the underlying theoretical frameworks. The implications for cross-cultural knowledge transfer of information systems development knowledge will then be considered with particular reference to the so-called developing countries.

4. MULTIVIEW AS A FRAMEWORK FOR THE ANALYSIS OF INFORMATION SYSTEMS DEVELOPMENT

4.1. The Multiview Methodology

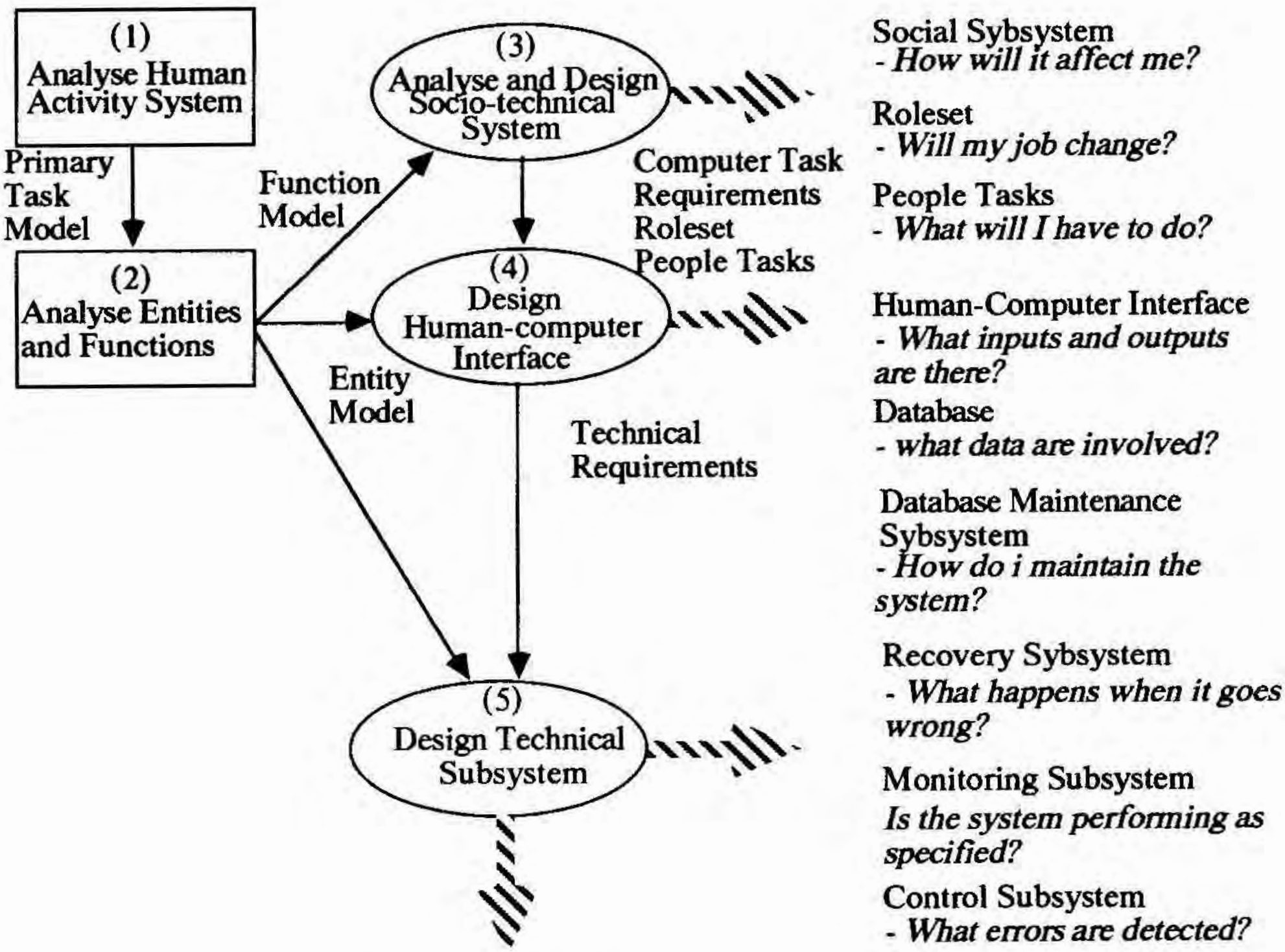
The Multiview methodology is something of a meta-methodology in that it uses the concept of the systems' design life-cycle to show how different methodologies may be used at different stages of the cycle. It also differentiates between information systems issues which may be mainly or solely organisational in nature and those which may demand technical or computational approaches. It has been developed by Wood-Harper [27] as an approach to information systems analysis and is presented in greater detail by Wood-Harper et al [29]. The ideas behind Multiview can also be seen in Wood-Harper and Fitzgerald [30] and also Wood-Harper and Antill [1] and its development and use in Episkopou and Wood-Harper [12,13].

Multiview presents five stages of information systems analysis and design, these being:

- The analysis of human activity systems.
- Information modelling.
- The analysis and design of socio-technical systems.
- The design of the human-computer interface
- Designing technical subsystems

Figure Two shows the process of Multiview and also shows how certain analyses lead to change which is predominantly organisational, whilst others lead to change which is predominantly data-structuring and/or work-structuring and change which is predominantly technical structuring These three different views of change relate to the three different theoretical paradigms for information systems presented earlier.

Figure 2
The MULTIVIEW methodology outline from Wood-Harper [28]



4.2. Theoretical Paradigms and Multiview Stages

Stage One operation within the paradigm of information systems is sociological. Because of this the output is in the form of a human activity system model which may be issue related, and so holds an hermeneutic view of the organisation. However, the output may also be task related and as such becomes entwined with the theoretical paradigm of functional restructuring. There is, therefore, an implied paradigmatic conflict in the development of task related human activity system models because of their dependency upon the functionalist view of information.

Stages Two in predominantly within the theoretical paradigm of the datalogical view of information systems. This is why its output is in the form of entity models or function models. This stage is consistent in its paradigmatic worldview and tends to equate data with information.

Stage Three is predominantly functional in its view of the information systems but does equate the task operations with human action and hence may be seen to hold a more sociological view of information systems. However, the sociology is that of functionalism rather than interpretivism and the functions tend to be the actions of work-tasks which have psychological consequences. In relation to information, the task needs information to support it but there is no real distinction between information as a meaning construct and information as data. Because of this, it is argued that this stage is predominantly in the datalogical view of information system although it has a sociological view of work.

Stage Four is also predominantly functional and hence tends to fall into the theoretical paradigm of the datalogical view of information systems. The human element is cognitive and technically restricted. The information processing capacity of the individual can be equated with data processing capacity. No distinction is made between data or information as each is just a commodity. The engineering to such commodities is the prime concern of this stage, as the technical aspects of the user and those of the computer interface become engineered to achieve an optimal fit.

Stage Five links the datalogical view to the computational view. The main concern is the recognition and management of subsystems so that the programs developed may perform according to the expectations of the technical data design. In this stage data is again equated with information data and may be subsumed under the heading of computation.

5. MULTIVIEW AND THE THREE WORLDVIEWS

The three worldviews may be used to overlay the stages of multiview so that each of the different methodologies implied may be categorised under the three areas of concern, ie, modelling, intervention and change, and situational metaphor. A summary of this analysis is given in table 1.

Table 1
Analysis in Summary

MULTIVIEW:

	Stage one	Stage Two	Stage Three	Stage Four	Stage Five
Worldview one: Modelling	Rational ideal types relevant Abstract/ Metophors Purposfull Human Action	Functional Representa-tive Logical Purposive Data/Entities	Functional Normative Purposive Workflows Data Human-Relations	Rational/ Functional Normative Purposive Cognitive Data	Rational/ Functional Abstract Purposive Computational Data/Entities
Worldview Two: Interven-tion	Learning/ Enlightnement Rational/ Functional Analyse as Rational Actor	Logical Normative Functional Efficiency Analyst as Logician	Participative Moral Functional Efficiency/ Effectness Analyst as Change Agent	Normative Analyst as Engineer	Structural Componential Analyst as Computator

Table 1
Analysis in Summary (cont'd)

MULTIVIEW:

	Stage one	Stage Two	Stage Three	Stage Four	Stage Five
Worldview Three: Situation	Pluralistic Human Action Empathetic Phenomenological Power-neutral	Unitary Data Entity Flow Rational Objective Socially neutral	Unitary Model of Work Work-based Self-Actualisation Ethical Potentially Benevolent	Unitary Data as Information Processing Dexterity-centered Socially-neutral	Unitary Data as Axioms Puzzle-centered Human as-irrelevant
Theoretical Paradigms of "Information Systems	Sociological with some Datalogical	Datalogical	Datalogical with some Sociological	Datalogical	Computational with some Datalogical

5.1. Stage One: Human Activity System

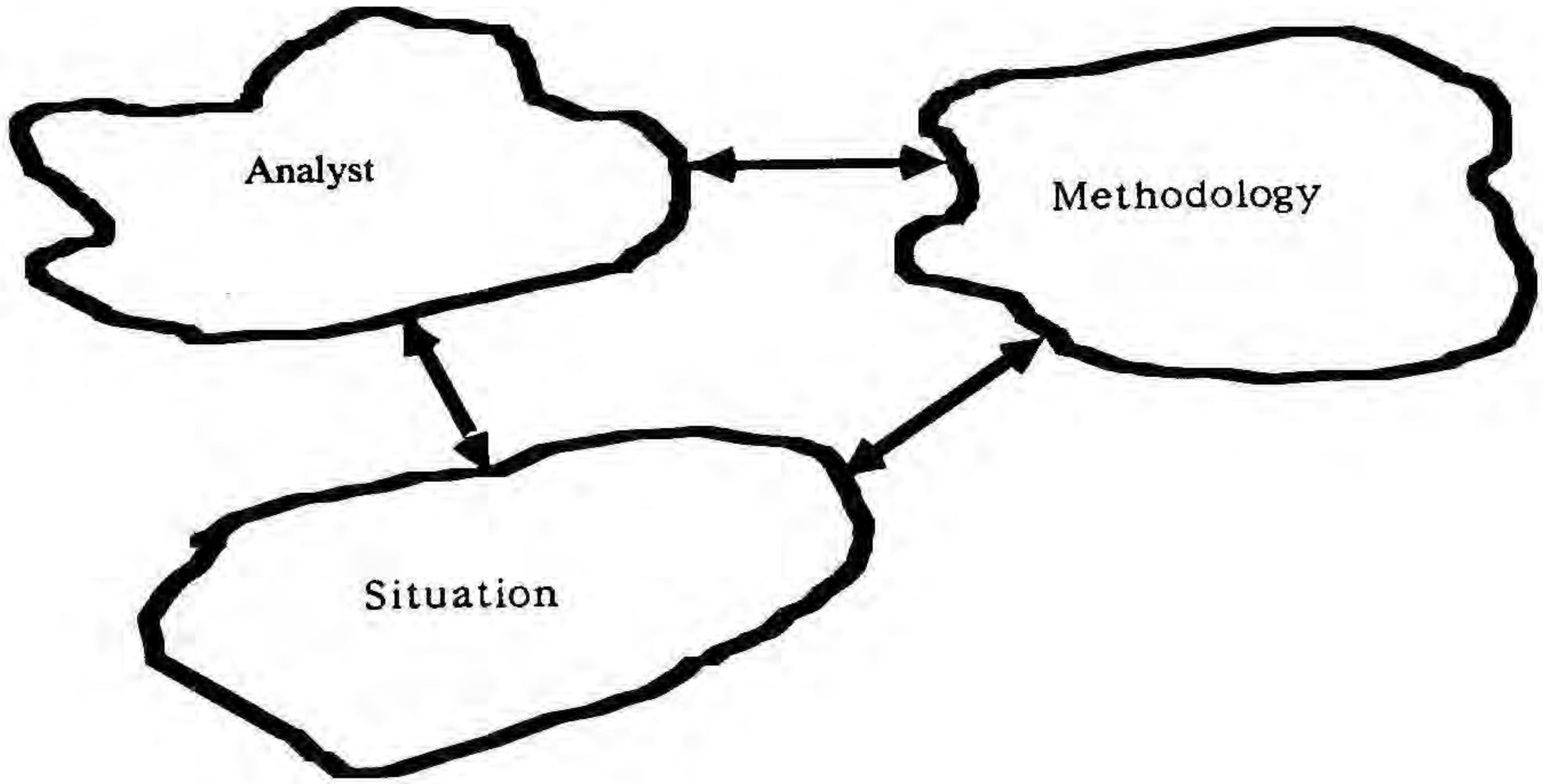
The primary methodology of this stage is that of Soft Systems Methodology [6] although Information System Methodology also uses the notion of human activity system [26]. The former deals with both issue related and task related change and hence is primarily functionalist in perspective. In this section, Soft Systems Methodology shall be concentrated on, as this is also the initial element of Information Systems Methodology.

In Worldview One: The rationality of modelling, Soft Systems Methodology (SSM) uses the epistemological construct of 'system' to develop ideal type notional models of relevant human activity systems. The human activity systems are argued to relate to the purposeful actions of the social construction of meaning and so are phenomenological in essence. However, the modelling metaphor of SSM modelling is that of the open system model [2] and hence is functional in origin. This is not to detract from the philosophy of SSM which argues that the models are developed for the phenomenological purpose of analysing possibly relevant systemic patterns and not to describe actual systemic patterns in the situation. However, it does indicate a possible conflict between the purely interpretive, sociological view of human action and the functionalist view of the action system.

In Worldview Two: The empirical process of intervention and change, SSM distinguishes between analysis of the situation and the process of inquiry as an approach to learning enhancing change in the situation. Although Checkland makes the distinction between the Problem Content and the Problem Solving System, he does not really clarify in any depth the hermeneutic role of the analyst in this process of understanding and change. Wood-Harper et al [29] argue that any methodology needs to consider the interaction between analyst, situation and methodology. This is shown pictorially in Figure Three. Because Checkland concentrates on a discussion of the situation and the methodology, SSM does not provide a great deal of help on how to understand the role of the analyst in relation to both the methodology and the situation [8] This indicates that the methodology is essentially rationalist and does not over concentrate on the empirical aspect of intervention and the elicitation of knowledge of the situation. This may mean that the user of SSM has to import further guidelines as to how to analyse the situation and this may lead to problems of choice and information overload [9]. It also means that the cultural worldview of the analyst is not considered and hence the situation is in danger of being treated in an over-rationalistic manner [10]. This means that the implied

model of the analyst in SSM may be that of rational actor rather than cultural actor and hence may not indicate the necessity f or consideration of the culture of the situation.

Figure 3
The interaction between the analyst, the problem situation and a methodology
From Wood-Harper et al [29]



In the later stages of SSM, culture is given explicit consideration but it is not at all clear how such cultural awareness may be developed if left until this later stage. This may indicate why the choice of relevant systems for modelling is problematical as this process of relevancy is situationally, and hence culturally dependent.

Worldview Three: The cultural metaphor of the situation in SSM this is related to the notion of change given in the Worldview Two aspects of the methodology. This notion of change is change through debate, leading to learning and enlightenment. Although such a view of the situation is essentially phenomenological it does not take into account the power differentiations in linguistic and communicative competence hence making SSM a potential tool for domination by the communication pattern controllers over the less influential communicators. This limitation comes from the politically neutralised view of the situation implicit in SSM. Although the notion of Weltanschauung allows for the development of different views, there is no mechanism for allowing for the management of different communicative styles and their possible relation to power structures. This is an effect of the essentially rational nature of SSM.

5.2. Stage Two: Analysis of Entities and Functions

The structured methodologies [11,15] fall into this category, including dataflow diagrams (DFDs). This is a relatively consistent and straightforward theoretical framework for analysis and change, even if somewhat naive of organisational life and ignorant of the distinction between information and data.

In Worldview One, the modelling rationality of this stage is that of modelling the logically prescriptive view of what the flow of data ought to achieve. It is highly idealised yet does not seem to clearly distinguish between the purpose of modelling as a way to explore change and the purpose of modelling as a way to design an absolute reality.

In Worldview Two, the only analysis conducted is that of the workflow of data. Following the logical modelling, the designer then seeks to change that situational structure to take the same form as the ideal model. The implication is that such a logical change will improve the performance in the situation and hence is a desired change.

In Worldview Three, the implied model of the situation is simply that of data flowing and in doing so supporting tasks which will achieve defined objectives. It is highly rational and has no notion of politics, power or culture. It is also very dominant in the field of information systems analysis and design.

5.3. Stage Three: Analysis and Design of the Socio-Technical System

The philosophy of socio-technical systems is found in many information system methodologies or approaches. It is the espoused theory of participative approaches in that the main aim is seen to be to restore some balance away from computing dominance and towards the recognition that all change, including computer-based change, affects the social relationships of work. It essentially espouses a moral view in that the users are argues to have a right to design their own work systems, and that this will improve work situations. It is necessary in analysing at this stage to make the distinction clear between information analysis and work analysis. It seems that a sociotechnical systems approach does not concern itself predominantly with a need to understand the notion of information. Instead, it is concerned with work and the impact that computers may have on the psychological and social aspects of that work. For this reason, information and data are not clearly distinguished. The major method for using a socio-technical systems approach to information systems development is that of ETHICS [23].

Worldview One: The modelling rationality of ETHICS is that of objectives modelling. However, there is no absolute notion of modelling in ETHICS and so objectives recognition and management is far more akin to the empirical process than to the modelling rationality.

Worldview Two: The empirical process of intervention and change this is the crucial part of ETHICS. Intervention must not be dominated by technical experts, nor by managerial power structures but must be user-led. In this way intervention allows for a process of user control to evolve and for learning to be a prime concern of the situational change. Change occurs by user management and by the improvement of functional performance in the situation. Another crucial element of change is that of the human relations element. Job satisfaction is the primary concern of the change strategy of ETHICS and hence the functional model of change is interlaced with the moral model of human rights.

Worldview Three: The cultural metaphor of the situation in ETHICS is that of the workplace as a context for self-actualisation. Information/data are secondary elements in the concern for redesigning work structures and processes. The situation is enforced with the notion of potential benevolence as users are given the political freedom to design for their own personal and social development. This is a fundamental weakness of ETHICS as it cannot help with power imbalances and malevolent situations. It is also questionable as to how far it considers culture in the situation. There appears to be a unitary model of the workplace which is developed from a human relations view and a functionalist perspective. Such a model may not be easily transferable on to very different cultures and so the cultural definition of work needs to be scrutinised when applying ETHICS to cross-cultural situations.

5.4. Stage Four: Designing the User Human-Computer Interface

Approaches to this stage are primarily concerned with the cognitive aspects of the user. The model of the situation is that of the cognitive model of information processing, with the user limited by perceptual and dextral limitations and by the bounded rationality aspects of decision-making.

Worldview One: The rationality of modelling at this stage is that of capturing the structural restrictions of data/information processing. Modelling tends to be of decision analysis or of ergonomic factors.

Worldview Two: The empirical process of intervention and change is almost obsolete in this stage. The change occurs by designing and analysing data which refers to the model of the situation rather than directly to the situation. If the user is dealt with directly, then it is to treat the user as a component of the computer system.

Worldview Three: The cultural metaphor of the situation is that of a world of perceptual inputs of data/information and the dextral and cognitive outputs of inquiring into the data/information base. It is a highly rationalised and unitary view of the situation.

5.5. Stage Five: Designing the Technical Subsystem

The methods used in this stage tend to be those of database design and/or structured programming. They are purely concerned with the management of data through the control of computation.

Worldview One: The rationality of modelling tends to be that of complexity management coupled with the restrictions imposed by the electrical aspects of the computer and the conceptual and structural aspects of the various programming languages. Models are developed as computational forms, with data forms, which represent an attempt at a solution to a problem.

Worldview Two: The empirical process of intervention and change once again, this is barely evident in these approaches. The intervention is upon the problem which requires logical analysis, but the problem is a pure form which is expressed in computation and hence relates little to the situational context in which the program or database will operate. The technical context of the machine is of far greater importance.

Worldview Three: The cultural metaphor of situation is hardly evident. If there is such a metaphor in this stage, it is that of the functional decomposition of problem structures and axioms into workable parts. The situation is a puzzle but in a rather hypothetical manner rather than an empirical one.

Each of these different stages can thus be analysed through the notion of the three worldviews. This explicates the particular modelling assumptions within the different approaches and can allow the user of the methodologies to be more cautionary when considering the limitations of the different views.

6. CONCLUSION

The implied assumptions of different approaches to information systems analysis and design have different theoretical paradigms in relation to their notion of information systems. To understand how these paradigms may affect the practice of information systems design, three worldviews have been used as a framework for analysing a set of different approaches. These frameworks have been related to a meta-methodology which combines various approaches in a life-cycle developmental view. In doing this it has been possible to separate out various aspects of different methodologies and to seek to understand why they may seem to hold only vaguely related views as to what an information system is.

The main aim of this paper has been to conduct this explication process so that information systems development approaches dominant in Western practice can be more clearly analysed. The message of the paper is to call for waryness on the part of the information system developer when attempting to transfer such Western views onto other non-Western cultures, ie, the so-called developing countries. The main issues in other cultures may not be those of functionally improving logical dataflows, or some other similar objective. It is questionable how worthwhile such views have been in the development of information systems in the Western world, or how much intuition, experience, or sheer talent have created useful systems development where methodologies may have been less than helpful. It is important to raise such cautionary messages before the problems and issues of already developed information systems are transposed to other nations. It is also important to be aware of the limitations of

language and underlying values in seeking to find a common arena for communication between cultures. The cross-cultural information systems developer needs to be a humble inquirer, seeking to learn, and to actively avoid being a deified expert seen as seeking to infiltrate. Such are the concerns underlying the analysis presented in the paper.

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INFORMATION TECHNOLOGY POLICIES FOR DEVELOPING COUNTRIES FACING A WORLDWIDE IT INDUSTRY

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Information technology must be considered a an part of the socio-economic fabric of Third-World countries. IT policies have been defined and implemented in most developing countries. This has occurred in increasing numbers since the widespread availability of micro-electronics. These policies have to cater for two often contradictory considerations. It is not always easy to reconcile a nation's specific needs with the constraints imposed upon it by a worldwide information technology industry.

1. INTERACTING WITH A GLOBAL INDUSTRY

The first point to note is that the IT industry is indeed a worldwide industry which has been founded by large, well-established, multinational corporations. Newcomers have to internationalize rapidly in order to stand any chance of being able to compete in this global market. The idea of a "product cycle" has fast been overtaken by a form of "homogenization", in which identical products and technologies are announced simultaneously throughout the world.

The second point is that the data processing industry can be regarded as a world oligopoly. IBM is at the head of the industry, as illustrated by the fact that it accounted for 61% of the mainframe market in 1974, at a time when mainframes formed the majority of the industry. The leading multinational organisations have been able to protect this oligopolistic situation by virtue of their strong market shares and their high levels of research and development expenditure. However, throughout the 70's and 80's new companies have continued to enter the industry. This has largely been made possible by the launching of new technologies, the creation of new products, and the introduction of new concepts. During this same period the segment of the market accounting for mainframe computers has diminished. By 1987 this had been reduced to 13% of the total industry sales. The IT industry therefore, must now be analysed as a differentiated oligopoly. The new situation is one in which the structure of market power varies, both in terms of the levels of concentration and in terms of the principal actors, from one segment of the market to another. Despite this, IBM continues to dominate the market. It retains its hold upon the mainframe market (54% of total sales for the leading 50 suppliers in 1987), while also leading the mini-computer (22%), micro-computer (38%) and peripheral (40%) markets. Hence it is clear that the application of computing throughout the world must take place using the same range of standardised products, application tools, and methods. The modes of production and the rules of competition apply across the IT industry worldwide.

The Third World plays but a weak role within the global computing market. The distribution of computing in these areas remains extremely irregular. The outcome is an unbalanced confrontation between, on the one side, the weak bargaining power of the purchasers, and on the other side, the strong multinational suppliers. This all too often results in the disregarding of local characteristics and peculiarities of the developing country. There appears to be a need for the governments of these Third World countries to intervene in order to regulate the interaction of their national industries with the worldwide computing industry. However, the Third World countries are far from being homogeneous and their variety is clearly reflected by the diversity of their policies in this area.

A typology can be founded upon the two main competencies, (i) utilisation and (ii) production which are combined to many different degrees:

(i) The utilisation policies includes all the measures aimed at selecting products and suppliers, building bargaining power, coordinating acquisitions (through standards and other recommendations or regulations), and optimising the computerisation process.

The Ivory Coast has striven to become more autonomous with respect to foreign service suppliers, by developing a local capacity for administrative data processing, and by promoting the employment of national technicians both in the public sectors and in the country as a whole. In India the Computer Maintenance Corporation (CMC), has been selected to represent the whole industry in the following ways; to act as the sole supplier for certain equipment, such as peripherals; to select appropriate products and suppliers: and to obtain competitive prices by bulk purchasing for the national computer industry as awhole.

(ii) The production related competance can include hardware and software production, as well as maintenance capacity. Such policies can be motivated by substitution of imports, stimulations of exports, or the desire for products which are adapted to real needs.

Brazil decided, at an early stage, to concentrate its efforts towards the development of a local industrial capacity, oriented at the outset to the production of micro-computers, and more recently to mini-computers. Other countries, for example Mexico, also attempted to establish a local potential, but limited production to less sophisticated technologies such as terminals. In 1985 Argentina launched a project, via invitation to tender, aimed at setting up a joint venture with a foreign partner, for micro-computer production in their country.

The two strategies described above are based upon two logical types; inward-looking policies and open policies:

(i) The first corresponds to inward-looking industrial policies and goes with protectionist measures.

India originally endeavoured to develop a close, purely national data-processing industry. The equity share of foreign partners in local firms was strictly limited, this included for example IBM to withdraw from the country. A public industry was charged with establishing the basis for a national design and production capacity. Software and systems purchases from abroad were strictly restricted and submitted for government approval.

(ii) The second consists of opening strategies aimed at integrating into the international division of labour.

Singapore has conducted the most outward-looking policy, offering to foreign investors, on a very liberal basis, well educated personnel at an extremely low cost. The majority of the small "newly industrialised countries" have opened their doors wide to multinational computer manufacturers, with the intention of acquiring a productive capacity for exporting to the whole world.

Clearly, the reality offers all kinds of intermediate situations, with various combinations of utilization and production policies. Until the end of the 70's, the IT industry as most other industries, was subjected to either inward or outward looking policies, with occasional shifts from one to the other. Since the early 80's, the search has been on for strategies that aim to reconcile both internal and external constraints. These strategies must address the fundamental paradox between national development needs and the global character of a worldwide industry. These attempts are typical of "double bind" behavior [2] in which the predominance of one type of logic, is confronted by a contradictory result that is linked with the constraints of the opposite logical type.

2. THE QUESTION OF USE:

The introduction of data processing into developing countries during the 60s and 70s was mainly due to:

- Multinational corporations, for purposes of integrating their subsidiaries within their global organisations, for example the oil firms in Venezuela.

- Administration needs, although not for assistance with decision making or planning. For example, in the 60's, in the Ivory coast, the first computer was installed to fill the void created by the departure of the colonial administration.

More recently, the micro-electronics revolution and its applications have instigated at earnest hope of eventually to respond efficiently to development problems [4]. This hope was sustained by the anticipated arrival of low cost, easy to use, equipment, which required less heavy infrastructures than previously. A large diffusion of data processing technologies seemed possible throughout the whole socio-economic fabric. Industrialised countries were at the same time discussing "the computerisation of society" [3]. This dream, however, rapidly assumed the nature of a myth, leaving behind either impressions of disillusionment, or of enthusiasm in many countries. Was this for developing countries, a fantastic opportunity for a technological leap, which would catch up with industrial countries, omitting the phase of industrialisation, to enter the information age directly?

In practice things appear to be far more complicated [1].

A first category of problems originates from infrastructure constraints. These are mainly geo-physical conditions such as humidity, heat and dust, the instability of the infrastructures.

A second category stems from the lack of trained personnel.

A third category results from the shortage of adapted application software.

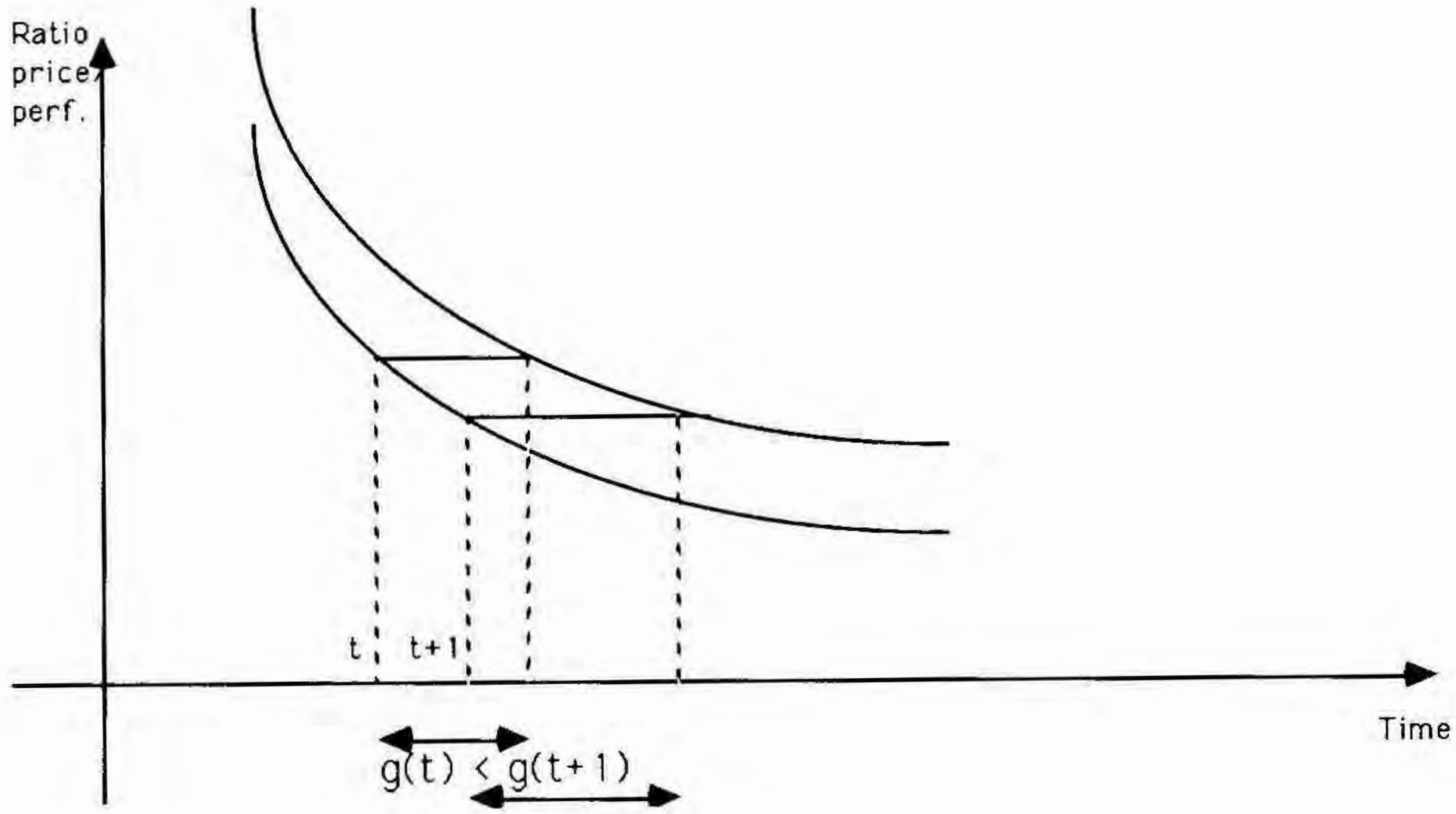
These problems give rise to a set of additional costs which must be born by the user. In developing countries, the tendency is for these costs to be met by the community, with the additional facilities being made available as externalities for individual use. These additional costs have an impact on the falling price-performance ration in less developed countries, as opposed to the equivalent ration for industrialised ones. This has induced an ever increasing gap in terms of computerisation costs, and consequently in terms of diffusion of applications. The theoretical diagram in figure 1 below indicates that there is indeed a time delay between a comparable price being attained in a developed country as opposed to in a developing country. Furthermore the extent of this delay appears to be increasing with time.

Additional questions also arise, for instance what are the impacts of computer applications on employment? Again the paradox exists between external constraints, (namely the international division of labour, which determines the international competitiveness of national agents), and the internal aims and specific national objectives. The question becomes that of the reconciliation of both sides of the paradox; the management of the "double-bind".

Some countries have tried to find a solution by introducing the distinction between the economic activities that are oriented towards the export market, as opposed to those which concern the domestic market. Such approaches have sometimes led to the adaption of "appropriate" technologies, which all too frequently have actually turned out to be intermediate technologies.

One conclusion is to suggest that the real question should be, not weather to adopt or to reject new technologies, but to begin with an analysis of what in technology is " power over nature", and what is "power over man" [5]. This conclusion would certainly be more widely applicable than to developing countries alone.

Comparison of theoretical ratio price/performance between developed (*below*)and developing (*above*)countries:



Comments: the level obtained at t (resp. t+1) in developed countries will be reached at t+g(t) (resp. t+1+g(t+1)) in developing countries.

3. THE VIABILITY OF PRODUCTION POLICIES

In general, any analysis should start with the question of the identification of needs. In other words, what is it that is included in Information Technologies, as technologies and not as final products, that could help in the alleviation of development problems? Furthermore, in which ways can IT become a factor of development? This has the result of introducing a real technological dimension into the formulation of IT policies.

In the most developed countries, the first steps in the process of computerisation have always consisted of the automation of previously manual tasks. Both an extension and an evolution of this process has resulted in new applications from which many currently available products have been developed. These systems and tools can be acquired by developing countries via commercial channels or via technology transfer programmes. However, as they have been designed within a completely different socio-economic framework, it is unlikely that they will meet the real needs for this new and distinct environment. In addition, the more dedicated to a specific application that a product becomes, the less likely it is to be easily transferable.

The actual application of information technologies to the problems facing developing countries may in fact lead to the design of new products, or even new concepts, which could eventually be transferred to the industrialised countries themselves. One example of this phenomena is that of the lack of reliable telecommunications networks adaptable for on-line tele-computing products. This problem can be solved by new "batch-telematics" concepts, which have to a large extent been developed in Brazil for their banking applications.

In this sense there is a very real innovative capacity within developing countries. This is contrary to the traditional idea of a technological gap and brings into question the practice of considering the northern countries' methods of industrialisation and technological development as a model.

Nevertheless, the viability of production policies is dependent upon the developing country's ability to truly link a national industrial capacity, in an appropriate manner, to the worldwide IT industry. Even in the countries that possess a large and protected domestic market, such as India and Brazil, concentration on the internal market imposes a limit to further industrial development. However, when such a country begins to export, it is severely handicapped in comparison to the multinational countries which do not benefit from protectionism. Regional cooperation can represent an intermediate step, however, this cannot offer a completely secure solution for reasons of market size. There may also be problems of arbitrating between national partners.

Another consideration is that the whole national fabric cannot be protected in a self sufficient manner, as sectors of the national economy have to be competitive with international standards. In India public policy had to face numerous contradictions owing to unreconcilable objective. During the first plans the policy was sustained by an almost autarchical logic. The industrialisation strategy aimed at supplying the domestic market with goods and equipment manufactured by Indian firms alone. The necessity to establish a clearly articulated internal industrial structure justified the gap which opened between the domestic and international levels of technology. However, since the middle of the 60's additional considerations have threatened the coherence of such a policy. A certain level of exports were required in order to finance the important intermediate goods and equipment. It then became impossible to maintain the distinction between the level of technology required by the national industry and the international standards. India was forced to compete with the South East Asian NIC's on the developed countries market. Therefore export oriented industries needed similar competitive conditions to those of their international opponents. Thus there became a conflict between the objective of establishing a national coherent industrial structure, and the desire to enter into international markets.

The IT industry in China was born during the 50's and has since developed in an isolated fashion. The technological developments in this country have been based upon standards quite different from those in the international community. The recent opening policy has raised questions concerning the technological compatibility of both internal and external development. In other words, is it possible to link a homegrown technological potential with a foreign technological contribution? How is this to be accomplished? Can the vas local experience gathered during the first twenty five years of the Chinese IT industry form the basis for the industry of the future, or would breaking off be the only way forward?

Despite the complexity of the articulation question, or "double bind" position, it is impossible to remain forever protectionist. The first problem to be resolved is to select those products that are to be imported and those that are to be protected. Clearly no general model exists, however, it is important to emphasise the enormous potential of the software and services field. The growing importance of intangibles within industrial activities is arguably the most momentous trend in the world economy at the present time.

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SECTION 2

COUNTRY/REGIONAL REPORTS OF COMPUTERISATON IN DEVELOPING COUNTRIES

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INFORMATION TECHNOLOGY IN ZAMBIA

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The paper presents an overview of computerization in Zambia with particular emphasis on the public sector. The major applications are listed, and key issues related to systems development, manpower availability and training are discussed. Computization in the private sector is also briefly discussed.

The second part of the paper provides an illustrative example of a primary school examination system. The system is described in detail together with the systems development process, user-computer interface, resource requirement, major impacts and major problems. Finally the paper presents a section on future scenarios.

1. OVERVIEW OF COMPUTERISATION

Computers have been in use in Zambia since the early sixties. The first machine in Government is said to have been an ICL 1500 installed in the Ministry of Finance. This was replaced around 1965 by an ICL 1904. These machines were mainly used for accounting systems such as Payroll, Government Accounts, Pensions etc.

At about the same time the ministry of Development Planning acquired an IBM 360/30 which was intended to provide services to technical departments. The applications were: Trade Statistics; Surveys and the Census for the Central Statistical Office; Hydrological Survey for the Department of Water Affairs; Meteorological and Geological data for the Meteorological and Geological Departments. One notable peripheral was the IBM 1287 Optical Reader.

In the early seventies, because of reorganisation in Government in which some ministries were abolished, both installations were placed under the Ministry of Finance two installations into one unit with a single computer system. In 1973 an IBM 370/145 was acquired on rental to replace the IBM 360 which found its way to another country in the region and the ICL 1904 which was donated to the University of Zambia where it served for some time. The decision to rent IBM equipment was not well received by some members of staff, the majority of whom at the time were British expatriates. The Data Processing Manager at the time resigned as a result of this. There were also some difficulties during the merger of the two installations as the ICL installation was run by the British whereas the IBM installation was under Scandinavians (mainly Finns). The first Zambian Data Processing Manager (the author of this paper) took over in 1981. The department has only two expatriate officers now, a British and an Indian, and has an establishment of one hundred and twenty seven.

In mid 1983 the IBM 370/145 was replaced by an IBM 4341 in order to introduce on-line capabilities and more flexibility. This system and associated peripherals have proved extremely reliable particularly the CPU and the 3350 disk drives. Since installation in early May, 1983 the CPU has only malfunctioned twice with the only serious incident occurring two weeks after installation during production of payroll. The fault was rectified with maximum efficiency by two local engineers assisted by an engineer flown in from a support center overseas.

The responsibility for computing services in Government has remained with the Ministry of Finance since the beginning, which it discharges through its department, the Data Processing Unit (DPU).

2. USE OF INFORMATION TECHNOLOGY IN THE PUBLIC SECTOR

(A) In Government, large scale computing is performed by the Data Processing Unit (DPU), which serves as a bureau to all Government ministries and agencies, that require such services.

There are however, other installations within Government serving specialised functions in ministries charged with the defence and security of the nation.

In addition there are numerous microcomputers and a few minicomputers in certain ministries and departments, such as the Planning Division and the Water Affairs Department of the Ministry of Agriculture and Water Development, the Census and Statistics Department and the Lands Department.

The DPU processes as Government Payroll for Accounts, the Ministry the entire Government as well Pensions, Primary School of General Education), Voters Registration (for the Elections office), External Trade and Census (for the Census and Statistics Department) to mention, but a few.

In the Ministry of Agriculture and Water Development, the Planning Division uses microcomputers in computation of basic agricultural statistics such as yield levels, hacterage, producer prices etc. in addition to storage and updating of these data.

The Water Affairs Department utilises microcomputers in processing data which is used in the production of hydrological yearbooks.

The Census and Statistics Department uses its microcomputers in processing and analysis of survey statistics on labour, household etc., as well as in the production of reports of such studies. The microcomputers in the National Commission for Development Planning are used in project preparation, appraisal, monitoring and evaluation. They are also utilised in expenditure monitoring for projects and programs in Government and the parastatal sector as well as external resource inflows. Demographic projections are also performed on these machines. Of late, use of these microcomputers has been extended to budget preparation and analysis.

In the Ministry of Power and Communications, the Department of Energy has some microcomputers used in planning and modelling and the Meteorological Department uses its microcomputer to facilitate its weather forecasting and related activities, which include the early warning system.

In the Ministry of Lands and Natural Resources, the Lands Department has set up a data bank of plots, farms etc. on its VS15 machine which is intended to improve land registration and revenue collection. The Government has had a lot of difficulty in collecting this substantial revenue due to a cumbersome manual system which made it very difficult to keep track of defaulting title deed holders. The data bank is still being expanded, the goal is to have all land allocations incorporated and future allocations automatically recorded.

Most of these micros and mini computers have been acquired through donor agencies. Microcomputers are now found in many other Government departments and a number of them appear to be properly utilised to fulfill various needs of those departments. In 1985/86 IBM donated through its Africa Institute concept, sixteen microcomputers and software to a number of Government departments and parastatal organisations.

In the local Government sector all major cities and some towns have computing facilities which are generally utilised in the production of payroll and bills for the usual services. The majority operate ICL equipment.

(B) In the last few years there has been considerable interest in data base management systems. The DPU utilises the Structured Query Language/Data System (SQL/DS) package for the budget preparation and monitoring system.

One significant development is that, at the very highest levels of the decision making process, there is a very healthy and encouraging level of computer appreciation which has resulted in the computer being viewed as a powerful tool to be used in facilitating delivery of services to the nation. This has brought the senior management of the main Government computing facility into the forefront of the decision making process. This is because the authorities view them as custodians of vital information who must therefore, be sensitised to the information needs of top management.

This situation has evolved quickly in the past few years as the economic situation has deteriorated, thereby highlighting the importance of accurate and timely information for making effective and efficient use of very limited resources.

(C) Major Applications in Government.

The following are some of the major applications proceed by major Government computer centers.

APPLICATION	MAJOR USER
Grade VII Examinations	Ministry of General Education, Youth and sport.
Government Accounts	All Ministries
Pensions	Ministry of Finance
Payroll	All Ministries
Census & various Surveys	Census & Statistics Department
External Trade	Census & Statistics Department
Hydrological Surveys	Department of Water Affairs
Motor Vehicle Registration	Road Traffic Commission and Police
National Registration	Registrar General
Geological Survey	Geological Survey Department
Voters Registration	Elections Office
Vital Statistics	Census & Statistics Department and Registrar General
Savings Bank System	National Savings and Credit Bank.
Land Registration	Lands Department

In the private and parastatal sectors most applications are the usual payroll, inventory, billing etc. At the moment there are only a few decision oriented applications because some people in key management jobs are not computer literate. Such managers are still a bit apprehensive about computer usage for supporting decision making.

3. HARDWARE/SOFTWARE AVAILABILITY

The key vendors of hardware are ICL, IBM, NCR, Computer Services Limited (agents for WANG), Woodgate Computer Systems (remarketer for IBM up to the 4361 and 9370 systems) and Data Care (agents for Memory Systems). A new vendor representing DEC has arrived on the scene, but has not as yet made significant impact.

The major competitors in the public sector are ICL and IBM, with ICL strong in local Government and IBM strong in central Government.

Most users of data communications lines often experience difficulties especially in the rainy season even though most lines are dedicated ones. The giant mining corporation has been pursuing the possibility of establishing its own private communications network but it would appear the telecommunications corporation has not been too keen.

Most software for mini and large systems are developed in-house, except for systems software, where the cost of importing packages is prohibitive. For microcomputers because of relatively lower import costs the popular packages are readily available.

4. PROCEDURES FOR PROCUREMENT OF COMPUTERS

(A) Up until the introduction of the Foreign Exchange Auction System in October 1985, all procurement of hardware required prior approval of the Computer Utilisation Committee (CUC) at Cabinet Office. The Auction System and the subsequent Foreign Exchange Management Committee introduced in 1987 appear to have invalidated this requirement at least for the private and parastatal sectors. The position in the public sector, while not as yet clear with regard to the CUC is that approval of the Central supply and Tender Board is still a requirement. It is prudent for ministries and departments to approach Cabinet Office and also to liaise with the DPU before submitting requests to the Board.

(B) Users are generally advised on the capabilities and suitability of equipment and software if they seek, CUC approval or request the DPU for professional assessment.

(C) There is no hardware currently manufactured or assembled in the country. However, a lot of in-house software is built because the importation of packages, other than systems software, is still limited, except for microcomputers, due to very high cost.

(D) With the introduction of the Auction System and its attendant liberalisation, import restrictions fell by the way. The duty on data processing equipment is in the region of 30%, with sales tax around 15%. There are no import restrictions on computer equipment in force, at the moment other than those dictated by the scarcity of the requisite foreign exchange.

(E) At the moment the Government appears inclined toward centralised utilisation of computer resources on large applications. In addition standardisation of equipment is evolving. This is due to scarcity of manpower skills and that of foreign exchange, which suggests that existing facilities should be utilised to the fullest extent possible.

(F) The CUC, in consultation with the DPU and other information technology professionals, was viewed as the agency for formulation of policy in the information technology. The situation has not been clear since the introduction of a stringent foreign exchange regimen.

5. PROCEDURES AND GUIDELINES FOR SYSTEM DEVELOPMENT

(A) The Data Processing Unit (DPU) in the Ministry of Finance is recognised as the organisation charged with computer systems development in Government. It is headed by a Data Processing manager at Deputy Permanent Secretary level.

(B) There is no set of Government-wide guidelines for systems development. However, agencies requiring computerisation of major applications begin the process by approaching the Data Processing Unit (DPU). It assigns staff to make the usual feasibility study intended to establish the exact requirement as well as assist in making a "go/no-go" decision.

When a need to computerise is established, one of the Systems and Program Development branches of the DPU is detailed to undertake the assignment. Once the system is operational, that branch is responsible for maintaining it.

(C) All major software development is performed in-house by the DPU including installation of systems software and packages. There are some departments with microcomputers such as the Census and Statistics, which have developed a reasonable level of programing capability for some of their requirements.

6. MANPOWER AVAILABILITY AND TRAINING

Only one college is offering formal training leading to a recognised certificate/diploma in computer studies. The University at the moment only offers a mathematics course with some computer science content. The college, located in the capital city, offering the course is doing so with the assistance of a donor agency, and commenced the course in 1986. The initial intake was between 25 to 30 students. The course is in two parts; the first two years will lead to the attainment of an advanced Certificate and an additional year to the Diploma.

For the most part a number of organisations including the Government survive on in-house training and advanced training abroad, with assistance from donor agencies, leading to Higher National Diplomas, degrees etc.

The Government computer centre intends strengthening its in-house courses and in this regard steps are being taken to acquire, COBOL programming and Systems Analysis courses and associated video equipment.

For organisations that have or had limited access to aid funded training, the introduction of the local course has come at an opportune moment as training officers abroad has become extremely expensive because of the drastic devaluation of the local currency.

7. COMPUTERIZATION IN PRIVATE SECTOR

There has been considerable computerisation in the private sector especially in banking and other financial institutions. All banks have a number of applications which have been computerised. The majority of the banks have opted for NCR equipment. One bank has even introduced some terminals in its Savings Centre, in the capital city. The National Savings and Credit Bank (NSCB) is serviced by the DPU of the Ministry of Finance for historical reasons. Indications are that this bank would like to set up its own installation some time in the future.

The National Provident Fund has a network, with lines to two centres on the Copperbelt, about three hundred and fifty kilometers away and another to Livingstone, about four hundred and fifty kilometers from the capital, with which it hopes to effectively and efficiently serve its members. The Fund utilises two ME29s and associated peripherals and depends on the Posts and Telecommunications Corporation for data communications lines.

Other notable users ICL equipment are the railways, LONRHO, the Post and Telecommunication Corporation (PTC) and the Electricity Supply Corporation. The Electricity Supply Corporation has a 2900 whereas the other three have ME29´s.

There are a lot of companies with micro and minicomputers. It is difficult to provide meaningful figures without a detailed study. Most vendors are unable to provide accurate figures on microcomputers in use in the country, because quite a number are imported directly without the

knowledge of local offices.

The largest computer installation in the country is owned by the Zambia Consolidated Copper Mines, a quasi-Government company, which has two IBM compatible National Advanced Systems AS 8200´s. They utilise a lot of IBM systems software. The company also has a considerable number of microcomputers of various manufactures in addition to VAX machines from DEC used at one of the largest open pit mines in the world.

The company has a network connecting some of its mines around the Copperbelt to its nerve centre in Kitwe in addition to a line to its headquarters in the capital city. A number of companies serving the industry have IBM System 36´s, WANG VS15's, ICL ME29s and 2903's, micros etc. used mostly for the usual financial systems.

The Industrial Development Corporation has acquired IBM System 36´s. These are used at their bureaux for the subsidiaries of this giant parastatal corporation. They are installed in the capital city and on the Copperbelt.

The farming community (i.e. the research centres and those engaged in large-scale farming) have not been left out. One large organisation utilises an ICL DRS 20 while another which is a subsidiary of a well known multinational in the poultry industry utilises an IBM System 34. The Cooperative Federation also utilises ICL DRS 20's in its activities intended to facilitate services to farmers that are members of provincial cooperatives. The National Agricultural Marketing Board has an ME29 used to facilitate its services to the farming community.

The National Airline has a WANG VS45, the only one in the country, which replaced an IBM System 3. It is used mainly for financial systems. An airline reservation system uses the WANG linked with at least two other airlines in the region, to a system in Atlanta, Georgia, U.S.A. The airline has had some difficulties introducing industry packages because it is said these are mostly written for IBM equipment. This has been a source of frustration particularly that the present management team was not responsible for the decision to purchase the current machine. However steps have been taken to acquire an IBM 9370 with the assistance of an airline on the Indian sub-continent to redress the situation.

The Zambia State Insurance Corporation (ZSIC) operates an IBM 4361 at its headquarters and a System 36 at its regional headquarters on the Copperbelt, the two systems are to be linked at a later stage. The systems replaced an IBM System 3 which had been with ZSIC for many years. The new systems are to introduce on-line capabilities which are intended to improve the corporation´s services to customers.

The University of Zambia (UNZA) also operates an IBM 4361 installed at about the same time as that at the ZSIC, but has progressed with notable speed as a result of effective preparation. Students utilise the system extensively. The 4361 replaced an ICL 2903 and is an 8 megabyte machine which will provide graphics capabilities, for the scientific and engineering faculties etc. It is also used for the usual financial and student records systems.

Both organisations were assisted by the Government DPU in training operators and systems programmers. These personnel were attached to the DPU Computer Centre for varying periods with those from UNZA spending more time.

This type of cooperation and assistance received full support of the Government as it invalidated the need to hire expensive overseas consulting firms to do what locals could do effectively and at a much lower costs preserving the much needed foreign exchange. In fact the University also acquired at no cost a payroll package from the DPU which resulted in a saving of two hundred and fifty thousand U.S. dollars which had been earmarked for a software package from abroad.

Consultancy services are available from countrybased vendors as well as international consulting firms. There are bureau services run by some of the vendors as well as one or two other private companies. There are one or two Zambian owned companies that are now

providing consulting services in the information technology field. They have yet to make themselves felt in the information technology community, but they appear to hold promise.

8. ILLUSTRATIVE APPLICATION: THE PRIMARY SCHOOL EXAMINATION SYSTEM

8.1. Introduction

Zambia is a sovereign republic within the Commonwealth, which is approximately 750,000 square kilometers with a population of approximately 6.5 million. The capital, Lusaka, a city of over 700,000 inhabitants, is centrally situated. Zambia has nine provinces viz Lusaka, Luapula, Northern, North Western, Copperbelt, Southern, Western and Eastern, with 56 districts. Each province has a Chief Education Officer who is responsible to the Permanent Secretary of the Ministry of General Education and Culture for primary and secondary school education affairs in the province. Each district has a District Education Officer responsible to the Chief Education Officer of the province. There is an Examination Officer at the Ministry of Higher Education in Lusaka. The Copperbelt, Lusaka and Central Provinces account for approximately half of all candidates that take the Grade VII examination each year.

Chief Education Officers liaise with the Examinations Office in Lusaka on all matters pertaining to the examination. It is taken in the first week of November and marking of the answer sheets normally commences around the middle of November and normally completed by the middle of January.

The computerised system was brought into operation to streamline and centralise the marking of the Secondary School Selection (Grade VII) Examination which is taken after seven years of primary school education. The examination papers consist of multiple choice questions for which candidates record responses on specialised answer sheets which are machine readable and are direct input to a document reader. The papers on the answer sheets are read and the responses scored and stored on a magnetic disk file. Analyses are performed on the scores and relevant reports produced which are used in the selection of entrants to secondary schools and the production of associated certificates.

The Ministry responsible for primary school education is billed for the maintenance of the specialised equipment as well as stationery in the form of answer sheets. The answer sheets are imported due to lack of adequate technical expertise in the country. Manufacture of these answer sheets requires high precision to ensure accuracy of the Optical Mark Reader (OMR), during processing.

The system originally ran on an ICL 1904 using a device known as an Universal Document Transport (UDT). Available records indicate that is utilized the UDT in 1969.

By 1974 the system had been modified to utilise an IBM 3881 Optical Mark Reader (OMR). This was as a result of the Government deciding to merge the two computer centres that had hitherto existed. A single installation utilising an IBM 370/145 was set-up to operate as a bureau, under the Ministry of Finance. The 370/145 was replaced in mid 1983 by an IBM 4341 but the 3881 OMR was retained and is still in use.

In 1972 the system processed approximately 270,000 answer sheets for some 90,000 candidates throughout Zambia. In 1988, 790,000 answer sheets were processed for some 200,000 candidates, from over 3,000 primary schools. Because there are fewer available secondary school places than candidates that pass the examination, the number of those who fail to secure secondary school places is very high. For example in 1981 only 22,021 candidates secured places in scheduled secondary schools out of 143,113 candidates. In 1986 only about 45,100 out of 180,000 secured places. It could therefore be said that between 15% and 20% of the total candidates taking the examination in any one year proceeded to secondary schools. The number of primary school classes, some built on self-help basis, have increased at a faster rate than those in secondary schools.

The examination system is one of the most sensitive applications processed by the Data Processing Unit to the extent that all those directly involved are required to take an oath, quite aside from the usual Official Secrets Act.

Every candidate known to be taking the examination is provided with answer sheets preprinted on the computer with his name, examination number and other relevant details. This sheet is also coded for later recognition by the document reader. The candidate marks his answer sheets with the responses he chooses from the alternatives in the multiple choice examination papers. There are 50 to 60 questions per paper.

Once all the candidates' papers have been scored, the results are analysed. An Item Analysis is performed to assess the complexity of the questions. Special algorithms are applied to the file in order to facilitate the creation of a file of standardised scores. The standard scores are used for the production of scores lists, distribution lists, determination of cut-off points for selection of Secondary School entrants, as well as production of certificates.

The Data Processing Unit receives the answer (score) keys and standardisation algorithms from the Psychological Service of the responsible Ministry.

Final reports and certificates (usually produced six months after the results are published) are produced only upon a written request from the responsible Ministry.

8.2. Objectives of the system

These are said to be:

i) Provision of a standard and objective procedure for marking examination papers.

ii) Completion of the marking, selection of secondary school entrants, and the distribution of certificates within reasonable time

iii) Provision of effective analysis of examination results in order to facilitate assessment of the complexity of the papers.

iv) Minimisation of malpractices and other improprieties.

8.3. Data and files

Each year a Candidates´ File is created from Application Lists submitted by primary schools and external centres that wish to enter candidates for the examination. The file changes completely from year to year. Each record on this file contains information on each candidate such as school number, examination number, name, sex, year of birth, secondary school of choice, raw scores and responses.

The Schools´ File, which holds information on each school, is updated yearly to incorporated new schools. Each record on the file contains information on each school such as the school number, name and address as well as the expected number of candidates taking the examination that year.

Both files reside on magnetic disk and backup tapes are taken periodically during processing.

There also exists on tape a Standard Score File which contains candidates´ particulars together with raw scores and their corresponding standard scores. This is retained for ten years.

Answer sheets, with responses entered by candidates, are the basic input to the system.

8.4. Processing of answer sheets

Each year the Psychological Service of the responsible Ministry prepares sample questions for

the final examination for all the papers. These sample questions for each paper are tested at selected schools. This is the pre-test phase which is designed to determine the level of complexity of the questions hence their suitability.

The pre-test is carried out utilising the standard answer sheets which are marked utilising the Optical Mark Reader in the normal way. The final product is the Item Analysis which provides frequency distributions of responses which greatly assist in the selection of the most suitable questions for the final examination.

Answer sheets are sent to schools prior to the examination, and are returned to the Data Processing Unit via the Examination Office, where they are read utilizing the document reader. The machine-coded heading is read to identify the candidate and the responses and scores are stored in the candidates record on the magnetic disk.

When a paper is rejected due to unacceptable identification information, doubtful responses or damaged condition, its responses together with identification information are manually entered on a plain answer sheet. This paper is then re-read on the document reader. Only about 50 teachers are required to assist in sorting, removing blank answer sheets as well as transferring information from rejected sheets.

If a paper is rejected due to intensity of the responses made by the candidate, it is re-read with the machine set for each of the three possible intensities (i.e. normal, light, dark). A maximum of seven attempts are made to read the paper. The machine performs better if responses are dark. At top and center of the answer sheet there is a computer printed reminder to the candidates to make their responses reasonably dark.

Late entries papers, i.e. papers of candidates whose names are not on the Candidates´ File, are marked in the normal way after candidates particulars have been entered on the Candidates´ File utilising an update program.

When all the answer sheets have been read, the Candidates File is checked to ensure that an answer sheet has been read for each subject paper, as recorded on the attendance register. Missing papers are listed and relevant attendance registers are referred to in order to determine whether or not he Candidate took the paper. Answer sheets for all papers determined to have been taken are physically traced and subsequently input to the system.

The responses are scored as answer sheets are read using answer (score) keys, producing raw scores which are subsequently analysed, to produce an Item Analysis showing the complexity of the questions in the examination, as well a standardised scores.

The Psychological Service examines these listings before advising the DPU of cut-off points for the selection of candidates for secondary schools and grades for certificates. The cut-off points are determined utilising the number of available secondary school places.

8.5. Justification of system

Prior to the introduction of document readers as input devices for processing these examinations, punch cards were used. The system at the time was divided into two; one for the Secondary School Selection and the other for the Leaving Certificate Examination, which was computerised in 1969.

By 1965 the Data Processing Unit, was raising serious concern about delays and irregularities that were taking place, due to missing data on candidates´ details. There were also problems associated with administration since a large volume of punch cards was involved. The number of candidates in 1965 was approximately 16,000 but, by 1968 this had reached the 50,000 mark which required punching 200,000 cards.

The need, also arose in 1968, to comply with a Presidential directive requiring an end to provincialism whereby students were required to select the nearest day secondary school. The

directive was intended to allow some students from all over the country to apply to a number of specified schools located along the main railroad where all major towns are situated.

There are also indications that part of the processing for these examinations was done in the United Kingdom which also contributed to delays, due to late arrival of tapes that were to be input to subsequent parts of the process.

As a result of these problems a decision was made some time between November 1968 and January 1969 to consider using machine readable documents for the 1969 examinations, which would do away with costly and cumbersome procedures associated with the punch card system.

8.6. Systems development processes

After consultations with the mainframe vendor in use (ICL) , it was decided that a Universal Document Transport (UDT) would be used to assess the viability of such an approach. One was located in Nairobi through ICL. Steps were taken to design a suitable program for the purpose of trials that were to be carried out in Nairobi. It was determined two trips would be necessary; one to confirm the validity of the document (answer sheet) that was designed as per specification from the manufacturer and the second to test the program for reading the answer sheets.

The new system would require despatching the answer sheets to Nairobi for reading on the UDT and output on tape would be returned to Lusaka for further processing.

Trial runs with the newly designed answer sheets were carried out by the Psychological Service of the Ministry of Education to determine whether candidates would have trouble using the sheets. These indicated that there would be no problem with the sheets.

One of the advantages of the UDT considered important was the fact that the School Selection Examination, which was at the time conducted much earlier than the Grade VII Leaving Certificate Examinations could be scheduled closer thereby improving the overall administration of the exercise.

It was the intention that should the exercise as proposed prove a success then a decision to hire or purchase a suitable document reader would be taken in order to do away with the expensive and cumbersome need to despatch the answer sheets to Nairobi.

The answer sheets were acquired from overseas (i.e. United Kingdom). This is still the case today but the sheets can be purchased from any country that offers a good price. The reason for overseas purchases is that there is still no technical capability in the country for the production of these sheets because of the precision required by the reader. Successful trial runs were carried out on the UDT of the Kenya Treasury Computer Services in June 1969 by a senior programmer from the Data Processing Unit. The production time for the exercise was estimated at 45 hours and the charge per hour was set at 32.10 Kenyan pounds.

Later in the year the actual answer sheets were sent to Nairobi for reading and writing on to tape with actual marking being performed by programs that ran on the machine in Lusaka.

In May 1970, a decision was taken to acquire an ICL Universal Document Transport on rental basis with a view to purchasing the machine the following year, when funds for the purpose were to be allocated in the budget.

This decision was taken after a detailed comparative study involving the ICL UDT and an IBM 1231-N1. The study took into account factors such as monthly rental costs, monthly maintenance costs, purchase price, document sizes, maximum reading speed, type of pencil required for recording etc. Even though the IBM reader was cheaper by most counts, its major weakness was its speed and the fact that it would have required approximately 3 man months in programming and systems effort to accommodate its specifications. It was rated at 33

documents per minute compared to 300 per minute for the UDT. The slower speed would have resulted in extra costs in machine time and operators time. Another factor in favour of the UDT was the availability of backup at Nairobi whereas the only other IBM-Nl in Africa was in South Africa, with which Zambia could not have Government to Government contact. The study determined that utilisation of the UDT for at least four years favored purchasing. The equipment was ordered in 1970 but it did not arrive until 1971.

In early 1971 it was decided by mutual consent of the two departments - the Examinations Office and the DPU - which was accepted by Cabinet, to combine the two examinations into a composite one consisting of six (6) papers. This necessitated redesigning the answer sheet, to incorporate 2 papers on a single sheet in order to reduce printing and reading time, as well as some re-writing of relevant programs in the system. The idea of combining the two had been mooted sometime in 1970 while assessing the viability of utilising machine readable documents.

8.7. Managing user/computer interface

During early stages of the system's life there were very regular meetings comprising managers and technical staff from the relevant departments i.e. the Data Processing Unit of the Ministry of Finance, the Examinations Unit and the Psychological Service of the Ministry of Education. It was common to hold more than ten meetings per year.

As the system matured the regularity of these meetings began to decline such that at the present time with the system very stable there are no more than two to three meetings of operations staff from the two departments in any one year. These meetings are generally for drawing up schedules and are therefore largely routine, except for the occasional special meetings of senior staff from both departments. Consequently there are no formal steering or project committees.

Because of the limited number of secondary school places the examination is of concern to literally every household at one time or another. Hence there has always been considerable nation wide interest in the system. Each year the results make front page news.

There is a lot of interaction between the two departments (i.e. the DPU and Examinations Office) during the year to ensure that schedules are adhered to. This increases during the period early November to mid-January when the answer sheets are processed and a lot of day to day coordination becomes necessary. Liaison is mainly between relevant one hand and the Operations Branch, and relevant officers from the officers Computer Systems system, of the Data Processing Unit on the other.

The Psychological Service usually interacts with the DPU when all reading and marking has been completed. They provide the algorithms for determining cut off points depending on available places in secondary schools. This is always after procedures and processes for determining any irregularities have been affected and appropriate corrective measures taken. Occasionally these corrective measures occur after the results have been announced.

8.8. Resource requirements

At the present time, during the preparations leading to the examinations, only one or two officers from both departments are required. However, during reading and marking of the sheets approximately 50 teachers are required to scrutinize and prepare rejected sheets for re-input to the document reader. They are normally accommodated in a hall some distance from the computer center. A few operate from the computer center working on sheets not requiring detailed scrutiny which can be quickly attended to and re-read.

At the Data Processing Unit, additional operations staff are required in order to maintain a twenty-four hour shift necessary to complete the exercise by mid-January. Usually four to six senior data entry operators, are temporarily assigned the task under the supervision of qualified computer operators. The officers from the System Development Branch in charge of the system are held accountable for the successful completion of the exercise and therefore in conjunction with counterparts from the Examinations Office supervise the day to day activities. The ultimate

responsibility for the system´s performance lies with the Data Processing Manager.

The major costs generally incurred are: the overtime for officers in both departments and fuel requirements due to the need to transport the answer sheets; the hall where the Examinations Office prepares them; and the computer centre where they are read and marked. Transporting computer operations staff to and from their homes is another cost. There is also the cost of the document reader, which is there for the sole purpose of processing the examinations as well as the cost of the specialised stationery (i.e. the answer sheets). These costs are not very high when compared to costs that would be associated with a manual system. Machine time (i.e. CPU time etc) is not included because the maintenance cost which is the major item of expenditure would be incurred regardless. The computer hardware is wholly owned by the Government.

The total of clearly attributable additional costs would be no more than 100,000 U.S. dollars for approximately 200,000 candidates, which works out at about 0.50 U.S. dollars per candidate.

8.9. Training of personnel

Since the basic concept of the system is not very intricate concentrated training of the user is not necessary. Training of data entry operators to man the document reader is a relatively easy task requiring no more a week on-the-job training.

Whenever need arises to change systems and programing staff provision of on-the-job training is a bit more involved. However, existence of good documentation and the presence of a number of experienced senior officers who are very familiar with the system makes the task manageable. Rotation of officers is effected as another measure of ensuring the integrity of the system.

8.10. Modifications and future plans

One major modification to the system was combining the reading and marking process which resulted in tremendous improvement in the processing time required to complete the exercise. Prior to the change in 1981 the processing involved reading the answer sheets and recording the scores on disk first, with marking and analysis of scores performed at a later stage. The marking and analysis used to take between twenty and 30 hours of continuous CPU time on the 370/145. Combining the process resulted in a requirement of abort 5 hours to analyse the scores. This is because with the change as reading is taking place the scores are also marked. The arrival of the 4341 system improved the situation further.

Requests come from time to time, for special reports and analyses, from the Psychological Services that are designed to strengthen the detection of irregularities, as well as to improve determination of the suitability of examination questions. For the past three years there have been fewer and fewer cases each year of serious and blatant irregularities as the system has demonstrated its ability to quickly highlight any undesirable deviations from the norm.

There have been some discussion with a vendor about availability of equipment that would assist in decentralisation of the system with central computing performing the aggregation process. The idea envisions suitable microcomputers or mini-computers and document readers at provincial centers where initial reading would be performed and results on diskettes or viable data communications lines sent to the central site for further processes etc. This has been brought about by the fact that the present 3881 reader has been withdrawn from the market and maintenance contracts will not be available beyond 1989 as well as the realisation that initial processing at provincial level could reduce the period required to complete the exercise. The University of Zambia or the Examinations Council is expected to take over the responsibility for all aspects of this system in the near future. The University already processes two secondary school examinations on behalf of the Examinations Council chaired by the Vice-Chancellor.

8.11. Impact of the application

The system streamlined the Grade VII Examination System such that an objective way of marking these crucial examinations exists. If this system were not available and a more subjective one was in place there are indications that there would have been even more serious social problems associated with the selection of candidates for the very limited secondary school places (in 1988 close to 200,000 candidates competed for approximately 50,000 secondary school places).

Through its detection of irregularities which always results in the re-examination of the offending school, the system at an early stage, clearly demonstrates to people at an impressionable age that cheating almost always does not pay. It has also assisted in instilling a sense of discipline in teaching personnel.

While the system has its critics, particularly those who miss what they term "the good old methods", it is generally conceded that it is a far more objective way of processing these examinations.

9. MAJOR PROBLEMS

The major problems affecting the pace of information technology are (a) the scarcity of foreign exchange and (b) shortage of both manpower and suitable skills.

Like most developing countries the debt burden with the associated critical shortage of foreign exchange has meant that insufficient foreign exchange is made available for the desired information technology requirements with the attendant adverse effect on the introduction of sophisticated equipment and packages especially for mini-and mainframe computers.

In Zambia the skilled manpower problem is quite acute because for a considerable period there was no institution of higher learning providing a recognised and suitable computer studies course. Some organisations simply depend on "poaching" and because of high turnover of staff certain critical projects do not get completed. This hampers the development and application of information systems .

The skills shortage in areas such as management, decision support and data base systems often means engagement of foreign expertise, at very high costs, to implement certain systems considered very important for decision making processes. This process often does not ensure continuity. There have been systems developed utilising expatriates which are no longer providing the intended services because continuity was not assured.

10. FUTURE SCENARIO

There has been a general realisation in the higher echelons of management in the public, parastatal and private sectors that the computer is here to stay and is a powerful tool which when effectively and efficiently utilised can enhance the performance of organisations. In the business community there is a realisation that computers can provide the competitive edge necessary for survival and profitability. In Government the computer is now viewed as a means of achieving efficient utilisation of scarce resources which in turn facilitates the provision of acceptable levels of services to the nation, thus creating a suitable climate for an efficient economy.

This realisation is evidenced by the proliferation of micro and minicomputers, in few years in virtually all the sectors, that are involved in planning and modelling as well as in the usual financial systems such as payroll, inventory control etc. This is despite the rapidly diminishing value of the Kwacha (local currency) which has rendered equipment very expensive in kwacha terms.

The author of this paper believes serious thought by relevant authorities should be given to the following:

(i) Adequate and urgent attention should be directed toward the establishment of a viable course in computer studies of international standard at the University, to augment that run by a polytechnic.

(ii) There should be urgent consideration toward establishing an institution or revamping an existing one that will be charged with formulating national policies on training, planning, procurement, coordination etc. of information technology.

(iii) Clearly defined procedures designed to exercise appropriate control in the procurement of information technology in the public and parastatal sectors should be introduced. The private sector is thought, to be generally geared toward exercising adequate controls through stringent accountability to shareholders and could therefore be excluded.

(iv) The involvement in the formulation of Information Technology policies of all relevant stakeholders such as the Computer Society, the Library Association and educational institutions should be encouraged.

(v) Standardisation of hardware and software should be fully addressed with efficient utilisation of the scarce foreign exchange and manpower skills in mind.

(vi) The possibility of viably assembling locally some of the hardware (especially microcomputers) as well as encouragement of software development for export should be seriously considered.

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IMPACT OF INFORMATION TECHNOLOGY ON NIGERIA'S SOCIO-ECONOMIC DEVELOPMENT

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Inspite of immense natural resources, high level of domestic consumption and rapidly expanding economy in Nigeria, Computer-based information technology as a means of improving economic and social development in the country started with the third generation of Computers in the sixties.

Since then, the country has witnessed appreciable but slow progress within the international community of "Computerised Society".

Nigeria is currently undergoing structural developmental processes as a result of economic crunch. This has necessitated the adoption of various computer applications in her efforts to revamp the ailing economy.

This paper will attempt to appraise situation of information technology in Nigeria, focusing attention on some computer applications that have aided national development.

The paper will also identify constraints and suggest strategic options available for Nigeria to promote high standard of computerisation.

1. INTRODUCTION

Nigeria is a country with immense natural resources, high level of domestic consumption and rapidly expanding economy. The country has a fast growing population with an estimated growth of 2 percent per annum. The climate is Tropical and major languages spoken are Hausa, Igbo and Yoruba. There are about 250 other linguistic groups. The official language of the country is English.

Although Nigeria is a secular country but main religions are Christianity, Islam and Traditional religion. Apart from the Federal Government which is controlled by the President, there are other 21 States Governments in the whole Federation and each state is being controlled by a Governor.

Unlike other less developing countries, Nigeria is well endowed with rich mineral and agricultural resources such as petroleum, coal, tin, columbite, natural gas. limestone lignite, lead, sink, cocoa, groundnuts, palm produce, cotton, soya beans, yams maize cassava, rice etc.

Business opportunities include prospect of promoting joint ventures between Nigerians and their foreign counterparts in the areas of electronics and computers, electrical products and commercial agriculture.

The table below gives general information about Nigeria:

Area	923,769 sq. km
Population	106 Million (Estimated figure Mid-1986)
Climate	Tropical
G.D.P.	N26.47 billion (1985)

Source: Lagos Chamber of Commerce Publication

2. COMMENCEMENT OF COMPUTERISATION IN NIGERIA

Nigeria's first experience of computer-based information system started with some third generation computers in the early sixties. The technology was new, the scope was limited and the available pool of technical knowledge was insufficient. Even though some people and organisations did realise the importance of the computer as a means of obtaining speedy, accurate and relevant information, the level of awareness was too low as to have any significant impact on the social and economic development of the country.

The focus of information technology then was mainly on mechanised systems as against more sophisticated applications in use today.

This period, referred to as the pre-oil boom era of the country, was when sources of foreign-exchange earnings were mainly from cash crops and the economy was relatively stable. The few industries that were in existence then produced at optimum level; and although they depended heavily on imported raw materials, these were non-the-less quite easily available.

Initially, not much emphasis was placed on information processing especially as industries were seemingly being run effectively, there was far less need for crisis management which necessitates dynamic flow of information for quick decision-making at all levels. People could not therefore see enough justification processing for computer-driven information systems.

However, by the early seventies, the first sign of meaningful steps towards computerised data processing was noticeable in Government and some big industrial concerns.

This trend continued and significant progress was steadily recorded inspite of the militating odds.

Today, Nigeria can be said to have joined the computerised society of the world. This assertion is supported by the wide range of computers now available in the country; the software packages that are in use for various tasks; the sizeable number of computer experts available, and the degree of computer awareness within the populace.

Tables 1 and 2 below show the growth in the number of computers from 1960 to date:

Table 1
Number of computers in Nigeria by 1979

TYPE OF COMPUTER	COMPUTER CLASSIFICATION	NUMBER
IBM'S System 3 Series NCR'S Century 101 System	Small Business	30
DEC'S PDPII Series NCR'S Century 8250	Mini and Midis	12
IBM 370 Series ICL 2900 Series	Mainframes	40
	Total	82

Source : Report of survey of Computer distribution and usage in Nigeria, published by the National Policy Development Centre. (Think-Tank) in 1979.

Table 2

	PERIOD	NUMBER OF COMPUTERS IN THE COUNTRY
1.	1960 - 1970	30
2.	1970 - 1977	70
3.	1977 - 1979	82
4.	1979 - 1982	Over 400
5.	1982 - 1989	About 1,000

Source:
1. United Nations Survey
2. The Nigerian Computer Users Directory
3. Same as in Table 1 above
4. The Nigerian Computer Users Directory
5. Author's estimate based on the known computer installations and progression of growth.

The figures quoted in items 4 and 5 of table 2 are mainly in respect of mainframes, minis and few super micros. A substantial number of micro computers are exluded.

This is not to say though that all is well with the use of information technology in Nigeria. For there are still many problem areas that require urgent attention and solution if our plans for economic, social, and political development are to be achieved.

One useful way to appraise the state and use of information technology in Nigeria, is by reviewing the past, examining present trends and extrapolating into the future of this pervasive technology. The final assessment must be based on the degree to which it has served as a

means of accelerating national development.

3. INFORMATION TECHNOLOGY IN NIGERIA: A PROGRESS REVIEW FROM THE EARLY SEVENTIES TO DATE

In examining developments in computerised information processing in Nigeria, it will be useful to look into the situation from the early seventies to date; this way we can bring out the gradual but significant gains that have been achieved in this area of national development. For purposes of dealing with the above topic, I have chosen to classify users of computers into four main categories:

(1) Government
(2) Parastatals
(3) Educational Institution
(4) The private sector of economy

It will also be helpful to look into these four main areas in terms of: Hardware; and types of past and current applications on equipment used, also we must look at our present manpower resources and those problems that have militated against speedy growth of automated information technology in the country.

3.1 Information technology in federal ministries

Among the users of computers in Government Ministries are the Federal office of Statistics (now under the Ministry of National Planning and Statistics); The Federal Ministry of Finance, Department of Customs and Excise and The Nigeria Armed Forces.

3.1.1 Federal Office of Statistics

The Federal Office of Statistics acquired an IBM 360/25 computer system around 1963. Recognising the vital role which statiscal data plays in the development of a nation, this Department was charged with the responsibility of collecting data and processing it with a view to supplying information to other arms of Government for planning purposes. From 1963 till a few years ago, the Federal Office of Statistics could not be said to be fulfilling the role for which it was set up. Among the problems it faced was lack of skilled manpower resources and Government's indifferent attitude towards establishing a sound national computer policy.

Today, the Federal Office of Statistics has offices throughout the Federation. Their main responsibilities are to assemble, process and provide statistical data for national planning purposes. It is also expected to serve as a data-base for some of the Data Bank projects in the country. Each state serves as a collection centre for the required data. The processing of such data is centralised and documents serving as input to the computer have to be batched from various collection points and taken to the central computer centre for processing.

Even though there has been some improvement in manpower training and utilisation of computer facilities, the quality of information obtainable from the Federal Office of Statistics cannot be said to be satisfactory. One major problem facing this Ministry is that of data gathering. Since such data would have to be collected either by questionnaires, interviews, or a combination of both, the process becomes labour intensive. Response to questionnaires have so far not been encouraging and at times the sampling technique is adopted to arrive at conclusions. Because of the apparent inaccuracies in the end-result of information produced by this Department, such information could only be of minimal use for the social, economic and political development of the Nigerian Society.

3.1.2 The Federal Ministry of Finance

The Federal Ministry of Finance which manages the nation's finance through delegation of certain functions to other arms of the Ministry such as Central Bank, Federal Inland Revenue,

Federal Audit Department and the Budget Office first used a computer in 1978.

The third major factor is the obsolescence of the type of equipment that are being used to process information. This is more as a result of government's indifferent attitude to keep pace with developments in IT than otherwise.

4. INFORMATION TECHNOLOGY IN GOVERNMENT PARASTATALS

The status of information technology in government parastatals is more encouraging than in the Federal Ministries. Most parastatals started computerisation very early, and some have been able to establish sound information processing techniques in their various organisations. Prominent among these are the West African Examination Council (WAEC), Nigerian Ports Authority (NPA), Nigeria Airways Limited and the National Population Bureau.

4.1 West african examination council (WAEC)

The WAEC is one of the early users of computers for speedy processing of large-scale examinations data. As a body charged with the responsibility of conducting examinations, releasing results and issuing certificates for such examination, (i.e. West African School Certificate, GCE Ordinary and Advanced levels and professional examinations such as the WAEC Technical Exams), the WAEC handles very large volumes of data on a seasonal basis to accomplish its objectives. The first computer acquired by WAEC was an IBM System 360, installed in the 1960s. Later in 1974, when numbers of candidates began to grow rapidly, an IBM System 370/125 was acquired.

Since then, the WAEC has expanded the scope of its operation to some state offices. The growth in candidature has necessitated the acquisition of additional computers (such as the Data General MV 10000), which are currently in use to cope with the variety of applications that have to be processed from time to time. As the WAEC's activities cut across all the states of the federation, it is currently considering the possibility of a network system that will link all its state offices with the headquarters in Lagos. When this is achieved, it will facilitate the provision of speedier services to candidates.

4.2 Nigerian Ports Authority (NPA)

The Nigerian Ports Authority carries out quite a large volume of data processing activities. With an ICL System 1903T and a multi-user PDP 11/34 computer, the main applications are Revenue Accounting, Monitoring of Ships' movement and Payroll.

4.3 The National Electric Power Authority (NEPA)

The National Electric Power Authority, whose use of information technology is having direct and serious impact on the entire society in Nigeria, is charged with the responsibility of providing electricity supply to both domestic and industrial consumers. The large volumes of data to be processed are in respect of energy consumption by its consumers.

The main computer unit an IBM 370/135 was installed at the headquarters of the Ministry. Some important applications on this computer are the Government revenue accounting system, banking administration which consists of local and international finance, Tax administration and payroll. This Ministry has its offices in all the states of the federation. Each state's office is known as Pay Office and serves as sources of input into the central computer system. The Pay Office reports to the Accountant General of the Federation through the Accountant Generals of all states Ministries of Finance. Many of the states are yet to computerise their financial accounting systems. As a result, large volumes of input into the central computer are batched. This has resulted in considerable clerical activity for compiling all inputs. Presently, the Federal Ministry of Finance is proposing to acquire new computers that would minimise its DP problems and ensure greater accuracy and availability of qualitative information.

4.4. Department of Customs and Excise

Being a major revenue yielding source to the Federal Government, the Department of Customs and Excise was one of the early users of a computer. The Department started with an ICL 1900 computer system which was centralised. The computer was devoted to calculating and determining revenue from Customs Duties and other tariffs fixed by Government. There is a close relationship between the Department and the Federal Ministry of Finance, since the latter is the main user of the Department's processed information. At present, the Department of Customs and Excise has expanded the scope of its operations. The department now runs partly an on-line interactive system to ensure faster processing and accurate reports.

4.5. The Nigerian Armed Forces

The Nigerian Armed Forces have recently come to realize the importance of computers to their military operations. Thus, we now have all arms of the Military acquiring computers for generating strategic, tactical and operational types of information. As the main responsibility of the Armed Forces is defence most of the applications on their computers are for research, planning and control.

4.6. Problems of information technology in government ministries

Many factors are known to contribute to the poor state of IT in most Government establishments. Paramount among these is the bureaucratic system of the Government. Most of the information produced are not qualitative and timely enough as to be used for effective decision-making.

Even when such information is used for taking decisions, most of such decisions lapse without leading to any action. Another major problem is the Government's inability to attract skilled professionals into Government Ministries. This is because of the poor salary structure and unattractive fringe benefits that are offered in the public sector of the economy.

Data are collected through the reading of metres installed in customers' premises and by the determination of energy points consumed. Because of the method of data collection and the manpower required to accomplish such a task, problems normally arise from late billings and the inaccurate/inadequate information given to NEPA customers.

The nett effect of these lapses is the NEPA's inability to collect outstanding dues from its debtors, leading to serious cash flow problems - a situation which makes it difficult for NEPA to maintain its electricpower generators.

Naturally, this inability to provide regular and steady power supply is partly derived from its cash problems, and the impact is such that many manufacturing industries are producing far below optimum capacity.

NEPA is currently trying to improve its IT facilities through the acquisition of additional computer hardware and application of better processing techniques. When this is realised, perhaps the improvement will have an appreciable impact on industry as well as the homes of its numerous consumers.

5. THE STATE OF INFORMATION TECHNOLOGY IN GOVERNMENT-OWNED EDUCATIONAL INSTITUTIONS

Government-owned educational institutions are mainly responsible for manpower development. Most of these institutions are the Universities, Polytechnics and Research Institutes.

Realising the importance of computerised information systems to national development, the majority of them offer courses in Computer Science at both under-graduate and post graduate levels. Mostly encouraged are subjects like Systems Analysis and Design, and Project

Management. Teaching instructions are given for languages like Fortran, PL/1, Basic and COBOL. Students are exposed to practical knowledge during their attachments to industries. Specific projects are given and must be successfully carried out on such conventional applications like Payroll, Stock Control, Personnel Records Sales Analysis etc.

Unfortunaly, most of these institutions are poorly funded both by State and Federal Governments and as such are in acute shortage of computer hardware. Some of the more older universities in the country are still using such obsolete equipment like the IBM 370 series and ICL 1900 computers. Nevertheless, students avail themselves with the computer hardware facilities in the private sector and thereby acquire the required degree of competence before leaving their institutions of higher learning.

5.1 Research institutes

The main aim of government research institutes in Nigeria is to conduct research and develop new findings that can aid national development. Although only a few of these institutes have computers for processing information, most of them liaise with Universities and Polytechnics to make use of available facilities.

6. INFORMATION TECHNOLOGY IN THE PRIVATE SECTOR OF THE ECONOMY

The emphasis on oil in Nigeria during the early seventies led to the neglect of our traditional sources of foreign exchange.

During the oil boom period which lasted till 1981 Nigeria's economy was allowed to be heavily dependent on a single source of foreign exchange earnings. Industries also depended mainly on imports. Because of cheap money, from an over-valued Naira and the structure of the domestic economy, the true position of the state of our national economy was never realised.

Suddenly, the boom period ended and Nigeria was faced with the problem of foreign exchange. External borrowing increased, there was accumulation of arrears, inflation and unemployment. In order to normalise the situation the Government of Nigeria embarked on Structural Adjustment Programme (SAP), aimed at restructuring and diversifying the productive base of the economy so as to reduce the dependence on oil and on imports.

To achieve the above, a number of measures were taken:

(1) Introduction of a second-tier foreign exchange market
(2) Adjustment of tariff to favour domestically produced goods.
(3) Import substitution of essential commodities from foreign countries etc.

As a result of these measures, industries found themselves in a tight corner and the task of management became very complex. Some companies faded away and those that remained in business came to realise the in-evitable need for computers as a means of providing complex, accurate and timely information for effective planning and control in order to survive.

From 1981 to date there has been a favorable revolution in computerised information technology in Nigeria. Prominent industries in the private sector that have warmly embraced computers are finance houses (banking and insurance) and manufacturing industries.

6.1 Finance houses

Before the advent of computerisation in Nigerian banks, banking operations had been very cumbersome and customers usually complained of long delays and inefficient handling of Banking transactions. The situation was heightened by the depressed economy of the country which imposed on banks the need to tighten their banking procedures.

But as the manual execution of new methods could have led to the total collapse of most banking functions, the need to computerise became inevitable.

Recent survey conducted by the Nigerian Institute of Bankers (Lagos branch) and published in the book "Computers in Banking" (1988 Edition) revealed the following facts:

Of the 12 merchant banks visited, 8 responded to completing the questionnaires, 2 did not and 2 could not because they were not computerised.

Out of the 15 commercial banks with head offices in Lagos only 3 were discovered to be "uncomputerised".

This, in effect, means that out of 27 Banks, 20 were confirmed to have computerised, 2 could not be determined and 5 were yet to computerise. The highest percentage of computerisation in some of these banks is 100% and the lowest is 9.4%

6.1.1 Application in banks

Most banks in Nigeria, especially commercial banks, use packages for their banking operations. Noteable among such packages are: SAMBA banking package, SIGNBANK banking package, BANKER 80 banking package and BANK MASTER.

In addition, good banking packages have been developed in-house by some banks. The package that is mostly used in Nigeria is BANKER 80. Banker 80 was developed in the US by Advance System Inc. Dayton and marketed by NCR along its I-series and 10,000 series computers. The main features of Banker 80 are:

Current accounts dealings, saving accounts, fixed deposit accounts, loan administration, and general ledger.

Inspite of all these banking packages that are available there is an area which is still neglected. We are yet to have banking hall system in most banks in Nigeria. Absence of banking hall system such as ATMS and other cash dispensers in our banks has made the operations of current and savings account very cumbersome. Because of manual handling of customers cheques and passbooks during verification of signatures many customers have to wait for an unreasonable length of time to withdraw money from banks.

6.1.2 Computer hardware in banks

Most of the banks in Nigeria use NCR Systems. Such Systems range from NCR 8140 to the NCR 9000 series. Memory sizes run into megabytes and storage capacities vary with each configuration. In addition to NCR systems, some of the banks use IBM systems 4341, 34 and 36.

One common feature with Nigerian banks is that they mostly run on-line system. This has facilitated easy access to records and quickened the response to customers' enquiries.

Thus, banking services in Nigeria have improved tremendously through the application of computers. The impact of the change in banking services on the Nigeria society is such that people now have confidence in the system and are attracted by the numerous facilities available in banks.

6.1.3 Applications in insurance

Many of the Insurance Companies in Nigeria use computers mainly for general accounting applications. However, there are some companies that use their computers to handle technical areas like the monitoring of the life span of insurance policies, determination of premium and issue of statements to customers. Most of the applications in insurance companies are developed locally and tailored to the needs of the users.

Computer hardware in insurance outfits are mainly IBM, WANG and NCR systems.

7. COMPUTER APPLICATIONS IN MANUFACTURING INDUSTRIES

The extent of hardship which has come to characterise the down-turn in the Nigerian economy has also strengthened the scope of computerisation in the manufacturing industries. Those uncertainties and vagueries common to a depressed economy have resulted in judicious management for resources such as materials, machines and manpower.

Prior to the introduction of the Second-tier Foreign Exchange Market (SFEM) which later metamorphosed into the Foreign Exchange Market (FEM), was the era of 'Import Licence'. During this period, no-one could import goods and services without first obtaining permission from government to do so through the issuance of a licence. Manufacturing industries were most hit by this system, as it often required a considerable amount of wheeling and dealing to obtain a licence to import. To compound the problem, there was 'credit squeeze' by banks, and industries were faced with cash flow problems. Similarly, as processes for obtaining raw materials became extremely difficult and lead-time for ordering unpredictable, so did the cost of procuring new machines become prohibitive, and that of servicing existing machines unbearable mainly due to the non-availability of spare parts. With all these factors costs of finished products became very high, partly due to high overheads.

The situation described above has therefore led to the development of a number of software applications that could assist in maximising the use of the available meagre resources.

Prominent among such applications are:

- Raw materials forecast system
- Raw materials stock control system
- Production Planning system
- Expenses monitoring system
- Costing and Profitability system

7.1 Raw materials forecast system

Raw materials forecast system is a simple system whereby the finished products projection is related to raw material needs. It provides for the determination of those basic raw materials required to manufacture specific volumes of finished products. Such volumes or quantity of goods are based on a number of factors such as projected sales figures from business area managers and production capacity.

The projected figures of such products are first entered into a product master file, which often contains the products code, and the formulation for each finished product of a specific size.

The percentage of concentration/density of all the recipes in a formula for every finished product must be 100 with each recipe having a percentage of the total concentration/density. After entering the projected quantity of each finished product, the system automatically calculates the basic raw materials that will be required to obtain the forecast quantity.

The system also provides for treatment of intermediate raw materials. Such intermediate raw materials are entered against the finished product and the system embarks on its breakdown from the highest level until it gets to the lowest level which corresponds to the basic raw materials.

After determining the volume/quantity of basic raw materials needed to manufacture each projected quantity of finished products the system accumulates summaries of those basic raw materials that are common in the recipe of a number of finished products. This facilitates the determination of the total quantity/volume of such basic raw materials that are needed to achieve the goals of the specific production plan.

Companies that have lube blending plants in Nigerian have found very useful the raw materials forecast system. These are mostly oil companies, breweries and paints companies. Formulations of their finished products contain many recipes and the need for efficient management and control of their raw materials cannot be over-emphasised.

7.2 Raw materials stock control system

The raw materials stock control system is linked with normal stock status at any point in time. It gives warning when raw materials fall below certain pre-determined limits. These limits are: Minimum stock and reorder level.

'Minimum stock' or buffer stock is the additional stock needed to allow for delay in delivery or for any above average demand that may arise during lead-time. 'Reorder level' is the level to which stock should fall before fresh orders are made. The minimum stock needed in the stock control system is obtained from raw materials forecast system based on three months' projection of raw materials usage. The reorder level is also obtained from materials forecast system using projection for leadtime (i.e lead-time plus minimum stockperiod) of raw materials usage. Both figures are subject to review for as the economic situation improves lead-time for ordering becomes more certain.

Minimum stock and reorder level figures obtained from running the raw materials forecast system are used to set up the necessary parameters in the normal stock system. During each subsequent month, raw materials forecast programs are run to obtain the minimum stock and reorder level figures needed to update the raw materials stock system. Based on the system's warning issued when stock falls below the required limits purchasing departments usually calculate the economic order quality and place order for the needed raw materials.

Among beneficiaries of the raw materials stock control system in Nigeria is the May and Baker Company Limited (M & B). Because of large volume of stock which the company has to keep, the management and control of the stock has necessitated the automation of its stock control system.

7.3 Production planning system

Ultimate objectives of Production Planning System in manufacturing industries are to ensure judicious utilisation of available raw materials, to assist in determining attainable finished products as against projected figures of finished products within such available raw materials and finally, to reduce to the barest minimum manual efforts involved in production planning.

8. IMPACT OF MICROCOMPUTERS ON INFORMATION TECHNOLOGY IN NIGERIA

It is quite relevant to mention the impact of micro-computers on information technology in Nigeria. Micro-computers have contributed greatly to the current revolution in information technology in the country.

The trend is not unexpected because of numerous advantages which microcomputers have over the minis and mainframes. Micro-computers are cheap, rugged and are users-friendly. They are very compact and do not require elaborate site preparation before they could be installed.

In a country like Nigeria where the electricity power supply is very unsteady and the communication system is not efficient, people see the application of micro-computers to their information processing as an economically viable means of producing timely information. Some computer installations that were formerly using mainframes are now embarking on decentralisation and are changing to micros.

Many companies and organisations are also using micro-computers to complement their mainframes and minis. Among heavy users of micros are the banks, oil companies, manufac-

turing companies, hotels and law libraries.

The recent introduction of computer education in secondary schools has led to substantial increase in the demand for micro-computers.

Apart from the large number of micro-computers that are now available in schools, some private homes now acquire computers for the purpose of educating their children on the machines.

9. INDIGENOUS MANUFACTURERS OF COMPUTERS IN NIGERIA

Taking the lead in their desire to produce computers that are wholly built in Nigeria are two universities (i.e.University of Ife (now Obafemi Awolowo University) and Anambra State University of Technology (ASUTECH)). The research and development unit of computer Department of the University of Ife embarked on the development of a brand of computers that would be built from the scratch in Nigeria.

It is almost five years now since we first heard about this noble venture and although the researchers were said to have made significant progress in completing their onerous task, they are yet to come up with a computer that will be labelled "Made in Nigeria" in the market.

The progress made by ASUTECH is very encouraging. The University has an Industrial Development Centre (IDC) with many arms. One of the arms of the IDC is the COMPUTER AND ROBOTICS TECHNOLOGY GROUP whose main responsibility is to conceive, research, design and build computer systems that must reflect Nigerian environment. In 1983, the group came up with a computer designed and built at Anambra State University. The call made by the group to the private sector and the Federal Government for support to sponsor the production of the machines was not encouraging. Because of the poor response, the orders received were not enough to enable the group embark on commercial production of the computer.

However, in 1984, the Anambra State Government, through the Anambra State Ministry of Finance and Economic Planning commissioned the Industrial Development Centre of ASUTECH to build four computers for the Ministry. Three of the machines built in Nigeria have been delivered and are now running and are being used by the Anambra State's Ministry of Finance and Economic Planning. Although machine problems do arise occasionally but such problems are normally resolved by ASUTECH.

As an encouragement, the Anambra State Government has given directive to commercialise the findings of ASUTECH. This has led to the establishment of a limited liability company called ASUTECH COMPUTERS LIMITED based in Enugu, capital of Anambra State.

10. THE FUTURE OF INFORMATION TECHNOLOGY IN NIGERIA

The future of information technology in Nigeria can be best appraised against the background of the prevailing political, social and economic climate in the country.

This is because major parameters like computer policy, electric power supply, communications and computer awareness will continue to have strong implications for the effective use of computers in the country. A brief discussion of these main themes for IT development in Nigeria will be useful.

10.1 Computer policy in Nigeria

Inspite of calls from various computer professional bodies in Nigeria, it has taken our Government sometime to realise the need for definite computer policy. Non-existence of a definite policy has encouraged dumping of all sorts of computer hardware into the country and

has also worsened the difficulty in regulating professional practice. Perhaps one of the reasons for the absence of a computer policy is the frequent change of Government in Nigeria. In the last ten years the country has witnessed the emergence of four different administrations.

A situation which has resulted in the discontinuity of the various programmes of each successive Government.

However, it is encouraging to note that the present Government is now on the verge of coming up with policy guidelines on the acquisition and use of information technology. The Federal Ministry of Science and Technology, in collaboration with the Federal Ministry of National Planning have set up a machinery to examine related issues in this area. Deeply involved in this national assignment are professional bodies such as the Computer Association of Nigeria, the Computer Users Association and the Computer Vendors Association.

It is hoped that in the very near future Nigeria will be able to take a precise position on this subject and hence provide a framework for practice and use of computing and computers nationwide.

10.2 Effect of electric power supply on information technology in Nigeria

The present economic crunch in Nigeria has hightened the frequency of electric power failure in the country. This situation has necessitated the need to acquire expensive generating sets as surer means of providing uninterrupted power supply and thereby making computerisation to be a capital intensive project.

The future of information technology in Nigeria will therefore depend greatly on Government's ability to provide efficient power supply services for industrial and domestic consumers.

10.3 Communications

Among the major factors militating against effective computerisation in Nigeria, poor communication systems have been identified as one. This problem has reduced the scope for establishing computer network systems within the country. Government is making efforts to improve things in this area, and some banks like Societe Generale, Allied Bank and Nigeria International Bank have established local and wide area network for their operations and their efficiency and reliability are very encouraging. However, future development of information technology in Nigeria, will still depend largely on Government's ability to provide more efficient communication systems in the country.

10.4 Computer Awareness in Nigeria

Computer literacy can be assessed by looking at the populace from four distinct standpoint. The first group are those who know nothing about computers.

The second group are those who are using computers for the fun of it.

The third are those who use computers for basic information storage and retrieval.

The fourth are those using computers for complex scientific applications.

These group thus constitute the client groups for implementing any programme on computer education and literacy. Recently, the Federal Government set up a committee to work on a policy for computer education in schools. The primary objective of this move is to ensure computer education in primary and secondary schools so as to produce pupils who will be well equipped to face the challenges of a rapidly changing technology for information processing. It is therefore certain that with a concerted effort from all and sundry Nigeria will emerge a winner in the race to join the advanced nations in the acquisition and use of this technology.

11. CONCLUSION

Nigerian as a nation now recognises the need to keep pace with the global revolution in information technology. Efforts are therefore being channeled towards achieving steady progress in computerisation. However, a number of factors have been identified as constraints against the speedy development of the country's computerised information systems. Such factors are:

(i) The lack of a good communication system which has reduced the scope of establishing a computer network system within the country.

(ii) Non-availability of ready and steady power supply from the National Electric Power Authority. This situation has necessitated the need to acquire expensive generating sets as a sure means of providing uninterrupted power supply and thereby making computerisation to be a more capital intensive project.

(iii) Lack of computer policy guidelines as a result of which there is proliferation of computers in the country.

(iv) No computer education by the majority of the people.

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ASSESSMENT OF THE IMPACT OF COMPUTERS AND INFORMATION TECHNOLOGY ON GHANA'S ECONOMIC DEVELOPMENT PROCESS

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The country report from Ghana provides an extensive but also very critical assessment of the way in which computer systems were introduced and the purposes for which they are used today in Ghana. The areas in focus are the Central Systems Development Unit, planning, IT-education, need for a comprehensive database, and cost-benefits of computer imports regarding the public sector.

The second part of the paper concerns a specific case concerning computerization in a bank.

The paper argues that computers in Ghana are being used almost exclusively for trivial office automation tasks instead of being used to further the economic development.

1. INTRODUCTION

Though the last thirty-five years have seen a significant growth and leap in the use of computers in the world, perhaps next only to oil (in terms of their economic importance to development), Ghana's experience has mostly been felt in the last fifteen years only. However, it is interesting to note that Ghana has been fully involved in the Information Technology Revolution at every phase of the worldwide developmental process.

This country's experience with computers dates back to 1949 when International Computers and Tabulators of U.K. (T.C.T., now International Computers Ltd. I.C.L.), installed a Power Samas Card Reproduction Machine in the Ashanti Goldfields Corporation, Obuasi (1949-1967), and the Central Revenue Department, Head Office, Accra, (1951-1968). By the end of the 1960s, these card reproduction equipment had been phased out and replaced by 2nd generation mainframe computers at these two installations. Meanwhile, other manufacturers such as IBM and NCR had entered the Ghanaian market in full force. The manufacturers, while sermonising on the importance and capabilities of their computers as economic developmental tools, had appointed as their agents, salesmen of proven abilities.

Thus, computers were sold to Government agencies by salesmen who were not in a position to assist their clients to make full use of this all important economic development tool. As a result, by 1978, there were twenty-two rented computers (see Appendix I) in a country with a population of 8.6 million and a literacy rate of 26.7%. With the exception of three, all belonged to Government organizations. Average capacity utilization was under 20% of estimated installed capacity of 400K memory of core store.

2. USAGE

The use of computers became widespread in Industry, Commerce, the Civil Service, Service Organizations and Academic Institutions in our country in the late 1970s. Obviously, the Government has accepted the computer wholeheartedly as advertised by the salesmen, that it was going to perform a great transformation in the country's economic decline - a promise

which was never fulfilled. Even as a data processing tool, the computers in Ghana have not achieved Government's objectives for two main reasons, namely:

(i) Lack of proper planning as well as the inability to streamline existing systems for the envisaged data processing activities for which these computers were purchased;

(ii) Lack of infrastructures for development of computer technology, coupled with inadequate skilled manpower.

Majority of installations were using their computers for payroll applications and 'mirroring' General Accounting applications. In other words, the accounting applications were written manually and transposed onto the computer and printed to give it a "data processing" look on a compuform.

A survey conducted in 1978 by the Central Systems Development Unit (CSDU) (see Appendix II) showed that over 80% of the twenty-two installations were engaged in payroll activities and 75% on General Accounting application. The levels of usage dropped sharply in other important application areas to 15% and below. Naturally, the computers have failed, to start with, as a scientific tool to enhance economic development programmes and activities.

It is worth mentioning here that the 80% and 75% levels of usage in payroll and general accounting were no significant deviations from worldwide trends. However, in the developed countries, the training facilities as well as manpower skills development programmes have been given priority attention, hence users comprehension of computing technology has been very advanced and well prepared to accommodate computer technological advancements. In our experience, these basic requirements for the development of computer technology, were not given the deserved attention. This has resulted in the country's inability to keep pace with various developmental phases to be able to match even the modest achievements in IT development in other developing countries, such as India, Thailand, Malaysia, Hong Kong etc.

3. CREATION OF CENTRAL SYSTEMS DEVELOPMENT UNIT AND DATA PROCESSING CONTROL BOARD

It is worthy of note that Governments have been interested in the development of IT in the country. In 1976, the Government of Ghana set up the Data Processing Control Board by Decree (S.M.C.D.19) and in the Civil Service, the CSDU was also set up under the control of, and to operate under the Ministry of Finance and Economic Planning. The functions of the Board were:

(i) To promote the development of computerised systems in Public Administration;

(ii) To promote the development of professional manpower in data processing;

(iii) To approve and control the importation of computers into the country.

The CSDU on the other hand had to co-operate with other interested organizations and be responsible for:

(a) Ensuring that Feasibility Studies were carried out prior to the development of computer systems and the acquisition of computer equipment;

(b) The co-ordination of computer work in the Public Services;

(c) Carrying out post-evaluation of operational and new computer systems;

(d) The development and general control of the supporting skilled manpower; and

(e) Such other functions as may be assigned to it by the Board within its terms of reference.

Despite such laudable objectives and formidable background of the Decree (SMCD19) referred to above, very little work has been done either to promote the development of computerised systems in public administration, or in the promotion of manpower development in data processing. On the issue of controls on importation of computers, some efforts were made in the 2nd and 3rd generation of computers. However, the micros and the PC´s have proliferated the market with both genuine brands and imitation pieces.

4. DEVELOPMENT OF COMPUTERISED SYSTEMS IN PUBLIC ADMINISTRATION

As at November, 1987, organizations in the Public Sector involved in one way or the other in some computerised systems work were as follows:

1. Ministry of Finance & Economic Planning;

(a) Statistical Service;

- Population Census (last census, 1984)
- Trade Statistics;
- Migration, Price Indices and Vehicle Registration.

(b) Customs, Excise and Preventive Service;

- A computerised system for revenue collection (under development);

(c) Internal Revenue Service;
- Payroll;
- Employers tax collection analysis;

(d) Budget Division;

- Expenditure monitoring system;
- External aid monitoring system;

(e) Accountant-General;

- Payroll for the entire Civil Service;
- Government Accounting System;

(f) Planning;

- Office Automation.

(g) Bank of Ghana;

- Accounting;
- Payroll;
- Balance payments;
- Establishment of Letters of Credit
- Receipts and Payments for Government

2. Ministry of Trade and Tourism;

(a) Import Licence Statistics.

3. Ministry of Local Government;

(a) Accra City Council.

- Payroll;
- Levies and Tolls;
- Accounting Systems.

4. Ministry of Agriculture;

- Market Surveys;
- Commodity Prices;

5. Ministry of Health;

- Payroll;
- Medical Statistics;
- Medical Research by Medical School Professors.

6. Ministry of Education and Culture;

(a)
- The three Universities;
- Payroll;
- Teaching Accounts;
- Research.

7. Ministry of Transport and Communications;

(a) Ghana Railway Corporation;
(b) Ghana Airways Corporation;
(c) Ghana Ports and Harbours Authority.

- Payroll;
- Stock control;
- Accounts;
- Traffic Statistics.

8. Ministry of Roads and Highways.

(a) Ghana Highway Authority;

- Stores;
- Work progressing system;
- Motor registration.

9. Ministry of Fuel and Power;

(a) Electricity Corporation of Ghana;
(b) National Energy Board;
(c) Volta River Authority.

- Payroll;
- Billing systems;
- Stock control;
- Accounting;

- Personnel records.

10. Office of the Head of Civil Service;

- Personnel records system (under development).

Appendix (III) gives the list of computer configurations in Ghana (1987) World Bank Report.

It is evidently clear from the above list that computerization has permeated the entire gamut of Civil Service administration and Government departments in our country.

This development dates back to the early seventies, perhaps, about two decades ago. However, the level of computerization and information technology as a tool for economic development has not matched the investments. It is estimated that during this period, over forty million dollars was spent on hardware equipment, spare parts and hiring of technical personnel.

This stems from the fact that "Data processing", in general, is more than just computer hardware and the work of a handful of programmers, it is a composition of a whole host of activities. These include:

- Planning;
- Availability of technical talent;
- Degree of co-ordination between users and programmers;
- Careful construction and enforcement of standards.

How have these factors fared in the development of Information Technology in our country?

5. PLANNING

Data Processing at governmental level, is a systematic decentralization of management activities including a wide range of technical tasks and ministerial responsibilities. It offers a country the opportunity to develop and operate computerised information systems that both match the national-cum-civil structure and promote national goals.

It appears that little or no planning has been done in our bid to computerise. For example while computers became popular in this country as far back as the early 1960s, the CSDU and the Data Processing Control Board (DPCB) (of SMCD.19) were established in 1976 and the decree actually promulgated in 1979; that is nearly three years later. Since 1982, they have ceased to function.

Presently, the Office of the Head of Civil Service is developing a Personnel Records System for the entire Civil Service to be linked up with the Accountant-General's payroll system. This is something which should have been done as the very first system to be developed within the entire Civil Service. It is on record that ghost workers on the Accountant-General's payroll have collected over the last 20 years, millions and millions of cedis (in real terms over US$10,000,000.00).

In 1985, some members of staff of the Accountant-General's Department were convicted of computer frauds and given death sentences. Today, there are prodigious efforts to rescue a badly planned computer system at the Accountant-General's Department, but at what cost? At a cost of millions of Dollars and even death penalties - life!

6. AVAILABILITY OF TECHNICAL TALENT - IT EDUCATION

While computers were introduced in Ghana as far back as 1949, formal training in Information Technology or Data Processing as it was then called, was not institutionalised until 1968 when the Management Development and Productivity Institute (MDPI) started running a course in

Data Processing. MDPI did not own computers until 1988 when it acquired two IBM PC´s!!

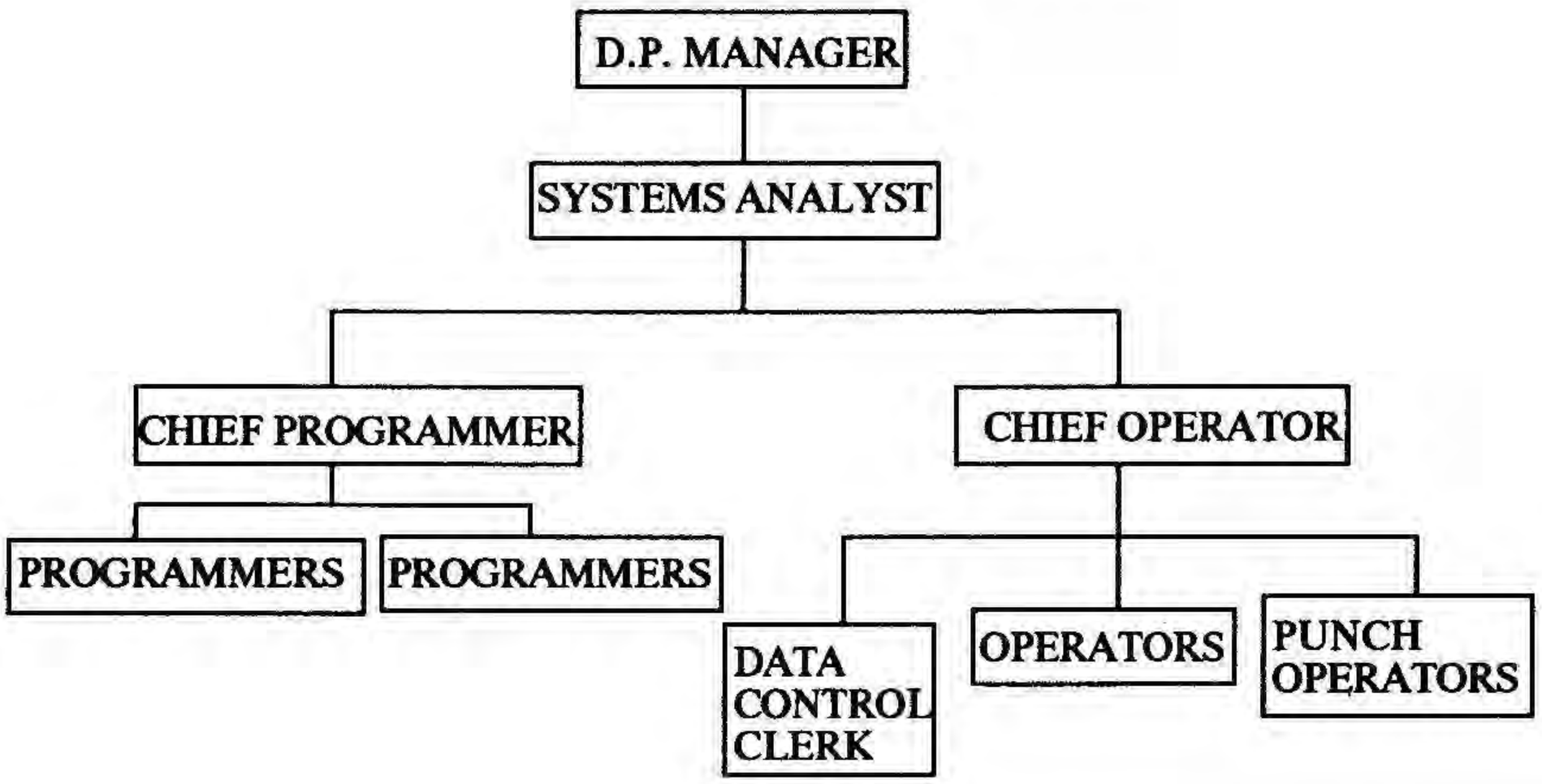
The three universities introduced computer training from 1973/1974 academic year. The University of Ghana introduced it as a core subject in the Physics Department in 1974 and the University of Science and Technology (UST), as a certificate course in Data Processing in 1972. Diploma courses at UST begun in 1974 and degree courses leading to the award of BSc, in 1977. The University of Cape Coase has a computer centre where students are encouraged to run their programmes and also take courses in computer related areas but it does not award certificates/ degrees in computer science like the other two universities.

Again as a British colony with external examiners from affiliated UK Universities, the syllabi were exact copies from the UK institutions. National objectives were not incorporated in the syllabi. Thus the courses are still geared more towards developed countries technologies than the local situation. This has led to a good number of graduates leaving the country to put their expertise where it belongs.

Where they have been employed locally, their training has not been useful to their organizations and also there have been serious conflicts with their colleagues on-the-job who have not had formal academic training. These locally trained experts, have resigned out of frustration or lack of practical know-how to cope with their jobs.

Another area of contention has been the level at which these graduates join organizations. In our country, a non-graduate in the Civil Service or any Government organization, enters the clerical grade and can earn promotion to the executive grade at the most. A graduate enters as a Trainee Manager or in the Administrative class, as an Assistant Secretary. Within two to three years, he becomes part of management. What has been happening in our country in the computer industry is that a Chief Programmer with no formal education cannot become a Systems Analyst, let alone, progress to become a Data Processing Manager. It is worth introducing, here, the typical organization structure of Data Processing Departments in Ghana.

TYPICAL ORGANIZATION CHART OF DATA PROCESSING DEPARTMENT IN GHANA



Most graduates, by the nature of their training, are ironically assumed to be higher than programmers so they enter as trainee Systems Analysts. Thus, their progression within the organization is accelerated to the disapproval of their less fortunate colleagues. This situation

breeds apathy on the part of the latter and they tend to sabotage the trained graduates who leave eventually. Since 1974 the two Universities have trained over seven hundred computer graduates. The ratios of Ghana and India are:

700 professionals: 12 million people;
3500 professionals: 700 million people.[1]

Yet Ghana cannot count on even 200 of the locally trained experts' availability in the country. In short, the talents have not been developed to suit local needs but foreign needs.

7. CO-ORDINATION OF COMPUTER WORK IN THE PUBLIC SERVICE

I have attempted to provide a comprehensive list of Ministries in the Ghana Civil Service and the various computerised systems they are engaged in. Firstly, it is significant to note that almost all the organizations with their own computers operate payroll applications; yet at the same time the Accountant General's Department is supposed to run a payroll for the entire Civil Service. Secondly, government departments in the Ghanaian context, are made up of the various Ministries as well as Corporations and Departments under these Ministries. For example the Ministry of Transport and Communications (MOTC) oversees the following organizations:

- Ghana Ports & Harbours Authority;
- Ghana Airways Corporation;
- Team Shipyard and Drydock Corporation;
- Black Star Line (State Shipping Corporation);
- Ghana Civil Aviation Authority;
- Ghana Railway Corporation;
- State Transport Corporation;
- Post and Telecommunications Corporation;
- Regional Maritime Academy;
- Meteorological Services Department;
- Omnibus Services Authority;
- City Express Service;
- Ghana Shippers' Council;
- Seamens' Welfare Board;
- Government Technical Training Institute.

Though all these departments or parastatal organizations work under the MOTC, those organizations which have computers have their own "standalone" systems, completely alien to the Ministry's own computer systems development unit. This situation is prevalent in all the sector Ministries and their affiliated organizations. For example, there are five Ministries and organizations involved in the export and import activities in this country. These are:

- Ministry of Trade and Tourism;
- Bank of Ghana;
- The various Commercial Banks;
- The commodity sector Ministry;
- Customs, Excise and Preventive Services.

8. NEED FOR DEVELOPMENT OF A COMPREHENSIVE DATA BASE

No attempt has been made to develop a complete system or sub-systems that are inter-related to enable this all-important aspect of economic activity in the country to be executed efficiently and effectively. As a result, the various sub-systems of the individual organizations are not coordinated, thus rendering the monitoring of imports and exports ineffective.

The country's economy depends on the exports of commodities such as cocoa, gold, bauxite,

aluminium, timber, diamonds, coffee, sheanuts, and other agricultural produce.

The ability of the Ministry of Trade to co-ordinate the activities of the other sectors of the economy who have a role to play, makes it imperative to employ the use of Information Technology. Similarly, the ability of the Bank of Ghana to efficiently and effectively account for export earnings is also in the realm of Information Technology.

The Ministry of Finance and Economic Planning, which is charged with the overall responsibility of managing the economy of the country, will equally need to employ Information Technology to enable it co-ordinate this all-important economic activity.

Information Systems must not operate independently of the organizations; they must exist to support organizational processes for the achievement of organizational goals. To be precise, they should support organizational systems. In our country, all the systems are inter-related and inter-dependent. Therefore, they must be designed to support each other. Thus Ghana needs more 'support systems', that is informationbased systems which support major organizational functions for the achievement of national objectives. In IT terminology, I am talking about "decision support-systems" (DSS).

DSS represent a different approach to information systems support for semi-structured and unstructured decisions. The approach is not to find the structure and automate it, but rather to support a variety of unstructured decision processes. This has several implications for the design and use of these systems[2]:

1. The designer of decision support systems applies a different set of skills than the designer of structured, operational systems. DSS designers must not only be technically competent, but also able to observe, understand, and identify with the decision makers world. Thus, in our country, there is the need to institute research at government level with the collaboration of other third world countries who have successfully implemented DSS eg. India, Malaysia, Hong Kong and the use of local expertise to design a DSS which will solve national problems and aid decision making at government level.

2. "The technology required for DSS is based on the need for flexible access. Reliable communication networks, availability of terminals, and more stand-alone personal computers are more important than large-scale data processing centres". This requires the availability of infrastructural facilities which are not available in our country presently. It will, therefore, be wrong to attempt any DSS development now until this collaboration with other 3rd world countries has begun. The developed countries will not have the experience required for the development of DSS in our country and we should not make the mistake of buying this technology from them.

3. "There is an emphasis on small, simple models that are easily understood and implemented rather than complex integrated models". In this direction, our country is doing well. There is now more emphasis on small computers and it is obviously a good sign.

4. The process of development of decision support systems is evolutionary and requires extensive participation by the end user (the decision maker). Presently, every Secretary of State has been provided with a PC and is being trained to use it as a source for information storage, retrieval, and analysis. The process has just begun. It can only be sustained by a genuine effort on behalf of government to create IT awareness through the institutionalization of an IT research programme for DSS and the development of other systems.

9. COST-BENEFIT ANALYSIS OF COMPUTER IMPORTS

It is estimated that between 1983-1987, the country spent well over US$2 million on the importation of IT equipment and consultancy services. This trend is likely to increase in the next three years. Indeed, the vendors have intensified their sales.

In the light of the poor state of the country's balance of payments, this expenditure level is very high and must show positive signs or significant improvements in the way things are done in economic related activities.

There are still delays at the country's ports in taking delivery of imports or in the export of goods. The procedures for doing these things are still very inefficient, causing delays which tend to adversely affect productivity in Industry, Agriculture and other business activities.

IT should enable us to do things better and more efficiently. It should enable us to eliminate waste and reduce economic losses caused by long and unnecessary procedures and red-tapism.

Such large investments in IT should provide access to international markets to improve dealings in the world commodity and money markets.

Despite the huge investments, the computer has not benefitted the country as it should have. Mentioning was made earlier on, of the question of lack of planning before plunging into computerisation. It is worth citing this real-life case-study of the computer department of a Bank in Ghana. I had the opportunity to review and re-organize the computer department, after 10 years of computerisation, of the entire banking operations.

10. THE CASE

A Bank with 168 branches and employing over 15,000 people in this country with over 600,000 customers, decided to computerise its entire operations. The project which was in phases, started with computerisation of the customer accounts in its Head Office branch. The other phases were to "network" the operations of all the 21 branches in the country's capital city. The final phase was to have a computer at every branch in the country and hopefully, when infrastructural facilities improved in the whole country, to network every branch into the Head Office computer. This case-study is limited to the 1st phase and its attendant implementation problems. The 2nd and 3rd phases are yet to be considered for implementation.

11. PHASE I

The Head Office employs over 4,000 people. There are 25,000 account holders in the branch. Daily customer transactions are between 10,000 to 15,000 on the average. The system's objective is to produce:

1. A payroll at the end of every fortnight for all the 4,000 employees in the Head Office;

2. To ensure that all account balances are made available in 'on-line' basis to cashiers to ensure prompt payment of cheques and update balances automatically for the next transaction;

3. Provide weekly returns in the form of management reports for the Bank's auditors to audit and certify okay.

The computer is made up of a mini and six work stations. It has a Data Processing Head supported by a supervisor and six Data Processing entry personnel and two Data Control personnel.

The department uses the services of the suppliers of the equipment overseas for maintenance of its software for a minimum fee of fifty thousand US dollars per annum.

There is no organizational chart, no job descriptions nor personnel specifications. The department is under the Director of the International Banking Division, who is not directly involved in local banking operations. In actual fact, local banking operations are under the Director of Treasury Services.

There are no systems documents on the payroll or the banking services used in the department. The payroll and the banking systems are all run on software packages supplied by the vendor. These are all patented.

The Head of Department and his deputy are '0' Level holders who have 10 years experience each in the Bank and have had six and three months attachment respectively, in the vendors country on operators' course.

12. OPERATIONAL PROBLEM AREAS

A. There was no systematic, orderly or organised way of running the department and the systems;

B. The operators had to rely on International phone-calls to correct or attend to error messages and operational problems!!

C. There was no Systems Analyst hence nobody understood the systems under operation including "operating systems";

D. Service support was inadequate;

E. The computers broke down at least every three days and the local agents had to provide maintenance with a very inexperienced team;

F. Systems objective was only being achieved at about 20%. This resulted in delays and customers were asked to go and come back the next day because the computer was down;

G. Posting of transactions done manually, always interfered with the days work, thus rendering 'on-line' activities ineffective;

H. Computer resources were only being utilised around 25% of installed capacity;

I. Customers were dissatisfied with the introduction of the computer;

J. Workers' morale was lowered due to incessant complaints from customers.

13. THE CONSULTANCY

The assignment's objective was:-

1. To design and document a new organization structure suitable for achieving the department's role in line with the Bank's objectives;

2. To prepare job descriptions for all positions on second hierarchy and above. These will clearly specify responsibilities of the positions as well as the qualities and qualifications of the personnel to occupy the positions;

3. To make recommendations for the improvement of the department's work in line with the proposed re-organization structure.

The Consultant came out with the following summary of observations, recommendations and conclusions.

14. SUMMARY OF OBSERVATIONS, RECOMMENDATIONS AND CONCLUSIONS

The Organization Structure:-

From the Organization Chart of the Bank, the activities of the Department have been placed under the treasurer, but the Director of Finance of the International Banking Division has sole responsibility for its operations at the present moment.

In order to ensure that the activities of the department will reflect the objectives for which it was set up and to ensure adequate utilization of resources to justify the investments, it is recommended that:

> The activities of the Department should be grouped under the Treasurer within the Deputy Managing Director's (Treasury Services) outfit.

This will enable the activities of the department to be integrated first within a functional area. The department will thus be headed by a Data Processing Manager with the following supporting staff:

- Systems Analyst; supported by
  - Systems Research Officer;
  - Systems Development Officer;
- Software Engineer; supported by
  - Head of Programming;
  - Head of Operations and Library;
- Data Controller; supported by not more than six
  - Branch (1) Supervisor;
  - " (2) "
  - Branch (N) Supervisor.

15. POSITION TITLES

The present organization chart of the Department provides for a Head of Computer Department assisted by two supervisors of the same grade and status.

It is recommended that titles suggested above, would cover the whole gamut of operational activities in the department. This will ensure that titles would conform to standardized titles pertaining to the industry.

16. POSITION DESCRIPTIONS

There is a certain amount of ambiguity in the department's position descriptions. These do not categorically clarify what the specific jobs of the Head and his two deputies are.

To ensure that personnel placed in appropriate positions understand their responsibilities, authority and reporting relationships, it is recommended that:

> Position descriptions provided up to the second level of the hierarchy are used

as guides to prepare position descriptions for the rest of positions in the organization structure.

This will provide basis for objectively assessing individual performance in the organization. It will also ensure accountability and responsibility for performances, inadequacies and non-performance of duties.

17. PERSONNEL SPECIFICATIONS

The academic qualifications and experience of the staff presently manning the department leave much to be desired considering the investments made and the level of efficient utilization of the resources available.

To ensure that personnel with requisite academic background and experience are placed in the right positions in the organization, it is recommended that:

Academic qualifications and experiences needed to man the department efficiently are clearly spelt out for the avoidance of doubt.

Provisions of qualifications and experience will ensure:

Proper recruitment and placement of personnel, and determination of training and development needs of the staff.

18. OPERATIONAL AND ADMINISTRATIVE MANUALS

These manuals were not found to be in place or available for use by staff in the department.

To ensure that systems and procedures for organizational effectiveness are well understood by operatives, it is recommended that:

Operating and Administrative manuals for the department be prepared and made available to personnel in the department on need-to-know basis.

The administrative manual will complement the usual conditions of service and Collective Bargaining Agreement in terms of making personnel aware of steps and requirements for getting jobs done efficiently.

The operational manual will ensure that operational duties are clearly spelt out to guide staff in the daily execution of their duties.

19. OTHER RECOMMENDATIONS

It is recommended that:-

General:

- A consistent, formalised and programmed set of procedures be adopted by the Bank in the processing of all its data on the computer;

- All levels of supervisory grade through to top management should actively participate in the development of the Data Processing Department/Computer Services;

- Computer operations should permeate the whole gamut of the Bank's operations;

- Rules and regulations should be established for the department and should be available on a need-to-know basis by all user departments;

- Job descriptions and personnel specifications outlined should be adhered to in line with all other existing ones available in the Bank.

Organizational:

- The present structure should be overhauled completely and replaced by a well structured organization chart;

- The present staff should be maintained but their backgrounds should determine the positions they should hold in the restructured department;

- The department should remain under the Treasurer's office with a Head of Department who should be a Chief Manager with the relevant and requisite background;

- A Systems Analyst should be recruited.

- A Data Controller should be appointed, perhaps from within;

- A Software Engineer should be recruited as a matter of urgency to forestall expensive (dollar) maintenance cost of software packages. The recruit should be sent on a course at the manufacturer's to study the technology of the equipment and systems;

- All present incumbents should be made to write detailed job descriptions of their functions in the department.

Operational:

- Sensitive data e.g. customer account balances, branch holdings etc., should be protected to ensure privacy;

- Measures should be instituted to prevent incorrect and fraudulent user action.

- Audit trails that would normally occur in both mechanised and manual systems should be established in the computer procedures;

- Systems Analyst, on appointment, should start developing a fully fledged integrated system in the following areas of operations: payroll, stores, purchasing, personnel records, branch operations, accounting, ledger, statistical analysis, budgeting, etc.;

- Programmes should be developed to ensure effective operation of a Management - Information System for the Bank through the use of the computer;

- Documentation of all operating systems should be done as a matter of urgency.

20. FINDINGS

Lack of planning before embarking on computerization of the banking operations was found to be the main problem facing the Department. In order to solve this problem, the consultant suggested that a comprehensive study and analysis of the banking operations should be undertaken. This study should look at the feasibility of introducing the computers through the use of scientific tools to establish the customers to be served per day by each teller, the total transaction records that will pass through the Data Control Section, the cost of operating the

computers etc. to arrive at the socio-economic implications of the introduction of the computers.

This problem is common to all installations in this country. It is better to tackle it now than never. The installations are in existence already but they must be used efficiently and effectively and the only way to achieve this is to go back and do what we should have done earlier on. Ghana is indeed better off being late than never.

21. CONCLUSIONS

We cannot escape the use of computers. We have invested over fifty million US dollars since 1960 into the acquisition, rental, staff emoluments, spare parts, stationery and servicing charges. This investment, if it should be made worth its while, demands a fresh and scientific approach to computerisation in our country and I take this opportunity to call on our friends in other developing countries like India, Malaysia, Hong Kong, etc. where greater strides have been achieved to come to our aid. We need to share computer resources both technical and personnel to achieve the right impact in the use of this all important scientific tool to achieve economic growth, emancipation and total economic cooperation for the welfare of our peoples.

This country's export trade is made up of 69.9% agriculture (mainly cocoa exports) and 18.9% gold. These two sectors by far dominate economic activities in the country. Yet 90% of computers are engaged in office automation activities and are used to make life easier for office workers. Perhaps it is necessary to attempt to express economic development in terms of how easy life can be made for our peoples the people who are engaged in economic activities that support national development.

The challenge this paper is throwing to our economic development planners is the ability to use computers to make life easier for our farmers and miners in our country. In other words, we must move from office automation to the socio-scientific arena in order to improve the lives of the people who produce the bulk of the nation's wealth. There is the need to install early warning systems for fire prevention, mine disasters, over-production (which tends to reduce world commodity prices) and production planning and control through the use of computers and Information Technology. In this way, we can justify the investments which have so far only benefitted 11.2% of economic activity in this country.

APPENDIX I[3]

DISTRIBUTION OF RENTED COMPUTERS IN GHANA - 1978

Inter-governmental organizations	1
Public Administration	6
Government corporations:	
- Insurance	2
- Services	2
- Construction	1
- Transport	2
- Mining	1
Universities	3
Private Industry	3
Ministry of Defence (Army)	1

APPENDIX II[4]

STATISTICS OF COMPUTER APPLICATIONS AT INSTALLATIONS IN GHANA - 1978

APPLICATION	INSTALLATIONS	INSTALLATIONS
Payroll (Personnel)	18	80
General Accounts	16	75
Cost Accounting	6	30
Budget/Budget Control	6	30
Statistics	12	55
Invoicing	6	30
Production	2	10
Inventory/Stock	8	35
Scientific/Engineering	4	20
Other	3	15

APPENDIX III

COMPUTER MARKET IN GHANA

MANUFACTURERS	SYSTEM TYPES	PLACES OF DEPLOYMENT
1. IBM	System 36, 4300	1.Bank of Ghana (4300) 2. Valco (370) 3. W.A.E.C. (4300/370) 4. IBM Office (4300/370) 5. Mechanical Lloyd (36)
2. NCR	NCR P.C. Mini 9100, 9020 8250	1. G.C.B. H/Q (8250) 2. Barclays (Ordered 9300) 3. Standard (Ordered 9300) 4. S. S. B. (8250) 5. S. S. B. (9100) 6. F.G.B.S. (9100) 7. Cocoa Board (8250) 8. Merchant Bank (9300) 9. GHAIP, Tema, (9020) 10. A.D.B. (9100) 11. B.H.C. (9100)
3. OLIVETTI (GNTC)	PCs and Super Mini PCs - M24, M22, M19, M28 (from October) Super Mini - CPS 32	1. G.C.B. H/S-CPS32 2. Foreign Affairs 3. Fuel & Power 4. G.N.T.C. 5. Water & Sewerage (3,4,5, are yet to take delivery of equipment)
4. ICL	ICL PC Quartro DRS Series ME 29	1. CRD ME 29, DRS 20 2. Min. of Finance & Econ. Planning, Me 29, DRS 20 3. Ash. Goldfields ME 29 4. Railways (one mth time) 5. Customs & Excise DRS 6. S. C. C. DRS 7. Cocoa Res. Inst. DRS 8. State Gold Mines DRS 9. Reiss & Co. Ltd. PC 10. Min. of Tran. & Comm. PC 11. Ghana Ports Auth. PC
5. WANG	PC, Mini Super Minis VS 15, VS 65 VS 80, VS 85	1. C.B.S. 2. N.C.D. 3. Ghana Navy 4. RIPS-Legon 5. Legon Finance Office 6. Texaco 7. W.A. Data Bureau 9. Volta River Authority 10. Electricity Corporation of Ghana 11. GOIL - Head Office 13. Noguchi Memorial In

ENDNOTES

1.
Computer Society of India proceedings, 1987

2.
Scott-Morton - Harvard Business Review, (1971 Fall)

3.
Source: 1978 Census of Computers in Ghana by C.S.

4.
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COMPUTER APPLICATION CHRONICLE AND POLICY ISSUES BANGLADESH CASE

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This article has been designed to fulfill the vacuum of an initial reference paper on computer scenario in Bangladesh. It also contains the 'Pointers' for further in-depth studies on strategic issues relating to information technology (IT). IT applications in Bangladesh have been described keeping in view a historical perspective . The description covers two phases: the first phase covers the period 1964-1983, when there was no government intervention and the second phase (1983 onward), where the Government intervened through definite policy actions designed to promote IT application. It is observed that considered & timely policy actions by the Government can accelerate effective application of computers. Finally, it appears that LDCs need considered, timely and appropriate policy actions to be able to use IT to obtain optimum beneficial impact on the economy & quality of life of their citizens. The paper chronicles the gradual transformation of the National Computer Committee (NCC) into a regular organisation named National Computer Board (NCB), in a time span of five years.

1. INTRODUCTION

Difference of opinion on necessity and extent of Government policy on computer or IT sector exists among professionals and the decision making community of both LDCs and developed countries. Although this issue deserves a detailed discussion, for this article let it be accepted that an IT policy for LDCs is needed.

Bangladesh first recognized this fact in 1972-73. A few officials of the Planning Commission tried to persuade the Government to establish some sort of a computer policy making body. But the move did not go through, mainly due to other higher priority issues of post liberation environment. The next decisive move was taken by the Government in mid 1983, when the National Computer Committee (NCC) was formed [1].

This article will touch upon the salient events which took place in last 20-25 years in the history of computing in Bangladesh and evaluate the impact of forming a single national policy formulation body i.e. NCC which has been transformed into the National Computer Board (NCB) in August, 1988 [2].

2. STATE OF IT SECTOR

Giving an overview on past and present computer scenario of Bangladesh is essential to evaluate the impact of policy application in this field. The first computer was brought in Bangladesh, (the then East Pakistan) in 1964 by the East Pakistan laboratory of the Atomic Energy Commission, mainly due to personal initiative and foresight of the then Chairman of the Commission. Marketing effort was started in 1965 by IBM. So, the history of computing in Bangladesh spans over about past two and half decades.

Though the country entered the age of computer in mid-sixties, growth in this sector has been unusually slow till early 1980s. The whole spectrum of computer sector scenario and erratic growth pattern can be discussed under following broad sub-titles:-

- Public sector acquisitions and applications (statistics, atomic energy, banks, agriculture, family planning etc).
- Computer marketing efforts (vendors).
- Private business sector acquisitions and applications.
- Computer in academic environment.
- Private banks & financial institutes.
- Promotion motivated institution building in private, and semiprivate sector.
- Private training institutes.
- Common issues affecting evaluation.

Applications initiated by foreign nationals living in Bangladesh:

- Foreign missions applications/ United Nations computer users group.
- Expatriate consultants role/micro computer users groups meet.
- Foreign aided non government organizations.

2.1. Acquisitions and applications in public sector.

So far as the IT application potential is concerned, public sector may be viewed as having following major groups of organizations :-

Ministry/ divisions	45
Departments/directorates /constitutional bodies	250
Semi-autonomous/autonomous bodies	109
Local government organizations	
- Zilla Parishads	64
- Metropolitan corporations and municipalities	84
- Upazilla Parishads	460
Public sector training and research institutes	200
Academic sector:	
- Universities	6
- Colleges including medical, engineering, and agriculture	900
- Polytechniques	17
Development projects sponsored by above organizations	700-800

Atomic Energy Commission, an autonomous body, took the lead by installing one IBM system 1620 system in 1964. The Institute of Statistical Research & Training, Dhaka University, installed a IBM system 101 Statistical Machine in 1964, along with Card Verifier, Reproducer, Sorter-counter in the same year. East Pakistan Statistical Bureau (now Bangladesh Bureau of Statistics, BBS), also acquired a system 360/30 in 1973. From 1973 to 1983 (i.e. till formation of the NCC), a total of 20-25 midrange systems, including three IBM 4341, 40-50 small systems were procured by different public and private agencies of Bangladesh [3]. BBS made noteworthy use of their System IBM 4341 in 1981 for the decennial population census, by

processing 100% data, instead of previous practice of 5%. They also brought down the time needed to publish the census data to two years, which previously used to take about four years.

Department of Family Planning got a IBM 34 as donation in 1981 and developed a relatively efficient MIS system. At present they are providing Monthly Family Planning Performance Monitoring Report to the Hon'ble President through this system. The implementation monitoring and evaluation division also procured a IBM 34 in the same year. They have developed a monitoring system for selected and vital development projects.

About 70% of GDP comes from the agriculture sector. But this sector applied this technology quite late. The Bangladesh Agricultural Research Council procured their 1st computer in 1982. Bangladesh Rice Research Institute, another leading edge research organization, got two-micro computers on donation in the year 1982 and is doing a good job. The only Agricultural University of the country procured one micro computer in 1986. Master Plan Organization, a strategic project on water resources, under the Ministry of Agriculture has about twelve assorted micro computers. Their utilization seems praise-worthy.

Nationalized banks: Though private banks (Habib & United Bank Ltd.) started taking lead in application of 2nd generation computers prior to liberation, they suffered retrogative set-backs after nationalization in 1972/73. Bangladesh Bank took two decisive steps after liberation:-

They procured one IBM 370/115 in 1980. Though the system was inadequate in comparison to the huge work load, it was naturally a step forward.

But it took another regulatory decision by banning acquisition of computer by any other bank. It further issued a directive to process data of all other nationalized scheduled banks (total 6) in their 160K 370. These decisions slowed down growth of computer application in the banking sector, because the bureau service concept did not make any headway in the computing culture of the country. However Agrani Bank managed to acquire a IBM 34 in 1985. But preliberation leader in computer application Janata Bank (the then UBL), had to dismantle their ICL system and sell it as scrap, mainly due to lack of post liberation maintenance back-up and absence of proper attention from the management.

Post NCC: In December 1983 NCC introduced the system of prior permission for acquisition of computers, by any public sector organization. Since then a total number of 122 proposals have been received and examined and permissions have been accorded in most of the cases. Necessity of prior permission was felt due to reports of under utilisation of some existing installations and unplanned procurement initiatives. The NCC's role on these issues was declared in its following objective:

> "Providing assistance to the prospective users in respect of configuration, software and systems development"

These promotional activities were extended to regulatory measures like filling up lengthy and technical forms, submission of the same to a NCC sub committee, and obtaining permission to go ahead with computerisation efforts. This procedural step served two purposes. Firstly it reduced unplanned procurements, secondly it also discouraged some potential and genuine computer users because of the newly introduced official formalities. But few key issues became quite prominent in the whole process:

- Critical shortage of uptodate and forward looking computer professionals with managerial skill who are capable to communicate effectively with their non-technical managers/ decision makers.
- Lack of functionally balanced and well equipped computer training institutes.
- Top management mostly unware and uninvolved in the activities of the computer installation.

While the above issues still remain mostly unattended, the permission part was eased in 1987 by introducing a simple one-page application form for small systems. A cursory view may be

formed from the yearwise summery of NCC permissions since its inception.

Table 1
NCC Permissions

Year	Size	Proposals for no. of systems	No. of Organizations	Main Sector/ Sectors
1	2	3	4	5
1983 (Dec.only)	Small	1	1	Rural Electrification Board (REB)
	Medium	-	-	
	Large	-	-	
1984	Small	-	-	-
	Medium	2	2	Insurance & Bank
	Large	-	-	-
1985	Small	1	1	University
	Medium	3	3	Agri Research Ins.
	Large	-	-	Insurance
1986	Small	13	8	Health & Export Promotion Bureau
	Medium	5	5	Shipping, Public Service commission, Family Planning, NGO & Bank
	Large	1	1	Bank
1987	Small	48	32	Energy sector
	Medium	1	-	
	Large	1	1	
1988 (upto July)	Small	52	19	Technical Education
	Medium	2	2	
	Large	1	1	
Total	Small	107	61	
	Medium	12	12	
	Large	2	2	
Grand	Total=	121	75	

The trend of application/acquisition of computers, mostly, is related to development projects.

2.2. Marketing.

At present there are about 25-30 computer marketing firms in the country. In Bangladesh IBM took the lead in the computer marketing sector by opening their East Pakistan Depot, under Karachi branch in 1965 and full-fledged branch office in 1971. Their first sale of computer equipment was to the Atomic Energy Commission (system 1620) in 1964, through Karachi branch. NCR also opened their East Pakistan Depot in late 1965 and Resident Office, under Karachi branch, in 1971. They sold electronic accounting machines in 1971 to The Eastern Federal Union Insurance Co. They sold their first mini-computer (system - 8150) to Hotel Sonargaon in 1979. ICL leased a system to the then United Bank Ltd (present Janata Bank), in 1968 mainly to provide Bureau Service to the banks' major customers. Honeywell supplied a system DPS-6/75 to the Dhaka branch of American Express Bank, as a result of corporate arrangement in U.S.A. Later on they appointed Graphics Information Systems (GIS), as their

agent in Bangladesh. GIS thus can claim to be the first Bangladesh company to obtain dealership of a major computer manufacturer. The Computers Ltd., another local firm obtained ICL agency in 1975 and sold their first mini computer to Chittagong Port Authority in 1987.

Next comes the issue of micro computer. The first microcomputer was probably brought into the country by an expatriate consultant in late seventies. Local marketing was pioneered by a firm named CIPROCO in 1982. Initially they achieved spectacular success by selling about 150-200 Radio Shack micro computers. Another local firm Flora, obtained agency of EPSON printers and gained about 70% of the printer market. Since then about 15-20 firms have entered the small systems market. Most prominent among them is Beximco Computers Ltd, of the BEXIMCO Group, which otherwise is presumably a "FORTUNE-5" company in Bangladesh. After some initial set backs with Radio Shack (USA), SWORD (Japan) and NCR (USA) finally they obtained marketing dealership of IBM PCs in 1985/86. Recently they have started selling IBM mini computers also, under an arrangement with the IBM. So far BEXIMCO has sold about 400 small systems. CIPROCO's total sale in five years is also about the same. Out of the new comers Unidev Computers Solutions Ltd, Technoheaven, Anandapatra Computer Division (Apple only), National Computers Ltd. and few more have established their position in the small systems market.

Trend of microcomputer application is generally growing fast. PC population is now about 3000 compared with just a few in 1982. Number of vendors are about 25-30 which was only 4-5 in 1982-83.

2.3. Private commerce and industry sector.

Prior to liberation, the first note worthy application of computer in business community is considered to be the United Bank Ltd. which was nationalized and renamed as Janata Bank after liberation. They installed an ICL system in 1968. As mentioned earlier, the ICL computer was leased for providing bureau service to their major clients. But the computer mostly remained unutilized and finally it was dismantled in late seventies. The Eastern Federal Union Insurance Co, also started leasing computer time for some of its functions. Nationalization of all banks and financial institutions after liberation in 1971 brought set back in growth of computer use. However denationalisation process was initiated in early 1980s. Since then the Bank of Credit and International Commerce, Indosuez Banque, Arab Bangladesh Bank, Bangladesh General Insurance Co. and few other companies have started using computers successfully. In 1983 NCC tried to promote the use of computer, by reducing customs duty to 20%, from 100%. Since then a large number of small systems have been procured by different business houses. So far no large system have been procured by any private business house. In the field of medium systems Adamjee Jute Mills took the lead by installing a IBM system - 370 prior to liberation. The installation is functioning efficiently (nationalized in 1972). Next comes SQUIB Pharmaceuticals, which installed a IBM system 34 in 1982. Hotel Sonargaon followed suit by using a NCR mini computer system - 8150. Some big trading houses and industries (specially garments and privately owned jute mills) have successfully used micro computers for their operational and pay roll function.

2.4. Computer in academic environment.

Bangladesh University of Engineering & Technology (BUET), is in leadership position in this field. They have one system 4331, one 370/113 and few assorted micro computers. They started MS course in Computer Engg. in 1985 and last year the first batch of B.Sc in Computer Science and Engineering students have been admitted. Dhaka University has acquired a IBM system 4331 in 1985. The computer centre is in the process of starting formal academic courses, using their system. Chittagong, Rajshahi, Jahangir Nagar and Mymensingh (Agriculture) Universities have procured micro computers, as embryonic effort to enter into the computer era. Institute of Post Graduate Studies in Agriculture (IPSA), has also procured two micro computers, to assist in their academic work. Fifty three micro computers have been procured for all the seventeen polytechniques and two Bangladesh Institutes of Technology. So far only Notre Dame College has started using computers as additional/optional extra curricular activities. American International School (pioneered by the US Embassy) has the only

full-fledged computer class room having about 20 Apple Computers, in the academic sector of the whole country.

2.5. Non-Profit promotional societies.

Few computer based non-profit societies/clubs have been organized by some leading computer promoters. Bangladesh Computer Society (pioneered by Dr. Patwary) and Micro Computer Users Group Meet (MUGMEET) are the earliest among these. Bangladesh Computer Association (BCA) was formed by the vendors. Bangladesh Computer Club, Computer Professionals Association, Computer Sector Employment Assistance Society (EASY) of JiBiKa, and UN Computer Users Group (UNCOG) are few NGOs in this field. These are playing important role in promotion of IT culture. Steps are in progress to represent Bangladesh in leading international professional groups.

2.6. Computer training institutes in private sector.

There are about 10-15 institutes running elementary computer trade courses. Few of them have microcomputers. Most prominent among them are Centre for Informatics & Electronics (6 micros), Computerland (20 micros) and so on. In addition some of the computer vendors like BEXIMCO, The Computers Ltd., National Computers Ltd., Ananda Patra Computer Division and few others also run computer courses on commercial basis, in addition to the tailored courses for their clients.

2.7. Expatriate consultants.

On an average about 1000 expatriate consultants work in different sectors of Bangladesh in any given time. In 1984-85, about 20-30 consultants were engaged in computer related sector alone[4]. Some forward looking consultants took lead in bringing microcomputers in late seventies, mostly for their children's education, games, home use or use in their consulting assignments. They also formed the first users group in the country named MUGMEET in 1982. Even now MUGMEET maintains its professional lead among computer sector NGOs. There are about 150 members, out of which 40% are foreign nationals.

2.8. Foreign Aided NGOs.

About 400 foreign aided NGOs are working in different voluntary social welfare and development sectors of Bangladesh. Many of these have started successful application of micro computers. CARE, CARITAS, Micro Industries Development Assistance Society, Helen Keller, etc are prominent examples in this field. Recently Social Marketing Project of family planning sector has installed the first mini-computer (NCR TOWER-4) in the country's NGO sector.

2.9. Foreign Missions, UN and other Multilateral Organizations.

Noteworthy users in this group are International Centre for Diarrhoeal Diseases Research, Bangladesh (ICDDRB) using IBM system 4341, UNDP, US Embassy, US AID, CIDA, SIDA, DANIDA and few more agencies.

Common issues affecting evaluation:

Dimensions of IT and Bangladesh:

IT may be analysed from different approaches. One of these approaches may group IT related activities in following major dimensions:

- Information Creation/Generation Technology (ICT).
- Information Management Technology (IMT).
- Information Processing Technology (IPT).
- Information Velocity Technology (IVT).

Each of the above disciplines need specialised training and research institutes. Bangladesh has made a humble beginning in IPT only, where the B computer installation may take the place of "Role Model", for its success in coping with adverse situation and contributing towards better performance

Technological Level/Generation: Public Sector Computer installations of Bangladesh may be grouped as under, based on their hardware capacity, software utilisation and skill level of their professionals:

- Uptodate & High performance Type (Category-A)
- Pulling-on & Medium Performance Type (Category-B)
- Backward & Least Performance Type (Category-C)

3. NCC's ROLE

3.1. Birth of NCC.

Formal order to establish NCC is the result of general need of the time - which was felt by and implemented under the guidance of the present regime. On assuming the helm of affairs of the country in 1982, the present President of the country instructed his Principal Staff Officer to examine the IT Sector and take appropriate strategic move to promote application of computers in all possible ways and means. One of his immediate priority was computerization of the 'Public Administration'. Accordingly a project titled "Personnel Management Information System/Management Services Wing- (PMIS/MSW)[1] was initiated in early 1983. It's objectives were as under:

> *"i) Obtaining relevant personnel data and information which include, among others, job description, job analysis, performance appraisal, upgraded individual officer files and a personnel manual of rules and regulations.*
>
> *(ii) Maintenance of data of government employees with following three broad aims:*
>
> *a) Data on officers will be arranged in a manner which can be processed and updated regularly for the purpose of administering/managing and monitoring them, and attaining optimum efficiency in administration and high morale for employees.*
> *b) To facilitate the process of decision making on matters connected with Personnel Management and Public Administration.*
> *c) Data for other non-gazetted employees will be collected for census purpose.*
>
> *(iii) Training of computer professionals for government sector and providing leadership in this area to the private sector.*
>
> *(iv) Providing standards of qualifi- cation for computer professionals.*
>
> *(v) Development of computer forms, introduction of new forms to facilitate computerization and subsequent development in the area of software technology, data processing system.*
>
> *(vi) To arrange computer familiarization courses for senior officers.*
>
> *(vii) To work as controlling body for introduction of computer in any other organization of the government."*

On the other hand the then General Staff Officer to the Chief Martial Law Administrator (CMLA) and Personal Secretary to the Chief of the Army Staff and CMLA processed necessary spadework for a national body in the computer sector. Vice Chancellor BUET played

the pioneering role. Ultimately on 29 August 1983, National Computer Committee formation order consisting of twelve members, was issued, by the then Principal Staff Officer to the CMLA. The Committee was headed by a Cabinet Minister and was allocated fifteen objectives. Subsequently three sub-committees with following broad functions were formed:

- Sub-committee- I	Acquisition
- Sub-committee- II	Application Assistance & Priority
- Sub-committee-III	Training & Research

The author was appointed as Member Secretary to the subcommittee-II (in November 1986 he was appointed as Member Secretary of the NCC itself and all its sub-committees). The initial objectives of the NCC were as follows [5]:

a) Formulation of strategy and policy guide-lines for promotion and systematic transfer and development of computer technology in the country.

b) Identification and selection of application areas and fixation of their priorities.

c) Formulation of action plan for developing necessary trained manpower. d) Formulation of policy guide-lines for:

The organization which resulted out of this project is named Public Administration Computer-centre (PACC).

(l) Procurement and installation of hardware and software from abroad.
(2) Standardization of hardware and software as an industry.
(3) Ensuring optimum utilization of hardware, particularly of the mainframe Computers.
(4) Promotion of higher training and research in the field of computer science and its applications.
(5) Control and supervision of private sector training activities.
(6) Promotion and development of requisite infrastructural facilities for rapid computerisation.
(7) After-sales service and maintenance by the manufacturers/suppliers.
(8) Allocation of resources for promotion and maintenance of hardware.
(9) Procurement of spare parts and supplies for computer equipments and related infrastructural facilities.
(10) Providing assistance to the prospective users in respect of configuration, software and systems development.
(11) Improvement and harmonization of emoluments and other service conditions of computer personnel in the country.
(12) Computer activities at national, regional and international level

The author also had the rare opportunity to be in touch with the pioneers of the NCC & NCB from conception stage. In early 1983, he was given the task to examine justification of computerizing Personnel Management Information Service (PMIS) of the Government as a component or the Public Administration Sector Project to be funded by the World Bank. To perform this assignment a "Status Paper" on the computer sector was prepared, which lead him to prepare a draft overall action plan for the IT sector as a whole. This was concluded with "22 Point Recommendations". PACC was a subset of the whole action plan. The points are as under:[3]

" RECOMMENDATIONS":2

13.1. Setting up of a National Coordinating Agency with representatives from the Government, computer centres, representatives of the Institutions of Engineers and the Bangladesh Computer Society to oversee the acquisition, utilization, training, facilities and technology transfer and also to coordinate informatics activities at the national, regional and international levels.

13.2. After detailed evaluation and examination a tentative phase-wise EDP long-term plan should be worked out. The plan should give emphasis on public sector, but a general growth pattern for private sector aLso should be included. An illustration for preparation of overall public sector EDF scheme is given in Annexure-D3 for guidance and reference purpose .
13.3. Standardization of optimum number of computer manufacturers and brands for the country.
13.4. Introduction of computer course in education system viz. in SSC, HSC and Degree level.
13.5. Introduction of standard diploma/degree in the field of computer education to be in line with any international system like British Computer Society.
13.6. Arrange short familiarisation seminar/course for senior Administrative/Business executives to increase computer awareness in top level of public and private sectors.
13.7. Introduction of computer courses/ lectures in higher government training institutes including Bangladesh Administrative Staff College (BASC).
13.8. Development of soft-ware programming and technology.
13.9. Development and promotion of computer service/ maintenance industry/ manpower.
13.10. Monitor and improve efficient use of computer to increase productivity and performance
13.11 Promotion of public awareness on the role of computers in daily life.
13.12. Carry out survey of existing computer professionals and project future demand of different categories of personnel.
13.13. Promotion and encouragement of periodical seminar/get together of computer professionals for development of computer service.
13.14. Keeping up-to-date information about technological/professional progress on EDP in other parts of the world.
13.15. Explore possibility/potentiality of computer assembly plant within the country.
13.16. Once the training system is geared up, explore possibility of employment of computer personnel abroad.
13.17. A National Computer Network System with time-sharing arrangement among the big computer installations should be set up.
13.18. The National Computer Network System should be linked up with the remote Informatics Application Centres of the country over micro-wave links / telephone channels.
13.19. A National Centre of Excellence for Computer Education and Training should be set up with all facilities for hardware, software, network technology and technology transfer.
13.20. No organization - Government, Semi-government or autonomous - should be allowed to enter into contracts to use pirated software.
13.21. To stimulate research and development activities on informatics.
13.22 To help National Computer Society or Associations in carrying out their professional development objectives including publication of journals, literature etc."

The whole paper and collected data were further streamlined and submitted as the course thesis, while the author attended Senior Staff Course (Regular Training Course-13) in the Bangladesh Administrative Staff College in mid, 1983.

In November 1983, updated and edited version of the author's article "Computerisation in Bangladesh - Problems & Prospects" were read in the first seminar on Public Administration in Dhaka. The article contained initial details on NCC & Public Administration Computer Centre also. This updated version was published in 1983 [6].

In mid 1984 a high powered committee was formed to examine the necessity of transforming the NCC into a regular body named National Computer Board (NCB). The committee

consisted of four senior officials and nominated the author as the Member-Secretary. The committee recommended in favour of forming the NCB initially with a total strength of thirty seven personnel, including ten professionals and a consultant's pool. The NCC accepted the committee report. But it took about three more years to implement the report. In January 1987, the Minister of Commerce, became Chairman of the NCC. The transformation of NCC into NCB took place under his chairmanship. He was also appointed the first Chairman of the NCB and the author relinquished the additional charge of Member Secretaryship to the newly posted full time Director.

3.2. Direct impact

From 1983-88 NCC undertook following promotional/regulatory measures by official directives, policy letters, gazette notifications etc.

- Acquisition rationalization in public sector.
- Encouraging acquisition by public & private sector by reducing customs duty.
- Encouraging Bangladeshi foreign travellers to bring computers by including micro computer as a baggage item.
- Introduction of standard computer professional designation in public sector installations to bring uniformity and get rid of designation confusion.
- Introduction of recruitment rule for each computer designation.
- Introduction of uniform pay scale for rationalised designations.
- Taking effective steps to introduce BANGLA in computer as dual language.
- Taking preparatory measures to introduce computer education in secondary/ higher secondary /teachers training institutions and universities.
- Providing free consultancy service to expedite successful application of computers in different public sector organizations, including following:
    - President's Secretariat.
    - Railway Sector.
    - Bangladesh Biman.
    - National Board of Revenue.
    - Comptroller & Auditor General's Offices.
    - Passport & Immigration Dept.
    - Agrani Bank.
    - Janata Bank
    - Rupali Bank
    - National Curriculum & Text Book Board.

Some of the direct measures mentioned above deserve elucidations.

Acquisition Rationalization in Public Sector:

NCC has issued five policy letters on this subject since December, 1983. Main theme of these letters is to ensure optimum utilisation of computer resources and provide proper advice before any new acquisition. The list of the policy letters are given below:

- Acquisition of Computers dt. 21.9.83 [7]
- Acquisition of Computers dt. 5.3.86 [8]
- Procedure Relating to the Procurement, Installation and Operation of Computer dt. 29.9.86 [9]
- Policy for Acquisition of Computer Hardware, Software and Environmental Services and SDLC dt.27.7.87 [10]
- Policy for Acquisition of Micro Computer and Standard Form, dt. 20.2.88 [11]

This subject is directly dealt by NCC Sub-Committee No-1, which is headed by a member of the NCC. He has five leading computer professionals and practical application experts in his committee as members. In last about five years the committee has processed 121 proposals as mentioned earlier. There has not been a single example of outright rejection of any acquisition proposal. Though in some cases the application authorities had to face the sub-committee twice or thrice to convince the members about their need for and capacity to utilize the computer efficiently. The sub-committee has also contributed substantially in promoting IT by taking following actions :

- Introduction of standard but simple application form for acquisition of micro computer, which can be filled up by a non-technical officer. [12]

- Introduction of System Development Life Cycle (SDLC), for acquisition of mini and mainframe computer. [13]

- Survey of computer installations, including their utilization level. [14]

Time has come to review the system of prior permission to acquire computing resources. Price of microcomputer has reduced to the level of electronic typewriter. Moreover word processing is the easiest entry path into the information processing world. Considering the promotional policy, it seems to be appropriate to waive the permission formality at least for the micro computers. However, to observe the trend of application and to keep some sort of census data a simple "Microcomputer Data Card" may be introduced which will be filled up by the buyers at the customs check point or vendors premises.

Customs Duty:
Before establishment of NCC, custom duty on computer and its peripherals was 100% . It was reduced to 20% in 1984 & 10% (for micro computer) in 1988-89 budget. This is one of the major promotional factor for exponential growth of micro computer acquisition, specially in private sector.

Baggage Rule:
Micro computer was included in the baggage item in 1985. Since then hundreds of travellers have availed the facility, thus increasing the micro computer population. Proposal has been forwarded to NBR, to make the rule more liberal [15].

Standard Designation:
There was no uniformity of computer professional designations in public sector computer installations. In 1985 twenty standard designations for computer professionals in six functional groups were introduced. Recruitment rule was also made for these designations. The pay structure of these designations were relatively elevated, which was approved by the National Pay Commission due to persistent efforts by the NCC [16].

Introduction of BANGLA in Computer:
The NCC has formed a powerful Task Force to introduce BANGLA in computer on high priority. The Task Force is being supported by adequate fund also from the NCC for necessary research and development. It is expected that outcome of this effort will make BANGLA data

processing possible within a few months [17]. BANGLA word processing, using Apple Computers and LASER printers are very common in the country.
Computer Curriculum:
Steps have been taken to introduce computer curriculum in science, mathematics and environmental science books of secondary schools and computer as a separate subject in college level [18].

Consultancy Service:
The member secretary of NCC has been detailed to act as technical adviser to most of the public sector computer acquisition projects, sponsored by different ministries/divisions. Names of major agencies have already been mentioned earlier [19].

Rational distribution of Computer Courses/Seminars Abroad:
Prior to NCC, the computer courses abroad were distributed on ad-hoc basis. After establishment of NCC, the job of allocating the courses and seminars have been vested to the NCC Sub-Committee No-3, which is headed by the Vice Chancellor, Bangladesh University of Engineering & Technology. The subcommittee has distributed about seventy computer courses/seminars to the actually needed installations and persons having appropriate pre--qualification & role in the work place [20].

3.3 Environment Creation impact

There is a general awareness and optimism in the country regarding the utility of computer in business, amongst computer professionals, home computer users and institutions in private and public sector. Net result is a sustained growth in number of computer systems both in public and private sectors and their use, from 1983 onwards.

Exponential Growth:
In 1984 NCC received only two applications for acquisition of computer in the public sector, whereas in 1987 there were 48 applications for micro computers. In the first half of 1988 permission for 44 systems has already been given. It is projected that number of permissions will exceed hundred this year, which means about 100% annual growth in public sector alone in 1988.

The impact of NCC's promotional measure in the private sector has not been surveyed formally, but statistics are available from the Bangladesh Computer Association (which is a vendors organization). From their records, it appears that the growth rate of computer in private sector is much higher than public sector. Moreover those are used more intensively than the public sector computers. Approximate number of computer systems in private sector is given below for a general idea:

-	Small Systems	- 2000
-	Medium Systems	- 30 - 40
-	Big systems	- 0

Registration of Consultants:
The National Computer Committee has undertaken steps to register computer related consultants (firms and individuals). The compiled list will be published after necessary scrutiny for information of users and to ensure continuous professional progress of the consultants [21]

International Exposure of IT Sector Through Asian Computer Directory (ACD) NCC took necessary measures to forward particulars of IT sector organizations (both public and private) to Hongkong based ACD. These have been included in the 1988 edition. Such publicity helped the computer sector to be known in the international community, which will bring multifarious benefits to the business community of the country [22].

Computer Knowledge Through National Media:
In Bangladesh, the media like radio, T.V. & newspapers have started to include computer related programs/publications. NCC has mobilized concerned organizations in this sector [23].

Use of DTP:
About fifteen daily newspapers and periodicals are being published using computerised desk-top publishing (DTP) through Apple Computer Inc. products. Moreover about twenty firms are providing bureau service in DTP field. They came up in last six months.

Home Computer Use:
Recently, it has been observed that some citizens have also started installing micro computers at their homes, mainly for children's education, games, word processing and some professional application.

The First National Exhibition:
NCC has inspired the computer community to hold the "First National Exhibition & Seminar" in December 1988.

4. NCC STRATEGY ON APPLICATION PRIORITY & PROMOTIONAL PROJECTS.

Computer Application Priority:
After considering all relevant factors, the NCC has decided that at this stage, highest application priority will be given to following public sector organizations/functions :

- Public Accounts Sector (Comptroller & Auditor General's Offices, District & Upazilla Treasuries)[25].

- National Board of Revenue (Income Tax Commissioners, Custom & Excise Collectors Jurisdictions)[26].

- Banking sector including investment/insurance houses [27].

NCC has also submitted a project titled "Macro Level Overview Study on IT Sector " to the Planning Commission [28]. This will help to identify priority need areas and pursue appropriate short and long term policy actions. Another Technical Assistance Project Proforma on "Computer Education & Training" has been agreed in principle by the External Resources Division of the Planning Ministry [29].

NCC has also made some headway to export "Data Entry Service" to USA [30] and other developed countries. The NCB is planning to enter the high growth software export market as early as possible.

5. POLICY ACTIONS INITIATED BY OTHER ORGANISATIONS

Some policy directives/initiatives, issued/taken by following organizations have worked as major promotional factors in the IT sector:

a) External Resources Division - Ministry of Planning:
In 1987, they formulated and implemented a policy, under which any Bangladeshi citizen can be employed as local consultant in any development project and can be paid consolidated monthly honorarium, ranging from Tk fifteen to thirty thousand i.e. approximately nine hundred US dollars. In special cases this amount can be increased by another 40% [31]. This is a substantial income in the context of Bangladesh, where highest government salary is less than two hundred US dollars. It has been possible to retain many computer professionals in the country, by paying the consultant's scale.

b) Organization & Management (O&M) Wing - Ministry of Establishment:
O&M wing has formed a special committee, headed by the author to examine the computer installations of the country and recommend to the Government about changes needed in the manpower, hardware, software and other situations - to make the installation optimally balanced. This has been named as "Computer Installation Table of Organization and Equipment

(TO&E) Rationalization Committee [32]". Any new computer installation also gets their manpower need examined and passed through this committee. Already study report on BBS, has been submitted and the recommendations are in the process of implementation [33].

c) Export Promotion Bureau - Ministry of Commerce:
They have formed a Electronics Products Export Thrust Committee (where the author is a member [34] to boost export of this non-traditional sector. Two Task Forces viz., on Data Entry Services/Software Export & Technology Scanning, have been formed, headed by the author [35].The Data Entry Services Export Sub-committee has already been able to help one private entrepreneur to get the first order on this sector.

d) Bangladesh Bank: The Bangladesh Bank has introduced a policy of 6% interest only, if anybody obtains loan for export of 90% of his products. Computer software & hardware industry also can get this benefit. Already Bangladesh Shilpa Bank has given press announcement for software developers - basing on this policy.

e) Ministry of Industries:
The committee on sanction of new industries, headed by the Hon'ble Prime Minister and Minister of Industries has given special priority for computer sector projects. Recently this committee passed the first micro-computer assembly project (joint venture) in a record time and with liberal conditions. Bangladesh Small & Cottage Industries Corporation also arranged the first National Electronics Exhibition, recently - where locally assembled computers were displayed.

f) Bangladesh Bureau of Statistics:
They have introduced standard rates for different computer related bureau services and printouts for the information they maintain.

g) PACC- Ministry of Establishment:
So far about one hundred senior officers (Secretaries, Additional Secretaries, Joint Secretaries, Deputy Secretaries and equivalents) have undergone computer familiarisation course in the PACC. More than one hundred more officers are going to attend the course soon.

6. CONCLUSION

In the fast changing field of information technology, Bangladesh is a new comer. Inspite of the usual constraints faced by any developing country, Bangladesh is going through a silent revolution in IT sector. With the transformation of NCC into NCB and a full time secretariat, the country will be steered into the era of information technology in a balanced manner. Though this path of technological evaluation has different phases, there are successful examples of leap froging by some developing countries. Among the smaller countries Singapore has leap froged most successfully. On the other hand India is another example of a success story, inspite of all its complex problems and large population. Bangladesh needs to learn from both of these and other countries and pursue a policy of technology-hopping.

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ENDNOTES

1.
The organization which resulted out of this project is named Public Administration Computer Centre (PACC)

2.
Annexure "D" is not included in this article. All public sector organizations are listed in this annexure and considered EDP application priority grading is allotted to each of these.

3.
Annexure "D" is not included in this article. All public sector organizations are listed in this annexure and considered EDP application priority grading is allotted to each of these.

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INFORMATICS IN LATIN AMERICA: PROMISES AND REALITIES

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This article reviews the regional situation in Latin America regarding the diffusion of computers and considers available information on foreign trade in hardware. It briefly refers to the level of development reached in the manufacture of computer equipment and in software production, and presents some information on the use of computer systems in different sectors and activities. Furthermore the article deals with the informatics policies for industry, software development and other areas, focussing especially upon the informatics policy followed in Argentina. The final section refers to regional cooperation mechanisms.

1. INTRODUCTION

The diffusion of computers installations in Latin America is very much smaller than that in developed countries. The region has approximately 2% of the worlds´s informatics equipment [1]. However, the computerization process has considerably accelerated in the last five years. As a result, on the one side, of the new horizons opened by microcomputers and user-friendly packaged software and, on the other side, of the policies applied in several countries of the region.

The growing use of computers, and in some cases the emergence of a local computer industry has increased public interest in the implications of informatics for development and social change. Informatics is regarded as a promise and, at the same time, as a threat. It seems to offer an opportunity to increase productivity and quality of manufacture, to improve management and, in particular, to introduce a tool for greater efficiency in public administration. On the other side hand, the lack of autonomous facilities created the feeling that informatics is a new and dramatic expression of economic and technological dependence that will further undermine the power of the State to exert its sovereign rights [2].

2. INFORMATICS DIFFUSION AND TRADE

2.1. The pattern of computerization

The first computers were installed in Latin America at the end of the fifties and early sixties. With rare exceptions, those installations were based on the definition of needs and on software designed and produced by international suppliers. Informatics systems were established, as a rule, as highly centralized structures, mainly used for dealing with administrative tasks. Few applications were designed for other fields such as agriculture, health or education [3].

Transnational corporations from the United States, in particular IBM, have maintained a dominant position in the Latin American market. In 1981, US suppliers controlled 98% -in value- of the large computers installed in the region [4]. This dominant position has been maintained throughout the present decade, but it is now under strong pressure from suppliers of Japanese "plug-compatible" mainframes and microcomputers "clones" originating in different countries, including Latin America. The "clones" have gained considerable penetration in the microcomputer market on the basis of price competition. In Brazil, the largest and fastest growing market in the region for microcomputers, American companies could not participate at

all, due to governmental regulations.

Hardware suppliers have generally played an important role in training local personnel to operate equipment. This training, however, was conceived as a part of the marketing strategy of these suppliers and emphasized the equipment operation and programming tasks, while disregarding the crucial aspects of systems analysis and design. As a result, many installations were put together on the basis of a poor definition of needs, which resulted in inadequate information systems. Frequently, rented equipment has clearly been inappropriate to meet the client's actual requirements. Moreover, in many countries international suppliers advocated the creation of large central informatics units for the public administration. These structures facilitated the suppliers' control over the computerization of the whole administration through the expansion of a central computer and the installation of terminals to respond to new demands.

The pattern of computerization in the public sector in particular, has been largely determined by suppliers' marketing strategies. The policies currently implemented in several countries attempt, among other objectives, to introduce changes in that pattern. The growing distribution of microcomputers is *de facto* actively contributing to that change.

2.2. Hardware

Latin America is the most computerized region of the developing countries, but is far behind the developed countries . Measured against the gross national product, the Latin American level of computerization is that of the United States . The gap is greater if the number of installations is measured per million inhabitants (see Table 1) [6].

Table 1

Hardware Installations in the World 1981

Country or Region	Number of installed systems (Universal computers) per million inhabitants	Value as % GNP
United States	248	2,5%
Western Europe	131	1,3%
Japan	208	1,5%
Asia and Oceania	1	0,2%
Latin America	15	0,5%
Africa (except South Africa)	2	0,1%
Middle East	4	0,2%

CEREM, op.cit.

It is not safe to make inter-country comparisons using the available statistics on computers installed in Latin American countries due to different methods of calculation and classification [7]. For this reason, the figures presented in Table 2 should be considered as a general indicator, and be interpreted very cautiously. In the case of Argentina, for instance, the data do not include homecomputers which in 1986, were estimated at more than 100.000 units. The figures for Mexico do not refer to units of hardware, but to the number of entities which have incorporated computers. In any case, the table suggests that brazil is clearly the country with the largest number of computers installed. It also indicates the importance of Venezuela as a user of informatics resources, as confirmed also by the import data (see 2.3 below).

The growth rates of computer installations in several Latin American countries, according to different sources [8], is very significant. It reached 27% (in units) in Argentina (1985) and 30% (in value) in Brazil (1984). As elsewhere, microcomputers are by for the largest number of installations in Latin America.

Table 2

Computers installed in
Latin America (selected countries)

Country	Year	Number of Computers
Argentina	1985	29769
Brazil	1984	153202
Colombia	1986	11673
Chile	1987	10298 (*)
Ecuador	1985	2000 (**)
Mexico	1986	10335 (***)
Paraguay	1987	322 (****)
Peru	1987	12000
Uruguay	1987	7623
Venezuela	1984	50000 (*****)

(*) Home computers: 47.951
(**) Improted equipment
(***) Number of entities and enterprises equipped
(****) Excluding microcomputers
(*****) Only microcomputers included

In the Andean Group countries (Bolivia, Colombia, Ecuador, Peru, Venezuela) microcomputers represent 93% of the total installations [9]. According to estimates by the Office of Computers and Business Equipment, the Brazilian Microcomputer market grew at an average annual rate of 74% from 1984-1987, which is considerably higher than the rates in the United States (15%) and in Western Europe (32%)[10].

2.3. Foreign trade

The foreign trade in computer equipment in Latin America reached US$ 1 billion in 1985, with an overall deficit of US$ 337 billion (see Table 3). The main importers of hardware have been Mexico, Brazil, Venezuela and Argentina (see Table 4). The four countries mentioned represented 83% of total imports. Venezuela and Mexico accounted for nearly 70% of the total regional deficit. For Argentina and Brazil, the exports, mainly by transnational corporations, to a large extent neutralize the weight of imports [11].

Table 3
Latin America: Foreign Trade in Hardware (1985)
(US$ 1.000)

Country	Exports	Imports	Trade Deficit
Argentina	106.774	122.592	- 15.818
Bolivia	---	1.545	- 1.545
Brazil	170.728	142.611	28.117
Chile	339	8.801	- 8.462
Colombia	28	42.773	- 42.745
Euador	---	25.211	- 25.211
Mexico	59.248	156.308	- 97.060
Paraguay	---	1.886	- 1.886
Peru	---	28.575	- 28.575
Uruguay	41	5.554	- 5.513
Venezuela	37	131.764	-131.727
TOTAL	337.145	667.620	-330.425

Source: SID, "Comercio Exterior de Bienes Informaticos en America Latina", doc. no. 37, Buenos Aires, Nov. 1987.

Table 4
Imports Distribution by Country (1985)

Countries	US dollars	%
Argentina	122.592	18.3
Bolivia	1.545	0.2
Brazil	142.611	21.4
Chile	8.801	1.3
Colombia	42.773	6.4
Euador	25.211	3.8
Mexico	156.308	23.4
Paraguay	1.886	0.3
Peru	28.575	4.3
Uruguay	5.554	0.9
Venezuela	131.764	19.7
TOTAL	667.620	100.0

Source: SID, doc. no. 37, op.cit.

Imports of hardware increased 26,6% between 1983-84 and 19,5% in 1984-1985. Exports doubled during the first period and grew 14,8% during the second. Imports accounted for a growing percentage of transactions on capital goods made in Latin American countries, particularly Venezuela and Argentina. United States firms supplied 73% of the regional

imports. This proportion was even higher in Venezuela, Mexico, Ecuador, Chile and Bolivia (see Table 5). Brazil is the second regional supplier, followed by the Federal Republic of Germany, France and Japan [12]

Table 5
Imports of U.S. Origin (1985)

Importing country	Total Imports	Origin USA	%
Argentina	122.592	84.452	68.9
Bolivia	1.545	1.340	86.7
Brazil	145.611	80.385	56.4
Chile	8.800	7.335	83.3
Colombia	42.773	32.389	75.7
Euador	25.211	22.345	88.6
Mexico	156.308	125.736	80.4
Paraguay	1.886	1.398	74.1
Peru	28.575	17.120	59.9
Uruguay	5.554	2.671	48.1
Venezuela	131.764	107.125	81.3
TOTAL	667.620	482.296	72.2

Source: SID, doc. no. 37, op.cit.

The intra-Latin American trade is very low. Most exports from the region by transnation corporations goes there to Japan and Australia and not to other countries in Latin America. Only 9,2% of the total regional imports originate in Argentina, Brazil and Mexico [13].

Finally, about 80% of the Latin American imports of semiconductors and electronics components were concentrated in Brazil and Mexico, as against 40% of the imports of finished equipment (figures for 1983) [14].

3. LOCAL PRODUCTION

3.1. Hardware

Several Latin American countries have started to manufacture or assembly hardware. Currently, the largest hardware producer is Brazil. Imports have represented around 10% of total informatics sales, which were estimated at over US$ 2,4 billion in 1986. A total of 40.000 persons are employed in the industry (5.000 in R & D activities). About 60% of the market is concentrated in six firms. As a result of Brazil´s informatics policy an estimated 50% of the market is controlled by Brazilian firms, which produce micro and minicomputers, peripherals, and other equipment for automation, instrumentation and control [15].

In Mexico, 60 companies were registered as hardware producers (32 of microcomputers, 29 of minicomputers and 12 of peripherals). The local content in production is small, despite the program established in 1981. The industry has created around 5.000 jobs [16]. Local production is by nationally-owned firms or by foreign subsidiaries. The government has accepted 100% foreign ownership in companies operating in this industry.

The manufacture or assembly of microcomputers has also been envisaged in Argentina and other countries (see points 5 and 6 below).

3.2. Software

Although it is frequently argued that Latin American countries have comparative advantages for the production, and possibly export of software, till now these activities have remained incipient.

There are few systematic studies on software development and trade in the region. In Argentina, a recent analysis by the *Subsecretaria de Informatica y Desarrollo* (SID) reveals that 70% of software sales are based on imported software (see Table 6). Local developments concentrate on administrative and accounting applications and on "custombuilt" software. Around one thousand technicians and professionals work in software production in about two hundred firms. A few "software packages" have been developed in the country. Some of them are exported to other Latin American and extraregional countries [17].

Table 6
Argentina: Software Market by Type of Product and Origin
(%)

		Origin		Type of Product		
Year	Total	National	Imported	Basic	Utilities	Applications
1980	100.0	73.9	26.1	12.3	9.3	77.5
1983	100.0	22.4	77.6	34.4	34.9	30.7
1984	100.0	22.2	77.8	35.3	34.7	30.0
1985	100.0	29.1	70.9	40.5	25.4	34.1

Source: Intituto Nacional de Estadisticas y Censos (INDEC)

The Argentine study further reveals that the remuneration of programmes and other computer technicians is several times lower than that in developed countries [18]. However, since the design and development of software represent only a minor part (15%-20%) of total costs, the differential is not necessarily a decisive advantage for competing in international markets, as proved also by the Indian experience [19].

In the case of Brazil, computer programs commercially in the country need to be registered with the Special Secretariat of Informatics (SEI). There are three categories of computer programs: A) software developed in Brazil by a national company using its own technology; B) software of foreign origin, the technology and commercialization rights of which have been transferred to a national firm, under a contract approved by the national Institute of Industrial Property (INPI), and C) software developed abroad by a foreign company and marketed by a subsidiary or foreign controlled company established in Brazil.

National registered software increased more than 30% annually between 1984 and 1986, against 5% foreign software. In 1986, the participation of national software reached 33,5% (see Table 7). Though there is a similar number of nationally developed computer programs (category A) to those of foreign origin (category C), the latter clearly prevail in "basic" and "support" software (see Table 8).

Table 7
Brazil: Registered Software by Origin *
(Number of registered programs)

	1983		1984		1985		1986	
		%		%		%		%
(A) Nationally developed	441	11.2	1627	23.7	2171	27.8	2926	33.5
(B) Developed abroad, commercialised by Brazilian firms	56	1.4	60	0.9	60	0.8	63	0.7
(C) Developed abroad, commercialised by branch or subsidiary	3949	100.00	6874	100.00	7791	100.00	8740	100.00

* Registration is made before the secretaria especial de Informàtica (SEI)
Sorce: SEI, Informe Nacional del Brasil a la X CALAI, Mendoza, november 1987

Table 8
Brazil: Registered Software by Types
(December 1986)
(Number of registered programs)

	Category *			
Type	(A)	(B)	(C)	Total
Basic	347	28	853	1228
Utilities	482	33	2832	3347
Applications	2097	2	2066	4165
Total	2926	63	5751	8740
%	33.5	0.7	65.8	100.0

* See Table 7
Source: SEI, op.cit. in Table 7.

In Mexico it is estimated that 40% of the computer programs in use have been developed nationally for a software market that could reach US$ 150 million [20]. Some programs have

also been exported[21].

In Venezuela about two hundred firms supply a US$ 6 million market with a high concentration of administrative applications. Some arrangements to produce software in Spanish for other markets have been made with foreign companies. Software has been exported to the United Stated, Mexico, Argentina and other Latin American countries [22].

Elsewhere in Latin America the situation is similar to that described above; software production is limited and is concentrated on administrative custom-made applications. Some exports have also been registered for Chile and Colombia.

Software production in the region is affected by several technical and economic constraints. There are serious methodology problems for software development, which have an effect on software quality. This is also seen in low standards of documentation. The lack of entrepreneurial and in particular of marketing abilities, presents a difficult obstacle to developing software which moreover has a small and fragmented market. Software may represent an opportunity to Latin America, but only if significant improvements are made in production and commercialization techniques.

4. MAIN FIELDS AND TYPES OF APPLICATIONS

Information on the sectoral distribution of computers is subject to important limitations. The public sector seems to concentrate the minority of the market (units) in Argentina (30%), Venezuela (25%), Colombia (6%), Peru (24% for microcomputers; 28% for minicomputers) and Ecuador (38%, for large and medium-sized computers) [23]. In Brazil, the public sector accounts for 27% (value) of the informatics market [24].

The largest part of computers installed in the private sector are within the services sector. In Argentina, for instance, industry only accounts for about 10% of total installations, and the diffusion of computers in agriculture is extremely weak [25]. In Colombia, similarly, 69% of computers are used in services (including trade and financial activities). Industry represents 20% and agriculture less than 1% [26]. The low penetration of computers in agriculture activities is striking, if the contribution of this sector to GNP in both countries is taken into account. The lack of adequate software, the traditional managerial practices prevailing in that sector and the shortcomings of suppliers maintenance and support networks, are among the factors that may explain the limited role so far played by computerization in the agricultural field.

Banking applications have grown rapidly during this decade and, in many countries (e.g. Argentina, Brazil, Mexico, Ecuador) they currently constitute one of the most dynamic segments of the market. In Brazil, for instance, US$ 675 million of banking automation equipment (terminals, ATM´s cash dispensers, etc.) were installed in 1987. The number of ATM´s reached 862 in that year, while about 100.000 banking terminals had been installed in the country (80%) of which in the South-East region) [27]. About 400 ATM´s have been installed in Argentina, 330 in Chile and 300 in Colombia, according to official estimates.

The most frequent type of computer applications relate to administrative activities and within them to accountancy, invoicing, etc. Word processing is rapidly becoming popular, though it is more as an isolated instrument than as an integral part of office automation programs. Tools for management support and planning are also increasingly used. More sophisticated applications, such as Decision Support Systems, are still very marginally employed. A few applications based on artificial intelligence have been developed for specific purposes (e.g. in the energy field) in Argentina and Mexico.

The diffusion of applications in social areas varies considerably between the different countries but overall the diffusion is quite limited. For instance Brazil, the Latin American country that has undergone the most intense process of computerization, exhibits a reduced use of computers in health services. They are basically applied to administrative tasks, to some extent

for planning and control, and in an experimental and marginal way for clinical purposes, such as diagnosis [28]. In Cuba, the development of health-related computer applications has been a major objective of the national informatics policy. Specialised software and equipment have been developed and are in use, including simulation software for training, experts systems for diagnosis and disease treatment, etc. The establishment of a national data bank has also been reported [29].

Finally, the use of computers is spreading over elementary and secondary schools and universities, but at a rhythm considerably lower than that observed in many industrialized countries. While some governments have set forth specific policies to promote such use (see section 6 below), in some countries private educational institutions are introducing computer applications faster than public schools. However, notwithstanding the expectations created by the potential applications of computers, the impact of informatics on educational systems is, in general terms, very limited. A major reason for it is the lack of appropriate software, as well as a shortage of adequately trained teachers.

5. INFORMATION POLICIES

Argentina, Brazil, Mexico and Cuba have defined, with varying degrees of comprehensiveness, policies for informatics development [30].

In Brazil, law 7232 of 1984 provides legal support for the policy initiated during the seventies of producing certain types of equipment locally (minicomputer, microcomputers and peripherals). It ratifies the "market reservation" as the main instrument for fostering the development of a local informatics industry [31]. It implies a prohibition on the importing of equipment when similar equipment is locally-produced and a restriction on related foreign investments. Only a 30% foreign participation is permitted, provided that the company is controlled by the local partner. The law also authorized the granting of incentives for research and development, production of electronic components and software development. After considerable debate, a law on the protection and commercialization of software was approved in December 1987. While establishing copyright protection for computer programs, law 7646 created a special registration system for software to be marketed in Brazil. When registration of an imported computer program is sought, there should not be any "functional equivalent" of national origin [32]. Further, the importing firm should assume a number of obligations, particularly as regards error correction, technical support and delivery of new versions.

The market reservation policy has made possible a considerable development of the informatics industry in Brazil, as shown by some industry performance indicators (see Table 9).

Mexico launched an industrial informatics policy in 1981, based on the granting on incentives, import restrictions and the acceptance of foreign participation in joint ventures only. After 1984, the policy, which was never officially approved, underwent substantial changes due to the authorization given to IBM for a 100% foreign direct investment in the production of microcomputers. In any case, the industrial programme stimulated the local assembly of micro and minicomputers and peripherals for the domestic market and exportation. In 1987, for each US dollar of computers and related equipment imported, 50 cents were exported (against only 2 cents in 1981)[33].

Table 9
Selected Indicators of Performance of
Brazilian Informatics Firms 1977/80/83/86

	1977	1980	1983	1986
1. Number of firms registered	4	29	80	310
% of total	10%	75%	80%	90%
2. Turnover (US$ million)	-0	280	687	1520
% of total	-	32%	40%	51%
3. Number of Computers installed	-	1588	7684	800.000
of total	-	17%	91%	98%
4. Number of direct jobs created	- 50	7264	15734	40316
% of total	2%	40%	60%	89%
5. Expenditure in R&D activities (US$ million)	-0	30	67	154
R&D/Turnover	-	8.7%	9.8%	10.1%
R&D/Number of employees (US$)	-	4130	4260	3850
6. Number of employees in R&D activities	-0	1200	2045	4900
R&D Employees/Total employees	-	16,5%	13%	12%

Source: Piragibe - "Policies towards the electronics complex in Brazil", paper presented at the Seminar Horizon XXI - Reconversion and Integration in Latin America, Mexico, 1987.

Cuba started to manufacture minicomputers at the beginning of the last decade. In 1976 the *Instituto Nacional de Sistemas Automatizados y Tècnicas de Computaciòn* (INSAC) was set up. Cuba began work, within the framework of COMECON arrangements, with the assembly of video-terminals, and then with keyboards. According to official estimated, sales of the latter to socialist countries will reach over one million by 1992. Cuba also produces electronic components and plans to reinforce its facilities for the design and production of integrated circuits.

Other Latin American countries, such as Colombia, Peru and Venezuela, have recently considered formulating industrial informatics policies. Assembly operations are currently covered by a special promotional regime in Peru (Supreme Decree 064-85 ICTI/IND). At least one Peruvian firm has successfully exported microcomputers to socialist countries.

Most countries in the region (Uruguay, Paraguay, Ecuador, Chile Bolivia, Mexico and Venezuela) maintain tariff protection below 25% for informatics hardware (see Table 10). Argentina increased tariffs (up to 100%) in 1985 to provide initial protection for national industries according to the policy in force. However, the tariff will gradually be decreased from October 1988 and during the following five years.

Table 10
Tariff Protection in Selected Latin American Countries
(informatics equipement)(*)

Country	%
Argentina	20-100
Bolivia	21
Brazil	20
Chile	15
Colombia	15
Euador	20
Mexico	45
Paraguay	10
Peru	45
Uruguay	15-20-35
Venezuela	22,5

(*) Tariffs and other charges are included
Source: SID, doc. no. 37, op. cit.

As regards software, there does not seem to be any explicit promotional or protective measures. One exception is the provision in the Brazilian law no 7232, which stipulates the granting of incentives for developing software "of relevant interest to the country`s production system".

As already mentioned, the software protection issue has been dealt with in Brazil, by law 7647. In Mexico, Chile and Argentina administrative decisions made copyright law applicable to computer programs. In Argentina, however, a draft law proposes the establishment of specific provisions for the extent of protection and other matters, without prejudice to the application of copyright to issues not regulated specifically.

Most Latin American governments apply regulations relating to hardware and software acquisitions and rental by public entities. This is, in fact, one of the main policy areas currently dealt with in the region. In general, prior authorization is required for these transactions. in some cases (Argentina, Mexico, Venezuela) model contracts have been developed in order to avoid the pre-established terms and conditions often imposed by large suppliers. Explicit or implicit policies are applied in several countries (Argentina, Brazil, Venezuela) to promote the use of microcomputers and distributed systems, as an alternative to the pattern of centralized systems which has prevailed up to now.

In the field of human resources and research and development, various efforts are also being made in Argentina and Brazil, to improve graduate and post-graduate courses and to enhance the scientific and technological activities of enterprises and public laboratories [34].

Finally, several governments are sponsoring or executing programmes for introducing informatics into schools. In most cases, the main purpose is to disseminate microcomputers at the high-school level as a tool for general teaching activities. However, some programmes (ENET in Argentina, *"Quimanche"* in Chile, etc.) concentrate on the teaching of computer languages and programming skills. Some governments´plans include the distribution of microcomputers to schools as in Mexico ("Microsep") and Peru *("Modulos Educativos de Còmputo")*. In others (e.g. the SID programme in Argentina, Educom in Brazil) the emphasis is put on teachers´ training so they have adequate knowledge for the proper use of computers in classrooms.

6. INFORMATICS POLICY: THE ARGENTINE EXPERIENCE [35]

Despite some scientific and industrial precedents [36], at the beginning of this decade the Argentine informatics sector had no articulated public policy, an extremely weak production basis, a small and dispersed effort in research and development, and a diffusion of technology basically determined by the marketing policies of transnational corporations.

In 1984, the market for computers and peripherals was largely controlled by imports from American firms, either directly or through exports from subsidiaries established in other Latin American countries. One transnational corporation (IBM) has over 70% of the total market in large installations, while in the area of microcomputers TNC´s were subject to growing competitive pressures exerted by local assemblers of "compatible" PC´s.

As already mentioned, software was starting to be developed based mainly on the production of applications for administrative purposes. Over three thousand electronic engineers ware identified, many of them working in activities completely unrelated to their field. Over four thousand informatics specialists were also available, though with a considerable disparity in the quality and scope of their training [37].

Public activities in informatics were not well organized and they were mainly determined mainly by suppliers´ attitudes. Although the public sector was computerized during the sixties, this process was characterized by serious mismanagement, excessive centralization of applications, lack of adequate information systems, lack of coordination, introduction of equipment unsuitable for the user´s actual needs, low standards in software development and unfavorable terms in contractual arrangements with suppliers.

Based on the work of a national commission (Decree 1234/84), an overall, long-term informatics policy was adopted in November 1984. There were two main premises. Firstly, the strategic character of informatics for development, due to this broad and profound impact on many areas. Secondly, the possibility to enter selectively a field of growing economic importance and special dynamism such as the "electronic complex", i.e. the industrial activities involving computers, telecommunications and industrial consumer electronics.

The policy established as its main strategic objective the introduction of a learning process at different levels, including manufacture, research and human resources development. This goal has been emphasized as the most important underlying principle in all policy areas [38].

The main areas covered by the policy referred to are as follows:

A) *Industrial policy:* The development of a selective informatics industry is to be promoted by a substantial increase in tariff protection for certain products, the granting of fiscal incentives and the regulation of foreign investments. In principle, these measures are to be applied only in relation to microcomputers (and "super" micros) and some peripherals [39].
The granting of incentives for production of the type of product selected, is subject to specific conditions concerning local content, research and development and exports. Further, in order to avoid an excessive proliferation of small-scale production, incentives have been granted to twelve enterprises on the basis of bidding for projects.

B) *Human resources development:* The upgrading of professional education is considered a crucial aspect. In order to improve the quality of specialists´ training a high level institution the *Escuela Superior Latinoamericana de Infomàtica* (ESLAI) has been set up. The improvement of skills has also been dealt with in a joint programme with Brazil since January 1986.

C) *Research and development*: The encouragement of research and development is also an important element of the policy. The setting up of an innovative industry and the creation of decision capabilities required an increased effort in

this area, with the objectives of strengthening the scientific basis and organizing an imitative path of technological development. A research and development programme for informatics and electronics has been proposed, which aims to support and finance projects related to industrial demands in particular.

D) *Public sector*: The policy regarding the public sector basically aims at: i) promoting the use of microcomputers and distributed systems, as an alternative to centralized applications; ii) emphasizing the critical importance of information systems and of the organizational framework in which they should work; iii) increasing competition among suppliers, to avoid dominant market positions and obtain better prices and conditions for the State; iv) stimulating the use of the public sector´s demand in order to enhance industrial development. Model contracts for hardware and software acquisition have also been prepared to obtain more balanced transactions.

The Argentine governments´s call for bids concerning manufacturing projects encountered a mixed response from transnational corporations (TNC´s). Several of them rapidly indicated an interest and started negotiations with local partners. Their wish to remain in the market and to reduce the risk of this eventual closure, as in Brazil, was probably the main reason for their rapid reply. Out of the different attempts made, two TNC´s - Bull and Burroughs - finally succeeded in structuring joint-venture agreements, with majority local participation in both cases in the hands of important national industrial groups.

Among the TNC´s that did not participate in the bidding, the case of IBM i interesting. This company has a clear, wholly-owned approach to the establishment of subsidiaries. While IBM did not enter into a joint-venture agreement, a possibility that it also refused in Mexico, it granted, perhaps for the first time in a developing country, a license for the production of terminals for banking applications. The licensee was granted to a major economic group which had acquired a small firm with some experience in producing microcomputers. The arrangement allowed IBM to preserved the principle of total ownership, while still participating in the growing market of banking applications, currently one of the most important and dynamic in the country.

7. REGIONAL COOPERATION

The first Conference of Latin American Authorities in Informatics (CALAI) took place in Buenos Aires in 1970, with the aim of promoting national policies, the regional exchange of experience and information, and cooperative arrangements among the Latin American and Caribbean countries. The Conference, which had held ten sessions up to 1987, has contributed to making governments sensitive to the strategic importance of informatics, and given them a better knowledge of the regional situation and policies. In accordance with the IX CALAI recommendations, studies have been done by the DALAI Permanent Secretariat on software production and commercialization and on Latin American trade in informatics goods [40]. Other initiatives have been launched at the multilateral level [41].

Within the framework of the Montevideo Treaty, which established ALADI, Argentina, Brazil, Mexico, Chile and Uruguay have adhered to an agreement for eliminating tariffs in the trading of informatics goods. However, the restrictions imposed as a result of the industrial policies implementated in Brazil and Mexico, and Argentina´s desire go give some protection to its emerging industry, determined the application of safeguards by the latter country (the main destination of exports from the other two countries) and the need to renegotiate the terms and conditions of the agreement. In addition, a regional preference (PAR) for intra-regional trade is in force between Argentina, Brazil, Chile, Paraguay and Venezuela. However, given the existing levels of tariff protection and of the agreement just referred to, the PAR might simply constitute an incentive for trade by Venezuela with Argentina and Brazil.

In addition to the multilateral action just described, Argentina and Brazil have started a programme for human resources training and research and development. Binational "schools"

are annually organized with 250 students from each country, including courses on micro-electronics and software engineering. Fifty students from other Latin American countries have also been invited to participate. Research and development projects have been defined and are jointly executed by Argentinean and Brazilian researchers, under a program established by the Undersecretariat of Informatics and Development of Argentina and the Special Secretariat of Informatics of Brazil. The "Ethos project" in particular aims at designing an "inference machine" by 1990 [42].

8. MAIN CONCLUSIONS

Latin America is undergoing a process of diffusion of informatics, which has been accelerating recently as a combined result of technological developments and national policies on the matter. Great hopes exist in the region regarding the potential contributions of such technology. The computerization process, however, has been characterised by considerable deficiencies in its implementation. The overwhelming dependence on foreign suppliers and the lack of local user abilities are to a great extent responsible for the gap between the actual and the optimal use of equipment and software.

Informatics has been viewed by some countries not only as a tool to modernize administrative and productive structures, but also as an opportunity to enter into a growing and dynamic market. The relatively more developed countries of the region, Argentina, Brazil and Mexico, have attempted to establish an informatics industry. Up to now only Brazil has reached a significant degree of development in hardware production. In the rest of the countries, the acquisition and use of informatics resources by the pubic sector has been the main focus of policy action, complemented in some cases by research and development and human resource development. Software production is still in the early stages. Unless substantial changes take place in the methodologies of software production and commercialization, no significant developments can be expected in this field.

In view of the weaknesses of the computerization process, and of the limited scope of the current production, the region faces a double challenge.

On the one side, the region should strengthen its negotiating capabilities and improve human resource training and different levels in order to become an intelligent user of the new technological resources available. This is a minimum goal that will require considerable efforts at governmental, industrial and educational levels.

On the other side, the informatics industry seems to offer room for new entrants in hardware production. Some Latin American countries have designed strategies to build up an industrial basis in certain segments of the hardware market, with varying degrees of openness to foreign participations and competition. One outstanding feature of the established policies, at least in the case of Argentina and Brazil, is not only to substitute imports but also to initiate a learning process which might lead to the creation of local technological facilities. However, at the moment, none of these countries is aiming at competing on the frontier of technological development, but is rather following an imitative path in selected areas.

Regional cooperation and, in particular, market integration, may improve Latin America´s chances of taking full advantage of informatics development. Some efforts have already been made, but the scope for further progress is still very wide.

In short, Latin America is currently defining its role in the informatics revolution. That role will be established from the outcome of the interaction of suppliers´ and users´ strategies, and of State policies and regulations. Until now State intervention has been limited, except in those countries where industrial policies have been implemented. Planned, long-term action will be required at the national and regional levels to translate into reality the promises of informatics technology.

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[30] For Argentina, see the following section.
[31] The inclusion of the market reservation for specific areas in the Brazilian Constitution is currently under consideration.
[32] In 1987 SEI refused to register Microsoft´s MS/DOS because there was a local equivalent. In response, the U.S. government announced retaliation under section 301 of

the U.S. Trade Act of 1984. The conflict was later settled by the SEI agreeing to register a new MS/DOS version.

[33] De Mateo, F. & Carner, F., op.cit. p.9.

[34] SID, "Politica Informàtica 1987", doc. no. 39, Buenos Aires, Nov. 1987 and SEI, Panorama do sector de informàtica, Brasilia, August 1987.

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SECTION 3

COMPUTERISATON IN SPECIFIC SECTORS AND OTHER RELATED ISSUES

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INFORMATION TECHNOLOGY IN AFRICA - AN OVERVIEW

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The paper argues the importance of a distinction between national policies and policies for the government sector, even though the government is a trend setter in the use of computers drawing on examples from a number of countries in the region. The paper identifies especially shortage of foreign currency and manpower as the major obstacles. It is therefore necessary to implement policies in these two areas together with policies regarding hardware acquisition, maintenance, sharing of data between ministries and decentralization of computer resources.

1. INTRODUCTION

The introduction of information technology is a relatively recent event in many African countries. Generally the first computers were introduced in the early sixties and were devoted to running payrolls and accounts. The growth of computing in both the private and public sectors has accelerated significantly with the advent of the microcomputer. Applications which would have been destined to backlog can now be run on micros with very short development times.

African countries have embraced information technology as a tool for development. Recent developments in computer and telecommunication technologies have given significant impetus to the demand for, and the provision of more and better information support in various public and private sector areas. It is recognised that more effective information processing is a sine qua non for more cost-effective management. Informatics is already causing changes in the ways in which Government and companies work in a number of African countries. It is a powerful agent for technological and social change. As a result considerable resources are spent each year acquiring computer technology and the manpower required to run the technology. However, practically all countries are beset by the dual problems of shortage of foreign currency and lack of trained manpower.

2. POLICY

In looking at policy aspects one needs to distinguish between policy applicable to the nation as a whole and policy relating to the public sector only. By large many Governments in Africa have formulated and implemented policy on the acquisition of hardware and software usually for the public sector only. Most Governments have established Committees to regulate the purchase of computer equipment.

In Botswana a high level committee chaired by the Administrative Secretary, meets to review all applications for the acquisition of computers by any Ministry and/or Department in the Public Service. The implementing arm of the Committee is the Government Computer Bureau whose Manager is a member of the Committee. The terms of reference of the Committee specially exclude the parastals and the Private Sector.

Kenya and Tanzania have a similar approach. In both countries applications are vetted by the Manager of the Government Computer Bureau who is ordinarily a member of the committee. The Committee is supposed to meet regularly to vet the applications. However, the committees in both countries have not been meeting for some time.

Zambia's procedures are very similar to those of Kenya and Tanzania. Zimbabwe follows a different approach. The Zimbabwean Ministry of Finance issued a Treasury Instruction some years ago to the effect that any Government Ministry or Department wishing to acquire computer hardware, software or service must first seek clearance from the department of Central Computing Services. In vetting such a request CCS would be looking into the question of whether the intended applications could be run on CCS's computers. If the application is for a service the question is whether the required service could be provided by CCS. The Department of Central Computing Services can only recommend to the applicant Ministry/Department and to Treasury. In practice either or both of these can ignore CCS's recommendations though this seldom happens.

The power of CCS extends in another direction. All posts in the Public Service are created by the Public Service Commission. If a Ministry or Department applies for a computer post the Public Service Commission will not normally authorize the creation of that post, without consulting CCS.

Mauritius has another approach. In the cases cited the Governments have strong Central Computer establishments. The resources of these centers are at the disposal of all Ministries. Mauritius also has a strong Central Computer Centre. In this case, however, the Government allows other Ministries to acquire their own Computing resources. The Government Computer Centre provided expert advice.

The main reasons for establishment of Committees to regulate the acquisition of hardware and software are :

- to avoid the proliferation of computers and the resultant problems in technical support.
- to maximise the use of hardware and software already acquired
- to ensure that applications implemented are supportive of developmental goals
- to ensure that if and when hardware and software are acquired the resources are in place to use them effectively.
- to ensure that the hardware and software acquired meets defined standards

The Committee system has, however, not been overly successful. The experience of many countries is that the Committees soon wither away and die. The DP Manager of the Central Government computer installation is normally saddled with carrying out virtually unaided the tasks of the moribund committee. One of the main reasons for the failure of the Committee may be lack of commitment by its non-IT members. The second reason could be that the Committees usually have limited powers. In any case they do not fulfill any function which would not be performed, perhaps even more efficiently, by some one else in their absence. Practically all the Government computer establishments suffer from high staff turnover. The main reason for this is that Government salaries cannot compare competitively with those in the private sector. University graduates who join public sector computer installations soon leave for greener pastures once they have acquired experience. The public sector environment is an attractive recruitment ground since Government Computer installations normally have the most modern Computer and Communications equipment. To date no Government has come up with an answer to the problem of high staff turnover. There are no policies dealing with the issue of manpower recruitment, retention and renumeration in information technology area. There are general policies covering the public service as a whole but not informatics as a special area.

3. ORGANISATIONAL STRUCTURE

As mentioned previously the leading informatics authority in most countries is the Central Computer Department. Almost without exception these Central Computer Departments are in the Ministries of Finance. The post of the head of the Computer Centre is usually of senior rank in the public service.

Basically there are three approaches relating to placement of computer staff in other departments. One approach is to centralize the placement of computing staff in the central data

processing department. These staff can be seconded to other departments if and when required. The second approach is the one more common. All staff belong to the Central data processing department and they are given assignments elsewhere as and when necessary. They are supervised by the data processing department. The third approach is to decentralise the recruitment and placement of staff. Each department recruits its own staff and they are under its supervision and control.

Some of the Central Computer departments have meetings with ad hoc user committees. In the Zimbabwe case each user department has a liaison officer who liaises with the Computer department. The liaison officer should be senior enough to have access to the head of department. If the liaison officer is not sufficiently computer literature he/she is given the necessary training. In the private sector computer departments usually fall under the office of the Financial director. Data Processing installations are usually small with about five to ten staff. The DP manager would normally report to the Financial Director. This practice has a tendency of hindering the development of integrated systems for the management of the whole company. The advantage, however, is that DP department gets adequate financial support for approved projects.

The practice of putting a microcomputer in each department is not widespread cue to the difficulties of acquiring the equipment. The total numbers of micros is still small in African countries. There is tremendous potential for expansion in this area.

4. PLANNING PROCESS

Government planning in the English speaking African countries generally fall into two levels. On the one level are the 5 year plans; on the other one the annual budgets. Therefore any information technology plans generally fall into either category depending on its size and potential impact.

In Botswana information technology plans extending up to the 5 year horizon are submitted directly to the Ministry of Finance. The funds so provided in the plan cannot be disbursed without the authorization of the Central Computer Committee. This requires the applicant department to provide justification for the project. The justification is analysed by both the Director of Finance and the Government Computer Bureau.

This is similar to the practice in Zimbabwe except that if a department already has a computer then it need not have its running expenditure approved by the Central Computing Department unless the proposed expenditure is considered to be major.

Generally, however, African countries place greater importance on the annual plan from an operational standpoint. The allocation of funds in the annual plans is usually done without the intervention of the computer committees. Approval of the Computer Committees is required for the actual expenditure of the allocated founds.

5. CAPITAL HARDWARE/SOFTWARE AVAILABILITY

The distribution of the different types of computers - mainframes, minis and micros is not known at this stage. The number microcomputers in Government is a great deal larger than minis and mainframes. Microcomputers, in turn, are more numerous than mainframes.

In Zimbabwe there are some thirty companies marketing computer hardware. Of these the largest are:

ICL
Data General
WANG
DEC
IBM
Concurrent Computers
Nixdorf, and
NCR

In Kenya the major vendors are

ICL
WANG
IBM
NCR

While in Zambia the leading computer companies are NCR and ICL. In Botswana ICL is the strongest vendor company. In Nigeria NCR and ICL are strong while in Ghana IBM, NCR and WANG lead the field. In Sierra Leone WANG and NCR are the leading vendor companies. The choice of computers for purchase by the Government depends on the availability of the after sales support for both hardware and software and in training. The major vendors tend to offer superior after sales service and therefore tend to dominate the Government market.

Only a few countries have local assembly of microcomputers. Kenya, Botswana and Mauritius are early starters in the field. Zimbabwe is a late entrant. An increasing number of computer companies are looking at local assembly as a means of avoiding the considerable import duties or getting favored treatment in the allocation of foreign exchange. Companies setting up local assembly and therefore employing local labour would normally get special project allocation as opposed to the normal import allocations.

Quite often the only local content is labour, though some companies source the extruded plastic cases locally. In such instances the mould is borrowed/hired from the original manufacturer. There is no industry making or assembling peripherals nor components. The electronic components that are manufactured are intended for the domestic audio electronics market.

While Fortran is used for scientific type application, Cobol is the commonest programming language, 4GL use is in its infancy. Database technology is relatively new as well. The Department of Central Computing Services in Zimbabwe has had all their major applications on a proprietary relational database systems since 1983. As a result of using 4GL features of this DBMS, the staff have had high productivity. What is perhaps the biggest database in the country (i.e. 1800 MB) is on this system.

Most major makes of microcomputers are available in Africa mainly through dealers. Microcomputer software packages used include Lotus, Visicalc, Wordstar etc. One might mention that wordprocessing is gaining in popularity though it still has a lot of new ground to break in Government.

6. HARDWARE AND SOFTWARE SELECTION PROCEDURES

Most Governments go through a tendering process when purchasing a computer. The body that orchestrates the whole process is the Government Tender Board. The actual evaluation of tenders is usually seconded to the applicant's Ministry/Department with the Government computer providing the technical resources. In some cases the request for proposals (RFP) and the evaluation are quite sophisticated. The evaluation procedure can include visits to reference

sites, use of weighted scoring tables and consideration of the viability of the vendor company. Both Purchase Agreements and Maintenance contracts do include penalty clauses in some cases. Maintenance performance expectations of 99 percent time are expected by the purchaser.

Private sector companies do not generally go to formal tenders. There is no legal requirement for them to do so. However, sometimes the Ministry allocating foreign exchange wants to see a number of quotations for the equipment or software, and that the winning proposal has the lowest foreign currency content.

7. TELECOMMUNICATIONS

Many of the African countries can support quite sophisticated data networks. Countries such as Botswana have a country-wide microwave network that allows data lines driven at 9600 between urban centres. Zimbabwe has installed an x.25 packet switching network called an interim ZIMNET. There are no data lines crossing state borders to neighboring countries. There are however, data links to Europe and USA.

8. MANPOWER

There is a shortage of trained manpower in Computing in all the African countries. This problem is acute in Government establishments due to the comparatively low salaries. Government employment is, however, attractive to the recent graduates because of the opportunities offered for further training. The manpower shortage has three possible consequences :

(1) inadequately trained personnel will be recruited at all levels

(2) less numbers of people will be involved in developing larger numbers of systems resulting either in incomplete or poor quality systems.

(3) there will be continual dependence on expatriates

Broadly the manpower needed may be divided into three levels. In the first level we have the junior trainee type who perform the normal day to day operations and programming. All countries recruit pre-university school leavers for these positions. There is no shortage of these people and such are therefore easy to fill. But training them to be effective and preparing them for the next level is a problem.

In the next level - the middle level - we have people in greatest demand. These are people with 3 to 7 years experience, are able to supervise, guide and provide on-the-job training to level 1 staff; understand the weaknesses and strong points in computers; know how to communicate and deal with demanding users; and maintain unhesitatingly undocumented systems left by others. Such people are hard to come by, and hard to retain. These are the people with extensive or advanced training in computer systems attained through attending advanced courses and working under skilled supervisors.

Computer managers fall into the third level. The situation here is difficult. Firstly the number of managers required is smaller than the number required at levels 1 and 2. Hence there is strong competition and more able people from level 2 move into the level 3 positions.

The other type of manpower required is hardware and software support staff. Government does not generally recruit hardware support staff. Where they exist in the private sector these positions tend to be filled by locals. In Zimbabwe there is not a single expatriate hardware support engineer. Software expatriates come in on short term contracts with specific terms of reference. Governments in Africa are now pretty sensitive about the recruitment of expatriates. It is certainly not a trivial matter for an expatriate to get a work permit.

9. EDUCATION AND TRAINING

Computer education is offered at three levels of the educational system i.e. at school, technical colleges and universities. A number of African Governments have formulated policies on computer education in schools. Zimbabwe and Mauritius are two notable examples. In Zimbabwe's case it has so far not proved possible to implement this policy for lack of hardware and software. The Ministry of Education feels that with scarce forex resources, computers can only be introduced in schools if there is local assembly of micros. Zimbabwe has infact commenced local assembly of micro-computers from semi-knocked down kits. As a result we expect to see implementation of this policy in the near future.

The drawbacks to full implementation of the policy are lack of both computer resources and trained teachers.

The problem of shortage of trained teachers also affects the polytechnics. These technical institutions offer undergraduate diploma courses with a good practical orientation. Some of the courses survive through the employment of part-time lecturers from industry. Polytechnics also face the problem of lack of adequate hardware/software resources.

Relatively few universities offer full graduate courses in computer science. There is tendency to offer composite degrees consisting of computer science and some other subject such as Economics, Accounting, Psychology, Mathematics etc. Postgraduate degrees are compiled to the one discipline. In East and Southern Africa the only universities offering computer studies at degree level are the universities of Nairobi and of Zimbabwe.

On comparing products of computer courses from universities and polytechnics one finds that, generally, polytechnic graduates tend to be preferred by employers. One of the reasons for this is the academic bias of university courses. This is so despite the fact that university graduates end up occupying technician-type positions in any case. Developing countries of Africa offer little employment potential to the academic graduate of technology or engineering studies.

Computer science subjects in particular, or Information Technology courses in general are not included in other disciplines. This means that non-IT graduates leave the University without an increased awareness of the potential of information technology as a tool for development. At this point in time there is little research, if any, in information technology.

10. APPLICATIONS

It is fairly common to find that the application to be computerised first are the labour intensive ones. Therefore Government Computer Centres are usually set up to run Payroll and Government accounts. The range and type of application is growing. Scientific type applications and modelling applications are on the increase. Typical applications include:

(i) Financial and Administrative Systems Payroll, Pensions, Personnel Information systems, Accounts, Fixed Assets Registers, Billing, Debtors and Creditors etc.

(ii) General Management Information Systems Wagon Control, Personal Statistics, Stock Control, Airline Passenger Reservations.

(iii) Planning and Development Model Population Census, Household Surveys, Agricultural Surveys, Industrial Surveys, Trade etc.

(iv) General Office Automation Wordprocessing, automatic telex message routing etc.

In the private sector accounting type applications dominate the industry. Debtors, Creditors etc are common applications both on minis and on micros. There are some manufacturing applications. There are very few decision support and modelling applications. Office automation is starting in earnest in the large urban centres.

A few companies in Zimbabwe and Kenya have produced software packages for export, and are earning foreign currency for their countries.

11. CONSULTANCY SERVICES

There is plenty of scope for consultancy services in all the African countries. This is all the more so in view of the shortage of manpower coupled with rapid growth in computerisation. The consultancy services offered either by multi-national companies such as Deloitees, Price Waterhouse, Arthur Young etc. In addition there is a fair number of level 2 and level 3 people who are coming onto the market and offering individual consultancy services. Consultants are usually used for requirements analysis, drawing up of RFPs, evaluation of tenders. Governments use consultancy services for a variety of jobs ranging from requirements analysis to training. The companies offering consultancy services also double up as software houses in many cases.

12. CONCLUDING REMARKS

Information technology is widely used as a tool in management and administrative tasks in Africa. In using this technology, however, Governments are beset with problems and constraints which require urgent remedy if information technology is to be effective.

Policies need to be formulated to deal with such issues as hardware acquisition, and utilisation maintenance; manpower recruiting and training; information system priorities which are in tune with the Government's own development priorities; centralisation/decentralisation of computing resources; sharing of data between Ministries, etc.

In most African countries, The Government is the trend setter in the use of computers. Therefore it is for the benefit of the country as a whole for the Government to spearhead the effective use of information technology as a tool for development. Lack of an appropriate policy framework to guide the development of information technology can be a serious drawback.

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COMPUTER DIFFUSION IN BLACK AFRICA. A PRELIMINARY ASSESSMENT

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In this paper, we look at computer diffusion in Black Africa from a broad historical perspective. Our interest for this subject stems from the belief that African countries will inevitably be increasingly affected by the new information technologies forged in the industrialized world, and that understanding this process, from its current initial stage, is a prerequisite for avoiding at least some of its undesired effects. First, we present some facts and figures about the timing, the extent and the diversity of computer penetration in sub-Saharan Africa. The aim is to show that the process is more varied than often thought, with differences appearing between Anglophone and Francophone countries. The common and distinguishing factors affecting computerization in these areas are identified. We then highlight three new trends: the redefinition of computer use and computer institutions in the public sector; the increasing role of development-oriented, aid-related computer applications and the emergence of a local computer industry. We finish by pointing to the difficulties in making reliable predictions and the need to improve theoretical understanding.

1. GROWTH AND DIVERSITY OF COMPUTERIZATION IN BLACK AFRICA

The first relevant feature of the computer diffusion process in Africa is its early start, which occurred before 1970 in more than half of all sub-Saharan countries (46 excluding South Africa and Namibia).

Table 1
First acquisition of digital computers in some African countries

1960	ETHIOPIA
1961	RHODESIA (ZIMBABWE), ZAMBIA
1962	IVORY COAST, NIGERIA, KENYA
1963	SIERRA LEONE, GHANA
1964	CONGO, SENEGAL, MALAWI
1965	CAMEROUN, GABON, LIBERIA, MAURITANIA
1966	CENTRAFRICA REP.
1967	MALI, NIGER, MAURITIUS, GUINEA, UGANDA
1968	TANZANIA, ZAIRE
1969	SOMALIA, BOTSWANA
1970-73	SWAZILAND, BURKINA FASO, MOZAMBIQUE
1976	LESOTHO
TOTAL:	29 countries (25 before 1970)

Source: Futuribles 1985, Pascual 1986 and others

Almost all these early computer installations were in the headquarters of some ministry (usually the Ministry of Finance or the Treasury), in the Central Statistical Office, or in some major public utility (railways, Electricity Board).

It was not until the late 1970s that the computerization process gained "momentum", and not until 1983-84 (with microcomputers) that observers started talking of a true informatics

"boom" in many countries.

In 1980, Africa (excluding South Africa) represented 0.3% in number (505 systems) and 0.2% in value of the worldwide stock of general purpose mainframe and mini computers. Considering installations in Developing Countries (DCs) only, Africa's shares were respectively 5.4% and 4.8%. Both indicators show that, in relative terms, Black Africa was, along with the poorest regions of Asia, the least computerized area of the world. During the 1980s, this relative position has changed only slightly, as shown by Africa's-share in exports from the OECD countries (tab.2). Computer import growth rates have nevertheless been high (above the average for all machinery imports), with total purchases increasing, between 1978 and 1986, from 56 millions US$ to 220, in the whole Africa, and from 21 to 107 millions in sub-Saharan Africa only.

Table 2
Composition (%) of OECD computer exports to LDCs

	1981	1982	1983	1984	1985	1986
Asia	32.2	36.7	40.5	52.2	52.1	58.8
Latin America	39.6	33.6	22.0	22.7	24.7	21.1
Middle East	20.9	22.8	31.2	18.4	16.9	13.1
Africa	7.3	7.0	6.4	6.7	6.2	7.0
Total LDCs	100	100	100	100	100	100
Total value (millions USS)	1451	1666	1925	2310	2679	3150

Source: OECD "Trade Statistics", various years

These aggregate figures (1, next page)[1], however, hide wide differences in computer diffusion among African countries. Over the period 1981-86, Nigeria alone counted for 20% of all computer imports in Black Africa. Eight more countries made up another 50% of total purchases: Ivory Coast (11%), Zimbabwe (8%), Cameroon (8%), Gabon (7%), Kenya (5%), Senegal (4.5%), Zaire (3.5%) and Congo (3%). The remaining 30% of the market was thus split among 35 countries, only six of which had average annual imports above the $ 1 m. threshold.

The fact that Ivory Coast, Kenya and Zimbabwe managed to keep constant or moderately rising computer import levels through the economic deterioration of the 1980's, and that Cameroon, Gabon and Senegal have more than doubled theirs in recent years, suggests that computerization is by now an established process in these countries. Elsewhere, sharp import fluctuations seem rather to indicate the opposite.

The cross-country distribution of multinational computer companies' subsidiaries, branch offices, agents, etc. corroborates this view. The six countries above host almost 40% of a sample of 220 such sales installations in Black Africa; Ivory Coast and Zimbabwe leading the group, with 23 and 20 vendors respectively.

Other evidence testifies to the more advanced state of computerization in these countries, for instance: the existence of public data communication networks in Ivory Coast (Sytranpac), Gabon (Gabonpac), Cameroon (Campac) and Zimbabwe (Zimnet); the greater variety and sophistication of computer applications and availability of trained manpower.[2]

Beyond bare figures, what we want to stress here is that, despite early experiences with computers in many countries, only a few, twenty years later, seem to have moved toward relatively high and steadily increasing levels of computer adoption. In particular, several Francophone countries show a distinct predominance in this field, compared to the Anglophone area.

What these differences actually mean is open to discussion and interpretation. High correlation between per-capita income and number of computers, among countries, has lead some authors [19] to relate computerization to the level of economic development (see fig. 1).

While this appears to be a faithful picture of reality, it does not say much about the origins of this situation, and may lead to the false assumptions that economic growth "per-se" will bring higher levels of computerization or that more intense use of computers will lead to faster economic growth.

Although links between these two aspects obviously exist, the nature of cause/effect relationships in such complex processes is far from straightforward and is also likely to change through different stages of socio-economic development [11].

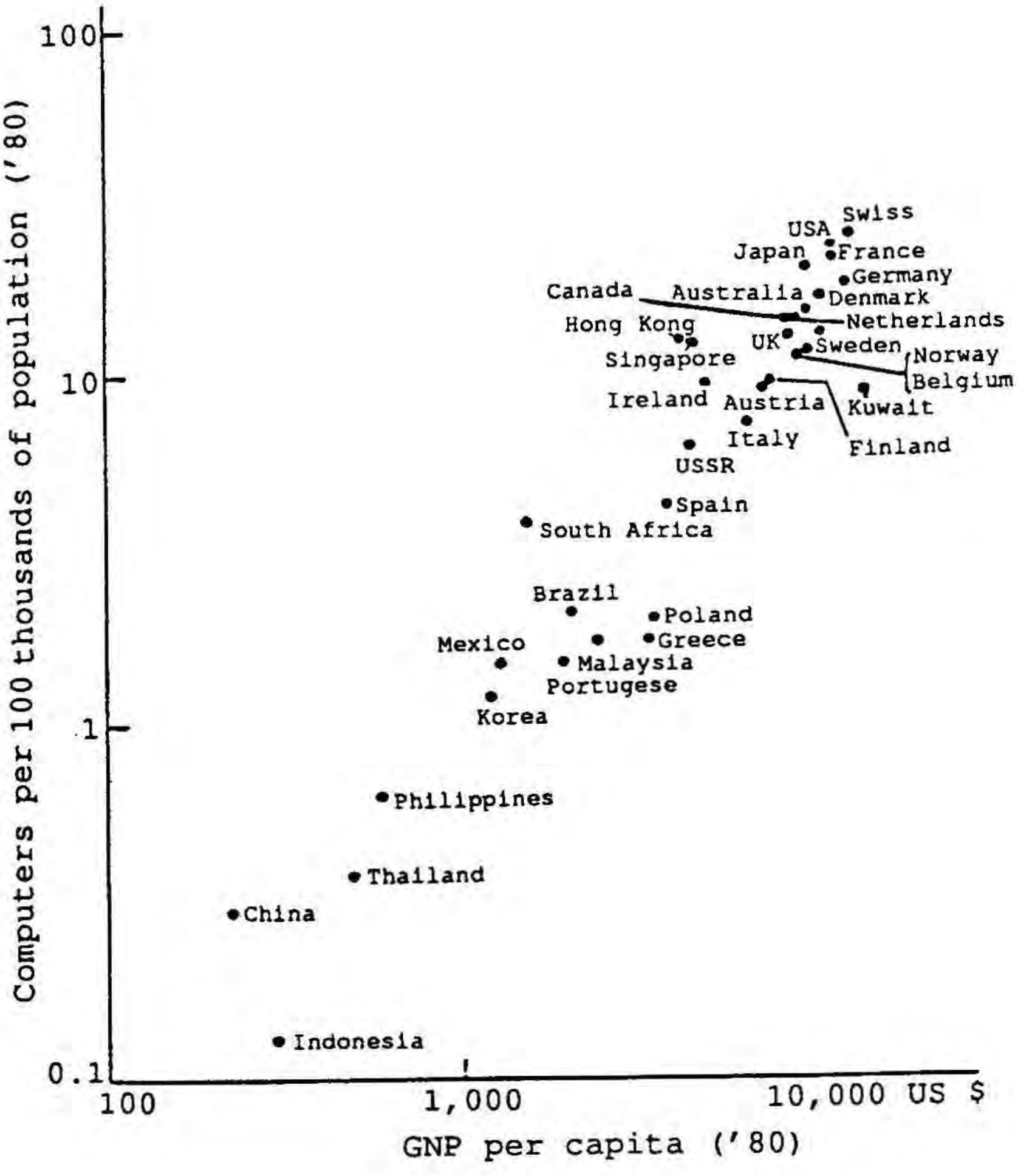


Figure 1 The Relationship between the Number of Computers and GNP

Source: YOKOI et al., 1986

The following short historical review and a first attempt to explain the differences between the French and English-speaking areas show the variety of the factors at work, even at this relatively early stage of computerization.

2. AN HISTORICAL PERSPECTIVE

Limited mechanization (with accounting machines, tabulators, etc.) had already occurred in some African countries even before independence, to serve the needs of the colonial administrations and of the companies involved in production and trade of primary agricultural and mineral commodities.

It was, however, soon after independence, on this limited basis or starting from scratch (the first commercial computers appeared at this time), that computers were acquired in the public administration sector in order to face the sudden lack of adequately trained civil servants needed to run data-intensive procedures in areas like payrolls, treasury accounting, tax and customs revenues management, national census, etc. This motivation has been clearly identified in several former French colonies [8] and was likely present elsewhere [13].

Shortages of skilled clerical and managerial manpower, due to migration of expatriate personnel, also affected large Stateowned enterprises (SOE) and public utilities after independence or following the nationalizations which occurred in many countries during the 1960's-'70s. Again, computerization was introduced to support traditional administrative routine activities (accounting, payrolls, billing, inventories, etc).

Where foreign companies were allowed to work unrestrained, they also quickly installed computers, responding to the need to conform to corporate procedures set by their headquarters on a worldwide basis, and later, with telecommunication development, for strengthening the central control and coordination of international operations.

Foreign companies have thus come to represent a significant share of local computer installations. Besides, the presence of expatriates appointed as managerial and technical support staff, in public and private companies and institutions, has also been reported as an important vehicle of computerization.

The government, the administration and SOE, on one side and local branches of multinational corporations and foreign involvement, on the other, have thus been the pillars of computerization in Black Africa. This faithfully reflects the broader roles that these same actors have played in the economic and political context of African countries: the State, "overwhelmed", as has been noted, by the functions of nation building, planning and implementation for the development process; and foreign corporations and other groups widely, often exclusively, controlling the most relevant sectors of the local economies.

Although these two factors, broadly defined, are common to all African countries, their absolute and relative weight is not uniform. This most probably explains a large part of crosscountry differences in computerization.

However, since no systematic quantitative differences seem to exist between the French and the English areas, in terms of these factors (levels of foreign capital penetration, dimension of the State sector, etc.), a more qualitative analysis is needed including two other explanatory elements: the patterns of international expansion of the computer industry and the policies of local governments affecting computerization.

2.1 Commercial pressure and foreign cooperation

The influence of computer vendors' commercial pressure on African computerization cannot be overstated. Computers were not an offshoot of local technology and industry. Nor was resorting to computers the only or the most at hand solution to tackle the organizational, problems and the skills, managerial problems we identified in the earlier section (and for that

matter, many of the problems for which computers are bought today as well). In fact, the large number of user failures that has marked the African experience [18]. shows how inappropriate this technology was, at least in its early versions, as was the mode of its introduction, for African reality. The pressure of computer vendors-often channelled through international aid-has thus been crucial to start and keep computerization growing.

Despite the small size of the African market, most computer manufacturers are active in it. On a sample of 67 sale establishments for which their creation dates are available, 18% occurred before 1960, 24% between 1961-1979 and almost 60% since 1980.

The initial location and market shares of firms clearly reflect the legacy of colonial rule and the power balance in the computer industry: Bull is strong in Francophone Africa, ICL in East and Southern Africa, IBM dominating to some degree everywhere.

Starting from this initial basis, we suggest that a differentiated evolution took place, with the French computer industry developing a strong "market creation" push on Francophone Africa, without a parallel phenomenon occurring elsewhere.[3]

The nature of French intervention can be briefly summarized in the following three points:

- early and widespread market entry by *IBM France*[4] (between 1935 and 1951, in Algeria, Morocco, Tunisia, Senegal, Ivory Coast, Madagascar and Cameroon), followed, between 1950-60, by Compagnie des Machines Bull in the same countries (except Tunisia). IBM France subsequently expanded and, since the early '80s, reduced its operations according to criteria like: market profitability, political relationships with governments, and changing competitive requirements (for instance, leaving PC dominated markets to independent dealers rather than to its own sales forces). Bull has in contrast increased its presence, especially since the late '70s, under pressure to widen its markets and backed by French cooperation;

- early establishment (since 1964) of a few *computer services firms* addressed to the heart of the newly independent nations, i.e., the public administration sector. These firms actively promoted the creation of the first data processing government centers, controlling their evolution through strong expatriate presence. By harnessing institutional and procedural similarities between the French and several African states, they also were able to spread applications and extend their markets[5]. In the late '70s, when demand took off in many Francophone countries, other companies were quick to enter the market.

Of 56 computer services firms identified in 1984 in nine Franco-phone countries the majority was created after 1979, 35 were owned or controlled by foreigners (mainly French companies and individuals), and only 8 were known to be under local majority or exclusive ownership (State or private capital) [15]; - early and explicit support by the *French government*, who started in 1969 a "cooperation informatique" on a bilateral basis, later extended through strong participation in IBI (Inter-governmental Bureau for Informatics), and "prestige" initiatives, like Centre Mondial pour l'Informatique, promoted by President Mitterand[6].

On one side, this range of actions reflects the strengths and weaknesses of the French computer industry: a hardware sector under permanent competitive pressure, with "national champions" (Bull) receiving strong public support and pushing to expand also on potential markets; and the second software industry in the world, with more than 3000 firms, twelve of which have more than 1000 employees.
On the other side, it also reflects the peculiar emphasis put by the French governments on informatics as a major factor for social change (see the Nora-Minc report "L'informatisation de la societe", 1978) and for reshaping internal and external economic relationships.

Given the strong links that France kept with its former African colonies, it is then hardly surprising to find relatively advanced cases of computerization in this area, characterized by intense, albeit slowly decreasing, direct involvement and control by French expatriates.

In Anglophone Africa, computer vendors' commercial pressure and widespread expatriate

support have also been common features of computerization. However, they do not show the endurance and the apparent coordination (be they the result of explicit planning or simply of functional adaptation among different actors) that we highlighted in the French case.

The reason for this is a matter for further investigation, possibly focussing: on the different legacy of British "indirect rule"; on the origins of computerization at government level; on the relationships developed with African countries after independence; on the different interaction between the government and the computer industry in the UK (also in the sphere of development cooperation); and on the different approach to international expansion by British as well as US computer firms.

2.2 Government policies

The factors identified thus far - foreign capital penetration, commercial pressure by computer vendors and its connection with cooperation policies - give a picture of computerization in Black Africa as driven primarily by external forces.

Some authors[7], however, have also shown how the latter met with the technocratic, modernization or reform strategies pursued by indigenous social/political sectors inside the Developing Countries.

Analyses relating these aspects to computerization in the African context are extremely limited. Still, the information available highlights the existence of different institutional behaviors at the State level. Again, Francophone and Anglophone countries show different records in terms of the extent and nature of government intervention in the computer field.

Until recently, only two countries, Ivory Coast and Congo, had established wide-scope national informatics policies (respectively in 1981 and 1982).

A survey of computer policies and institutions in seven Francophone and five Anglophone countries [15]. revealed that between 1962 and 1982, 24 public organisations were established (56% before 1974): 17 in the Francophone area and 7 elsewhere. Administrative/technical organisations are the overwhelming majority in Francophone countries. Consulting and advisory commissions and committees are the overwhelming majority in Anglophone countries.

The large number and the functions of computer institutions in the French area clearly reflect the cultural and political influence of the "interventionist" approach adopted by the French state to deal with informatics matters in France. The State does not simply use computers for its own needs, but actively promotes their application in the Administration and among the general public. The launch of Tamtel (a local version of Minitel) in Ivory Coast is symptomatic of this. Noticeably, this model has been replicated in countries with both "capitalist" (Ivory Coast) and "socialist" (Congo) political orientations.

The "softer" institutional framing developed in Anglophone countries probably reflects both a more limited (or, possibly more pragmatic?) commitment to computerization by public authorities and the stronger autonomy of the computer sector actors (local computer societies, university-based professionals, vendors) vis-a-vis State control.

The extent to which informatics policies where adopted, or policies affecting computerization[8] have actually been effective and have contributed (beyond the public sector itself) to the different computerization patterns is, obviously, a complex and still largely unexplored issue.

Empirical evidence and theoretical analysis both suggest that national policies do matter, even in contexts characterized by strong dependency and influence by external factors.

The explicit request to establish national and regional computer policies, made by country representatives at the first Conference of the SADCC region on informatics [21], shows that the pressure to establish them, where they have been missing, is also growing.

In order to draw stronger conclusions from past policy experiences or to make suggestions for policies for the future, however, we believe that a much deeper understanding is needed of the nature and the determinants of computer diffusion and use on a country by country basis.

3. NEW TRENDS IN COMPUTERIZATION

The stylized picture drawn in the previous paragraphs is currently undergoing significant changes under the effect of three new trends: 1) the redefinition of computer use and computer institutions in the State sector; 2) the increasing role of development-oriented, aid-related applications; and 3) the emergence of local entrepreneurship in the computer sector.

These three trends are directly or indirectly related to changes in computer technology itself and, particularly, to the advent of microcomputers and related developments in the software scene (advancements in computer/communications integration having still a limited impact in the African context). Technical change is easing the way toward these trends. However, the driving forces behind them, especially in the first two cases, are much broader and largely autonomous political and economic factors.

3.1 The changing role of the State

We mentioned before that the central position attributed to the State in the newly independent African nations has been reflected also in its central role concerning the computerization process.

Since 1979-80, under the pressure of stabilization and structural adjustment programs promoted by the IMF and the World Bank, a growing number of African countries have been going through a far reaching process of "rationalization" of the State sector. This follows three major lines: cuts in government spending (hitting primarily public employment and investments); deregulation of agricultural markets (bans or radical changes in price fixation, of State control on internal and external trade, etc.) and of other service sectors like transport; shut down, restructuring and privatisation of SOE.

This generalized move[9] could have two implications which are also partially requirements for its success. On one side, the incorporation in a smaller range of State activities of stricter planning and evaluating procedures, with emphasis put on financial viability and efficient use of resources, in general. On the other, greater vitality and expansion of the private sector (indigenous and foreign capital), which, freed from excessive constraints, should begin to modernize under the pressure of increased competition.

Leaving aside any comment on the validity of these solutions for the African problems or on the likelihood that their intended effects will take place [7], it is no surprise to see computers called rapidly on stage in support of these goals[10].

The lack of data doesn't provide proof, yet we suggest that a large part of the increase in computer purchases registered, since the early '80s, despite the worsening of economic conditions, can be ascribed to these processes.

The desire to improve efficiency in an increasingly difficult economic environment is unanimously identified as the major push to acquire computers in the private sector [21]. And the promise of computerization seems to work, as shown by the fact that 50% of the PCs censed in six countries in 1984, were in medium and small enterprises (Afrique Industrie, 1987).

In the State sector a shift has started from high centralization of hardware, human resources and applications to a more decentralized situation[11]. Mini and especially microcomputers - increasingly donated or brought in by aid projects - are spreading in various government departments and first experiences with network applications are taking place.

Also, an attempt is being made to extend applications from traditional data processing (automation of manual, rule-based procedures), to information systems, incorporating databases and techniques for problem solving, controlling, optimizing, predicting, planning, etc. The introduction of such "administrative/managerial" rationality to modernize bureaucracies, however, is a complex task whose requirements and implications largely transcend the technical issues on which attention is usually focussed [1].

In general, until now, only a few studies have explicitly related experiences of computer adoption to the broader process of administration reform in African countries[12]. Neither has any assessment been made of whether computers play a role, if at all, in the reorganization of SOE and services. If our conjectures are correct, however, the needs and conflicts disclosed by these processes and their progression should be given a central position in any empirical and theoretical investigation concerning computerization in Black Africa.

3.2 The increasing role of foreign aid

Involvement of international organizations and aid agencies in the computerization process is unique to Developing Countries and is increasingly relevant for Africa, in recent years[13].

According to some observers (African Business, Oct. 1985), almost half of the African computer market is currently comprised of somebody's foreign aid. In the poorest countries, where foreign investment is limited and local purchasing power is low, this share is probably even higher.

Two major factors can explain this situation. On one side, the economic crisis of the 1980's has increased the overall dependence of African countries, and especially governments, on confessional loans and grants. These are also increasingly associated with programs and projects involving the active participation of donor institutions and experts. On the other side, development agencies and Non Governmental Organisations (NGOs) from the Industrialized Countries have started making intensive use of microcomputers at the institutional and project level, thus- spreading these tools (often left after project completion), together with some kinds of skills, gained through simple practice and/or training.

The implications of this strong and increasing external influence on the computerization process are varied and still difficult to assess. We can, however, make a few observations.

Albeit officially non-profit motivated, bilateral aid being largely "tied", is in fact a well known channel for market penetration by commercial companies. Many computerization projects are thus started because the money is available or, because computers are donated by companies eager to gain a foothold in strategic sectors. New entrants in the market (like many microcomputer firms in recent years), also see the development agencies working in Africa as the initial market, providing a testing ground and a vehicle for long-term product recognition.

In principle, this "filter" role could be turned to the advantage of the recipient country. At the micro level, it is partially happening that aid professionals and organizations in many cases are learning how to best use, test and adapt this technology for their own purposes. To the extent that this learning process is socialized in the development community and in recipient organizations, it is certainly beneficial.

At the macro level, however, most bilateral initiatives are scarcely related and coordinated to an explicit informatics cooperation policy or to the recipient country's broader needs in the computer field.

Among multilateral agencies, a few (UNIDO, UN University, World Bank) have only recently begun to "recognize IT as an important sector in itself, and to subject it to integrated rather than piecemeal analysis and planning" [17].
Among the implications here are well-known negative effects on the cost and quality of maintenance, training, communication of data and applications, etc.

The establishment of national informatics policies capable of channelling foreign support to local needs would obviously contribute to improve this situation (yet, only Zimbabwe has an official body overviewing aid-related computer acquisitions).

Beyond the implications for the transfer of computer technology, foreign aid also affects its applications. Since a large portion of aid in Africa is spent on "basic needs" problems, computers end up being used here, at times, for relatively unexplored tasks like famine relief programs in Ethiopia, elementary education (experiments with LOGO in Senegal and Kenya), primary health care (experiments with expert systems for health workers in Chad and Mali). These are obviously still very limited experiences which touch, however, on very critical issues. Once extended on a larger scale, they could have unwanted (as well as positive) effects, which are hard to predict today. This then is another area to which both research and policy making should pay attention in the near future.

3.3 Local entrepreneurship in the computer sector

Among the trends we have been examining, this is certainly the weakest one. Heavy dependence on foreign skills, technologies and products will undoubtedly continue to characterize, for some time to come, the evolution of the computer sector in most, if not all, African countries [14,17]. Since the advent of microcomputers, however, one can track in many African countries the birth of small companies, started by individuals or existing firms (often with the contribution of foreign capital). These usually start as dealers or distributors for foreign computer firms. On this basis, more sophisticated activities are beginning to emerge: from consultancy and software services, to hardware maintenance, and a few cases of hardware production.

Foreign exchange constraints and import duties are certainly crucial for these local suppliers, who also take advantage of close knowledge of customers, of national habits and regulations, and of the few valid computer professional available on site.

Most efforts are currently concentrated in the consultancy and computer services business: consultancy, custom software development and maintenance; computer bureau services; training on system and application software. To varying degrees, all these kinds of activities are carried out in most African countries. A few cases are also reported of application software packages developed by African companies (in Zimbabwe, Cameroon and Ivory Coast) for the local market and/or sold abroad.

Unfortunately, no figures are available to measure the extent and growth of this sector in African countries. Besides, qualitative aspects are absolutely crucial in this field. According to most sources, however, local service capabilities are qualitatively inadequate and quantitatively insufficient to support the ever increasing growth of hardware and applications.

Formal training, and especially, on-the-job experience (which necessarily takes time) will be crucial to overcome these deficiencies. Some technology trends may also prove important: fourth generation languages and software tools used on standard micros, make it easier to concentrate on *applications*, where local expertise counts and enjoys a comparative advantage, rather than on the intricacies and time consuming tasks of coding.

Whether African countries are already taking advantage of these opportunities, or will do so in the future, is again matter for investigation and for policy making.
New computer technology, such as the "open architecture" of machines like PC clones and cheap labour, are already making some inroads possible also on the hardware side. Experiences in this field are reported in Morocco, Nigeria, Kenya, Zimbabwe and Botswana [14].

It is too early to judge the impact and the long term prospects of these initiatives. At least in some countries, they suggest that computerization is starting to be rooted in local capital, skills and, potentially, technology. However, a factor that should not be understated here in prospective assessments is the racial/minority issue. The Indian community in East and

Southern Africa, the white minority in Zimbabwe and South Africans in the SADCC region, expatriates communities in Western and Central Africa, tend to be at the center of the local computer industry development. Its future and its true "indigenisation" will thus largely depend on the evolution of the broader political and economic relationships between these groups, the governments and the rest of the black population.

4. CONCLUSIONS

The well-known situation of African economies and societies is currently one of deep crisis, with little hope for its quick and successful resolution. Within this crisis several changes are taking place, resulting both from the involution of existing structures and behaviors and from constructive attempts to build up new ones.

Since the deployment of new information technologies occurring at worldwide level, seems to be replicated in accelerating the diffusion in the African context at this stage, we suggest that some links exist between these two phenomena. We have started to investigate these phenomena. From the evidence we have gathered, it is still hard to predict the future.

On one side, one can picture computerization supporting more flexible, selective and decentralized State actions, an improved functioning of agricultural production (credit distribution to small-holders, extension services, etc.), and a more efficient use of resources (particularly capital, energy and intermediate inputs) by manufacturing units. From this perspective, once supported by adequate policies, foreign aid could be used to diffuse appropriate technologies and applications, and to act as a link between users, producers, and researchers both inside and outside developing countries. The spread of computer applications should also open market niches at national and regional level for local computer companies, supported by appropriate policies on training, technology transfer, market protection, etc.

But an opposite evolutionary process may also occur. Computers could be used to tighten social and political control by the central government and to reinforce hierarchical organization structures. The competitive advantage gained through the sophisticated use of information technologies by foreign corporations could offset any benefit that would accrue through increased computerization to local companies. Foreign aid would become even more an outlet for the overcapacity output of the international computer industry. This could wipe out, through technological superiority and lower costs, any attempt to start local hardware production. Largely imitative application patterns would also favour imported (standard) software products, hindering the growth of a local computer service sector.

The actual evolution, in fact, will likely borrow from both scenarios and will certainly differ among countries. The current state of our empirical and theoretical knowledge unfortunately does not allow more reliable predictions.

From a theoretical perspective, the most extensive conceptualization of the processes we have considered here is one recently put forward by R.L. Katz [11]. According to his three-stage historical model, in "the first stage of state-building, information technologies are mainly used by the state apparatus. Thus the political variable (and the networks of international influence) has more weight than the economic variable in determining their diffusion. In the second phase, which we might call 'infrastructure building for economic development'.. communications development is driven by economic needs, mediated by the political system.. In the third phase - that of 'maturity' - .. as a result of the industrialization process, the manufacturing and service sectors become the main contributors to the expansion of information and communication systems. In this phase, the economic variable is the one that has more weight.. (Also) the private sector tends to develop a conflictive relationship with the regulatory structures of the state and.. technological developments.. limit the government's capability to enforce the control of diffusion of technologies" [11].

Being a historical model, this scheme cannot necessarily be expected to be generalized for the current condition of African countries. Methodologically, we believe that it does point to the

most relevant explanatory variables. How these influence one another and the underlying assumptions on agents' behavior need, however, to be reviewed.

First, Katz himself stresses that "while industrialized countries have followed the three stages in a more or less linear fashion, developing countries tend to face the challenges of statebuilding and economic development simultaneously" (p.65). The interaction between economic and political variables is thus more complicated.

Second, a radical change in the nature, cost and usability of IT is also occurring at this stage. The role that information and new IT play in processes like state-building and the creation of industrial activities can then be expected to be different from the past.

Because of their intrinsic properties, new IT is not a neutral and more efficient way to achieve abstractly defined ends (better decision making, management, etc.). In fact, at the deepest level "informatization itself (e.g. formalization, mediatization, quantification and finalization of human communication) is the essential expression of social change" [3]. Investigating the latter, its determinants, features and implications, is bound to improve our understanding of IT diffusion in LDCs much more than measuring the information workforce growth or the information intensity of various economic and social activities.

Third, dependency and neocolonialist relationships which dominate African societies (a specific type of "international influence"), should also be fully included in the framework within which computerization is analyzed.

These last remarks indicate that it is precisely the interaction between endogenous and exogenous forces that future research should look at. Also, that the impact of information technologies (for instance, centralising/decentralising effects) should not be assessed separately from the broader political and economic trends in which their diffusion takes place.

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ENDNOTES

1.
The use we make here of OECD trade data to measure crosscountry trends in computers diffusion should be seen as a tentative exercise, yet the only feasible one at the moment. Only computer hardware expenses are recorded. Smuggled computers (a very important aspect with micro-computers) are obviously out of the picture. Trade with South Africa, which is notoriously relevant in the SADCC region, is also neglected. Besides, some countries play a trade center role at sub-regional level, thus distorting the actual distribution of final export destination.

2.
Recent, reliable and comparable data on these last aspects are not available. Various information sources (country reports, journals, etc.) confirm however this general statement.

3.
A similar pattern has been identified by Katz (1988), concerning the diffusion of television broadcasting and receivers in former French and English African colonies.

4.
IBM France was created before the First World War and was therefore directly involved in French colonies in Africa, where it kept marketing/assistance responsibility after independence. IBM UK was created only in 1950 and marketing responsibility for Anglophone Africa has been primarily in the hands of IBM Europe-Middle East-Africa.

5.
"The French firm SINORG was, since 1964, the main contractor in the installation of Office Central de Mecanographie (OCI) in Ivory Coast, assigned with controlling the execution of the State Budget. The initial system was then extended, functionally, to cover a growing range of applications in the Administration and, geographically, in about 20 countries in Africa and the Middle East" (in Zimmermann 1984, p. 80).

6.
IBI, created in 1974 out of the restructuring of UNESCO´s International Computing Center (Rome), was the only multilateral organization specifically devoted to promote informatics policies and technology transfer in LDC´s. Its members were primarily Latin American and Francophone African countries, with France and Italy contributing to the bulk of its budget. France´s withdrawal in 1986 lead to IBI´s crisis and suspension of activities in 1988. The Centre Mondial was started in 1981 as a research institute for studying appropriate computer applications for LDC´s. Its activities have also been radically cut back since the mid-1980´s. In both cases, the French governments´s behavior has been related to the will to keep a tighter control on its informatics cooperation, in order to maximize the benefits accruing to the French computer industry.

7.
See Mattelart and Schmucler (1983) for the Latin American experience. Pascual (1986) has applied a similar framework of analysis to the case of Ivory Coast.

8.
Policies directly affecting computerization are: regulations on computer imports (duties), on the installation and maintenance of public computer purchases, etc. More basically, one should consider also policies on training/education, telecommunications, foreign investments, etc.

9.
More than 50% of all sub-Saharan countries have been involved by stabilisation/structural adjustment programs since 1980.

10.
Even the World Bank, in the "World Development Report 1988", cites explicitly computerization (p.101) as a mean to improve public administration practices.

11.
The analysis (Pascual, 1986) of 270 software and consultancy contracts carried out for public sector institutions, between 1965 and 1982, by a leading French company shows that:
a) 1978-79 is indeed a turning point in computerization, with a high increase of annual contracts signed since then;
b) after 1980, computerization expands rapidly beyond traditional customers (financial ministries and banks), to a wider range of sectors and below-national level institutions.

12.
See Garriot (1985) and Broadman (1985) on Kenya; Babington (1987) on Ghana and Calhoun et al. (1986) on Soudan.

13.
On the history of informatics cooperation, see Conqui BeerGabel (1984) and Schware and Choudhry (1988).

14.
In *Morocco*, Societe Internationale d'Industrie et d'Ingegnerie (3-I) was created in late 1984, as a joint-venture among ODI (the Moroccan Office for Industrial Development), Imeg (the major computer services company in the country started in 1973 by former IBM personnel) and Symag (a French micro-computer firm, partly owned by Control Data). "3 I" started assembling micros named "Atlas", having as first customers the Moroccan universities and the Ministry of Education.

In *Nigeria*, Anambra State University of Technology developed in 1984-85, and later started t assemble, the ASUTECH series of micros for use, initially, by the Anambra State Government.
In *Kenya*, Kenya Microcomputers Ltd. started in 1987 to produce the Neptune PC, a super-turbo 16-bit XT compatible micro, also in a lap-top version. Hopes for a full take-off o KML are placed in the Government's plan to launch a major program for computer education i schools in the next two years.
In *Zimbabwe*, Communications Systems of Zimbabwe (CSZ) has been recently created, as a joint-venture between Plessey (already producing military electronics equipment) and the parastatal Industrial Development Corporation. CSZ plans to produce two 16bit models and one 32-bit model (all compatible with the IBM AT and XT range) for the local and regional market.
In *Botswana*, Tek (Pty) Ltd., official distributors for Microsoft in the SADCC Region, have since 1988 started the production of the Tek PC88, an IBM compatible PC, which was improved for resistance to dust, high temperature, etc. Another company, Computer Professional & Associates, has also recently started production for the local and regional markets of the Freetron PC, a full IBM compatible 640 K RAM micro.

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INFORMATION TECHNOLOGY IN KENYA AND INDONESIA: A COMPARATIVE ANALYSIS

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The growth of Information Technology use in a country is said to depend on a number of factors like policies, manpower, and economic infrastructure. But it is difficult to say which aspects play the most important role in the growth. This paper looks at Information Technology in Kenya and compares it with developments of the industry in Indonesia. The factors which help or hinder the growth of computerization are analysed.

1. INTRODUCTION

Despite the differences between Kenya and Indonesia in their social, cultural, economic, demographic, and many other aspects, they can be considered to be in the same category when developing countries are classified into different groups according to the development of information technology. This paper examines the development of the IT industry in Kenya and relates it to the growth in Indonesia. Certain hindrances to the development of an industry like foreign exchange, trained manpower, telecommunications infrastructure, suppliers and 'favorable' IT policies are available in Indonesia and yet they don't seem to have affected the growth of the industry that much.

Kenya is trying to cope with computerisation since the early 1960's and by doing such a comparison with Indonesia, which is at a similar stage in it's IT development, we can learn what steps Indonesia took to establish its industry. The main aim of this study is to compare and contrast the two countries and see what aspects affect the growth of an industry, although it is difficult to pin-point specific areas, as it is usually a combination of many factors. In this paper, I have used the term computer in the narrow sense often to mean uses of Information Technology or Informatics.

The second section of the paper brings into consideration the political and economic histories of each country to help understand certain aspects which may have affected the growth. The third section briefly looks at the computer industry in each country, where the history of the industry, the types of computers used, the users, etc., are considered, as well as the environment or infrastructure in each country, ie. IT policies, telecommunications, education, and training facilities available. Section four describes some of the issues which may have hindered or helped the growth of the industry. The paper then goes on to analyse some of these issues.

2. THE POLITICAL AND ECONOMIC HISTORIES

Kenya was a British colony which obtained its independence in 1963. Jomo Kenyatta ruled the country as President till 1978 when he was succeeded by Daniel Arap Moi who has ruled ever since. The population of 22 million is made up of many different tribes and is eighty percent rural. The large population is draining resources and eroding standards of living coupled with urban drift and serious unemployment. Kenya was until recently considered to be one of the most stable countries in subsaharan Africa. The government has been consistently pro-western.

Kenya's economy has been based on free enterprise and a competitive market. From the time of independence, Jomo Kenyatta encouraged commitment to a capitalist society. Private

industry has always done very well in the country. The country mainly depends the on the agricultural sector for its contribution towards the GDP - 30%, and the export earnings from tea and coffee (40 % from coffee). Therefore, the economy and the availability of foreign exchange depend a lot on the weather. Droughts in 1982/3 drastically affected the country's economy. The total GDP and GDP per capita have been on decline due to world recession, drought, rising population, etc. since the late 1970's. The total GDP was US$ 5,825 million and GDP per capita - US$ 310 in 1983. The shilling is a stable currency and Kenya has never suffered high inflation. However, the balance of trade has been negative in Kenya since its independence, the main import being oil for which Kenya spends 90% of its foreign exchange. At the end of 1985, Kenya had a debt of US $4.2bn which was approximately 76% of the GDP.

Indonesia is an archipelago with 13,677 islands and a population of 164 million. It was a Dutch colony until 1949 when it won its independence. The country has been politically stable under General Suharto for the past two decades. Luck, in the form of unexpectedly increased oil revenues (up to 80% of its export earnings are from oil and oil products), has helped Indonesia build up its economic infrastructure more rapidly then predicted, though the recent fall in the oil prices has affected the country drastically. This has made the country nearly self-sufficient in capital formation. Indonesia's economic development has followed a sequence that leads from oil export earnings, to government revenues, to public savings, and to public investment in development projects. Foreign investment, mainly from Japan, has also played a crucial role in Indonesia. One of the regime's greatest accomplishments has been the development of a national body of educated people which had been scarce only for the last few years.

The percentage contribution of agriculture to Gross Domestic Product(GDP) is as high as 25% followed by mining at 20%. The total GDP and GDP per capita have been on a decline since 1982 due to world recession, fall in oil prices, etc. The total GDP was US$ 78,344 million and GDP per capita US$ 502 in 1983 [1]. Indonesia has managed a positive balance of trade since the 1950's and its economy (like its neighbors) is closely linked to that of the developed world. As a result of this, the recent recession in the developed world has seriously affected its economy.

It can be seen from the above that Indonesia is at an advantage compared to Kenya both financially and politically. Kenya is still too dependent on its ex-colonizers, both for financial aid and for the technology transfer. British people plays an active role in the government and the policy making and has invested US$600 million into the Kenyan industry. Kenya's trading capability has always been negative and therefore the scarce foreign exchange has to be spent on more important things like importing oil, agricultural products, machinery, etc., whereas Indonesia's have been positive and therefore it has the foreign exchange to import the latest technology. There is also a big difference in other economic indicators between the two countries like the GDP per capita being US$ 502 for Indonesia in 1983 and US $310 for Kenya in 1983. Indonesia exports oil which brings in more revenue than the coffee and tea Kenya exports. There are also other factors like the socio-economic development in a country which are known to affect the growth of an industry in a country, although it is difficult to say what role they have played in Indonesia and Kenya. Some of the variables which can be taken as indicators of national development, are closely comparable: literacy rate (Indonesia - 75%, Kenya - 60%); Life expectancy at birth (55 years in both countries); infant mortality rate (80 per 1000 in both); enrolment rate in primary schools (Indonesia - 79%, Kenya - 69%); etc. The only big differences between the two countries are in the literacy rates and school enrolment, which can partly be the reason for the slow "diffusion" of computer literacy in Kenya. However, more research needs to be done to understand the consequences of such indicators on the growth of the industry.

Indonesia's economy depends to a large extent on the foreign investment in the country, more recently in the electronics industry for the export market. Apart from the economic benefits, technology is transferred by these corporations. Kenya has around 200 multinational corporations operating in the country. These cater mostly for the domestic market and are not export oriented. The technology transferred through these organisations is limited.

3. THE COMPUTER INDUSTRY

3.1. Kenya History and Growth

In Kenya, the first data processing activities began in early 1953 when the first punch card tabulators were introduced in the Kenya Government and Kenya Railways and Harbors, formerly East African Railways and Harbors. These ICT (now ICL) machines were replaced by ICT's first generation computing machines in 1962. An ICT 1500 machine was also installed at the Kenya Power and Lighting Company in 1964. The uses were confined to payroll, accounts, billing, etc., like anywhere else. Shell and BP installed an IBM 1401 each in 1964 and the Central Bureau of Statistics bought two computers - an IBM 370/135 and 370/138, in the same year. In 1966, the third generation computers reached Kenya with the installation of an ICL 1902 at East African Posts and Telecommunications, and an IBM 360/20 at East African Airways. By 1971, there were 21 computers (mainframe and minis) in the country and this figure rose to 127 in 1981 [23].

By 1987 there were over 300 mainframes and over 2,000 microcomputers in the country. Predictions are that by 1990 there will be around 1,024 mainframes [9] in the country if the present rate of growth continues. But this is an optimistic view as microcomputers are used in most of the new installations and shortage is likely to become a problem.

The suppliers - Most of the main suppliers and manufacturers of hardware are represented in Kenya including ICL (the most dominant), IBM, NCR, Amstrad, Wang, CR7, Apple, Burroughs, Fujitsu, Olivetti, Unisys, Neptune, Apricot, Commodore, Sinclair, Televideo, etc. Kenya has recently started assembling microcomputers (Neptune Turbo - IBM compatible) locally with imported components which are selling for as little as 50% of the competitors' prices. Comprite CR7 multiuser mainframes are also assembled in Kenya. There are about seven software houses, 9 companies offering data processing bureau services and 6 word-processing services.

The users - The percentage incidence of computer use around 1982 were as follows - banking/finance 12.94%, energy 9.41%, insurance 2.35%, central government 3.53%, computer bureau 5.88%, distribution/marketing 7.06%, engineering consultants 3.53%, transport/communications 7.06%, education 2.35%, research 2.35%, manufacturing 28.24%, service industry 4.71%, national food board 3.53%, and others 7.06% [4]. Most of these organisations use the computers for general applications like payroll, accounts, personnel details and for statistical reports. The only on-line systems are at Kenya Railways, Kenya Railways, National Bank of Kenya, University of Nairobi, and the meteorological department.

IT Policy - Kenya has no explicit IT policy or guidelines for computerisation or procurement, but there is an import duty plus sales tax of 115% on all information processing equipment imported which renders the local purchase price in Kenya at least 2.5 times the actual price abroad. The ongoing maintenance charge is tied to between 10-20% of the local purchase price making the running costs of such equipment prohibitively expensive for all concerned. In general, however, there is a lack of awareness and hence co-ordination at government level in information technology.

Telecommunications infrastructure - There are no computer communications networks in the public sector. Many organisations have showed interest in computer networks like the Kenya Commercial Bank and Kenya Power and Telecommunication Corporation is working on proposals. It is also hoping to move to digital technology in the near future. In consonance with government aims for District Focus for Rural Development, the K.P.T.C. is implementing an ambitious rural telecommunications program which will extend automatic telephone service to the smallest administration centre by the end of the plan to period in 1993. The central government including parastatal organisations, utilize about 30% of telecommunications services. The services therefore provide a major vehicle for government operations. In the latest year available, the number of telephones in Kenya were 13 per 1,000 inhabitants.

Education and Training facilities - The University of Nairobi has been offering a post graduate diploma course in computer science since 1981. Two computer science units are also taught in the Faculty of Science undergraduate program. Kenya Polytechnic offers an Ordinary National Diploma and a Certificate in computer science. Apart from these institutes, Kenyatta University, Moi University, Egerton College, Kenya Technical College, and Mombasa Polytechnic all offer technology based courses.

ICL Kenya Ltd, NCR Computer Science Institute and Computerland Engineering offer IT training for IT professionals and end-user. Private IT training institutes include City College, Graffins College and Associated Computer Services. In 1980, 80% of the training for computer personnel was carried out in the country. The other 20% were sent abroad for courses, mostly on British Council grants for post-graduate courses. There are a few schools in the country both private and public which use computers.

3.2. Indonesia History and Growth

- The history of computerisation in Indonesia dates back to 1938 when the National Railways (PJKA) [10] installed the first IBM punch card data processing machines. The army and oil industries followed with similar installations. Like anywhere else, the machines were used for accounting, payroll and other administrative oriented applications.

It wasn't until the early 1960's that three new second generation electronic computers were installed. These were IBM 1401 computers at STANVAC refinery complex in 1962 and at the Army Personnel department in 1964; and a Univac 1050 at the Central Bureau of Statistics in 1964. In the late 1960's and early seventies, third generation computers were installed at the police head-quarters and the Jakarta Municipal Council. Both were IBM S/360 computers. The first two scientific/engineering computers - IBM 1130's, were installed at the Public Water Works and at the Pertamina Oil company for engineering calculations. The state Electricity Company (PLN) installed a small computer - an IBM S/3 for customer billing and logistic applications.

In 1973, an IBM S/6370 was installed at the Bank Bumi Daya and many other similar installations mainly in the oil and banking industries followed. The applications continued to be confined to billing, personnel accounts, accounting, statistics, revenue calculations, etc. Processing was mostly done in a batch due to the low demand for results. The first two government organisations to acquire computers were the Ministry of Defence and Ministry of Finance, who acquired Univac 1106 machines around 1976. In 1977, there were 73 computers in the country, 55 of which were in the government.

The growth accelerated in the late 1970's and by 1980, and it was estimated that there were around 400 computers (both mainframes and minicomputers) in the country [20]. This figure accounts for both private and public sector installations. The uses of the computers increased from simple tasks (payroll, accounts, etc.) to sophisticated applications.

The number of enterprises with computer installations in 1983 was 324 with a total of 721 computers [2]. The computer installations vary in size, ranging from installations with only one microcomputer to installations with more than one mainframe, mini- or microcomputer combination. In 1986, there were 349 installations [3] with computers with roughly 800 computers (mainframes, mini and microcomputer). Minicomputers have been successful in the country due to their low price. Somehow, microcomputers have not been as much in demand as would be expected compared with developing countries. The annual rate of increase of computers has showed a declining trend from 107% in 1980 to 21% in 1983 [20].

The suppliers - Most of the well-known computer manufacturers and suppliers including Apple, NCR, ICL, Radio Shack, Commodore, Fujitsu, Burroughs, IBM, DEC, Data General, Wang, and Hewlett Packard are represented in the country. IBM was the first to enter the computer market in Indonesia and has been dominant ever since. Apart from introducing the computers, it has guided its customers into successful use of their computers. IBM was followed by Wang who were pioneers in small computers. The number of vendors (suppliers,

data preparation centres, software houses, bureau, recruitment centres, etc.) were also high in the country - 235 in 1983 [20]. But this figure fluctuates rapidly because of companies going bankrupt at a very high rate.

The users - The private industry is the main user of computers in Indonesia. The percentage of the public and private users in 1983 was - private - 73% and public 27%. The percentage distribution of computer installations by major industry around 1982 was as follows - agriculture 2%, mining 2%, manufacturing 15%, electricity and water 2%, construction 3%, hotels 21%, transport/communications 5%, finance/insurance 22%, communications and social services 23%, others 6%.

The number of computer installation by type of use around 1983 were - routine office data processing 239, business data analysis 53, research 71, customer service 63, industrial process control 63, training 34, communications 3, data bases 38, design (CAD) 17, and other uses 3 [20].

IT Policies - Indonesia has taken some initial step towards a computerisation policy but has not yet worked out specific national objectives and national plans. A government committee called Bokatan which was formed in the late 1960s, has been responsible for the co-ordination of computer use in the public sector. Recently, the government decided to centralise procurement of computer hardware and services. The government policy is to plan procurement in such ways as to encourage the growth of the local computer industry and business. There is also a government move to create a national computer board for policy making and planning of information systems [20].

Telecommunications infrastructure - Indonesia has one of the most advanced telecommunications system in the whole world based on digital technology. In 1978, Indonesia took a bold step in establishing a satellite based telecommunications structure. The Indonesian domestic satellite communications system, PALAPA, has proved to be very effective in providing telecommunications services to the extracting industries in remote areas, to the government's administrative and defence communications networks, and to a national television program for rural development. The satellite system also plays a crucial role in binding culturally the geographically dispersed people of Indonesia. There are only 4 telephones per 1000 people.

Training and Education facilities - The first degree program in computer science was started in 1978 by Bandung Institute of Technology Polytechnic (ITB). In 1982, ITB started offering an undergraduate degree course. The University of Indonesia and Brawijaga University both now offer a degree course in computer science. There are also many other private computer training collages in the country. Most of the computer vendors offer in-house training courses. In 1984, only one in 100,000 primary schools in the country owned a computer and offered computer education.

Computer associations - Indonesian Computer Users Association (IPKIN) is one of the associations in the country. It is more like a computer society than a computer users association carrying out surveys, organising conferences/seminars, publishing monthly journals, etc. Indonesia is also a member of SEARCC South East Asian Regional Computer Conference.

4 . ISSUES

When we compare both computerization in the two countries, we can see some of the issues that may have slowed down the growth in Kenya. Some of these issues are examined below.

1. Computerisation in Indonesia started more than a decade before it begun in Kenya. It seems that the earlier introduction of computers in Indonesia has helped build up the computerization by making users (or potential users) more aware of the technology and spreading computer literacy.

2. In both countries computers were introduced in the railways by their colonisers. The computers were used by organisations as a solution to processing of high volume of data and to produce statistical reports. In Indonesia, it was the oil refineries and the banks which realised the benefits of computers in the early days, whereas in Kenya it was the parastatals. It was not until the mid-1970's when the government ministries (Finance and Defense) were computerised in Indonesia whereas in Kenya the government had been using computers long before than.

The percentage distribution of computer installations by major industry are different in the two countries. In Indonesia, approximately 23% exist in the communications and social services followed by 22% in banking and insurance [20] whereas in Kenya, 28.2% are to be found in the manufacturing [4] sector. This does not mean that Kenya is more advanced in the manufacturing industry, but that the two countries have seen the applications of technology differently. The Indonesian government is using the computers towards the national and social development of the country by computerising areas such as social services including health, education, housing, police and military. The Kenyan government lacks the finances to computerise such services and it is mostly the private sector like manufacturing, who are making the most use of computers. Private users account for 60 to 70% in Kenya and the figure for Indonesia is around 73%. The computers are mostly used for applications like payroll, accounts, personnel details, billing, and more recently for production control. The public sector (government departments, parastatals, etc) are still lagging behind in making use of the latest technology mainly due to lack of finance, but those that are making use of it, usually use big machines.

3. The mainframe/minicomputer markets are dominated in both countries by suppliers. IBM is dominant in Indonesia whilst in Kenya, ICL is the leader. The reasons for these being for Kenya, the colonial link with ICL and the British influence the country still has, and in Indonesia, the domination of IBM is related to keeping away Japanese competitors. This affects the growth of the industry to a certain level depending on the companies policies, like types of machines they are willing to market, and the availability of the machines. Suppliers also have the tendency to manipulate or bias the users towards their products. Managers familiar with a particular brand will generally prefer to purchase that type of equipment. This is partly the case for IBM, NEC, Apple and other vendors who have donated substantial amounts of hardware, software and services to computer education programs both countries.

4. It is difficult and mis-leading to compare two countries accordings to the number of computers each country has. Firstly, the size (memory) of the machines vary and secondly, the utilization of the machines is different. For example, only a few of the computers in the public sector in Kenya are working to full capacity. Furtherware, each country has different computing needs and capability. Kenya is a major user of microcomputers compared to Indonesia, because they are much cheaper and are sufficient for the applications they are used for, whereas in Indonesia, it is the mini computers which make up a large proportion of the total number of machines.

5. The education and training facilities make some difference to the growth of computerization. Both countries complain of not having enough computer personnel, though the figures for the vacancies for staff in Indonesia are not known, where as those of Kenya are very high. Indonesia in theory should not have a problem with its universities offering degree courses for the past decade. Many Indonesians have been trained abroad. There is also the availability of many training centres though in proportion to the population, their may not be enough. Kenya lacks many of these facilities and new courses are urgently required at the institutes. For example, from the post graduate diploma course, only about 12 students (of which some are from neighboring countries) [6] graduate each year. This figure is very low compared to the rate at which computerisation is taking place. At present, the government trains personnel and provides the private sector with finished products. The private sector's contribution to manpower development in Kenya is very little. This happens due to the large differential in the level of renumeration between the government and the private sector. Apart from these, there are many training centres being set up every day, mostly managed by those from the ethnic minority and attended by a few individuals who can afford to pay for example, £170 for a 10

hour Lotus-123 course. Many use big names like Association of Computer Professionals (London) qualifications to attract students. The relevance of this needs to be very carefully examined.

6. Kenya does not have a computer society or an association whereas Indonesia has IPKIN and Bokatan, and it is also a member of SEARCC. This can help the growth of the industry to a certain extent. Through activities like conferences, seminars, etc. the computer users manage to play an equally important role in the present state and the future of computerisation. This helps change the role of the users from a passive recipient of computer technology to active partner in the transfer of computer technology and implemented thereof. Such associations would help spread computer literacy and advice governments (as IPKIN and Bokatan do) and other private users with regard to buying computers.

7. The telecommunications infrastructure also makes a difference in the growth of IT in a country. The telephone density indicator does not indicate how the country's telecommunications structure is evolving, in fact, leaping in the information age. Kenya has 13 telephones per 1,000 population whereas Indonesia has 4 per 1,000 population. With the Indonesian economy better than Kenya's, one would expect more telephones but then Indonesia has a problem with the population spread out over a large number of islands. PALAPA is used for transmitting the education programs, television, etc. to different islands and used for computer communications, and therefore decentralisation of computers is possible. Kenya is still behind in this area. The benefits of converging technologies in computers and communications have yet to make an impact in Kenya. There are no public computer communications networks and systems are isolated and decentralised, with most locations in the capital city of Nairobi. With the great demand for microcomputers, this situation is getting worse, because people are undertaking collecting of data, for example, which could easily be shared by more than one organisation.

8. The two countries have completely different so called 'policies' affecting computerisation. However, it is difficult to say how much difference this has made to the number of computers in the countries, though it can be argued in the case of Kenya that if the import duty was not as high, the growth would have been more. In Indonesia, consequences of the recent relaxation of tariffs by government needs to be seen. The government has started playing a leading role in computerisation by initiating information systems projects and by introducing computers in government management and office work. Its policies are orientated towards application of products and services that improve international competitiveness in both domestic and foreign markets. In both countries there is an abundant supply of unskilled labour and both unemployment and under-employment problems exist. Therefore both governments emphasize the development of labour-intensive industries. In Kenya, only 20% of the potential work force of approximately 7 million are formally employed.

9. Indonesia has learnt to deal more effectively with the Transnational Corporations and is taking advantage of the technology transferred through these corporations. They are improving their high technology education and training facilities. The information industries transnational corporations in the US and Japan for example, IBM, DEC, HP, Fujitsu, Hitachi, etc., are the most important external factors in the growth and development of computerisation in Indonesia. These corporations and the semiconductor firms are the main suppliers of the hardware systems, services and training. They transfer information technology by direct investment and by making packaged deals with local firms in the country. In contrast to this, the Kenyan government is less willing to give investors a protected position, even though the Fifth Development Plan (1984-1988) [25] welcomes foreign investment and technology. It has also showed interest in export oriented ventures but regional export potential is limited by poor infrastructure and low level of economic integration. Financial constraints and past failures have already stopped direct investment in joint ventures.

5. ANALYSIS

It is apparent from some of the above issues that Kenya needs to reform its 'policies' and the infrastructure necessary, for the growth of the industry. There is no longer doubt about the benefits of computerisation for the economic development of the country. Kenya needs to take advantage of this new technology and it can learn something from the Indonesians about how they managed to establish their level of computerization. Some of these issues are analysed below and recommendations are made for the steps Kenya needs to take.

1. Policy: The Kenya's Fifth Development Plan [25] states that the government seeks to control the role of imports by maintaining a realistic exchange rate and if required, by manipulating the level of tariffs. It states further, that with regard to manpower, government will discourage labour-saving technology. This is understandable with regards to the large percentage of workforce unemployed. But there is no evidence that computerisation causes unemployment, and the government in Kenya is slowly beginning to realise this. It was mentioned during the last budget that import duty will be reduced but this hasn't been put into practice yet. Apart from the reduced tariffs, Kenya desperately needs an IT policy or an organisation which will further the growth of the computerization. The country has other pressing priorities like education, developing rural areas, housing, etc. but it can not really afford to loose out on the information age. The Kenyan computer policy should aim at utilising it in reorganising the government administration, supporting small and medium size business, reforming large business and regulating working conditions. The country should concentrate on the judicious choice of applications for the enhancement of its socio-economic development. A pragmatic and systematic approach to the development of IT. should take into account the socio-economic priorities, current level of technology, and manpower resources together with the infrastructure and organisational capabilities available. The IT policy and planning issues should consist of a government central body to study and manage the infrastructure necessary for the development of IT in the country.

2. Ttraining and education: The training and education facilities need to be reviewed and examined in Kenya. The relevance and the validity of the courses offered by these so called 'training centres' has to be looked into, as well as the beneficiary. Should only a few from the elite be trained? What role do they play in the growth of the industry, especially with regards to the development of the IT industry in the country?
The universities and polytechnics also need to expand the courses they offer. There is great need for a degree course. Students usually have to go abroad to undertake the graduate and post-graduate courses at the moment, and in the long run it would be cheaper to start a course in the country, even if it means employing expatriates to teach the course. The government has realised the need to spread computer literacy and is hoping to introduce computer courses at some secondary schools in the near future. Computer education is generally seen as a means to increase national employment as well as to train computer-capable government employees. Indonesia has a well established core of computer professionals as well as many training centres and courses at the universities.

3. Telecommunications: The telecommunications infrastructure is currently being improved in Kenya and K.P.T.C. is beginning to make use of digital technology. But the involvement of the K.P.T.C. in the area of computer communications leaves much to be desired. In extending its economy, Indonesia has regarded communications as the 'arteries' of the nation, to facilitate the flow of goods for export and import, as well as providing inter-island communication. In other words, the Indonesian government has regarded this as a major step to attract foreign investment. Kenya is still at the stage of forming communication links with the rural parts of the country. Unfortunately there hasn't been a need to attract foreign investments since the export potential of the country is too little.

4. Suppliers: Most of the main suppliers of hardware exist in both countries but it is difficult to say how they have affected the growth apart from the fact that some companies like ICL in Kenya and IBM in Indonesia are dominating. In Kenya, the colonial links still require some government organisations to buy ICL equipment. ICL is one of the few companies in the country which has sufficient spare parts and capable maintenance staff to support its equipment

(although some of their technology is out-of-date compared to IBM, for example) which increases its dominance in the market. It is not appropriate to suggest that organisations try other suppliers because the services offered by others is often of questionable quality.

5. Local assembly: At the moment there is no scope for an electronics industry in Kenya nor for local assembly of components or computers. Therefore it can not copy Indonesia. The latter is at an advantage of being located in centre of the likely market (Japan and other South East Asian countries) for the electronics. Kenya is too isolated from the likely market and therefore can not benefit from the foreign investment which helps transfer technology into the country as well. The quality is always questioned of the two machines (Neptune -Turbo and CR7) currently assembled in Kenya. Users attitudes are biased towards using imported machines; so it will take a few years before people start appreciating the cheaper machines available locally. The quality of these should be improved to attract a market. Apart from this, there is some scope for writing software locally instead to importing and then adapting it to local needs. This software can also be exported to neighboring countries, some of which use similar administrative procedures.

6. CONCLUSION

It can be seen from some of the issues outlined above that different countries are affected by different constraints when it comes to developing computerization. Basically, the two countries have similar problems with regard to development, apart from the differences in the population and the finances. Indonesia is at an advantage with the latter two aspects, as well as foreign investment which has helped the growth of the computerization to a certain extent. In Kenya, the need exists for the creation of national ability (personnel, training facilities, policies, computer centres) to cope with the newly emerging problems about coping with this new technology so as to free a society from the vicious cycle of underdevelopment. The success of computerisation will depend on the extent to which computers are integrated into the economic and cultural life of each developing country. In other words, the nature and amount of attention paid to computerisation will vary from country to country, depending on many factors, including the status of development in agriculture, industry, physical infrastructure, education, health and other services. In Indonesia, the international trade has been a very import factor in the growth of the industry. The different approaches taken by the two countries demonstrate both the diversity of the developing countries and the different interpretations of where their self interest and priorities lie. Some like Kenya put high tariff barriers to the import of computers while others like Indonesia encourage importation as at least a short-term necessity for the assimilation of the technology. But the Indonesian situation needs to be reexamined after a few years to see how much difference in the growth of computerization this encouragement in import of computers has made. In Indonesia, computers are mainly seen as a strategy for improving development communications and control and for improving the efficiency and productivity of the public sector which bears the heavy burden of planning and implementing development projects. Despite the lack of foreign exchange and the high tariff, the growth of computerization in Kenya is also impressive. But a clear and progressive legal framework for computerisation will protect the interests of the public in general, the users of the computers and the computer industry. A policy on the development of IT in Kenya to enhance the socio-economic process by establishing application priorities in tune with developmental strategies is urgently required.

To sum up, one can see that there isn't one single aspect which affects the growth of the computerization. It is mostly a combination of many factors. Kenya basically needs an IT policy (or an organisation) to enhance the use of the technology in the country (though how effectively it will be used is a topic of discussion on its own). Even a country like Indonesia which has managed to do without a policy for so many years, feels the need for a policy in the rapidly growing area of computerization.

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INFORMATION TECHNOLOGY IMPACT: QUANTITATIVE ISSUES AND CASE STUDIES

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The development and impact of Information Technology (IT) in four nations - India, USA, Japan and the UK- have been viewed on the basis of empirical data. The Information Technology (Development) Level Index and the Information Technology Penetration Level Index, provide a quantitative basis for the analysis of the relative development and impact of IT in these countries. The rate of technological progress for IT is depicted by a logistic curve; the gaps in relative IT levels between these nations show up on this curve, so also their stage on the (information) technology life cycle. A schematic for IT transfer incorporates technology gaps; examples of new developments (optical and molecular transistors) are indicative of the trend toward the future.

1. INTRODUCTION

Computers are the world's third largest industry, after petroleum and automobiles. This highlights three attributes of high importance to the human race - energy, mobility and information processing.

Given that a third industrial revolution has been fuelled by the microchip, it is no wonder that infrastructural changes around the world are being affected, albeit to varying degrees in different nations (economic units). This wave of the fifth Kondratiev on which the world now climbs [1], is therefore heralding more intense technology transfer activities within, and across, economic units.

Kondratiev observed that the new technologies brought about technological and hence cultural and economic changes in society, approximately every fifty years, at a period (near the trough of a cycle) when 'old' technologies were nearly at the end of their technology life cycle. This fifty-year wave of crests and troughs- *long waves* -are known as Kondratiev cycles. The current restructuring of the infrastructure in world development is a result of the newly emergent technologies - microelectronics, biotechnology and genetic engineering, solar cell and tidal power technologies.

2. TECHNOLOGY TRANSFER

Technology transfer activities involve various levels and complexity of decision making; in order to be successful, decision support systems and allied tools can provide timely assistance for the transfer. With the growing stature of the information processing industry, around the globe, the transfer of information technology (IT) products and services, is becoming a significant activity.

3. IT DEVELOPMENT AND IMPACT

So as to assist in decision support, two new Indices were formulated the Information Technology (Development) level Index and the Information Technology Penetration Level Index. While qualitative assessments have been made, about the development and impact of compu-

ting in various countries, a quantifiable indicator for a variety of nations and computed on a standard as well as relative basis does not seem evident, at present, for the whole spectrum of IT. Thus, these two new IT Indexes are tackled in a quantitative manner.

Figure 1 shows IT development levels (ITLs) in the USA, Japan, UK and India, over the years 1970-81.

The IT development level Index is a relative measure, for given comparable economic units and on a scale of 0-100, of the level of development of IT within that economic unit (which, in this paper implies a nation). This Indicator is designed to reflect more of the physical/technological attributes of IT. The changing IT levels over the years shows the effect national policies can have. With the allowance of freer technology imports into the U˜, there was the advantage of assimilating technology and using it to spur development within the country, and the 70's showed strong growth; ITL Index values moved up from 38 to a peak of 61 (Appendix 2, Table 1). Whereas, in contrast, India's tough import policies showed up in terms of a negative growth rate, over the corresponding period. Foreign exchange for technology collaborations was limited, hence technology flow into the country was restricted and the channels of IT (Appendix 4) could not be fully exploited. The UK achieved some remarkable growth around 1976, when the microcomputer first arrived on the international scene and the leverage of this new microprocessor-based technology added to IT development. The UK has had one of the highest numbers of per capita home and personal computers. Japan was quick to utilise microprocessor technology in products and services and has also shown good capability in the assimilation and adaptation of new technology. Where IT levels have fallen, it implies that during that period the full potential of that nation was not utilised, in relation to the others within that group of nations. This also implies a wide scope for investment in areas of IT, in a particular nation that shows unutilised potential.

The rate of technological progress in IT has been the highest for Japan and the UK, in that time period, while the USA maintained its lead position as the nation most advanced in IT. India remained at the initial/growth stage of development (figure 2). Computational details are given in [2].

The technology life cycle (TLC) stages of initial/introduction, growth, maturity, and decline/innovation stage (or, when no threat from a competing technology is evident), can be framed onto this growth curve. In such a situation, the IT (development) Level Index values relative to the maximum possible, may be plotted for a given nation and ascertain its stage on the (Information) TLC. The gaps in relative IT levels may then be highlighted between two countries and reasons for different rates of technological progress in IT examined, upon the basis of the input parameters (Appendix 1) and their associated factors. Also, this illustration for the rate of technological progress in IT may be extended to allow a mapping for any nation, upon the basis of common parameters, onto this logistic curve and thus view technology transfer as well as development potentials. For example: In 1981 India's ITPL was 10, the USA's 87 and Japan's 56. India's Information Technology gap with the USA would then have been 7.7 (the value of D), and with Japan 4.6. What could her technological choice have been- transfer from the USA or Japan? Obviously, very sophisticated technology from USA could cause adoption and assimilation difficulties in India. The penetration being higher in the USA, ensures that the workforce has the basic training that technology requires for its use. On the other hand, Japan's penetration levels being lower than the USA may be advantageous to the diffusion of a similar level of IT in India because the adaptation may be easier given that a lower level of training may be required for use of that technology. According to the type of equipment being sought, the performance of individual characteristics (variables) may be studied for each of the two potential transferors of information technology. However, there are also other factors such as finance, training and back-up services, licencing, amongst others, that are involved in a technology package, which are dealt with on an enterprise-to-enterprise basis. Thus, it may also well be that in a particular area of IT, the USA may provide a better choice than Japan.

For nations to position themselves further along this logistic curve (figure 2), a number of steps were necessary for realising their IT development potentials- each nation according to

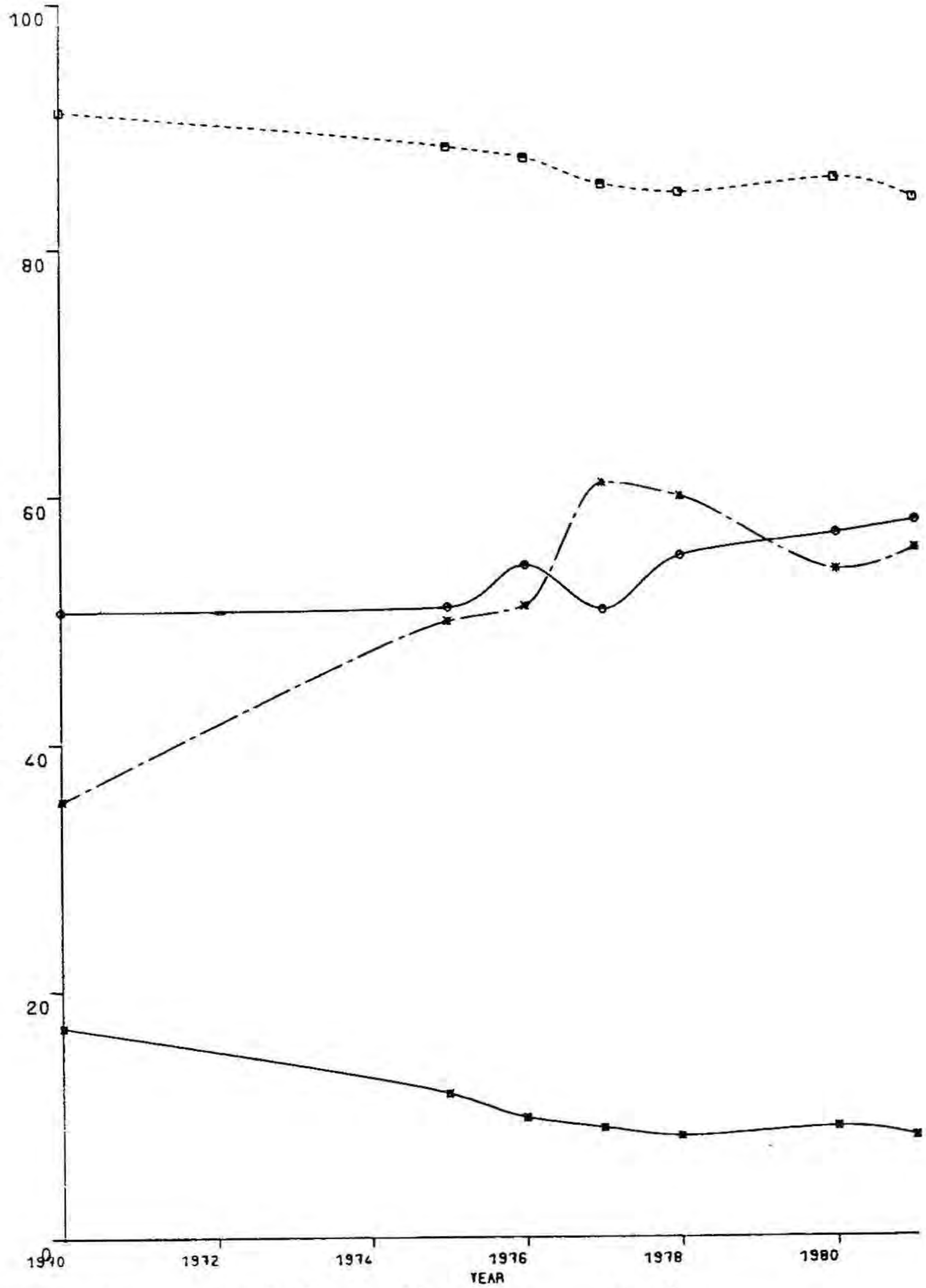


Figure 1: Information Technology Level Indices.
Source: [2].

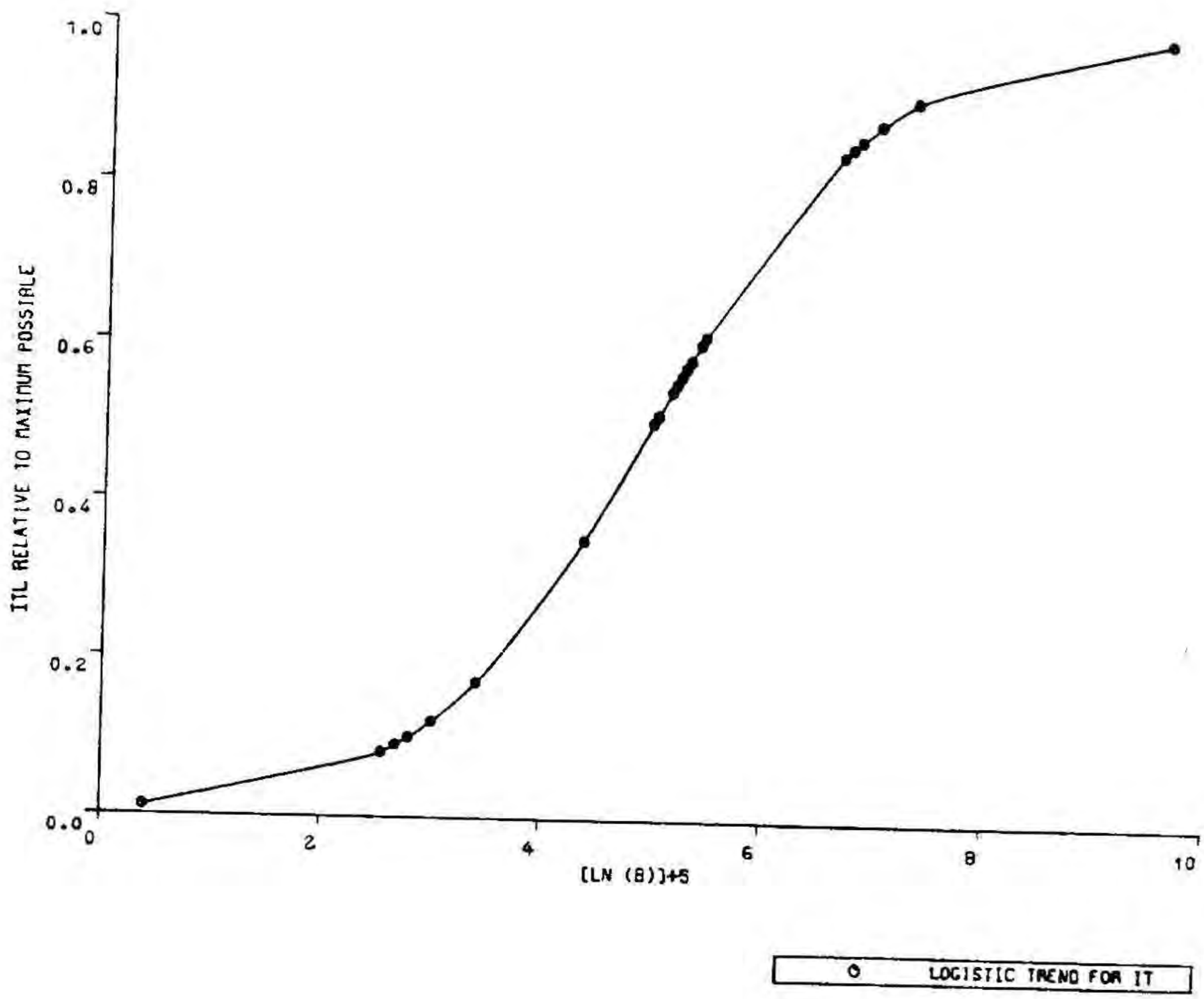


Figure 2: Rate of Technological Progress for IT. Source: [2].

their particular circumstance and environ. Two examples: Japan and India, in the early eighties.

Japan promoted large co-operative research programs to shorten the technological gap with the country most advanced in IT i.e. the USA. India strived to achieve/re-establish dynamism and competitiveness of her computer industry, through: (a) reduction of import taxes on computer parts, (b) encouragement of joint ventures and technology transfer, and (c) progressive opening to foreign competition [3].

A full example of the IT Transfer model, on the basis of the Technology Transfer Model iII Appendix 3, would exceed the scope of this paper at present; however, the author may be approached for illustrations of the model.

A second new statistic, the Information Technology Penetration Level (ITPL) Index, is computed using inputs that reflect socio-economic and demographic parameters, and also is a relative measure for given comparable economic units, on a scale of 0-100. This Index is shown to be useful in assessing the impact of IT in a country vis-a-vis a group of others. It also incorporates the ITL Index as one of the parameters. Figure 3 portrays the relative IT penetration levels (Appendix 2, Table 2) in the four nations. Impact levels for IT appeared to be steady for the USA and India, relative to the UK and Japan. What is observed for India, a relatively less developed nation in respect of IT, is that while ITL values fell over the years 1970-81, ITP values remained more or less constant; this is indicative of India having utilised its existing IT resources more effectively although impact was still low. A similar scenario existed for the USA in terms of IT levels, but IT penetration was still very high in performance terms (i.e impact) vis-a-vis the other three nations. Japan had a lower ITP level in 1970, compared to the UK, again highlighting a greater assimilating capability in the UK; this scenario changed as Japanese investment in their IT industry began to increase (semiconductors, computers and peripherals), and again will surface as a consequence of the ICOT supercomputer programme and the 5G blueprint for massive national IT investment. Their telecommunications industry has also invested heavily in fibre optic and satellite technology [4], with blueprints for the year 2000.

4. FORMULATION OF THE INDICES

The statistical modelling of parameters that are indicative of the development and impact of IT in an economic unit, involved selecting a sample of 11 parameters for the development level indicator and another 6 (plus the ITL Index) for the penetration level indicator (Appendix 1). These 17 variables were selected from a set of 55 (see [2]), since they showed the best consistency over the period of time (7 years). These 55 parameters covered the spectrum of IT-hardware, software, telecommunications and networking, component technology, socio-economic and national planning parameters. In order that the comparison between different economic units be relative and on a standard basis, these variables were factor analysed to arrive at a single statistic for each of the two groups of parameters. These two indicators could then be used to study the relative levels of IT development and IT impact in case study exercises of several nations.

5. IT TRANSFER

Figure 4 depicts the variables involved in IT transfer, the direction of flow of technology, and assuming that A is the transferor of IT. The technology gap at a point in time is defined by D, as it occurs in the technology transfer model given in Appendix 3. Some channels of technology transfer are given in Appendix 4. The ITL and ITP Indices are contributors to the Technological Level, in each of cases A and B (figure 4). The ITPL Indices are utilised in the determination of D for two given countries. A simulation of D values for different sources of IT then makes it possible to evaluate technology transfer decisions, while observing individual parameter values for each of the economic units.

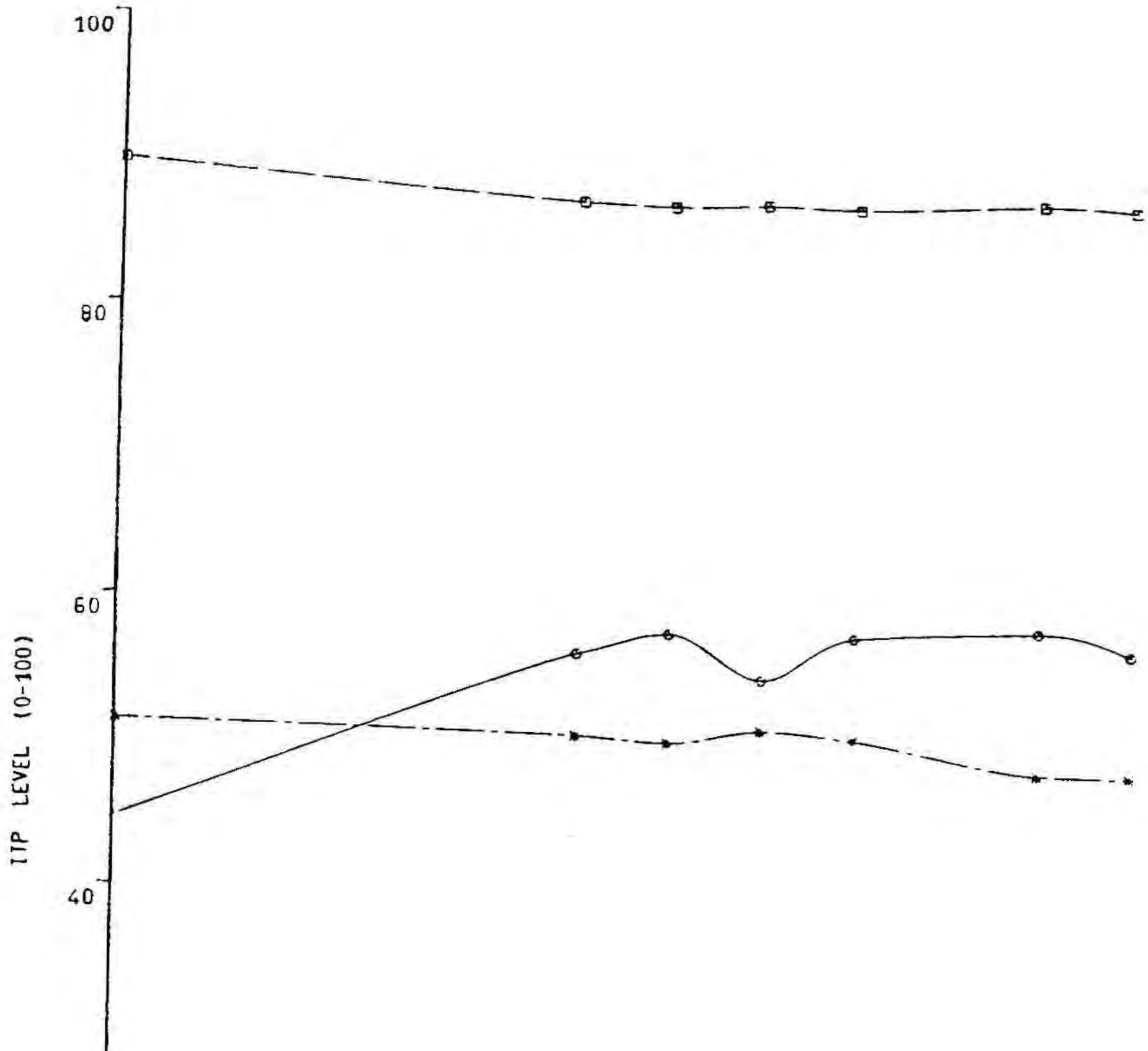


Figure 3: Information Technology Penetration Indices.
Source: [2].

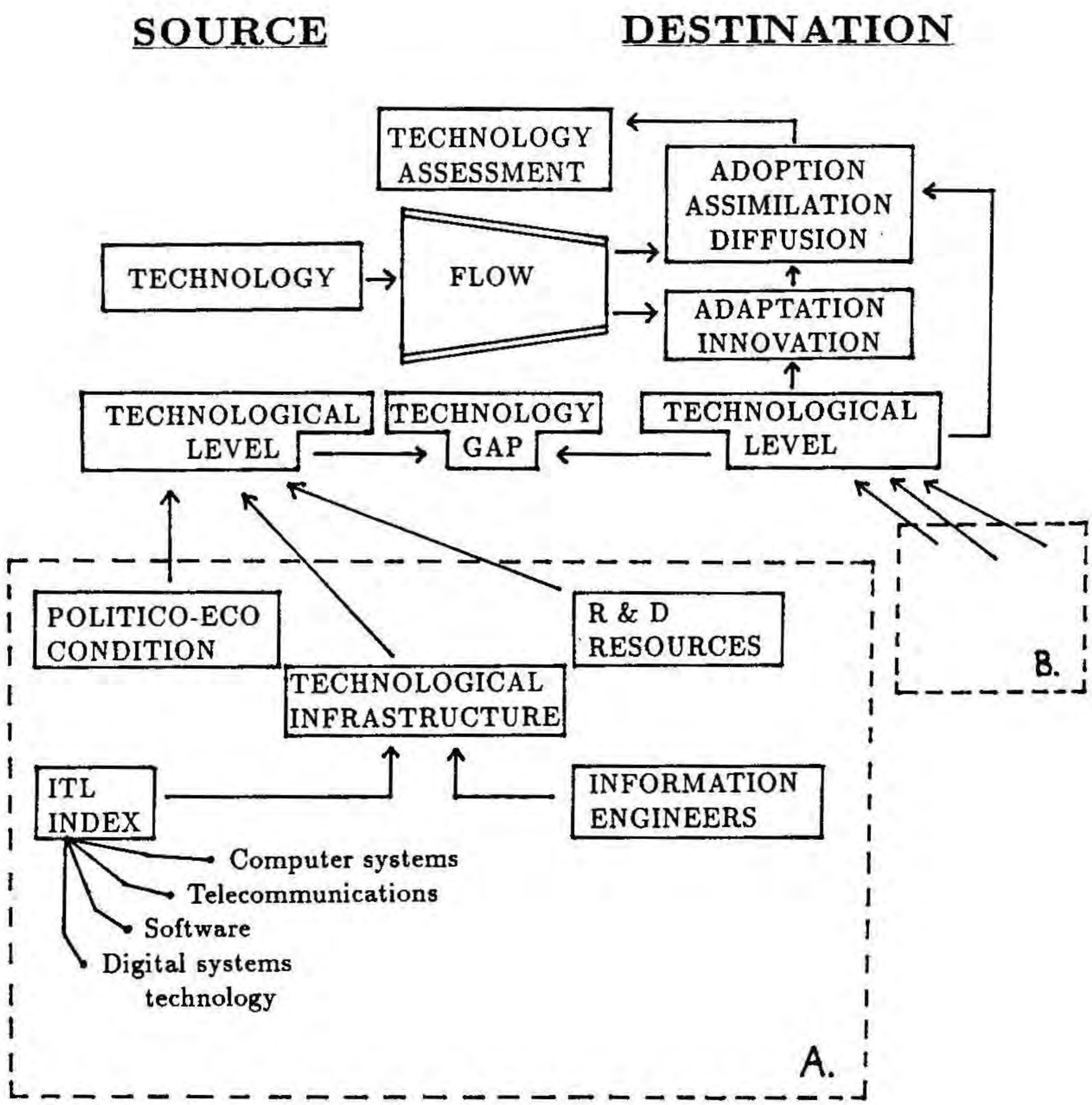


Figure 4: A Schematic for Information Technology Transfer.
Source: [2]

6. SOME TRENDS

The polymer and optical transistors are being developed and tested in prototype IT systems, as chemical sensors and in parallel processing machines respectively. Already, in the early 80's some major Western nations have formed new IT strategies and policies, to boost the infrastructural development and competitiveness of their local information processing industries. The results, in terms of development and impact as a consequence of these initiatives, are bound to be remarkable given also that the first generation optical and molecular transistors will be making their debut. The forecast is for possibilities of technological leapfrogging by some less developed nations that can afford licenciates' rigorous and often expensive demands; for those that cannot, their hope is a stake, or share, in the development or evolutionary process of IT and a consequent spin-off or ripple effect locally. In either case, several refined and reliable DSS (decision support systems) and allied tools will be at their disposal to assist in the evaluation of choice or strategy for IT.

APPENDIX 1

Source: [2]

Characteristic (variable)

V 1 No. of general purpose computer systems installed.
V 2 Production facility for microprocessors, in country.
V 3 Sophistication level of the technology.
V 4 Telephone traffic (no. of calls)... [x 10^6]
V 5 Paid telegrams... [x 10^3]*.
V 6 Telex traffic (chargeable minutes)... [x 10^3]+.
V 7 Number of telex subscriber lines.
V 8 Telephone stations of all kinds/100 inhabitants.
V 9 Most common transmission rate (in bps)... [voice grade]@.
V 10 Telephones/100 inhabitants.
V 11 Television receivers/100 inhabitants.

V12 Total population (millions).
V 13 GDP/Capita (at purchaser's values) ... [US$].
V 14 Research + experimental Development (total) ... [US$].
V 15 Total educational expenditure as a percentage of GNP.
V 16 No. of scientists, enggrs and technicians engaged in R+eD (mns).
V 17 Radio receivers/100 inhabitants.
V 18 The ITL Index.

** In order to make the Indices comparable on a standard basis, this parameter is included in the Index computations. Even though V 5 is a negative correlate, because of the rise in telex capabilities and traffic, several less developed nations have a very large volume of telegram usage. Telegrams are one of the common carrier telecommunications forms.*

+ For the USA, data for V 6 was for international telex traffic only and not the total telex traffic.

@ The transmission rate, in bits per second (bps), along the national telecommunications network is indicative of the density of traffic on average. There are slower and faster communications channels for telex, data, video, facsimile, etc. and also there is the use of packet switched networks.

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APPENDIX 2

Source: [2]

Table 1: Information Technology Levels (1970-81).

Year	USA	Japan	UK	India
1970	91	51	35	17
1975	88	51	50	12
1976	88	54	51	10
1977	85	51	61	9
1978	85	55	60	8
1980	86	57	54	9
1981	84	58	56	8

Table 2: Information Technology Penetration Levels (1970-81).

Year	USA	Japan	UK	India
1970	90	45	51	12
1975	87	56	51	10
1976	87	58	50	10
1977	87	55	51	10
1978	87	57	50	9
1980	87	58	48	10
1981	87	56	48	10

APPENDIX 3

Source: [5]

TECHNOLOGY TRANSFER MODEL

$$ln\left[\frac{f(D,t)}{F_{MAX}\,e^{-D} - f(D,t)}\right] = c_1 + c_2\,t$$

where ln : natural (Napier) logarithm of the function in [ ],

D : Technological Gap between the supplier and recipient of technology. This is determined by $D = \frac{Ix - Iy}{Iy}$

where, I: technology levels of supplier (X) and recipient (Y), resp.

$f(D,t)$: level of assimilation at a location with potential technological distance (PTD) at D, at time t,

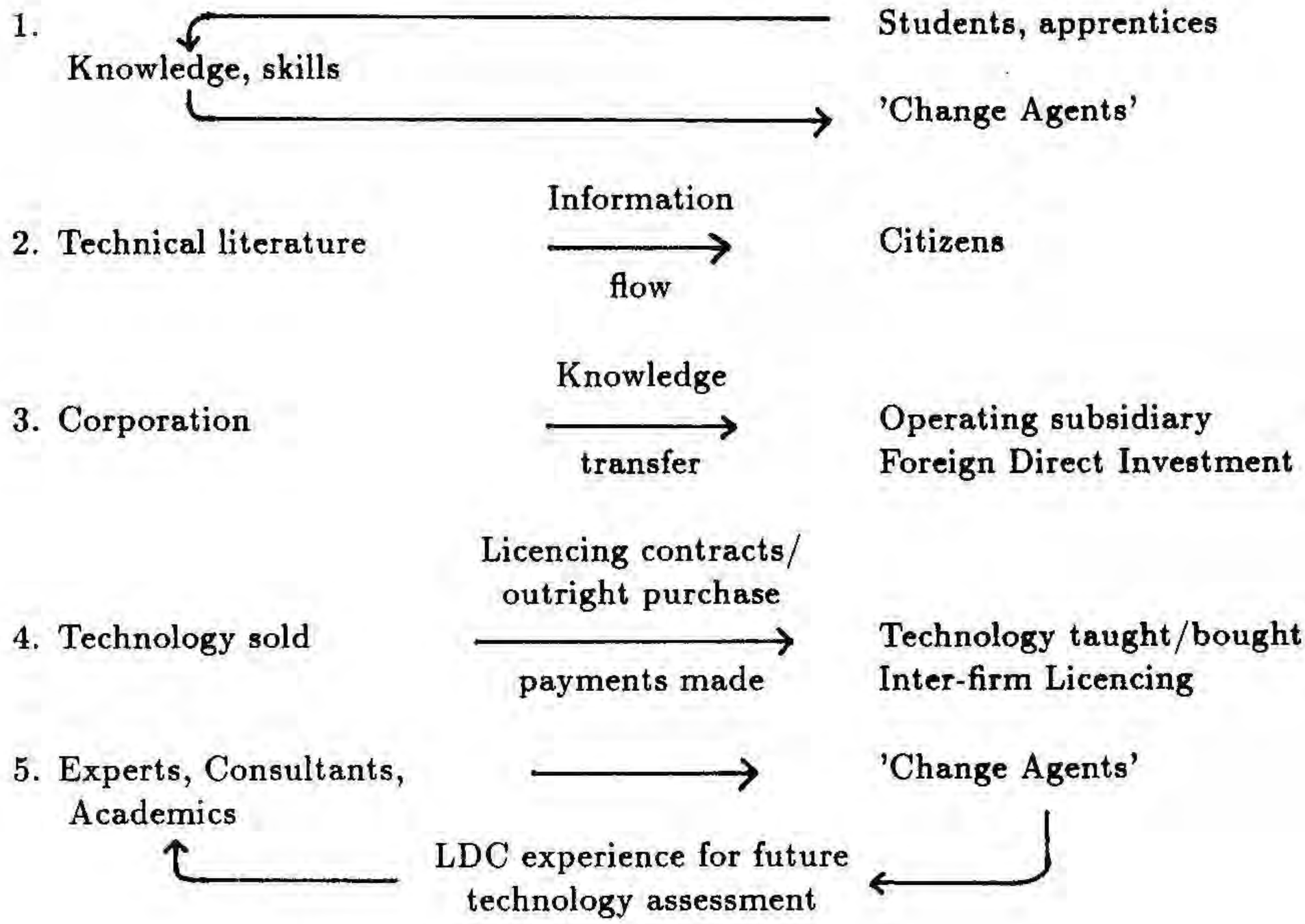
F_{MAX} : the maximum possible level of assimilation,

c_1 , c_2 : constants that depend upon F_{MAX}, the PTD at t, and the assimilation rate at a location.

APPENDIX 4

Source: [2]

CHANNELS OF TECHNOLOGY TRANSFER



* *Industrially Advanced Country.*

° *Less Developed Country.*

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DECISION SUPPORT SYSTEMS FOR DEVELOPMENT

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Decision Support Systems which offer interactive access to databases and models through a flexible and user convenient interaction, can contribute extensively to the efficient use of resources. This paper examines the issues related to the successful design and implementation of decision support systems through a case study on the design of irrigation networks. While development of decision systems require good system design skills, extensive user participation in the design and implementation stages of the system is vital to their success.

1. INTRODUCTION

Major investments in developing countries are made in the construction of dams, irrigation works, power stations, refineries, steel industry, rail and road transportation etc. Studies [1][2][3][4] demonstrate that innovative use of information technology can provide savings to the tune of four to five percent in these areas. Through the recent developments in the field of information technology, it became possible for the decision makers to have direct access to the low cost yet powerful computer systems at their desktop. Major benefits would therefore be feasible, if the computer based models or systems are brought closer to the decision maker through decision support systems.

The Decision support systems as defined by Sprauge and Carlson [5] have the following characteristic:

" They tend to be aimed at the less structured, under specified problems that upper level managers typically face.
They attempt to combine the use of models or analytical techniques with traditional data access and retrieval functions
They specifically focus on features that make them easy to use by noncomputer people in an inter-active mode.
They emphasize flexibility and adaptability to accommodate changes in the environment and decision-making approach of the user."

Design and implementation of decision support systems would therefore require clear understanding of user context to provide effective interaction of decision maker with computer based models to facilitate the solution of under specified and unstructured problems. In addition, user involvement in the design of such systems is vital for the successful implementation. The system building skills involving the development of graphical interfaces, models and data base interactions is yet another important necessary input. It is difficult to find such combination of forces working harmoniously, particularly in developing countries where computer applications for development in government are at infancy [4]. Study on the design of conveyance and delivery networks for a major irrigation project in India, presented in this paper, substantiates point that a close coordination between model builders and users with extensive user participation in the design of systems can offer scope for development of effective decision support systems. Such decision support systems can contribute significantly to the economy of developing countries.

2. IRRIGATION SYSTEMS

Irrigation systems consisting of conveyance and delivery networks for large projects involve huge investments. For example the Sardar Sarovar Project of Government of Gujarat, India, is estimated to cost a total of Rs. 57920 million. It is estimated that the planning of entire system is likely to take about 16 years [7]. This system is expected to provide irrigation facilities to around 2.124 million hectares of command area. A large portion of the Gujarat state is expected to benefit from this project both in terms of irrigation and drinking water.

Following are the steps involved in the design of irrigation networks:

i. Marking the command boundaries, turnout positions and alignments of branch canals, marking the service area boundaries, command boundaries, turnout positions and alignment of sub branches/distributories and service area turnout positions on survey of India maps.

ii. Working out net cultivable command area for each service area and aggregating to obtain net cultivable command area for each distributor and for each branch canal; working out channel capacities from basic discharge coefficient values at service area and aggregating the same along with addition of losses and applying capacity factors.

iii. Selecting Hydraulic Gradients, designing the Cross Sections, preparing design discharge statements and plotting Longitudinal sections and typical cross sections for each channel.

iv. Preparing detailed estimates for earth work lining and land acquisition.

v. Preparing designs and estimates for structures.

It can be seen from the procedure explained above, that attempting alternative layouts for obtaining an economic system would require huge effort in terms of human judgment, draftsmanship and calculations.

At present these operations are performed sequentially with extensive use of calculators.

The study presented in this paper was conducted jointly by the Narmada Planning Group, Sardar Sarovar Project, Government of Gujarat and Indian Institute of Management, Ahmedabad with the basic objective of developing a methodology and to provide a tool which helps the designers in finding out economically optimal solutions to the various network parameters, within the framework of policies and standards [7] laid down. This study was also supported by the UNDP and Department of Electronics, India funded project on Computer Aided Management at Indian Institute of Management, Ahmedabad.

2.1 Evaluation of alignments

In order to evaluate alternative alignments it is necessary to first identify the items of canal network construction that contribute significantly to the cost of the network. Secondly it is necessary to formulae for estimating the costs of those identified items for a given alignment. An analysis cost of constructing the canal network shows that the items contributing to significant cost of the network are:

i. Excavation
ii. Embankment
iii. Conveyance of earth
iv. Borrow Earth
v. Land acquisition
vi. Lining
vii. Structures.

By computing the quantities of the above items using the formula developed for their estimation, and applying the rates as per a standard schedule of rates (SOR), the cost of constructing the proposed network can be estimated.

All most all the items listed above depend on the dimensions of the canal cross section and the difference of ground level and canal bed level at different points over the canal length. Out of several dimensions of canal cross section, the canal Bed Width (BW), Full Supply Depth (FSD) and Hydraulic Gradient (HG) applicable for a discharge can be computed using Manning s formula[8]. However several other dimensions related to inspection path, service road, dowels, spoil banks, maintenance land, catch water drains, boundary gutters, longitudinal drains, cross sectional drains, lining, light and compacted embankments etc. are standardized for a project and tables giving these values for different ranges of discharges are expected to be developed. In this study we assume the availability of such tables as data.

Since it is not possible to get any simple mathematical function to the ground surface, we descretize the longitudinal section of the canal into a number of intervals of equal size and assume that the ground follows linear plane in each interval. The ground levels at these fixed intervals over the length of canal (longitudinal section) are taken as data for a given alignment.

The canal bed levels are computed from the full supply level at the start of a reach, the hydraulic gradient adopted for the reach and the drop or loss of head at various structures within each reach.

The quantities of relevant items between two subsequent intervals of the longitudinal section are computed and aggregated to obtain the total quantities for the entire reach. This method of discritization and numerical integration gives reasonably accurate estimate of the quantities, provided we choose an appropriate interval based on the ground profile.

The cross sectional areas for relevant items at any two subsequent intervals of the longitudinal section are computed, averaged and multiplied by the interval length to obtain quantities for the corresponding items.

The excavated earth in excess of requirements in embankments at the interval of its generation may be transported to be used for embankments at intervals where the short fall exists. The surplus or shortfall earth at each interval over the longitudinal section of the canal is estimated by first computing the quantities of excavation and embankment including the earth generated due to drains and earth required in dowels and side fills. The balance earth is treated as surplus earth if positive, else as short fall earth (if negative). In doing so it is assumed that the entire quantity of excavated earth is suitable for utilization in embankments. It is however possible to take into account, the nonsuitability of a type of soil for use in embankments by taking additional inputs with trial pit data.

A multi stage transportation scheme in which the earth from each surplus point is conveyed to short fall points within the specified upper limit distances of each slab in each stage is used to obtain the minimum cost solution for conveying the earth.

After applying the transportation scheme we would be left with new status of surplus and shortfall quantities. The surplus earth is dumped on the canal sides as spoil banks while the short fall earth is obtained from the borrow pits dug on the canal sides or obtained from borrow area.

Earth required for embankments in an interval has to be acquired from borrow pits, if it is not met with by the earth generated due to excavation in that interval and by the earth transported to that interval from surplus points. Such quantity of short fall earth aggregated over all intervals gives the net requirement of earth to be borrowed and is used to estimate the cost of borrow earth. The rate for the borrow earth is obtained from the schedule of rates data.

Area of land to be acquired from different villages for the purpose of constructing the canal depends upon the width of canal cross section at ground level at different intervals of the longitudinal section that fall in each village.

The width of land to be acquired at any interval depends upon the relative levels of ground, canal bed and free board and on the quantity of surplus or short fall earth at that interval.

In case of surplus earth, we need to acquire land for dumping this excess earth on sides of embankment as spoil banks. The base width of spoil bank at each surplus interval is computed by using the quantity of surplus earth, and values of the slope, minimum width and maximum height of spoil bank as specified in the canal standard data. In addition to this the values in canal standards data specifying the location of catch water drain, the widths of maintenance land on service road side and inspection path side, the base widths of dowel, catch water drain, boundary gutter are used to compute the total width of land.

In case of short fall of earth, the dimensions of borrow pit are computed from the short fall quantity and the values of parameters governing the borrow pit dimensions. The distances of first and second borrow pits as specified in the canal standards data are used in estimating the total land width in addition to other items such as widths of maintenance land, service road, inspection path, dowels, and boundary gutters required in computing the land width.

In order to ensure that uniform stretch of land is acquired over reasonable length, the maximum of the widths obtained over the given number of consecutive intervals is taken as the width of land to be acquired for all the intervals in the bunch. This bunch size (number of intervals) is taken as data along with ground level information.

The chainages of village cross over points of the canal network are taken as input data and are used to calculate village wise areas for land acquisition. The cost land acquisition is computed by applying the village rates which are also taken from the same data set.

The area of lining is obtained by computing the wetted perimeter after applying correction due to curvature at bed-slope junctions and also by adding the widths of lining keys. The data items such as lining slope, bed-slope junction radius, width of lining key are taken from canal standard data. Excavation due to lining is computed by multiplying the lining thickness with the area of lining. The cost of lining is obtained by applying the rates given schedule of rates data to the items computed.

Additional items such as filter quantity, area of polytene layer in the cases where water table appears above canal bed level are also computed by using the values of filter thickness, clearance depth for water table etc. as given in canal standards data.

Structures such as regulators, siphons, rail and road bridges, aqueducts etc. are required to be built on the canal network for the purpose of regulating the flow through the canal and to overcome the obstacles due to existing systems. These structures contribute to significant cost of the canal network. Requirement of such structures does not vary with alternate vertical alignments. Therefore in order to evaluate various vertical alignments for a given horizontal alignment, it is necessary to have an assessment of variations of their cost with reference to the variations in parameters like bed width, full supply depth and canal bed level.

The total cost of a reach in the canal network can be obtained by computing the costs of excavation, embankment, conveyance of earth, borrow earth, land acquisition, lining and structures as illustrated above.

The major parameters of canal section such as bed width and full supply depth are designed for the required discharges for different values of permissible hydraulic gradients using the Manning s formula. The canal standard data giving the minimum values of bed width and full supply depth and the step sizes for increments of these items as well as the ranges of the ratio of bed width to full supply depth are used in arriving at the minimum cost dimensions of the canal section. Minimum and maximum velocity constraints are also taken into consideration

while computing these values [6]. Provision is however made to explore the entire range of feasible domain of these values to find minimum cost section for cases in which cost structure or situations like non requirement of lining violate the above mentioned minimum cost solution. The package for evaluating the cost of a given network is used repeatedly with different values of the canal section dimensions to obtain the minimum cost solution.

2.2 Minimum cost vertical alignment

Once the levels of the off-take points are fixed keeping in view of the command areas to be covered by the subsystems under such points, the minimum cost solutions can be explored by choosing different combinations of hydraulic gradients and fall sizes for all reaches of the network. This is a combinatorial problem involving the selection of the minimum cost combination out of possible thousands of feasible solutions. This is a typical multi stage optimization problem involving non-linear cost functions. Therefore it is modeled as a dynamic programming problem [9]. Use of dynamic programming technique is reported in the literature for the optimal design of water conveyance systems [10] and aqueduct routes [11]. These studies however did not address the detailed cut, fill, land acquisition and transportation costs in modeling the problem. Since they are significant in open channel irrigation systems, the study reported in this paper applied the dynamic programming model on the detailed and simultaneously estimated costs of canal works as described in section 2.1. Close interaction with users has facilitated the understanding and feasibility of incorporating these items in the model.

By computing the permissible limits of full supply levels at each point of fall in the network, the algorithm proceeds to compute the total cost of constructing each reach for different values of full supply levels at the starting point of each reach within the derived limits. The minimum cost solution is then arrived at by picking up such combination of elevations that gives overall minimum cost.

The permissible limits of full supply levels at the starting point of each reach are also used to evaluate alternatives in addition to the above derived levels.

2.3 Horizontal alignment design

Marking the command areas, drawing the alignment of branch canals, marking the service areas, drawing the alignment of distributories, computing the discharge requirements at various off-take points by working out the cultivable command areas and the water requirements and finally fixing the full supply levels at the off-take points constitute the tasks associated with the horizontal alignment design of the conveyance network. Such tasks require extensive use of cartographic information such as contours, village boundaries, existing and proposed rail, road and irrigation networks available on survey of India maps.

Any tool that helps in the design of horizontal alignment must therefore provide facilities to access the above identified information readily, capture the data related to the suggested alignment, and finally evaluate the alignment.

A model based Decision support system which uses a color graphic work station with digitizer to capture the cartographic data and plotter to obtain the drawings of the worked out alignments, was developed to address the problem of horizontal alignment design.

The system provides facilities to capture cartographic information from Survey of India maps using digitizer. It then displays all objects on the screen with facilities to see any of these objects (villages, roads, railway tracks, ponds, existing irrigation network) selectively. Facilities are provided to mark command areas, choose outlets and full supply levels at the outlets. Canal routes can be interactively entered and modified. Ground levels for the suggested alignment are computed with the help of a program which converts contour data into ground levels through interpolation. Such data along with additional information on the discharge requirements can be passed on to the model for optimizing the vertical alignment and obtaining

the construction costs. Therefore using this system a number of horizontal alignments can be interactively designed and evaluated to obtain a minimal cost network.

The result of altering full supply levels on the area of command under any subsystem can be studied readily using this interactive system since the area of coverage with a specified full supply levels is graphically displayed.

The positions of falls can be interactively fixed to minimize the cost, since the system displays the longitudinal section of any given canal segment and provides interactive facilities to alter the full supply levels and positions of falls.

3. RESULTS

Through this study we presented an integrated approach to the design of irrigation canal network in which various significant items of cost such as excavation, embankment, conveyance, borrow earth, land acquisition, lining and structures are simultaneously evaluated to obtain a minimum cost solution. A set of computer packages were developed to illustrate the feasibility of the approach. These programs compute detailed estimates of quantities and costs of all items except those of structures, from the basic design parameters and ground profile data. Miyagam branch canal data was used primarily to test the approach and the packages developed based on the approach.

From the over all cost minimization point of view, the optimization model developed requires modules estimating the costs or variations to costs of Structures on the canal network with reference to variations in bed width, full supply depth, elevation from ground level. As and when these are available, they can be integrated with the optimization package so that the minimum cost solution is arrived at by considering this component of the network cost also. Within the scope of the study, the package developed computes a minimum cost solution by estimating all other items of cost. While estimating, the optimization possible with reference to conveyance of earth and land acquisition are automatically carried out by the package.

The only case study where optimization model was used to obtain minimum cost solution is the design of Miyagam branch canal [6]. Ignoring the variations in the cost of structures (since they were not available at the time of study), the computer solution did show 3% to 4% improvement on the manual design. However we understand that after the cost of structures was estimated for the solution obtained by the model, it turned out the savings demonstrated were reduced considerably, due to the increase in the cost of structures. This is expected in systems where the structures account approximately for 40 to 50 per cent of the overall construction costs. It is therefore necessary to conduct such research to obtain broad understanding of the trend of cost of structures. Till such time the computer model developed can be used for the following:

i. Estimation of quantities and costs for a given vertical alignment. We understand that it takes three man months for a team of an executive engineer, deputy engineer and a supervisor to complete the estimates and develop measurement sheets for canal stretch of 20 km. It took on the average two to three days including data preparation and verification of results to do the same thing using the computer model.

ii. To evaluate alternatives in vertical alignment design: Although Structure costs are not estimated, it is possible to constrain the model not to produce such solutions which might increase the cost of the expensive structures. This can be achieved by giving appropriate limits to the full supply levels at points of those identified structures. Minimum cost solution obtained by such constraints would therefore be close to optimal solution. Either by examination of solutions worked out the model during the process of arriving minimum cost solution (which is given as output by the package) or by trying more solutions by altering the constraints, it is possible to obtain a near optimal solution.

iii. To use it for investigating the horizontal and vertical alignments: With some modifications to the package for the design of horizontal alignment, the data captured through interaction can be made available to the package designing vertical alignment, and precisely evaluate each such alternative.

iv. With cartographic data captured on the computer media, it is possible to design service areas, identify off-take points, study the implications (such as loosing or gaining command) of change of full supply levels at those off take points, and to compute basic discharge coefficients etc. The bottom up design (chak design and upwards) is now feasible. Addition of module on variations of structure costs can bring in a great deal of automation in designing canal networks.

v. The results presented in this study can be extended to other construction networks such as railways and roads.

4. DISCUSSION

Based on the above presentation on the design and implementation of the model based decision support system, the following significant issues merit the discussion:

i. User participation in this study is substantial. An officer on special duty (OSD) at the level of Superintending Engineer and his team have spent an year continuously interacting with the model building and implementation team at the Indian Institute of Management, Ahmedabad. The OSD has played a vital role in ensuring that the computer system developed is owned by the users. By giving input and output specifications that are widely acceptable to the users, by ensuring that results obtained are in conformity with the manual computations and by conducting internal workshops illustrating the functioning of the computer based system, the OSD ensured the successful implementation of the computerized system. This substantiates the observation by Korpela [12] that " The most important guarantee for including all important aspects is participation - or more properly, cooperative design of the computer-supported work activity by a group consisting of users as well as computer experts. It is most important that concepts and media for common language would be created through mutual learning and teaching."

Packages involving very detailed computations illustrated in section 2.1 were developed to build the confidence in the user that the system gives the same results as the manual computations upto third decimal digit of accuracy. In fact quite a few computations do not vary with different alignments. These are however included to provide a tool with which users are comfortable with.

ii. In the areas where major inputs are required from other departments, the study could not achieve the desired progress. For example, non availability of cost curves or cost estimation modules for structures such as road bridges, regulators siphons etc., restricted the scope of optimization. It is expected that a team designated to provide these inputs would soon come up with its suggestions. Till then the solutions obtained by the software will have to be re-evaluated after estimating the cost of structures separately to obtain over all minimum cost solution.

iii. The time required for estimations of earth work, lining, service roads, and land acquisition reduced considerably. The existing manual system required a team of three members of the engineering staff, around two to three months to work out the estimates for a canal of 20 kms long. With the use of the computer based system, it required just two to three days to obtain complete estimates after trying out several alternatives to pick up a minimum cost alignment. The cost computer time is just negligible, since it takes only about three to four minutes on a HP1000 system to do the estimation work of the canal system. This system has been ported recently to IBM compatible PC/XT systems on which a typical run takes about eight to ten minutes to do the same estimation work.

iv. The system demonstrated about three to four percent savings over a manually designed solution. This meant a savings of about 1.0 to 1.4 million Rupees over an estimated cost of 36 million Rupees for canal length of 20 kms. These savings are achieved within a given horizontal alignment. The potential savings could therefore be much more if alternative horizontal alignments are also explored using the DSS.

v. With these limitations, the computer aided estimation system for conveyance and delivery networks of the irrigation system was put in to use on regular basis by the government of Gujarat, India for the estimations of their irrigation projects. So far it is used to estimate around 1500 kms of canal works in Gujarat with other states showing keen interest to adopt the system.

vi. Based on this experience, a decision support system was developed using the graphic equipment available with VAX-11/750. The cartographic data is collected through a digitizer (Calcomp 9240). The graphic interaction required for developing alternative horizontal alignments is provided through TEK 4107 graphics terminal and the TEK 4957 graphic tablet. It is envisaged that this DSS would address the problems related to capturing the user´s experience while developing the alignments. Non-graphic version of the software is made available on IBM compatible PC/XT systems.

vii. Lengthy interactions were required between the users and model builders. Although, the users are ready to accept computer based solutions, their expertise in developing the required software is limited. The end user packages with personal computers have limited scope in the application areas discussed above. Hence in the initial stages, such interactions are un-avoidable.

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INDUSTRIAL MANAGEMENT EFFICIENCY ENHANCEMENT IN DEVELOPING COUNTRIES USING COMPUTER BASED INFORMATION SYSTEMS

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The recent advances in computer technology has only had a marginal impact on developing countries. Most smaller developing countries do not have the pre-requisite computer oriented human resources and the capital resources to benefit from the on-going computer revolution. Considering these resource limitations, developing countries must first of all identify the computer application areas which would generate the maximum benefits towards their national development efforts. The present computer vendor marketing strategy in developing countries has been largely to promote accounting and office automation application areas. Rather than allowing the computer vendors to dictate the computerisation policy, developing countries themselves must analyse their computer requirements and needs and develop an appropriate policy. This paper analyses the reasons for the failure of the industrialisation programmes embarked upon by developing countries and identifies problems related to inadequate and improper industrial management as the main reason for the difficulties encountered. From the possible computer applications in industry such as Computer Aided Design/ Manufacture (CAD/CAM), Computer Aided Production Management (CAPM) and Office Automation (OA), the paper points out that considering the industrialisation aims of smaller developing countries, types of industries established, and resource constraints, the most logical computer applications should be in CAPM. The paper also identifies the necessary policy measures needed for such computer applications, including the development of computer-literate managers, greater awareness of CAPM benefits and computer vendor change in marketing strategy.

1. INTRODUCTION

In the last few decades there have been significant advances in the area of computer technology, which has resulted in numerous application possibilities. From a historical perspective, the rate of this technological development is unprecedented, the only marginally comparable event being the 'industrial revolution' in the west in the nineteenth century. In the case of the 19th century industrial revolution, the knowledge benefits arising from the event was not available to developing countries, due to the protective policy adopted by the colonial powers at the time. Had there been no such protective barriers, the technology knowledge base of the developing countries would have improved and their capacity to develop as industrialised nations enhanced. During the computer revolution on the other hand, almost all developing countries were independent nations and were in a position to benefit from the new technology. Although the technology was available, according to Narasimhan [1] the developing country inability to develop hardware and system software, has limited their ability to benefit from the technology available. These human resource constraints together with the shortage of capital resources, have limited the proliferation of computer applications in developing countries.

One way of measuring the extent to which computers are used in developing countries is to look at published statistics on the global distribution of data processing equipment. Table 1 shows the World distribution of data processing equipment from 1960 to 1988 according to Rada [2]. As seen, over this 28 year period, there is a slight increase in the 'other Country'

share, but considering the fact that the 'other Country' category includes eastern europe, developed countries such as Canada, Australia and newly industrialised countries such as Korea, Taiwan, Hong Kong and Singapore, it is probable that the actual developing country share has remained static or even has declined. Lind [3] has attributed this slow growth of computerisation in developing countries to three main reasons: financial constraints, lack of knowledge and limited vendor interest.

Table 1

World Distribution of Data Processing Equipment
percentage value

	1960	1970	1973	1978	1983	1988
U.S.A.	70	62	53	46	43	41
Western Europe	20	27	28	29	32	32
Japan	4	5	7	8	7	8
Other Countries	6	6	12	17	18	19
Total	100	100	100	100	100	100

Source: Rada [2]

The need to apply computerisation to areas where benefits are apparent has been discussed by Kuhn & Kaiser [4]. In this context it is important to identify the development objectives and development priorities pursued by developing countries in identifying areas for computer applications. Many developing countries embarked upon ambitious industrialisation programmes after independence, but they have not generated the expected benefits. Problems such as low productivity, low product quality, inability to produce goods on time, low capacity utilisation, high production costs (in spite of low wage rates) and the like are common in developing country industries. Consequently, in spite of these industrialisation efforts, according to UNIDO [5] statistics the actual developing country share of manufacturing value added has only seen a marginal change over the years. The industrial development problems experienced in developing countries were initially identified as being a result of the reluctance on the part of developed countries to 'transfer technology' and even international agencies such as UNCTAD [6] have concentrated their efforts in promoting the transfer of technology. Lately however, a number of studies [7,8] have identified in-adequate and in-appropriate Production Management, being the major reason for industrial problems encountered in smaller developing countries.

Lind [3] has classified the computer applications in industry on a scale ranging from administration oriented functions to process oriented functions. Much of the software available for industrial management work were written mainly for use with mini/ main frame computers, since the industries themselves were large and complex and needed a fair degree of computing power. Industries in most smaller developing countries are smaller in size and without relying on mini/main frames, can perform most of their industrial management functions on micro computers, provided sufficient software and human resources are developed. This paper identifies the industrial structure and the industrial problems in smaller developing countries and identifies suitable application possibilities for effective industrial management and proposes the policies necessary to achieve these objectives.

2. INDUSTRY PERFORMANCE PROBLEMS IN DEVELOPING COUNTRIES

2.1. Industrialisation Policy and Type of Industries Established.

The general industrialisation policies pursued by many smaller developing countries had certain common key features. Foremost, these nations wanted to broaden the economic base from the

traditional agriculture base and inherently assumed that industrialisation (the path followed by developed western countries) should be the ideal process. At the same time, the growing balance of payment difficulties experienced as a result of large scale imports of consumables, dictated a policy of import-substitution industrialisation. On the other hand, these smaller developing nations lacked the capital resources and a domestic market to go in for the manufacture of capital goods and as such, the import-substitution industrialisation policy was considered the most suited. Therefore, the majority of industries established in such developing countries tend to be fairly low technology small scale industries, and often complete factories were imported. Along with the establishment of local industries, a policy of supporting the industries was initiated and as a result, imports were restricted. Often the industry established did not posses the required capacity to meet the total demand and as a result a protected under-supply market situation emerged, which assisted the manufacturers. Quality of local products were often low and as has been pointed out recently [9] , the low quality is a reflection of the market demand modifications arising from the ban on imports. Further, due to the absence of competition in the local market, there are no major pressures on manufacturers to reduce production costs and develop innovative procedures.

2.2. Engineering Education Priorities

The general Engineering education policies adopted by many smaller developing countries also have a definite impact on the success of industrialisation programmes embarked upon. Probably fearing the obstacles to technology transfer, most Engineering education policies attempted to concentrate on generating graduates in the conventional engineering fields such as civil, mechanical and electrical engineering and largely neglected [7] the significance of industrial engineering education. What was actually needed was more practical engineers capable of maintaining and utilising the technology acquired, rather than theoretical engineers. Analysis of engineering education programmes in developing countries [10,11] have shown that they are not ideally suited for industrial development aims and further, the academic's lack of practical exposure has resulted in a higher emphasis on theoretical knowledge, which is counter-productive considering the technology needs of developing countries.

2.3. Appropriate Production Management

Industrial surveys in developing countries [12] have shown that one of the major reasons for low industrial productivity is the low priority given to production management. Part of the difficulty arises from a shortage of personnel capable of performing these functions due to deficiencies in human resource planning. In addition, some of the industrial management problems in developing countries have been attributed recently [9,13] to the use of inappropriate production management concepts and techniques.

3. COMPUTER APPLICATIONS IN DEVELOPING COUNTRIES

3.1. Computer Aided Design/ Manufacture (CAD/ CAM)

One of the major computer applications in industries in developed countries has been in Computer Aided Design and Computer Aided Manufacture (CAD/CAM). The application possibilities and potential benefits of CAD/CAM have been well documented [14]. In developed countries the introduction of CAD/CAM has revolutionised manufacturing, where the computer plays a key role from the design stage to final manufacturing, which reduces overall costs and improves quality and efficiency.

Although this technology option is available, an important question to be asked is what is the cost involved in applying this technology and is this technology appropriate to the needs of smaller developing countries? To obtain a logical answer, one must look at the specific CAD/CAM application areas, the benefits obtained and the relevance to developing country needs. Computer Aided Design (CAD) is particularly beneficial in industries that require frequent design modifications and needing complex design procedures. On the other hand Computer Aided Manufacture (CAM), due to the high capital costs involved, is particularly

applicable to large volume precision manufacture where costly expert manual machining processes are taken over by the computer. Further factors to be considered in introducing CAD/CAM technology is the need to have a highly trained specialised engineering personnel, capable of maintaining the machinery and also the access to high capital resources to acquire the expensive machinery and equipment. Considering the industrial background in smaller developing countries, most of these pre-requisites for the application of CAD/CAM technology do not exist.

Industries in smaller developing countries tend to be import substitution industries, where design changes are not so frequent. Most product development and design modifications are carried out overseas, mainly by the technology supplier and hence the opportunities for Computer Aided Design does not arise. Industries in smaller developing countries largely produce goods for the local market and the volume of production is not high. Further, as indicated earlier due to the protected market situation, high precision production techniques for higher quality is not a ma or demand. In addition, the wage rates of all categories of staff including specialised skills are relatively low and hence, there are no significant cost advantages to be obtained by the application of Computer Aided Manufacture (CAM) in smaller developing countries. A more important question to be raised is whether developing countries have the necessary technology base to sustain this high-tech applications and further, considering the high unemployment and limited capital resources, should they opt for such technology?. The analysis of these related parameters indicate that CAD/CAM applications are not appropriate to the current needs of smaller developing countries.

3.2. Computer Aided Production Management (CAPM)

The other major application of computers in industry is in the area of Computer Aided Production Management (CAPM). Functions such as production planning, production control, inventory control, can be performed efficiently with the aid of computers. In the case of job scheduling and sequencing under multiple batch production situations, computerised production planning and control has definite advantages over manual techniques, considering the numerous alternative schedules possible and time constraints [15]. It has been discussed earlier that much of the industrialisation problems experienced in developing countries emanate from inadequate and improper production Management. It was also noted that due to deficiencies in the education policies adopted, smaller developing countries do not have sufficient number of qualified personnel capable of performing the production management tasks. Therefore, one can easily justify the need to promote the application of CAPM systems specifically in smaller developing countries.

Considering the small scale nature of the industries, much of the CAPM functions can be performed using a micro computer, provided the required software is developed. The price of micro computers have fallen over the years and they are within the capital investment reach of small industrialists. Application difficulties may arise from the computer vendor emphasis on promoting accounting applications in developing country industries and their lack of appreciation for the need to develop capm systems for small industries. Further, any attempts to modify the standard CAPM packages generated for use in developed countries, should take in to consideration the specific industrial environment in developing countries and the need to develop CAPM systems more appropriate to developing countries.

3.3. Training of Managers and Decision simulation

Computers can be effectively used in management education and training exercises. Specifically in the industrial management environment, computer generated training programmes can be used to generate the industrial management manpower needs for the future. In production planning and control under multiple batch production situations, the manager is confronted with a wide array of decision options, each option having a different resource utilisation impact on the industry. Computer based simulation models [15,16] can be utilised to train managers to undertake complex decision tasks. Without having to experiment on a real industrial situation, which may induce costly errors, the computer based simulation models can be used to expose the managers to hypothetical but very realistic decision situations. A series of computer

generated decision options can be presented to the manager and further, the actual impact of the selected decision can be simulated, so that the manager can immediately visualise the results of his/ her decisions and use the experience gained to improve the decision making capability.

Computer generated simulation models can also be used to identify policy decisions for the managers. Specially in multiple batch production situations, where it is extremely difficult to optimise work centre capacity utilisation by manual methods, a simulation model can assist the manager to plan work more efficiently. Management information can be obtained from the analysis of past work centre load patterns and decisions related to new investment on plant and machinery and the possibility of sub-contracting and modifying product lines to suit present capacity and the like can be made with better confidence. Simulation models can also be used to develop short term marketing policies to generate a profit maximising product mix [14,17].

3.4. Office Automation (OA)

One of the more wide scale application of computer technology recently in developed countries has been in the area of office automation. New generation of Personal computers are capable of taking over most small office functions such as accounts, billing, letter writing, inventory control, payroll and the like, and considering the low cost of the micro computers, a large scale shift towards office automation was experienced. The shift to office automation was in many ways justified in developed countries, particularly since a saving in the number of office support staff such as accounts clerks and office assistants could be reduced and at the same time efficiency improved. On the other hand, smaller developing countries have sufficient number of clerical and accounts staff capable of performing most of the typical office automation functions and the relative wage rates for these categories of staff are very low. Further, considering the high unemployment rates in developing countries and the low wage rates, there has not been a significant shift to office automation. Another contributory factor has been the capital constraints, since most smaller developing country economies lacked the capital to invest in computers for office automation work.

In spite of these developing country specific office environment, a certain degree of office automation has taken place and computer vendors promote office automation applications more than industrial applications. Even in industries where much more tangible benefits could have been obtained if the limited capital resources could have been diverted towards computerising industrial management functions, the available computers are usually used for pay roll and accounting work. Since it was stated earlier that smaller developing countries have sufficient number of manpower at relatively low cost to perform these accounts work, it is necessary to identify the reasons for this particular computer application pattern. There are two major reasons for this development. Foremost, as indicated earlier developing countries have neglected the significance of industrial management education and this vacuum is filled up by qualified accountants who take up senior management functions in industry. Since they are not aware of the potential additional benefits associated with computerised industrial management, they tend to apply the obtainable computer resources to their own area of speciality. The second reason arises from specific marketing policies adopted by computer vendors. Considering the large scale industrial organisations in developed countries, the development of industrial management software were generally limited to main frame and mini computer applications. On the other hand, industries in some developing countries were much smaller and they lacked the capital resources necessary to acquire mini and main frame computers. Further, even though it was possible to develop software for micro computers for certain industrial management functions, a conscious effort was not made by computer vendors to promote such software. In the area of accounting, software packages can be applied universally without major modifications. However, considering the different industry features from the production and management point of view, any standard CAPM package developed needs certain modifications to make the package work efficiently under different industry settings. Considering this additional software modifications needed and the additional time to be spent with the client in understanding the industrial set up and the small profit margins associated with micro computer sales, computer vendors concentrated more on accounting and office automation applications.

4. APPROPRIATE POLICIES

4.1. Identify Priority Computer Application Areas

It was highlighted earlier that many smaller developing countries do not have sufficient capital resources to satisfy all their computer investment needs. Therefore it is very important that the limited resources be applied to the most needed sector. The possible industrial application areas discussed earlier were CAD/CAM, CAPM, Office Automation and Management training. The applicability of CAD/CAM technology in smaller developing country industrial environment was discussed and conclusively decided that there are limited benefits to be gained by such technology at present. In the case of 'Office Automation' application possibilities, although there are marginal benefits, the availability of low cost office skills such as accounts clerks and the high unemployment rate, suggest that limited computer resources should first be allocated to other more important areas. The industrialisation problems in smaller developing countries were largely attributed to the negligence of the significance of industrial management, in-appropriate techniques used and a shortage of qualified industrial management personnel. Therefore, the obvious priority application area should be in computer aided production management (CAPM) with adequate provision for using the computer system for management training and simulation work.

4.2. Train Manpower & Develop Software

To pursue this policy of encouraging CAPM applications in industry, two necessary pre-requisite conditions must be satisfied. Sufficient number of computer personnel should be trained to support the computerisation needs and in addition, the industrial managers must be given adequate exposure on the benefits of CAPM and the various industry application possibilities. Further, for this policy to be successful there must be adequate and appropriate software available. As discussed earlier, considering the large and complex industries in developed countries, the computer industry concentrated on developing CAPM software for mini and main frame computers. Developing countries lack the capital resources to invest in mini computers and further, micro computers would be adequate for the CAPM needs of the much smaller scale industries in developing countries. Since there is a general shortage of micro computer based CAPM software and the computer industry itself has not taken a conscious effort to promote micro computer based CAPM applications, for this policy to be successful, the computer industry must develop suitable software and also change their overall marketing strategy.

4.3. Promote Awareness of CAPM benefits

A major pre-condition for the growth of computer applications in industry is the industry awareness of the potential benefits of computerisation. The shortage o1 computer-literate management personnel in most smaller developing countries and the computer industry negligence of the potential market for CAPM applications in developing countries have resulted in an information vacuum related to the potential CAPM benefits. The common developing country feature of accounting personnel heading key industry management positions and the computer industry promotion of accounting and office automation applications, has generated the feeling that the more important computer applications are in accounts and office automation.

Therefore, for the developing countries to benefit from the computer revolution, adequate policy measures must be adopted and promoted to inform both the developing country industries and the global computer industry of the potential benefits. In the case of the developing country industrial sector, adequate short term training courses, workshops and seminars must be held to increase the management awareness of the potential CAPM benefits and the associated computerisation cost and human resource development needs to sustain the new technology. At the same time, the computer industry must be informed of the potential market for CAPM applications in developing country industries and promote the development of appropriate software. The pursuance of both these policies will ensure that more and more industries in developing countries would adopt CAPM techniques, resulting in better industrial productivity and growth in developing countries as well as generating a totally new market for

computer vendors.

5. CONCLUSIONS

A major constraint responsible for the slow growth of computer applications in smaller developing countries has been the shortage of developed human resources capable of sustaining the computer technology acquired and the inability to divert a significant share of their limited capital resources towards purchasing computers. In this context, logically the limited resources should be diverted essentially to key application areas which would benefit the development aspirations of these nations. It was highlighted here that developing countries have embarked upon ambitious industrialisation programmes with the belief that industrialisation would alleviate unemployment, poverty and take them on the road to economic growth and prosperity. These aims and objectives have failed largely due to poor utilisation of resources arising from inadequate and improper industrial management.

The more developed countries have applied computers for major industrial sector functions such as CAD/CAM, CAPM and office automation applications. Considering the development aims, industrialisation problems, capital resource limitations, human resource short falls and the nature of industries established, it is only logical that computerisation efforts in smaller developing countries should be geared towards promoting the application of Computer Aided Production Management (CAPM) Systems. This application area would generate the maximum benefits. The paper also identified major policy efforts needed to promote the application of computers in the industry for CAPM work. The major policy guidelines proposed were the training of sufficient computer support staff and computer-literate management personnel, promoting the awareness of the potential benefits of CAPM among industries, and changing the computer vendor marketing policy in developing countries so that the vendors market micro computers for industrial management work, with adequate software packages developed. If these policy measures are adopted and promoted, smaller developing countries can benefit immensely from the available information technology and would also generate tangible benefits in the form of better industrial resource utilisation and the achievement of industrial development aims and objectives.

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END USER COMPUTING: POLICY LESSONS FOR DEVELOPMENT ADMINISTRATION

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Information technology diffusion in development administration requires a new policy concept both at the conceptual and practical level, for integrating microcomputers into administrative functions and obtaining gains from its application. Microcomputers have to be managed and not used and sustaining the change affects the dynamics of the administrative system. In this process the need for cross sectoral communication is critical. The role of the key institutional actors and the way they intervene is the fundamental issue.

1. INTRODUCTION

How microcomputers can best serve the needs of development administration is an important policy issue. There are several reasons for the neglect of information technology diffusion. Historically ministries have supported inventions through subsidies, rather than innovations which require demand for their application by those following a strategy of adoption. It is often ignored that the change is a complex non-linear process. Technical objectives can be specified more easily than organizational objectives and are more consonant with those who have technological rather than administrative backgrounds. It is also easier, both administratively and politically, to manage public funding for the supply of equipment than the demand for applications. The major barrier to effective diffusion is the unfamiliarity of administrators with the potential of microcomputers.

The availability of microcomputer does not ensure their quick adoption. Both macro and micro level policies influence the strategies of departments and diffusion involves more than the mere purchase of equipment. Most prescriptions on the policy issues are characterizations of how microcomputing "ought" to take place, because of the limited experience with end user computing. Microcomputers will affect structures, processes and people. In the resistance to change it is not apparent what is being resisted. In this paper a framework is suggested to manage these issues in a three step approach, requiring a specific role for the different actors. Unless end-users at all levels understand, for themselves, the dynamics of the change, microcomputers will remain as irrelevant devices.

The term "End-user" itself needs clarification. It is not limited to an administrator sitting before a screen and interacting directly with a microcomputer. No more than 10 - 15 % of senior executives in large american companies have microcomputers on their desks, and only half of them are using them properly; in 150 British companies that are particularly heavy users of information technology only one quarter of the managers themselves use screen based systems [6]. An audit of EDP in Government, in Sweden, found that only 10% of the personal computers were cost effective because a clear strategy for administrative development by the end users was not carried out [10]. The important role played by users in all technology management is only now being accepted [8]. The essential issue is not where the microcomputer is placed or even who programmes or operates it, but who is responsible for it.

Two institutional approaches are being followed by developing countries in determining their policy for initiating microcomputers. Most countries continue to rely on familiar models and techniques of development planning for designing national information plans, and create a specific government machinery for the purpose. A few others are giving cohesion to activities of different ministries to ensure consensus on certain strategic issues regarding information

standards, organizational relationships and creating the right attitudes in end users as preconditions for the use of microcomputers. The "few" are the successful ones; and, this paper will seek to.

2. FRAMEWORK FOR COMPUTERISATION

Governments, as the leading sector in developing countries, play a crucial role in initiating, promoting and organising the use of microcomputers. This role depends on the mechanisms chosen. Where the government intervenes directly the results are mixed. Where the government fosters a conducive environment, the results are more positive. The use of compulsory measures to advance computerisation needs to be carefully evaluated.

The familiar control oriented responses of Governments to a new idea, programme or project activity are inappropriate for microcomputer innovations. The usual initiative to set up a structural mechanism to give direction to policy, places more emphasis on controlling the acquisition of physical assets rather than managing the resource.

Procedural mechanisms for coordination, expenditure control orders issued by Finance Ministries, are also ineffective because of the nature of the processes involved; micro computers provide a service and not goods or savings. It is inappropriate to think in terms of a parallel "computer sector" of a developing country economy in the way one envisages an agricultural or energy sector.

Legislation has been suggested to substantiate micro computer policy with little success. In the USA the Brooks Act, 1963, and the Paper Work Reduction Act, 1980, divides the responsibility, in the federal government, for automatic data processing between three agencies - policy making (Office of management & budget) setting standards (National Bureau of Statistics) and procurement (General Services Agency). The Paperwork reduction Act gives OMB responsibility for developing guidelines in the way the Government handles all aspects of data: automatic data processing, telecommunications and paper records. These measures have not been able to provide the needed integration: studies of the Treasury, Federal Judiciary and Army Corps of Engineers in the USA, show a general lack of coordination in the acquisition of computers [7]. Legislation induced responses can hide or attenuate attitudes and behaviors that are much more difficult to change.

Development of capacities for microcomputer usage is also not a matter of replicating the institutions and approaches of the developed countries out of adapting them to the priorities and contextual characteristics of the developing countries. Their economic structure is characterised by mainly low value added activities, with some sophistication and diversification with the addition of new industries like chemicals and financial services. In the developed countries the emphasis is on high value added activities, like industrial electronics precision tools, telecommunications and consultancy services. Apart from the economic structure and diversification the education level of the workforce also differs greatly. Moreover, in developed countries computerisation came through mainframes, with emphasis on communication technology, and local capabilities were not developed. The issues before developing countries are not linking microcomputers to mainframe systems but dealing with stand alone micro´s which can communicate with one another, if required.

The central functions required are very different to the reasons usually given for the setting up of such agencies: that the applications cover a wide area which cannot be reviewed by a single department; overall modification of traditional routines of general administration are involved; and, reasons of economy of scale. The objectives for the setting up of the agencies for implementing policy initiatives for microcomputer use cover a much wider spectrum. Though there are problems common to several ministries which call for the same solution, each can go about solving it in its own way. This can lead to duplication, waste and inconsistency, if the change is not integrated into the administration as a whole.

The essential policy requirement of managing the transition, rather than providing the

equipment, has not yet been recognised as the most important national concern. Developed countries are only now appreciating this need, eg. the Swedish Agency for Administrative Development (Statskontoret) has brought out a purchase manual in 1986 decentralizing purchase decisions, within designated parameters, to end users. The breakthrough h in using microcomputers in administration in India has come late in 1987 with the decision of the Rural Development Department to determine parameters and allow District Officers to place their own orders. Within nine months micro´s are available in over three-quarters of the 439 districts of the country, and end users have begun experimenting with prototype applications. End user involvement must start with the analysis of information needs on, which the purchase decision should be based, and not the other way round.

Unfortunately, in most developing countries the reliance continues to be on a single ministry to be fully responsible for all matters related to microcomputer use. The limitations of this piece by piece approach are now becoming apparent. India modified in April 1988 the earlier policy of placing operational, regulation as well as purchase decisions with the Department of Electronics, by putting the responsibility for promoting computerization on the National Planning Commission as they are the main users of data in government.

The experience of Asian countries clearly shows that there is a reluctance on the part of governments to take decisive action. A framework has to be set up to influence key institutional actors and their promotional roles rather than a regulatory body or purchasing agency. In Japan, the Management and Coordination Agency, MCA, set up in 1983, carries out policies and common activities to encourage each ministry to promote its computerization - identifying major issues and discussing them in working groups. These policies include utilization, data bases and office automation [12]. Singapore´s National Computer Board has identified three major shared data bases concerning land, people and companies for long-run success and has avoided the duplication and divergence experienced by South Korea [1].

These experiences show that for developing countries, the current need is to have a national policy for setting central direction in three areas - analysis of information needs, developing integrated data bases, and support services. Otherwise, in the case of micro-computers, the usual motives for centralization are not valid and, in fact, need to be guarded against (Table 1).

Table 1

FRAMEWORK FOR COMPUTERIZATION

ISSUE	STRUCTURE	OBJECTIVE	ROLE
1. National Policy	Ministerial committee	Quantitative spread	Managing technological transition
2. Departmental coordination	Administrative body	Common data base	Organizational concerns
3. Continuing Support	Training Institute	Decision support system	Actor oriented strategies

3. INFORMATION NEEDS

Computer specialists are not able to draw the line between organizational computing, which focusses on priority setting, and end user computing, which focusses on problem solving. Three issues are already emerging. Firstly, there is overcontrol in the access to data. The earlier role of owning the data in MIS departments largely continues; because they still advise users, design systems and do consistency checks. Secondly, the need for interconnectivity standards is used to give approvals rather than indicate emerging possibilities. Thirdly, too much hand holding makes users dependent, without developing their ability to think analytically about the potential applications. Computer specialists have now to adopt a facilitative role and make the data processing needs of the end user easier.

One of the most difficult goals to attain is motivating the computer specialist to work with non-technical user groups. A study of 6000 computer professionals in the USA revealed that they have little need for social interaction, a great need for challenging work and find it difficult to work with managers [5]. Officers of the Indian Administrative Service attending computer training programmes also consistently complain that the power of the spreadsheet was shown on the micro without telling them that a popular package was being used, and simple questions about applications were answered with a standard - a programme will have to be developed - response. The result is that a number of administrators are developing their own, admittedly imperfect, applications disregarding the information professionals.

The government of Sri Lanka launched an Information Technology Application Project at Kalutara with ESCAP assistance, to develop a methodology for village level planning. Five years later the system is only handling pension payments, because this was the most pressing problem and an activity for which the flow of information could be easily achieved. The application has usual attitude of handing computerisation to the specialists and expecting no further involvement until it has been implemented. This often leads to disaster because these bodies have an interest in maintaining the status quo or at least a slow change.

The information analyst is generally a mainframe specialist and microcomputers are also new for him. Decentralised computing affects his importance in the organization and he continues to treat applications as technology driven rather than user - driven through standard software packages. The most popular software package in the Federal Government of the United States is Lotus 1-2-3 [11] but its use is still very limited in developing countries.

There are three requirements for end user computing:

- Reflect priorities of Government in economic and social development,
- Provide the ability to build horizontally integrated data bases,
- Effectively and efficiently use the resource for decisions.

Administrators alone can determine the first, computer specialists are needed for the second, and both have to work together for the third. This was the major recommendation of the task force on district level databases for decentralised planning set up by the department of science and technology, of the government of India. The national Planning Commission has now set up a study group to identify the information gap, with specialists and administrators, in an effort to determine an accepted data format for district planning.

Such exercises are important because administrative procedures also need to be streamlined as a step towards modernization and decentralisation. Since end users have over-lapping data needs, a precondition for success is to avoid over-information and to horizontally integrate the process of computerization by using an unique identifier in all files, so that data use does not remain limited to at function, project or department, and resources can be shared between organizations as well as the local and central government. The objective should be to identify the main functions requiring the use of general purpose software packages - DBMS, spread-sheet, wordprocessing - to ensure exchange of information between these tools.

This will require attention to three factors:

- Adoption of standards, methods and procedures.
- Developing queries, or decision requirements.
- Defining the role of the statistical reporting system.

Centralization of statistics is important for evolving a unified policy regarding methodology, collection and processing of information, and the main methodological approaches towards its analysis. These systems must be connected horizontally as well as vertically, facilitating timely collection, audit, multiple use of data, and mutual accessibility to the information.

Coordination of information generation and usage is essential in developing countries because of the scope and nature of planning decisions, related to different levels of planning, different types of plans, and their implementation. Strategic decisions also tend to be defined more clearly than needed on the operational level. The existing statistical systems describe aggregate conditions in the economy suited to the needs of decision-makers who are individual entrepreneurs rather than a central authority. A public administration information system has to be re-designed to provide the basis for decisions by state planners using microcomputers. Initiatives for such policy harmonization will require a political governing body.

4. DATA BASES

The organizational requirements for the use of microcomputers for decision-making has not yet been appreciated in developing countries, and they continue to concentrate on the technology. The reason is that their microcomputer applications have largely followed trends in the USA, where the impetus came form the finance department, and top management did not intervene in the process. Most of the activities of aid-agencies involving microcomputers in developing countries have also been focussed upon coordinating projects, maintaining inventory and distribution systems, budgeting, and processing a population census [4].

Micro computer development projects for the activities computerised generally have three major components: provision of expert services, supply of equipment, and training of local staff. As the impetus for computerization is from outside, applications are limited to low information intensity decisions and objectives involving internal operations without significant structural changes. Consequently they remain isolated projects; their evolution comes to a standstill after a few years.

Development Administration is not merely physical handling of records and correspondence - document processing, storage of data, retrieval of reports or timeliness of outputs - on the lines of the activities of US IRM managers, who use the resource rather than manage the technology but it has a behavioral aspect very different to Western corporate requirements. The user is also the community. This requires a distinct shift in perspectives on the part of the administration. Development administration

- looks at locational choices rather than performance of people,
- is concerned with linkages within the system rather than the functioning of an organization, and,
- the information intensity for decision making increases at the implementation rather than the policy end of the hierarchy.

Studies of municipal government in the USA also show a similar trend in data-based mode of use: searching specific facts, linking files, and developing meaningful patterns (Danziger and Kraemer, 1986). The essence of local level, or end user computing, is the shift from sectoral to spatial decisions.

There are three issues in the learning curve of such end user computing efforts in development administration. Firstly, the managerial context, determining the design of data structures for the development of common systems to realise benefits through economies of scale and standar-

dization of products and procedures. Secondly, the technical criteria for choice of software package, which will determine the implementation process and set clear goals. Thirdly, the effects on organizational arrangements, particularly on problems with data collections and developing new relationships, which need to be planned for. Experience shows that nearly two-thirds of the time and staff resources should be spent in analysis and design in the beginning rather than in the actual construction of the system. Data and technology have to support decision-making. The present ad-hoc measures for data collection and large volume transactions processing need to be converted into coherent policies.

The base of the system is the field level worker, who is collecting and recording data. When systems are oriented toward information generation rather information usage - not meeting recognised or felt needs - its collection and processing become unwelcome tasks to those who provide it only to others. It is important to have discussions between users and data collectors before the system is established. The completeness and accuracy of the reporting improves substantially with a participative approach.

Detailed requirement of data entry can lead to breakdowns in the system. Field staff already spend a disproportionate amount of time on record keeping, attendance at meetings and report writing. Computerisation should not add to their workload. Unless staff at all levels benefit, and understand the importance of the data they are collecting, the value and use of the information system will be negligible.

The conventional record based data collection system at the local, or field, level will usually need to be overhauled. This will entail defining minimum information needs; ensuring data quality and systematic flow of information; and, ensuring involvement in and feedback of the data collected. What decisions will be made with what data? What information is needed, from whom, over what time frame, and in what format? This becomes an importent and relevant question that is not usually asked. The present record forms show great diversity; their number, design and format do not facilitate efficient data processing. Duplicating manual systems does not reduce paperwork or increase efficiency. It has bees estimated in India, in the first meeting of the study group on the information gap, that changes in formats will reduce the number of required data by 50%. However, the development of a unified form consolidating key indicator information can take upto one year to prepare.

In addition to elimination of routine collection and processing of data, guidelines for analysis and presentation of information and formats for graphic presentation will need to be determined. A major improvement in the specification of objectives, targets and indicators is s prerequisite, to facilitate analysis and utilization rather that mere description.

Managing such a change to computerization in administration is a measure of organizational and administrative reform and requires positive attitude, particularly from key groups at the lower and middle level. The process includes a set of data, human resources, as well as procedures to collect, enter, retrieve and use data. The effects of the change on the middle level have been extensively studied; these show that the objective should be benefits to the end user. Consequently the choice of applications will need to facilitate service rather than better control. It is also vital to look at the concerns of the field level, and work with them as well as the clerks.

To provide for interagency coordination and interaction between professionals and users it is necessary to set up a nodal agency to decentralize information management along with planning, i.e. have a set of guidelines to increase useability of data, enable transfer of software applications and personnel from one project to another and, in this manner, help administrators new to the process.

5. SUPPORT SERVICES

The accelerating pace of technological change and time lags in reforming training systems make the task of the decision maker increasingly difficult. While aware of the importance of training,

it is usually not carried out beyond what is required to meet short term needs. Training institutions have to play a dual role to proved pressure as well as support.

The process of initiating microcomputers is an organizational, rather than a technological or a planning exercise. Familiarization is the key in bringing about more favorable attitudes towards micro computers among local level officials. Most have never even seen the equipment and mental preparation is needed to reduce the mystery and uncertainty. This has also been the experience in developed countries [2]. Informal networks can be profitably encouraged during training programmes which successfully later develop into user groups to share experiences, as in India and Nepal.

The curricula, recommended for public management education by the National Association of Schools of Public Affairs and Administration, in the USA, with three levels of computer literacy courses: involving appreciation, use and management; for the uninitiated, administrators who manipulate data and professionals who understand programming, respectively, is also the dominant model for developing countries [9]. Such training remains essentially technical skills oriented with either a continuing over emphasis on programming reflecting the needs of mainframe systems, or limited to merely providing a vocabulary and types on how to purchase equipment. The need is to remove resistance at all levels, provide exposure to practical problems and prepare individuals for successful interaction. A favorable attitude, and even leadership at the data entry level, is vital for husbanding support within the organization. This is also the experience in Kenya (Ministry, 1987).

Guiding principles:

Analysis of information needs
Investigation of data sources
Establishment of data collecting pathways
Specification of system
Identification of appropriate software
Selection of suitable hardware
Streamlining procedures for data management
Broadening the use of information

Judicious selection of priorities and applications is important. Development administration involves dynamic interaction between information, analytical models, and individual judgement, for problem solving. Availability of end-user oriented DBMS software packages and personal computers now equip administrators with powerful extension to their thought and action in resolving real-life problems. These decisions are often large and complex, demanding advanced skills from the decision-maker, which are scarce at the District level. Software packages, also, tend to stand between the decision-maker and his decision-making process, forcing unproductive digression in taking care of minor details involved in operating the package.

By requiring focal points, such as training institutes, to build decision support systems (DSS) it is possible to free the decision-maker from being preoccupied with detailed technicalities of packages, and even from the necessity of learning their advanced features. Decision Support Systems enable the decision-maker to have flexible and dynamic interaction with the underlying database and criteria relevant to his decision context through a menu driven unobtrusive dialogue system. The DSS developed at the Academy of Administration has three features which enhance the local capability of the district planner by providing support for the multiplicity of choices frequently required to be taken:

1. Determining decision requirements by developing standard queries. Most useful information is the result of multiple pairs of query-response, each response providing more input to an ever-refined query. The process acts as a stimulant to explore options until at "satis fying" level is reached. Many more combinations can be considered than would be possible in a manual system.

2. Building decision models for establishing relationships between data in different files as well as analysing it against predetermined criteria input into the computer. Demographic, land use, infrastructure and economic data needs to be integrated for analytical purposes, such as calculation of land/man ratios. These relationships can be stored for repeated use; commands can also be specified which will perform operations based on data values or entries. This is a desierable way of introducing flexibility and realism into plan, design and implementation.

3. Graphic presentation procedures and formats facilitate the use of quantitative information in databases as graphs and charts. Comparing different areas within the district have been found to be particularly useful. This facilitates greater local participation in the selection and use of indicators for taking spatial decisions of allocation and location.

The introduction of a DSS is itself a powerful motivator for change, because of its technical demands for clarity of thought and precise specification of procedures. To make microcomputers serve local development, by moving from sectoral and descriptive to spatial and village based analysis of information, only requires a knowledgeable end-user.

The key issue is an approach that focusses a large part of the responsibility on the individual. While top level administrators need to be convinced to initiate computerisation, the middle level needs continuing advice to manage the process. To provide problem solving skills, funds need to be allocated for regular in-service training to cover the entire development process of computerization. This will require mechanisms for experience sharing, updating know-how of users, information dissemination and assistance. The objective of developing a knowledgeable end user for analysis of specific administrative problems, who can be assigned responsibility for managing the process, has been effectively done in Singapore, and is also being implemented in India, with encouraging results.

6. CONCLUSION

There are three policy issues to enable interagency coordination for regular use of microcomputers in development administration:

- A strong political cross-sectoral governing body at the national level to establish the strategic direction, and to give effect to the design requirements,
- A separate administrative committee to anticipate and settle the internal issues in implementation which cross intra-departmental boundaries, for managing data as part of the administrative function, just like resources, material and personnel,
- A focal point to support administrators to use microcomputers in decision making, by developing prototype applications from available general packages and creating synergy among a broad array of actors.

The policy for using micro computers in development administration should aim to integrate users working in different departments and levels through a data base of information, rather than create a separate computer sector like the industry or energy sector. The major strategic issue is to create the institutional framework to specifically look at these organizational concerns, organization and information flows, which are closely related. Administrators will have to play a leading role in this process because the expertise needed concerns the decision situation rather than technology. The critical success factor for successfully introducing microcomputers in developing countries will be better use of the resource of knowledgeable end-users.

STRATEGIC ISSUES: COUNTRY STUDIES

COUNTRY		INITIATION POLICY	ROLE	IMPLEMEN-TATION	RESULTS
1. Bangla desh	1983	National Computer: Committee headed by a Cabinet Minister	Acqui-sition	National Computer Board (proposed)	Low
2. China	1984	Leading Group for the promotion of electronics Industry: headed by a Vice Premier	Acquis-tion, personnel, coordination	State Planning Copmmission in Science and Technology	High
3. India	1988	Planning Commission	Opera-tions, develop-ment	National Informa-tics Centre	Mixed
4. Japan	1983	Management and Coordinating Agency	Promo-tion, utilization of data	Inter-minis-terial Council of Director Generals In charge of Govern-mental Information Systems of Ministeries	Very High
5. Malaysia	1985	National Data Processing Committee; chaired by a Minister in PM´s depart-ment	Acquisi-sion, technical operations, training		Mixed
6. Philippines	1983	National Computer Centre	Acquisi-tion	National Informa-tion Technical Board (Proposed)	Low

STRATEGIC ISSUES: COUNTRY STUDIES (CONT'D)

COUNTRY		INITIATION POLICY	ROLE	IMPLEMEN-TATION	RESULTS
7. Singapore	1980	Committee on national computeri-zation	Software development. training	National Computer Board	High
8. Sri-Lanka	1984	Computer & Informaion Technology Council	Acquisition, training operations	Working Committees for technical opreations	Mixed
9. Thailand	1974	National Computer Committee headed by a Minister in PM´s office	Acquisition	Budget Bureau	Low

* Source: Trends in IT Application in Asian Government Systems, Asia & Pacific Development Centre.

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COMPUTER-BASED INFORMATION SYSTEMS AND MODERNIZATION OF PUBLIC ADMINISTRATION IN DEVELOPING COUNTRIES

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Computer-based information systems are often considered as means to raise inefficiencies from public bureaucracies in developing countries, i.e. to modernize them. However, the development of computer-based information systems in public institutions is not merely a technical task but an intervention which introduces many socio-organizational changes; the resulting effects depend on the social reality which sustains the particular public administration system as well as the potential of information technology.

This paper examines the prevailing characteristics of public institutions and their environment in developing countries and traces some factors which constrain the development of computer-based information systems. Moreover, it argues that the objective of introducing administrative rationality by means of computer-based information systems is unrealistic. Such an objective leads to requirements for radical changes, which amount to transformation, beyond the abilities of information systems specialists to plan and control.

1. INTRODUCTION

The literature on computers in developing countries traces a number of problems which prohibit such countries to benefit from the potential of information technology: severe shortages in foreign exchange which limit the imports of hardware and software, lack of computer skills, lack of technical infrastructure, inadequate maintenance support from the manufacturers of computers, to mention some of the most frequently listed problems [1].

While these are undeniably prohibitive factors, the development of computer-based information systems in developing countries is also hindered by organizational and cultural factors. Such factors have been inadequately addressed in information systems projects in developing countries.

In industrialized countries with widespread application of information technology the importance of organizational and social characteristics of information systems is now recognized in both research and practice [2,3]. The main benefits of introducing computer-based information systems are not expected to accrue from the efficiency of technology only but from re-organizing effectively work and decision processes with the support of information technology. So far as an organization relies on humans a computer system should be viewed as being only part of its information system. A computer-based information system is always complemented by manual procedures as well as informal ways of communication and action developed by the personnel [4]. Therefore, the effectiveness of a computer-based information system can only be considered within its broader organizational context.

Thus the development of information systems often follows methodologies which guide an intervention for organizational changes far beyond the development of a new technical system. For example, in the U.K., the socio-technical approach guides the design of a new computer system simultaneously with the redesign of job roles and procedures so that the final system is technically efficient and also effective through a satisfying work environment [5, 6]. There are

also methods, like the Soft Systems Methodology, aiming at the achievement of consensus on plans for actions in cases where organizational problems make difficult to decide upon appropriate changes of information systems or to foresee the potential effects of proposed computer-based information systems [7]. Thus, the application of the technology is placed within a much broader effort to improve the functioning of an organization.

As each organization is a unique case, effective interventions require careful analysis of the particular organizational circumstances, such as existing procedures, norms, attitudes, relations, etc. Nevertheless such analysis is always done on the basis of some general understanding of the nature of organizations and human behavior within them. In developing countries the organizational context of information systems is often substantially different from that in industrialized countries. Models of organizations and experience of intervention for change which prove useful in the industrialized world are not directly transferable to developing countries. According to models or theories that describe organizations in industrialized countries public administration institutions in developing countries often appear only as inefficiently or irrationally functioning enterprises. Without better understanding of their functioning, their dynamics, and the causes of their inefficiencies, any modernizing intervention - such as the design of a computer-based information system usually is - becomes a precarious task. Systems analysts' implicit assumptions on organizational behavior, desirable changes and ways to implement them may be inappropriate for an organization in a developing country.

This paper examines public bureaucracies in developing countries and juxtaposes their most common characteristics with the nature of the computer-based information systems development process.

2. PUBLIC ADMINISTRATION IN DEVELOPING COUNTRIES

Any attempt to generalize in studies concerning developing countries faces the problem of the enormous differences among them. Thus, developing countries are, in general, characterized by a wide range of attributes, like poverty, gross disparities in income distribution, high level of inflation, high birth-rate and over-population, poorly developed financial, administrative and political institutions, significant non-wage farming sector, permanent high levels of unemployment or underemployment, etc. Nevertheless, the group of developing countries includes countries as different (in resources, population, history, culture, religion, prevailing ideology and many other factors) as, for example, Brazil and Burma.

In particular, public administration in developing countries has significant diversities. Nevertheless in comparative studies of public administration the administration of developing countries is usually classified as one category characterized by a number of common patterns most of which are perceived as problematic - and the common function of pursuing national development [8].

However, underdevelopment can be better understood as a relationship of dependence within the world economy. Indeed, public administration in most developing countries is imitative rather than indigenous. It has been shaped under conditions of domination from outside centres (under colonial regimes or under the influence of 'protecting' super-powers) rather than being the creation of the countries' political forces. Heady (ibid), comparing between public administration of developed and developing countries, writes:

> "A country that was formerly a colony almost certainly will resemble the parent administratively, even though independence was forcibly won and political apron strings have been cut.... Of course some countries have been more fortunate than others, depending on whether the colonial power was distinguished or otherwise for its skills in administration, and whether or not it systematically undertook to tutor its colonials in these skills."

Colonial administration was established to serve the colonial economy and was a version of the

administration of the metropolis. Inevitably it reflected the values of the industrial states of the nineteenth century which, in most cases, were totally different from those of the traditional societies and caused social disruption. For example, MacPherson [9], in an examination of the nature of colonial welfare institutions, writes:

> "... the entry of colonial administration, and especially the colonial economy, came into direct conflict with a pattern of social relations which put primary emphasis on group responsibility for welfare, patterns of obligation and reciprocity and acknowledgement of social value regardless of material criteria."

MacPherson argues that as the balance of social life according to the values of pre-existing communities was disrupted, the imperatives of economic development, oriented to metropolitan interests, determined the nature of organized welfare, i.e. the kind and extent of services like health, education and housing provided and the features of the emerging public institutions. With few exceptions, the services were minimal, as the resources made available were very small and the institutions were essentially designed for control and the downward transmission of policies formulated elsewhere. They were highly bureaucratized and extremely centralized, based on an authoritarian legal system and staffed almost entirely from the metropolitan countries. Similarly Heady concludes:

> "The colonial administrative heritage includes one incidental feature that has lasting effects. The colonial version of British, French, or other system of administration was suited to the requirements of colonial government rather than government at home. It was more elitist, more authoritarian, more allof, more paternalistic. Remnants of these bureaucratic traits have inevitably carried over to the successor bureaucracies in the new states."

After national 'independence', public administration has taken a significant and highly political role - that of planning and implementation of the development process. Heady writes that administration in newly independent countries had two main general goals to achieve: nation-building and socio-economic development. As the boundaries of most developing states were drawn by imperial powers without regard to ethnic groupings, excluding people with close cultural ties and including minority groups opposed to assimilation, the achievement of nationhood became a thorny issue which marked both politics and administration. At the same time the existing institutions, organized to serve colonial purposes, had to undertake a task as difficult as the pursue of socio-economic development under external financial and technological dependency. Thus, not surprisingly, public administration in most developing countries is political, with many elements that seem irrational - inefficient versions of western type bureaucracies.

The most common patterns attributed to the public administration of developing countries are described by Heady as:

- *Shortage in trained administrators* with management capacity, developmental skills and technical competence.

- *Orientations other than production-directed.* As in many cases the values of industrial societies have only superficially substituted those of the traditional societies, there are deviances from the bureaucratic model like status based on ascription rather than achievement, or recruitment and promotion according to loyalty rather than merit. But there are often more dysfunctional characteristics like corruption ranging from payments to petty officials for speeding a minor transaction to bribes of impressive dimensions, clientellism (i..e. use of political influence and provision of preferential treatment to further personal and party political interests), or maintaining a surplus of public employees to relieve the problem of unemployment.

- *Formalism, meaning widespread discrepancy between form and reality.* Extensive formalization of administrative procedures, regulation and political management are often in practice bypassed informally and quietly while there is an urge to make things seem more as they

presumably ought to be rather than what they really are.

- *Imbalance between policy-making institutions and policy-implementing structures.* In theory there is an agreement transcending differences of political ideology that bureaucracy should have a strictly instrumental role, uninvolved to political processes. In many developing countries civil servants have considerable expertise and prestige and play a highly political role.

Bishop and Meszaros [10] in their comparison between four European and four developing countries - Nigeria, Egypt, Tanzania and Chile - report similar characteristics of the public administration of the latter and conclude that despite their importance in achieving policy goals they lack professional standards, and resources; they are inefficient and ineffective.

3. COMPUTER APPLICATIONS IN PUBLIC ADMINISTRATION

Public bureaucracies were among the first organizations which introduced computers in developing countries. Hamelink [11] reports that according to a survey by the Intergovernmental Bureau for Informatics (IBI) in 1978, out of a sample of 43 developing countries 34 had 'imperative' or 'incitement' policies for the utilization of informatics in public administration. Typical applications include statistics, accounting tasks and pay-roll, data handling for social security and collection of taxes. Computers have also been applied to support development planning; they are used to store censuses data and analyse them with statistical and forecasting packages. More recently there are attempts to co-ordinate development efforts by integrating data systems at a national level: national information systems [12].

It seems obvious that information technology can support the functioning of bureaucracies. It provides efficient means for massive transaction processing on the basis of regulations and fits perfectly in organizational systems which are meant to function impersonally by following rules. Indeed, the most common applications are of this kind: 'automation' of manual, rulebased procedures. What is not so obvious is that computer-based information systems which reinforce the formal bureaucratic rationality of law and order can raise the endemic inefficiencies of bureaucracies, particularly in developing countries where deviances from the ideal bureaucratic model are very significant. By building a system according to the regulations governing a bureaucracy one may damage mechanisms which are essential for the functions of an organization, like the discretion exercised by civil servants or informal aspects of team work.

However, information technology projects aiming at introducing a different kind of rationality in public administration organizations are much more challenging for information systems experts. This is the administrative rationality [13] according to which decisions are taken by systematically discovering and selecting satisfactory alternatives rather than by following and legitimising regulations. Administrative rationality and the discipline of information systems share the same philosophical and scientific roots. Their genesis has coincided and the evolution of one has influenced the progress of the other. It is common in designing information systems to incorporate techniques for problem solving, controlling, optimizing, predicting, planning, etc. which originated in Operational Research, Management Science, Formal logics, i.e. 'rational' scientific models of reality. Thus, computer-based information systems are often considered as means for modernizing traditional public bureaucracies, i.e. increasing their productivity by the application of science.

However the application of information technology as means of modernization has little chance to succeed. The development of computer-based information systems that introduce new, effective ways of functioning is a demanding task beyond the capacity of many public administration institutions. Basic aspects of the information systems development process are incompatible with the prevailing features of organizations as outlined above.

Schware's report on computerization in Burma is an example indicating how more difficult it is to introduce systems for managerial purposes rather than data processing [14]. Many developing countries have been using data processing systems which include software built by

computer manufacturers or software houses in industrialized countries. Although such systems are not without problems, it could be claimed that more sophisticated or flexible software can meet particular requirements. Schware reports that the payroll system available by the manufacturers of a system installed in the Telecommunications Corporation of Burma, one of the few computer systems of this country, had a very limited number of fields for standard deductions, while that organization's payroll has nearly a dozen deductions. Such a problem could perhaps be overcome by installing a more flexible package. However the same author finds that the difficulties are much more serious in applying computers for supporting decision making tasks:

> "In a relatively isolated country like Burma, the shift from the day-to-day paper work processing functions to applying the computer to deeper and better analysis for monitoring an organization's progress will not "just happen"."

The design and implementation of a new information system, (i.e. both a computer-based component and the necessary socio-organizational changes) requires an ability to search for solutions to perceived problems and steer changes in the organization accordingly. This ability is often too limited in public administration institutions in developing countries as such projects are likely to face the following obstacles.

- *Inadequate scientific, managerial and technological support.* It is well known that poor technological infrastructure and scarcity of computer technology skills characterize developing countries, with few notable exceptions, like India. Similarly systems analysis and project management expertise is limited and it is usually imported either in the form of employing expatriate experts or by training local personnel in methods practiced in industrialized countries. The choice or synthesis of suitable methods for information systems development projects is in general considered of crucial importance and it is a particularly demanding task which requires deep understanding of both the socio/organizational environment and the system under development. Lack of indigenous skills has the risk of a poor match between a systems analyst's approach and managerial style with an organization's culture.

The successful design of an information system depends also on the availability of a number of other technical and scientific skills. In order to design effective changes systems analysts rely on the co-operation with experts in subject areas such as Administration, Finance, Operational Research. To the extent that such skills are not available the difficulties to steer the modernization process and the risk to develop a non-usable system by transplanting foreign models increase.

- *The formalistic environment hinders requirements analysis efforts.* In cases of strict formalities covering a substantially different reality of informal behavior, or where political behavior takes place under the cover of a formal bureaucracy or where gross dysfunctions like corruption exist, the necessary investigation of organizational affairs to determine the needs for change is a task beyond the capacity of most systems analysts.

Of course some information systems experts recognize the significance of irrational, informal elements of human behavior in organizations and have written about the political nature of the information systems development task [15]. However almost all approaches at present presuppose a predominantly rationally functioning organization. For example the choice of a proposed new system is most often decided by measurement-based techniques like cost-benefit analysis or utility analysis. Even where political aspects are acknowledged it is assumed that they can be understood and handled [16]. It is believed that conflicts in requirements can be revealed and negotiated. The approaches which are most sensitive to organizational issues suggest also a consensus attitude to deciding organizational changes, in line with the democratic ethos that western societies value [17]. Thus they require the active involvement of those who will be affected by the changes (users). User participation however becomes ineffective when employees are not motivated by a genuine interest to contribute to the changes under development.

The information systems literature suggests that, in general, information technology offers

powerful means for increasing further the effectiveness of organizations which have already effective work practices and management. However, as Strassmann [18] writes, "A bad strategic situation cannot be corrected by automating it". It is also recognized that the design of new technology systems has to be accompanied by extensive re-organization in order to fulfil objectives of organizational effectiveness. In the case of public administration in developing countries the socio-organizational changes required for the effective use of information technology are radical. Some of them may be:

- Changes in key positions, so that their holders are facilitators rather than barriers to the desirable reforms.

- An extensive education program which both legitimates the new rationality and produces the skills required to introduce and support it.

- Familiarization of the employees with the new organizational behavior, incentives for a productivity orientation.

- Changes of the legal framework governing the institution. Simplification of inter and intra institutional bureaucratic procedures, in cases where public administration is so tightly integrated that decision taking is complicated and the authorization for actions delayed.

Such deep administrative changes are mostly political. As Nef and Dwivedi [19] write:

> "A general development policy, as well as a policy of administrative development, entails a series of political choices. These are eminently value-laden and conflictual, resting ultimately upon legitimation and enforcement by state authority."

Obviously, such a process is beyond the capacity of systems analysts or other information systems experts to steer. They have neither the necessary knowledge nor the required authority. Similarly, expatriate consultants on technical and organizational subjects can have only a limited, although very important, role to the transformation process. They may contribute technological and scientific knowledge but most probably their understanding of socio-political factors is inadequate.

If computer-based information systems projects are to contribute to the elimination of dysfunctional characteristics of public administration, they should be part of a long program of farreaching reforms. Political issues should not be considered as an annoyance to technological progress but as the most significant aspects of a socio-organizational transformation process which science and technology may be called to support.

It is also important that in designing and implementing new information systems attention is given to establishing a transition and learning process as well as producing immediate effects. Information systems are not static constructs and their computer-based components will have to be redesigned as organizational and technological changes render them obsolete. Thus building the capacity in an organization to improve its computer-based information systems is significant if a non-ephemeral change is to take place. Technology transfer, a crucial issue for modernization, is achieved when indigenous capacity for independent development of the technology is acquired.

Finally, in cases where the technology is introduced with the catalytic role to support organizational reform, the evaluation of computer-based information systems should include the assessment of success according to the driving administrative concerns. Evaluation practices established in industrialized countries most probably will prove inadequate for such a task. So far research and practice in Information Systems concentrates in tools and techniques for the evaluation of efficiency and effectiveness, and relatively little attention has been given to other organizational effects like rationalization.

4. CONCLUSIONS

The importance of public administration in developing countries cannot be over-emphasized: public administration bears the main responsibility for planning and implementing socio/economic development. Yet, in most countries government institutions are caught in the middle of a conflict between traditional and modern organizational behavior which has impaired their effectiveness and led to problematic dysfunctions. Setting aside a value judgement on the merit of modernization, this paper examined the possibility of advancing it by introducing computer-based information systems. It argued that the development of computerbased information systems in order to introduce administrative rationality in public bureaucracies in many developing countries cannot succeed, unless such projects are incorporated in programs of far-reaching reforms.

Under the conditions which prevail in public administration institutions in developing countries, information systems projects aiming to introduce and support a new rationality cause a snowball effect to requirements for other changes in the organization; the intervention amounts to organizational transformation rather than modernization.

As far as such an information system change does not take place as part of a transformation program, there are two possibilities:

- A information systems project may be cancelled through frustration or lack of support and resources, or

- The new system development project is assimilated to the institution's established way of functioning. While the systems development process concentrates on the analysis of the details of formal procedures, usually neglecting the real dynamics of the informal aspects of the organization, the new system may be considered a significant instrument of political functioning. It may provide the means for power gains to certain administrators while it is seen as threatening some established positions. The operations of the new information system may well continue to be driven by political rather than rational behavior.

If the administrators do not appreciate the need of taking decisions by applying scientific models and techniques on collected data, and if they do not attach real value in the use of the scientific techniques incorporated in a new information system, most probably it will be misused. If decisions and plans made by such 'rational' methods are overruled by superiors who act according to their political criteria, the modernization objective is not realized. Finally if the personnel cannot implement a plan made by scientific means the new system has no practical effect.

The introduction of information technology in a bureaucracy does not necessarily speed up evolution towards modernity. Effective use of information technology in public administration institutions requires self-reliant problem-solving capability. Thus, in many developing countries effective computer-based information systems can only be developed within an extensive program of actions for administrative reform.

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FOURTH GENERATION LANGUAGES (4GLs) AND THE INDIAN SOFTWARE INDUSTRY

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Use of fourth generation programming languages (4GLs) is relatively new to India but it is increasing and, since 4GLs are rather different from software tools that have gone before, this has some important implications. This paper looks firstly at definitions of 4GLs, and examines the wider implications of the microlevel benefits which are reportedly associated with 4GLs. It takes both generalisable features from US and UK surveys and those specific to India garnered from a short survey of Indian software companies. It makes an assessment of some of the constraints on using 4GLs and some of the drives behind use of 4GLs. Finally, it examines current software policy in the light of these findings.

1. INTRODUCTION

Fourth generation programming languages (4GLs) can be used in a variety of software development activities but, in India, 4GLs are used almost exclusively on export-related work. Patel [15] notes of one-off, customer-specific software development that 'Virtually all our current software export earnings are from this kind of activity'. Therefore, use of 4GLs by software houses for export customisation contracts and the implications for export-related issues form the main focus of this paper. Before investigating these issues, however, it is necessary to consider what 4GLs are.

2. DEFINITIONS OF 4GLs

Fourth generation languages are software tools used on a computer to develop and produce other software. They have followed on from their first generation (machine code), second generation (assembler languages), and third generation (COBOL, BASIC, etc) predecessors. However, while in many respects the progression from 1 st to 2nd to 3rd generations can be seen as relatively linear and basically concerned with making the 'words' (i.e. commands) of those languages represent more complex and powerful computer instructions, the developments and differences between the 3rd and 4th generations have branched out in a wide variety of directions.

Some overriding factors do seem to be agreed upon, one of which is that most 4GLs represent a further move from the procedural to the declarative. That is to say, when using a 4GL, we tend to specify more *what* we want the computer to do rather than exactly *how* we want the computer to carry this out, the 'how' part being left to the internal workings of the language. Because 4GLs therefore require software developers (programmers, system designers, etc) to use fewer commands to complete a given task, fourth generation languages can also be said to represent a replacement of labour by capital.

All 4GLs are not alike in their functions, and Jones [11] outlines a simple classification, using four main categories:

1. Integrated development tools - these 'are 4GLs which have grown out of a proprietary database manager. They are often bundled in with a database, although they can usually be bought separately. They aim to support programmers, not end users'.

2. Database-independent 4GLs - these are 'not associated with any particular database. They too are meant for programmers'.

3. Applications generators - which 'differ in one fundamental way from most other 4GLs: they generate code and machine calls rather than final machine code. This code then needs to be compiled. All 4GLs in this category are database-independent'.

4. Information centre products - which could also be termed information generators because they are aimed at end users. '4GLs of this type are nonprocedural, have high-level commands and extensive default options, and don't presume that a user knows anything about programming. The user "writes" a program by filling in the blanks on a series of menus, and out comes the application'.

This categorisation is by no means flawless but it does provide a 'quick and dirty' guide to 4GLs. From it one can see, for example, that the 4GLs used in the Indian software industry fall mainly into the first category.

A word must be said here about the dBase family (dBase II, dBase III, dBase III+, etc). These are database management programs for microcomputer with which many users are familiar. It is probably fair to say that although these are regarded as being technically within the definition of a 4GL, they are not commonly thought of as 4GLs. Certainly, inclusion of dBase in this category and discussion would produce some very strange results, e.g. that 4GLs are owned by more users than any other programming language in India, or that India has more 4GL programmers than any other type. A separate paper could be devoted to the impact of dBase and, in general, while it will be mentioned, the focus of this paper is more on minicomputer and mainframe software tools.

3. REVIEW OF IMPACTS ASSOCIATED WITH 4GLs

Jones' categorisation, although useful, still tells us relatively little about the intentions and objectives behind the use of 4GLs. However, Martin [14, p.15] outlines what he sees as some of the basic principles behind the creation of 4GLs, and these will be reviewed in greater detail. A number of impacts on work have come to be associated with 4GLs and these are generally seen as arising at least in part from the principles that underlie 4GLs, although one should not claim that they always and necessarily arise from some intrinsic technological aspect within 4GLs. The actual impact of 4GLs will be mediated by the social and organisational environment into which they are introduced.

3.1. *The principle of minimum work*

- the desire to put computers to work with the minimum effort.

This can also be described as the desire for greater productivity in the production of software. One of the main reasons underlying this desire is the perception of a software backlog - the large number of software systems which are waiting to be undertaken, but cannot because there are insufficient resources (normally of the human kind). Thomas [21] notes that 'the number of programmers cannot be increased to match the growth in the number and power of computer systems. Programmer productivity has to be increased instead - hence the need for high productivity languages'.

There are plenty of examples within the press and the literature which highlight the productivity improvements associated with 4GLs. For example, results of the 1988 4GL Grand Prix indicated 'that, overall, COBOL development is slower by a factor of nearly 10 than an efficient 4GL' [19]. Schofield [17] quotes the example of a grocery distribution firm which, in 1980, took three years to produce a system. In 1984 production of a similar system using the 4GL Linc was the work of two people working for two weeks only, giving an expected 80% saving on programming time and 95% maintenance overheads saving. In summary, Comes [5] states that 4GLs are 'of proven worth in cutting the time and cost of developing new systems by a factor of at least two or three, and reducing the cost of subsequent maintenance by even more'.

Figures often vary depending on the number of stages in the software development lifecycle (analysis - design - coding - testing - maintenance) that are taken into account. Improvements in the productivity of coding are the figures most frequently cited in connection with 4GLs, but it does appear that the new languages can be more productive across a wider range of tasks. For example, as noted above, 4GLs can dramatically reduce maintenance time costs. Similarly, 4GLs can also have effects further 'upstream' in the software lifecycle. They can reduce design time because an error in the system specification is no longer 'fatal' at the programming stage and because of 4GLs' applicability to prototyping. Having said this, the main potential impact of 4GLs is on the later stages of coding and maintenance.

By being more productive, 4GLs can reduce the amount of labour input required in the software development process. However, this decrease in the labour-intensity of software production may have a negative impact on the low labour cost advantage that India currently enjoys.

3.1.1. Low labour cost advantage

A simple calculation will serve to indicate the problems of reducing the labour-intensity of software development work in India. There are no definitive figures on software costs, and what figures there are tend to vary quite widely. Therefore, the calculation should be viewed merely as a very broad indicator of trends - it is not intended to be accurate.

Kumar [13] estimates that normal software development costs split 9:1 between labour and other costs in the West. One may then compare this with a situation in which the labour element falls to 75% of total cost through the use of more productive techniques, such as 4GLs. These figures can be used to calculate the relative competitiveness of Indian software costs compared to those in the US, based on Kumar's assertion that labour costs in India are one-tenth of those in the US, but that other costs (e.g. hardware) are twice as expensive. In this imaginary example, dollars are used as the units.

	90% labour cost		75% labour cost	
	US	India	US	India
Labour costs	$90	$9	$75	$7.5
Other costs	$10	$20	$25	$50
Total	$100	$29	$100	$57.5

In this calculation, a move from more labour-intensive production (90% labour) to the less labour-intensive situation (75% labour) roughly halves the international competitiveness of the Indian industry. Of course, this example is likely to be inaccurate and is very simplistic, taking no account of other factors such as overall hours worked, productivity, and qualitative aspects. However, whatever the actual figures, the calculation does point to a worsening of India's competitive position when trying to compete using more automated, less labour-intensive methods, unless other factors change. One should note, though, that although India's comparative cost advantage is reduced, it is not reversed - in this example, it is still cheaper to produce in India than in the US and, in absolute terms, the use of labour-saving technology may reduce the actual cost of a project.

There is another element currently operating in India's favour. In the West, wages seem to be rising for 4GL specialists, because demand is greater than supply. For example, Computing [4] reports that 'ICL's QuickBuild fourth generation language is proving a happy hunting ground for programmers and analysts who can command salaries of £35,000 a year after only six months' experience'. Those with about three years' commercial experience may get over £50,000 per annum. Such salary figures are more than double what an equivalent 3GL software developer would get. Demand is so much greater than supply because 4GLs are

relatively new and because there are no standard 4GLs, so that finding someone with skills in the 4GL you want has a high premium attached to it.

By contrast, the major firms in India all stated that there were no pay differentials between those staff using 4GLs and those using other languages. Stated reasons for this were the current low level of demand for 4GL skills, and that many staff tend to be generalists rather than 4GL specialists. In other words, 4GL experience is only one skill among a range, so much less of a premium is put on it. This situation therefore offers India an increased cost advantage when compared to software development using 4GLs in the West.

3.1.2. Jobs

If 4GLs are more productive than previous software tools this should mean that costs and/or time required for production are reduced, but this will also mean that for a given output of software, less labour should be required. If this led to job losses within a country's software industry, that would be seen as a problem since software has always been regarded as an area which may 'mop up' jobs lost in other industries which have been automated.

There is an awareness of the job loss danger within the software industry - '3GLs provide DP (data processing) people with what Kinloch described as "a job for life" and 4GLs do not'. Once a 3GL system is created, work can continue in maintaining it, whereas 'when a 4GL the system is finished the DP man "has no secure home to go to."[17]. Such possibilities are being seen in practice and the latest UK Price Waterhouse/Computing survey [16] reports 'DP managers are hoping that switching to these high productivity tools will lead to small, but significant, savings on the number of staff they have to employ'.

Having said this, there also seems to be general agreement that the impact of 4GLs on jobs is still relatively small and that for the foreseeable future the gap between demand and supply for software development labour will continue. A recent US Department of Defense study [18] concluded:

> "The demand for software is increasing at an annual rate of 12%, but the number of expert software professionals is growing at only 4% annually. Present software productivity tools boost the resource growth rate by only 4%, leaving a 4% annual shortfall that will amount to a shortage of as many as one million software developers by 1990."

As far as India is concerned, there are no very accurate guides to employment in the software industry, but from figures given in the CEI Export Strategy Paper [3, p.7-8], one may make a guesstimate of around 15,000 computer professionals employed overall, with around 2500 engaged in software exports [8]. One may conclude that even if some of the more pessimistic predictions about 4GLs come true, there are not likely to be massive redundancies in India. It appears more likely that the pattern in India will be similar to that in the West. Hence, if any effect were to be seen, it would be more likely to create a rather gentler upward slope on the demand curve than has previously been predicted. This would be beneficial rather than harmful to India, at least in the medium term.

However, while the demand-supply gap is likely to remain, its skill profile may be altering partly because of the effect of 4GLs.

3.2. The principle of minimum skill

- the desire to put computers to work as easily as possible, avoiding esoteric training if possible so that the maximum cross section of the public can employ computers.

According to this principle, one would expect to see a much greater range of people taking on coding-type work and, indeed, the 4GLs defined by Jones' 'information centre products' category (see above) are turning end users, albeit unwittingly, into programmers. Such a possibility ought to be of great benefit to India, which itself is suffering a skills shortage in computer professionals estimated to rise to several thousands by the start of the 1990s.

However, as noted above, the commonly observed impact of 4GLs is not equal across all stages of the software development process. They usually necessitate less time being spent on coding and maintenance work, but this reduction in time spent on later stages in the software lifecycle therefore places greater emphasis on the earlier stages. By thus altering the balance between the relatively less skilled activities of coding and testing, and the relatively more skilled activities of analysis and design, 4GLs, though they may be based on a principle of minimum skill, will actually cause an average upskilling of software development. Therefore, the work of the software developers using 4GLs is subject to a changing skill profile in which proportionately more time is spent on the more complex (and scarcer) skills of analysis, design, and telling the computer what to do, and proportionately less time is spent on the simpler skills involved in the minutiae of telling the computer how to do the job.

India has based its hopes largely on an ability to harness its sizeable base of graduates who can fairly easily be inducted into the software industry as programmers. This may now be changing, with 4GLs being part of the trend to de-emphasise programming (i.e. coding and maintenance) in favour of higher-level skills. The problem of a shortage of computer professionals in India is now seen not as 'a shortage of programmers to write programs but a shortage of quality analysts able to decide what a business was all about and how best to represent it in computing terms' [1]. Faqir Kohli, director of Tata Consultancy Services, states 'Programming is incidental, routine and will soon be carried out by computers using program generators. We are trying to develop systems analysts.' [2].

It is now the lack of these more skilled personnel which is seen by many as the major constraint in achieving software export targets and there are estimates that India will need 12,000-15,000 systems analysts by 1990 to reach its target of Rs 3bn of software exports [2]. Authors such as Schware therefore see the development of what he calls 'semiautomated programming' technologies such as 4GLs as a retardant to Third World software development as 'the quality and availability of skilled labor will become more important than labor costs' [18]. Thus, use of 4GLs might serve to aggravate the existing shortage of most highly skilled software developers. In these terms, were the use of 4GLs to grow considerably, this might harm future export expansion plans.

3. 3. The principle of minimum time
- the desire to utilise computers without lengthy delays for application development

One of the main ways in which development time may be saved is by the use of prototyping, a technique for which 4GLs are often used. A prototype system looks just like the finished application on the screen but lacks some of the essential underlying machinery.

Prototyping is used within the design and coding phases when the prototype is presented to the client, who then gets a much quicker and better understanding of the workings of the new system than would be possible on paper. More valuably, the communication between client and developer is thereby enhanced and the system can be modified to fit the client's needs more accurately.

This technology has a utility in India for export contracts, where misunderstandings between clients and developers from different organisational cultures can and do arise. 4GLs could also help domestic market software development - Indian software houses aiming at the domestic market often feel hampered in their software development by what they see as either user ignorance (not knowing what the system can or will do) or user naivety (believing that the system will do everything and soon), which leads to problems at the requirements specification and design stages.

Use of 4GLs could also be extended from one-off customisations to the selling of packages into niche markets. Using prototyping and the 4GL's building speed and flexibility, one could present a core package in prototype to each customer and offer the ability to customise it to meet that client's specific requirements.

3.4. The principle of minimum errors

- the desire to minimise the probability of human error and the attempt to catch as many of those that do occur automatically.

Programmers' errors can be costly to correct. 'About 80% of errors in coding software are produced at the design stage. These errors are also the most expensive to deal with, because an error at the start of the design process creates a mistake that is repeated many times throughout the software' [7]. Because they are easier to use, and via various automatic scanning mechanisms, 4GLs aim to reduce the number of errors that occur in the first place. More importantly, because of their flexibility, 4GLs can quite easily be used to change a system in which a design error has been detected.

3.5. Summary discussion of 4GLS

Summary discussion of 4GLs has, until now, largely focused on the micro-level of their impact on individual software developments. Drawing this out to a wider level and placing it into the Indian context one can see that, whilst it has some advantages to offer, use of 4GLs is not without its potential dangers for India. Although India's comparative labour cost advantage is unlikely to be removed because of the use of 4GLs, it does seem likely to be reduced. Actual job losses also seem unlikely, but there may be a reduction of potential job opportunities. Finally, by being a generally upskilling technology, 4GLs may create a relatively greater requirement for software analysts and designers than for programmers.

4GL suppliers put up a barrage of hype about the benefits of 4GLs. The next section deals with what they often conveniently forget - the potential constraints and problems of using 4GLs.

4. CONSTRAINTS AND PROBLEMS ASSOCIATED WITH USING 4GLs

4.1. Lack of standards

There is a clear lack of standard products in the 4GL marketplace and a number of the 4GL suppliers do not yet have enough reliability and weight behind them. 4GLs are also still proprietary - while one may think of COBOL, FORTRAN and even C as public property, Oracle comes only from Oracle Corporation, QuickBuild only from ICL, and so on. These factors make it more difficult to choose the 'right' 4GL, make them generally much more expensive than 3GLs, and make it more difficult to get a return on investment from them. In addition, finding trained staff is not at all easy.

4.2. 4GLs and training

At the moment (excluding dBase) 4GLs are not well recognised on established training courses within India. The relative novelty of 4GLs is one reason behind this, but so too is the lack of standard 4GLs, so that demand for any one 4GL is likely to be too small to support a course. Lack of training in 4GLs is reported [10 Vol II p26] to be one of the most important problems facing India although, on a more positive note, most observers agree that 4GLs are easier to learn than previous programming languages.

4.3. Use of hardware resources

4GLs do not win any prizes for machine efficiency and usually require much greater computing resources than their predecessors.

> "Statistics on 4GL performance from a survey by the Institute of DP Managers of 266 UK users indicate the sort of performance problems associated with 4GLs. The survey reports the following average increase after 4GL installation:

Core and file space 70%
Processing time 94%
Response time 41%" [11]

However, it should also be noted that 'While some extra resources may be needed to run such new tools and programs, the price of processing power continues to fall and the need to conserve resources becomes less critical' [20].

4.4. Costs and barriers to entry

A number of writers are 'upbeat' about the ease with which small firms can overcome barriers to entry and get into the software business. For example, the Economic Times [6] notes

> "The incredible reduction in start-up costs for software entrepreneurs. A careful study would show that a software start-up project of Rs 7.5 lakh in 1980 can now be floated with only Rs 1 lakh."

However, for firms wishing to be export-oriented, the situation is rather different. Setting up in this field can be very capital-intensive, marketing costs are high, and 4GLs add to the problem by making it difficult for new, small firms to break into the market. They do this in a number of ways.

Firstly, there is the initial cost of the 4GL (up to Rs 5 lakh - c.$40,000) and the associated investment in staff training. Larger organisations can afford this much more easily than small ones.

Secondly, there is the problem of how much use will be obtained from the 4GL. When a software house buys a 4GL, it is unsure over how many projects it can spread the investment. One may compare this with the cost associated with buying a COBOL compiler, which the firm can be sure will find a use on a large number of projects and which is a language one can assume the majority of clients will already have access to and experience in using. Lack of standardisation in the 4GL market means no such assumption can be made for them. Larger software firms, having a greater number of contracts, may be more certain of spreading the cost of the 4GL than a smaller firm.

Finally, the high cost of a 4GL favours their use on large rather than small projects. Once again, this tends to favour the large firms, which are much more likely than a small company to undertake large projects.

Thus, the increasing use of 4GLs may, like other factors mentioned above, create a widening gap between the large and the small firms. The effect on exports of such a gap is unclear because it is the five or six largest Indian software companies which account for the vast majority of India's software exports. Indeed, it has been suggested that the Government should recognise this and look to the smaller firms for domestic market work and to larger firms for export performance. However, this would probably also serve to increase the decoupling between the export and domestic markets and, in general, polarisation between small and large firms is not regarded as a positive development.

It is also interesting to note that almost all of the software houses in India which are using 4GLs are those which have tie-ups with firms in the West. Not only may this have an effect in increasing the Indian firm's exposure to 4GLs, but the Western multinational is often the producer of a 4GL and could therefore be expected to provide it free or at reduced cost, therefore potentially alleviating the cost problems noted above. The more pessimistic view of this is that almost all new software export deals (three or four new ones are recorded every month by the Indian computer press) require the collaboration of a firm in the West. The range of firms getting drawn into the software export market may be growing, but few of these are independent operators, and 4GLs may be strengthening this trend at present.

4.5. Existing systems

Computing languages have a much longer life than hardware partly because, being hardware independent, they are not dependent on some other time-limited technology. FORTRAN is now over 30 years old, and even supposedly 'new, trendy' languages like Pascal and C are 15-20 years old. There is, therefore, a lot of accumulated experience in these 3GLs and, just as importantly, a lot of accumulated software. Hamilton [9] reports that 'There are 80 billion lines of COBOL language in the programming arena and that figure is growing . . . at the rate of 1.5 billion lines a year'.

Yet, 4GL suppliers often ignore the operational problems that go with using the newer languages in an environment still dominated by 3GL systems. 4GLs may not fit with existing user interfaces and not all 4GLs can import and export data from external databases or even from other non-4GL modules in a program.

4.6. Attitudes in India

In almost all the Indian software houses contacted, staff attitudes appeared to be generally positive towards 4GLs. There were two main strands to these attitudes. The first was of short-term attitudes relating to work content. One programmer stated that 'no-one thinks of coding as being a prime activity' - the better part of the job is the conceptualising and therefore staff like software tools which release them from the drudgery of coding towards more creative and analytical work.

The second attitude area was longer term and was slightly less positive. No-one yet seemed to feel that a software developer in India could base a career solely around skill and experience with a 4GL. To do that would be limiting to a career, which still has to be based around abilities with one of the traditional 3GLs (usually COBOL or BASIC or C). Seen in these terms, 4GLs might help those who wish to spread their career risks and widen their experience, but they would not necessarily help in major career-aiding moves, which were seen to involve learning more 'upstream' software development techniques such as analysis and requirements specification.

Nor are 4GLs going to be welcomed by everyone? The accumulated experience in 3GLs creates an inertial reaction to 4GLs, just as 3GLs were resisted when they emerged by those with a lot of experience in assembler. Managers reported that some COBOL staff in India were 'awkward' about using later generation products, and they talked in terms of a 'tension' such that older programmers might not wish to use 4GLs because of 'fixations' on certain traditional languages that were hard to get away from. In part, of course, such feelings may come from a lack of awareness or exposure to the new tools.

Analysing the sources of these perceptions, it would appear that one way to explain the difference in attitudes is to look on it as indicative of a difference between relatively more positive attitudes in the software houses and relatively less positive attitudes in client/end user organisations. One possible explanation for this is that, in the end user organisation, the programmer is often concerned with maintenance, so that the 4GL has the potential to take over most of what they do whereas, in the software house, the programmer does some design, and certainly aspires to do more of it, so that removal of the coding aspect can be regarded as upskilling rather than job displacing.

Of course, the software development staff are not the only ones to be wary of change. Software managers can be reticent to see their 'empires' diminished by the shedding of staff through use of more productive tools (although they like the bigger budgets that go with new technology), and they may hold a 'not on my project' attitude, because they believe that orthodox development methods will offer a more guaranteed return on resources invested.

4.7. Areas of application

Just as the introduction of 3GLs did not eliminate use of assembler for certain software tasks,

so too there are situations for which 4GLs are not felt to be appropriate, for example, very novel or complex situations, or those which are 'close to the hardware' and in which speed of operation is at a premium.

4.8. Summary

In practice, there may be problems associated with using 4GLs, or constraints which have to be worked around. Certainly it would be simplistic merely to associate use of 4GLs in India with the beneficial principles that are intended to underlie their development. The training needs that use of 4GLs creates have to be considered more carefully, as does the question of access to these new tools by smaller software companies, particularly if one seeks to prevent them entering into a dependent relationship with a Western firm.

5. USE OF 4GLs

The overall conclusion from these impacts and constraints associated with using 4GLs is that it is by no means clear that 4GLs will be totally beneficial to the Indian software industry. However, some further questions need to be asked about the realities of using 4GLs - does India have any choice over whether or not to use 4GLs, and are 4GL skills being transferred from export to domestic markets?

5.1. Export-related use

The products in use, of which there are at least a dozen different ones, are mainly integrated development tools, such as Linc and QuickBuild. As another indicator, IDC [10,Vol. II p.57] found that, in 1987, 5% of minicomputer owners were using 4GLs, and they predicted that 4GL sales would be one of the fastest-growing market sectors. There is also a steadily increasing number of advertisements in the Indian computer press offering 4GLs for sale and seeking software developers with 4GL experience to work on export contracts. Examples of 4GL application include use of ICL's QuickBuild to build a telephone enquiries system, and Relational Technology's Ingres to build a hospital management package. In addition, some Indian firms are starting to create their own 4GLs, although at the moment these are relatively simple and are usually only for microcomputer use.

Thus, although usage of 4GLs within Indian software houses is still quite low, it is clearly growing. Why should this be, given that there are problems associated with using 4GLs?

The bulk of India's software exports are made up from contracts involving custom-written software for a single client. Overall, professional computer services, which includes custom-written software, is one of the most strongly growing sectors in the US (which takes 90% of India's software exports), predicted to grow by 20% per annum between 1985 and 1990. 'One reason for this is a new determination on the part of commercial companies to have software written especially for them, to give them a particular competitive advantage' [3]. This determination also involves 4GLs:

> "Whereas three years ago, the main reason for buying a 4GL was to attack the growing list of applications to be developed over the year, now companies want the facility to produce systems quickly in response to changes in their business direction." [20]

As an example of this increased use, it is now estimated that 80% of computer installations in the UK have some kind of 4GL product in use [5], and the US figure is probably higher.

4GLs are therefore becoming the 'weapon of choice' when writing software in the West and this increasing use obviously has implications for Indian software firms. One Bangalorebased software firm recently found problems winning contracts in the US. The only way to successfully secure a contract was to include use of a 4GL, with its consequent reduction in overall cost estimates. Many other firms have found it necessary to adopt a very pro-4GL attitude with Western clients, and stated that they 'always bring up 4GLs as an option for any

new client.

One may conclude that software firms in India which are oriented to the export market will find themselves having to use 4GLs on some contracts if they wish to continue to compete. Certainly, India does not have a monopoly position in Asia in offering low-cost, high-quality software labour, and if Western companies making use of 4GLs do not find a market for their contracts in India, they will turn to countries in South-East Asia which will no doubt take up those contracts.

However, there is another side to the increased use of 4GLs in the West. Sweet [20] notes, for example, that software spending in the UK is on the increase and that 'much of the money looks as if it will be spent on fourth generation software products'. From these results, in the latest Price Waterhouse/Computing survey [16], 'the implication would seem to be that companies are changing focus from hiring in programming expertise to tackle their applications development towards buying more 4GLs and productivity aids'.

In other words, there may be less use of outside software firms to develop in-house systems. This may therefore reduce the demand in the West for overseas contracts. Such a problem does not appear to be greatly feared by the Indian software companies, probably with reason, since demand for software development and developers is still forecast to outstrip supply in the short-term future. However, the increasing automation of programming in the West is a dark cloud looming on India's software horizon. At the moment, India's impressive export figures are heavily reliant on one-off overseas contracts, but it may be forced to diversify into other areas such as package development for niche markets. History is littered with the failures of those who put all their economic eggs in one basket and the Indian software industry needs to read and act on the message being given out by the increasing use in the West of high-productivity, semi-automated programming tools like 4GLs.

5.2. Domestic market use of 4GLs

Above, we have seen that 4GLs can offer advantages and that they are being used on export contract work, but what about the use of 4GLs on internal projects? There is a commitment to transferring skills from overseas to domestic work and a number of firms stated that, in general, if someone gets experience of some new product or method on an outside contract, they try to pass it on to the rest of the organisation. Certainly, export contract work appeared to be the main source of experience and knowledge of 4GLs. However, I believe there is a serious decoupling between the domestic and the export markets in India which will hamper the transfer of 4GL skills and usage, and that 4GL use will be predominantly in the export far more than the domestic market for some time to come.

Domestic market work is generally regarded as the 'poor cousin' of overseas work, and software developers often cut their teeth on domestic projects and then graduate onto export work. Thus, the flow of experience and staff tends to be from the domestic to the export markets and not vice versa.

Secondly, there is, as yet, little drive to adopt new software tools on domestic contracts, which are not subject to such high competitiveness as international market contracts. One reason behind this is the relatively poor awareness of new software tools and methods, such as 4GLs, amongst client organisations in India. One company attempting to market a 4GL product within India achieved no sales at all. Their tactful explanation was that the product was, perhaps, a little 'too novel' for the domestic market. Others put it more bluntly, and IDC [10, Vol. I p.29] complains that 'features and benefits of 4th GL and application development tools are not yet understood' within India.

Thirdly, contract size can be a factor. Export contracts are often larger than most of the domestic market work undertaken, which runs against domestic market use of 4GLs. While accurate sums have not yet been calculated, there was surprisingly close agreement between different Indian firms that mainstream 4GLs (not dBase) only really became viable in economic terms for projects of greater than about Rs 50 lakh (about $400,000). These figures were based

on costs of around Rs 5 lakh for the actual 4GL, plus staff training costs. This explains why the 4GL is seen as a tool for large projects only.

Of course, all such 'back of an envelope' calculations involve very narrow cost-benefit measures, and fail to take account of the benefits that may accrue from re-use of the 4GL on a subsequent software development project, but they are certainly indicative of the general opinion of software developers that they should not use 4GLs on smaller contracts, which tend to dominate in the domestic market.

Finally, almost all client organisations eventually have to service and maintain the software that is written for them. If the software was developed using a 4GL, then the client must have staff with experience in using that 4GL. As noted above, many end user organisations in the West now have 4GLs and some have 4GL-skilled staff. This is definitely not yet the case in India.

5.3. Summary

The reality of 4GL use highlights three important points. Firstly, it would appear that, in large part, the increased use of 4GLs derives from the drive in the West to use these new software technologies. If India wishes to remain integrated with the global market, it will have to follow the trend. Secondly, the increasing use of 4GLs in the West has inherent dangers for India, though there may be little that can be done about this. Finally, hopes that opening up the export-oriented part of the industry to 4GLs will lead to a transfer of the tools and their related skills to the domestic market do not appear to be well founded.

6. INDIA'S SOFTWARE POLICY AND 4GLs

In general in India, there has been an overemphasis on software product and an underemphasis on the software development process. Writing in 1983, Joseph [12] criticised the software development process in India because 'primitive design and production techniques are still being used for software, despite its high cost'. Things may have moved on since he wrote this, but there is still a large amount of truth in this productprocess division. For example, most publications that seek to extol the virtues of the Indian software industry talk about the products that are being created rather than about the way in which they are being made.

If one were to draw an analogy with the car industry, then it would be as if everyone was discussing the merits of adding 4-wheel drive or of developing an all-terrain vehicle, instead of how to automate production lines. Those who have survived in the auto industry, while they have thought about their products, have remained in business only by radically restructuring their machine tools and method of production. 4GLs and the like are the machine tools of the software industry, and there must be a greater recognition in India of this process element in software and of the potential advantages and problems that go with it.

The present software policy has had its successes, but it does not seem to differentiate sufficiently between the software tools which are used to make a product, and the finished software product itself. The slogan for India's computer policies, both hardware and software, was 'flood in, flood out'. One could see a central part of this as being the use of new tools imported in a flood from overseas in order to improve the quality and competitiveness of Indian products. Yet this is not explicit within the policy, the main meaning of which was actually that a flood of software should come into the country to stimulate the domestic software market and to raise its standards to those of the international market.

A number of worries were expressed about large-scale import of Western software products and the damage to the indigenous industry that might result. A campaign from the industry was largely successful in achieving a modification of policy to reduce software imports, but the modified policy rather threw the baby out with the bathwater by clamping down equally on the import of software tools. This was clearly not the intention of those who sought to get the policy altered. For example, Kumar [13] states:

> "It would appear necessary that the country accept a slower pace of computerisation while developing the software industry in the areas feasible and import software either for specialised applications or as tools to develop further software."

Yet, as it stands, developers who wish import hardware or software tools must take on an obligation to develop and sell exports of between 150% and 350% of the foreign exchange used for imports. Kumar [13] also points out the anomaly that while a general user can freely import software on an actual use basis, software companies are tied to the export obligation. In this context, the policy appears to discriminate against the use of software tools because it makes product import easier than tool import.

If the policy were to distinguish between tools and products then it would keep the positive aspects of access to the latest technology while, at the same time, protecting local firms which have spent a large amount of resources on developing software products for the indigenous market.

7. CONCLUSIONS

When dealing with a new technology, one cannot just focus on the micro-level benefits claimed for that technology. Every technology has an organisational, national, and international context into which it is introduced and the implications of its introduction have to be considered in these wider environments too.

One should not be deluded by extravagant claims of benefits like 1000% productivity rises. Set in the wider context of the Indian software industry, its battle for share of the world market, and overall costs and benefits, 4GLs may not be so beneficial as first thought. Software houses, governments and other organisations therefore need to be critical in their evaluation of 4GLs.

India's cost competitiveness may be reduced by use of 4GLs, as may employment prospects in programming whilst, ironically, there may be increased pressure on sections of the labour market which are already suffering a shortage of the most highly-skilled software analysts and designers. In addition, use of 4GLs may raise the barriers to entry into software exports, whilst skills and knowledge are not effectively transferred to the domestic market.

However, one must draw out even further than this national context to look at the global setting of the software market. The West is calling the shots, particularly in the form of the US customers who make up the potential pool for India's software exports. In their estimation, 4GLs are viewed positively because of their time and labour cost reduction potential, and Indian firms which can offer 4GL programming should be viewed similarly. Indian firms are therefore increasingly likely to find themselves using 4GLs in export-related work.

Software policy also has to recognise this wider context and, this being the case, there is an argument for greater differentiation between software tools and software products to allow easier access for Indian companies to 4GLs, related tools, and the training required to use them.

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THE ROLE OF INFORMATION SYSTEMS ERGONOMICS IN DEVELOPING COUNTRIES

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Current developments are reviewed in three fields:
(1) general ergonomics, (2) human-centered information systems science, and (3) ergonomics of developing systems in developing countries, is found to be a new but important approach. It is one of the key issues in adapting informatics to benefit the developing countries.

The most important features of this approach are drawn up into five points.

1. INTRODUCTION

Disappointing experiences in technology transfer projects in developing countries stress the point that technology is not independent of its social context. At the same time dramatic events like Bhopal and Chernobyl have made people reconsider the very nature of the relationship between technological progress and human needs.

Within the area of information systems in developing countries, turn-key packages from industrialized countries have also met with disappointing failure. That is not to be considered as an indication of the inappropriateness of computer technology as such, but of the lack of adaptation to the local society. "Fitting the computer to the human" seems indeed to be one of the key issues in enabling informatics to benefit the peoples of the developing countries, the majority of mankind.

The relation between society and technology is a philosophical issue in its broadest sense. However, engineers and computer scientists should not regard themselves as outsiders in the debate. "Sleep of reason produces monsters", as the artist Goya titled on of his cartoon series. With today´s powerful technology, the ignorant engineer may produce Bhopals and Chernobyls.

Engineering cannot directly draw practical conclusions from philosophy. An applied, practically oriented discipline is needed. In this paper, recent developments in some general fields are reviewed in order to find approaches and results that might benefit information systems development for and in developing countries. More specifically, the following developments are examined in later sections of the paper (see figure 1).

(a) *General ergonomics* has been enlarging its perspective from physical to psychological and social aspects of work. This "third generation" of the discipline is now called macroergonomics [19]

(b) *Information systems science* has also been progressing from a narrowly technical, structuralist theory. There are now several schools of thought searching for ways of considering computer systems from a "human" perspective.

(c) *Ergonomics of developing countries* has emerged as an independent branch of science and practice.

(d) *Information systems of developing countries* are a major potential factor in national

development. While practical experience exists, it is scattered and no established discipline has yet emerged. Better understanding of the special conditions and methodologies in this field is greatly needed.

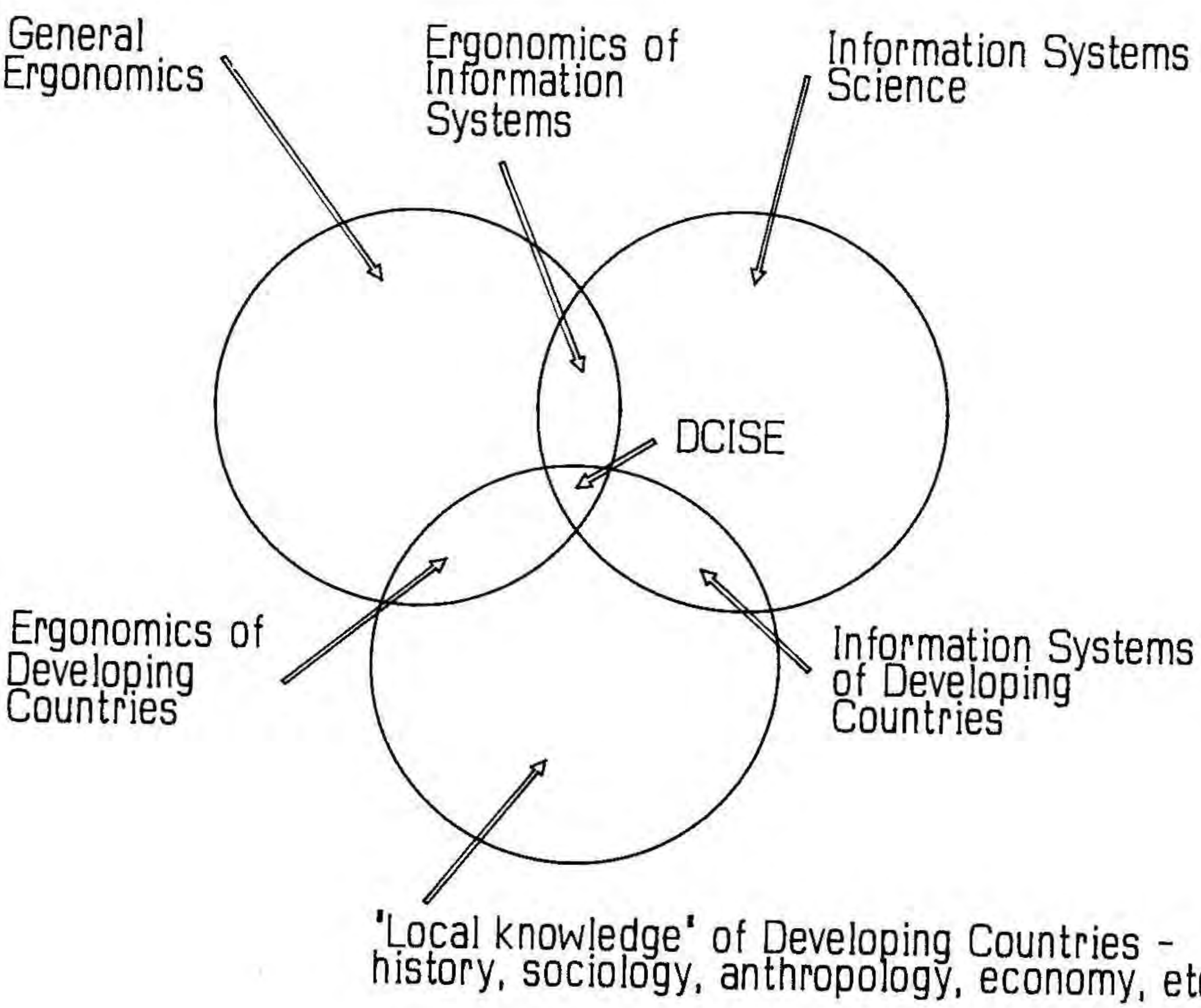


Figure 1: The context of Information Systems Ergonomics in Developing Countries (DCISE)

The main objective of this paper is to examine whether there are elements in (a), (b), and (c), which could be applied to (d). After looking more closely in the separate disciplines, some conclusions are drawn.

2. ERGONOMICS AS AN APPROACH TO TECHNOLOGY

Literally translated from Greek, ergonomics means "natural laws of work". It deals with systems consisting of man, technology, environment, and work. It is multidisciplinary by nature, applying human sciences to the design of technology, environment, and work in order to benefit the working man. Classically its goals include improved safety, health, and efficiency. Today more far-reaching goals are also set.

Besides science, ergonomics is thus and approach to technology, comparable to the economic, engineering, and ecological approaches. All of these perspectives are needed as they complement each other.

To most informatics professionals the common image of ergonomics is no doubt made up of comfortable chairs, non-glaring terminal displays, low-profile keyboards, and the like - that is, physical ergonomics. It is true that these issues represent the oldest and most basic area within ergonomics.

Yet ergonomics today also applies other perspectives to human beings. One level might be called perceptional - the study of signs, displays, and so on. A more recent one is the level of cognition - eg. menu structures or editing as a cognitive activity.

Work today is not done by isolated individuals, but by organized groups of cooperating people. Consequently the latest branch of ergonomics studies collective work and collective technology. It is a relatively new phenomenon, called organizational, system-level, or macroergonomics [19].

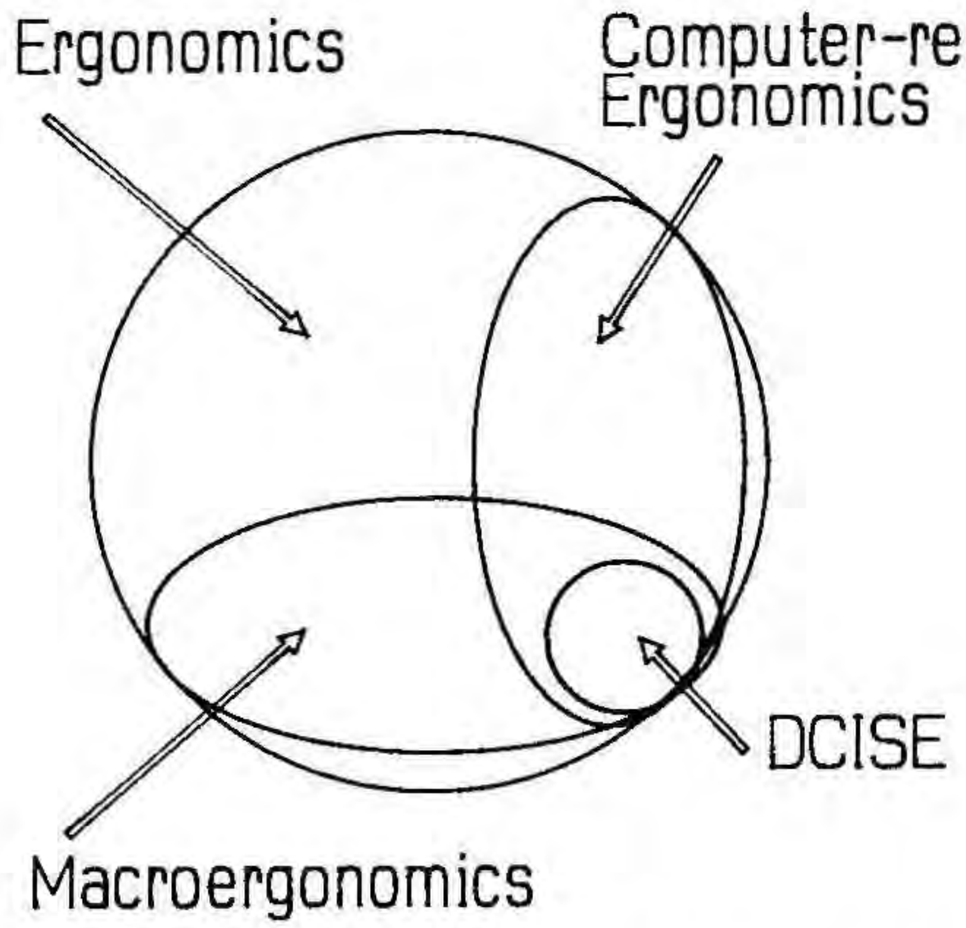


Figure 2: DCISE and Ergonomics

On all of these levels, ergonomic study has in recent years increasingly focused on informatics [34]. Ergonomic studies of video display terminals had spectacular commercial success in the beginning of the 1980s. Subsequently, the main emphasis has been in cognitive aspects of the human-computer interface [6]. It is natural that computerized information systems, being collective technology by nature, have been one of the main objects of research in macroergonomics [see figure 2 and 7,28,40].

Maurice de Montmollin [31] describes the new frontiers of ergonomics in a concise way. Suppose we are sitting in comfortable chairs, the temperature and lighting are perfect, and we are using user-friendly systems with attractive visual interfaces. Has ergonomics become

superfluous? That is, are problems between man and technology completely solved with this kind of remedies? Looking back to Chernobyl one can state: No, the biggest challenges in fitting technology to human needs are only starting then.

3 . INFORMATION SYSTEMS SCIENCE: IN SEARCH OF "THE HUMAN"

In the beginning, computer science drew mainly from electronics, logics, and mathematics. Early theories of information systems development were also mostly founded on the logical structure of the system.

Today, information systems science is an established, although not a very well-known discipline. It includes the study of the development and use of information systems in their organizational contexts. The structuralist, information-theoretical thinking has not disappeared, but more comprehensive theories are now being pursued.

On the one hand, some schools of thought stress the management's point of view in assessing information systems as a competitive weapon in the marketplace. Other researchers, notably in the United Kingdom and in Scandinavia, try to find improved ways of incorporating "the human" into systems science (see figure 3).

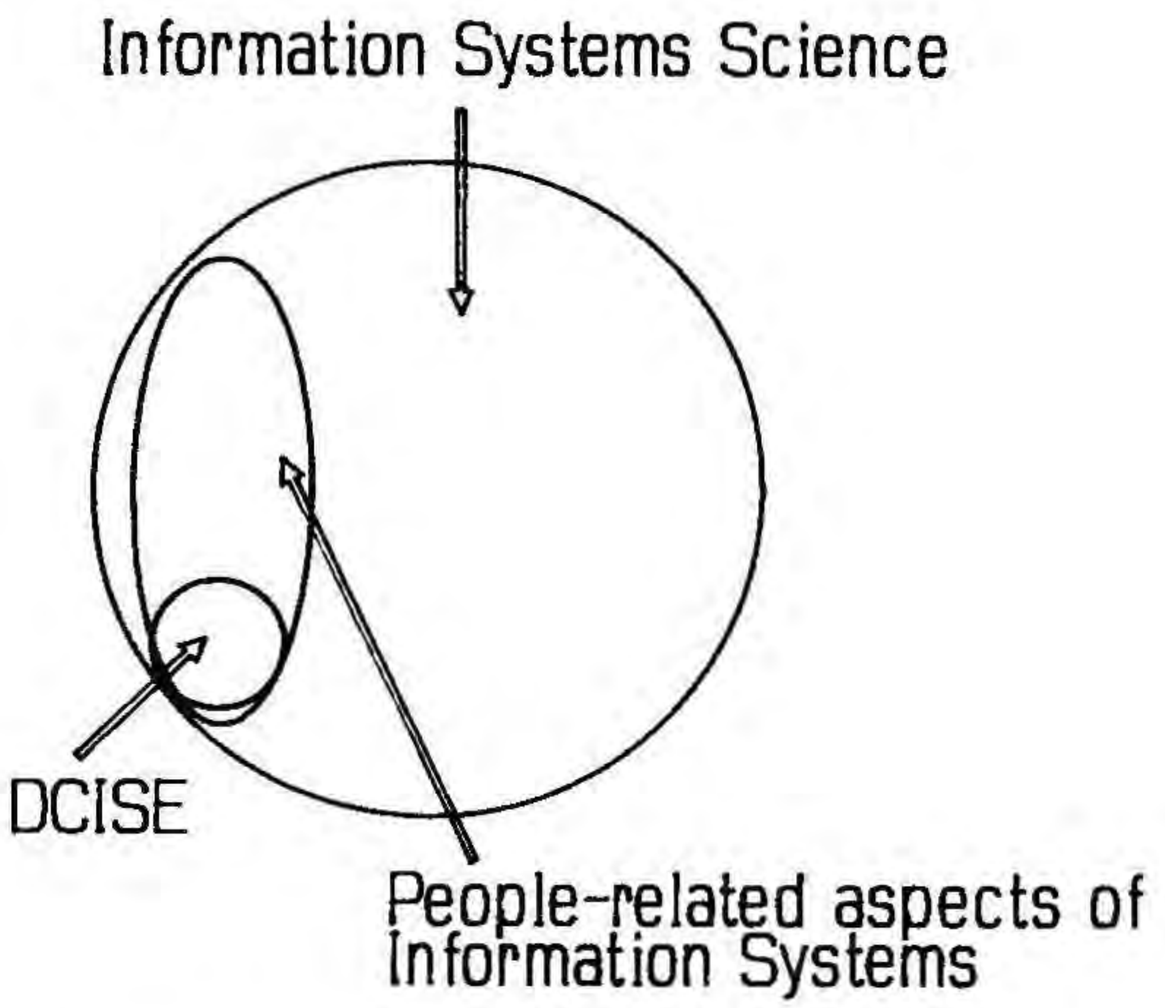


Figure 3: DCISE and Information Systems Science

In his influential book, Peter Checkland [9] follows the systems-theoretical tradition, but suggests that "soft" human systems and "hard" engineering systems need different methodologies. The former have no given, well-defined problems to solve, and conceptualization is needed instead of straightforward design (ibid., p. 189-191). One might say that the problem of the information systems developer is to find out what is the problem - after that, solutions are much more easily derived.

Another notable theorist, Enid Mumford [32], deals explicitly with two separate sets of goals, namely the human and the technical or efficiency goals. According to her, the former are in the interests of the users of a system, the latter in the interests of the management. The successful integration of these objectives with each other is her principal goal (ibid., p. 64), and the participation of all affected groups of people is the main means of reaching it.

Scandinavia has been one of the strongholds of information systems science. There has been

internationally recognized research both along the structuralist tradition and following the "humanistic" ideas of Checkland's and Mumford's [3].

A rather unique phenomenon in Scandinavia is the strong tradition of research concerned with trade unions. As with Mumford, this tradition recognizes different interests in the setting of systems development, but contrary to her, it views these interests as being in conflict. Groups of people with different degrees of power represent these different interests (ibid., p. 203-207). The principal goal is the democratization of working life, and systems development is a potential vehicle for this.

4. THE MERGER OF MACROERGONOMICS AND SYSTEMS DEVELOPMENT

The three above-mentioned systems development traditions, represented by Checkland, Mumford, and the Scandinavian trade-union researchers, try to examine explicitly the relationship between "the human" and "technology" in information systems. They all have their roots in systems development practice. In more general terms, Checkland draws from Systems Theory, Mumford from the Socio-Technological tradition, and the trade-union researchers from different branches of critical Social Philosophy.

As described earlier, there is also a major branch of macroergonomics focusing on the same issue. Macroergonomics, however, draws from Psychology, Organizational Theory, and Social Psychology, and has less to do with systems development practice. As conventional ergonomics, it is design oriented - that is, it does not view technology and work as static objects.

Obviously, macroergonomics and human-centered theory on systems development study the same issues from a similar viewpoint, but they have originated from different scientific traditions (see figure 4). Both approaches also encompass schools of thought with differing social interests. Quite recently, representatives of the two disciplines have made explicit attempts to integrate the approaches [eg. 4].

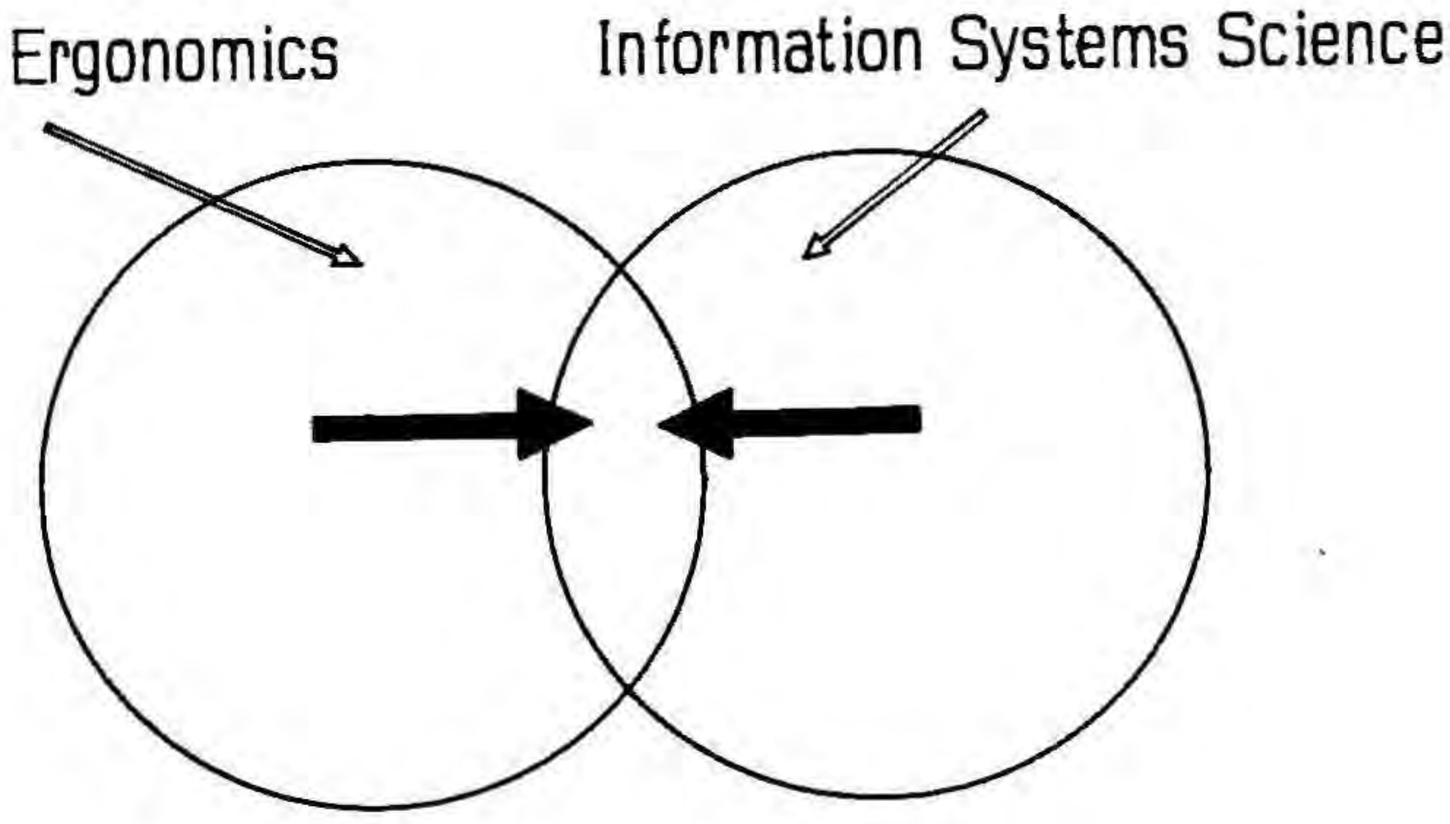


Figure 4: Macroergonomics and human-centered Information Systems Science study the same issues from different scientific traditions

One can conclude that it is possible to define a field, but not a single theory, of the macroergonomic inquiry of information systems. Its object of research is computer supported work activities at the systems level. This is in contrast to traditional MIS and DSS research, which is interested in the system or its products, rather than the people "running" it.

Participation of workers in shaping their working conditions is a key methodological issue in all the above mentioned human-centered approaches to computer technology. Different schools of thought take different positions on this, ranging from enlightened technocracy to self-government of working collectives [15].

It is important to note that human-centered systems theory cannot avoid controversial social issues. "The human" came to represent different interests for different groups of people. The management's goal in macroergonomics is to increase profitability, the workers' goal is to improve their working conditions, and there is even the "national" or "global" interest - that is, the wider social needs that the organization is serving (represented by customers, consumers, "the public", etc.). There can be conflicts between each of these three interests, and the setting varies in different social systems.

5. ERGONOMICS OF DEVELOPING COUNTRIES

Researchers and practitioners of ergonomics gradually realized that their body of theory was perhaps not as universal as they had first supposed. As Alphonse Chapanis [8, p. 153] put it :

> "Ergonomics deals with people, and people around the globe differ greatly and in many important ways." ... "Indeed, I now think that one of the most challenging problems we face today is how we can make ergonomics robust enough to cope with national and cultural variables."

The object of ergonomics is composed of people, work, technology, and working conditions. If there are differences in these components from place to place, then the objects and results of ergonomics must also be different. What is universal, is the approach and much of the methodology.

This simple idea is still hard for many in the industrialized countries to accept. It is easy to believe in the universality of what "we, the forerunners of science", have found true in our circumstances. Yet the ergonomists of India have studied the "national" adaptation of technology since the 1950s [35]. In the 1980s the ergonomics of developing countries have gained momentum both in the North and in the South [23].

Two main directions can be distinguished in it. The first one deals with traditional, mainly agricultural work and technology, and the second with industrialization and the transfer of technology.

What makes the ergonomics of developing countries an independent branch of science? That is, in what ways do people, work, technology, and working conditions in developing countries differ from those of the industrialized countries?

(1) Much research is engaged in the so-called traditional, local work activities. Hoes or rickshaws are old inventions, but even with them, ergonomic inquiry can make work less hard and more fruitful [23].

(2) The majority of the people of the world work in hot and humid climate, which has a negative effect on work capacity [24]. This must be taken into account in designing the workplace and periodization of work.

(3) Quite simply, the physical measures and proportions of different nations are different. If a cabin of a truck is designed to fit to the measures of 90 % of Americans, then only 10% of Vietnamese are tall enough to use it without modification [12].

(4) Millions of people in the Third World are suffering from malnutrition and illnesses [24]. It is of course most important to fight the causes, but meanwhile we must also reduce the energy requirements of work in order to make it tolerable even to the less powerful.

(5) Moving from physical to psychological ergonomics - people of the developing countries often lack experience and training in technical devices, written language, pictorial representation, and so on [10,11,16]. This is a delicate issue where unscientific racial myths easily go on living even in academic society. Therefore it is important to stress that

(a) there are no differences between mental capacities of different peoples [37]

(b) lack of practice in pictorial literacy, for instance, reduces rapidly with experience [16],

(c) lack of experience in some narrowly defined "Western" skill does not mean lack of experience in other kinds of skills (maybe unknown in the "West"), nor in cognitive functions in general [10], and

(d) very diverse experience can lead to equally useful operative mental models [37]

Thus, ergonomics must identify and make use of the experience that people have in advance, combine it with learning new skills, and not stick with a static view of people's "deficiencies".

(6) Industrialization in developing countries takes place in an environment of lack of funds, poor transportation and communication, lack of maintenance and other services, and use of "local" languages. This is very different from the case of the earlier industrialized countries, which had at least many decades of time for evolutionary development. Detached pieces of technology transferred from a very different context cannot succeed [30]. Here again, macrolevel ergonomics is needed. Total transfer of technology, organization, and services is suggested by some researchers [1,29,38]. Actually, it might be better to speak about acquisition and adaptation of technology, instead of transferring.

(7) People around the world have different cultural traditions and habits, ranging from sitting postures through esthetics and religious values. There is no universal "culture of developing countries", but all local ergonomics in developing as well as industrialized countries must cope with the features of the local culture [see 14]. Furthermore, there are cultural differences between various social strata even within a single nation.

Finally, some notes on methodological issues. Ergonomics research in developing countries is characteristically pragmatic [23, p. 80]. There is more work to do than can be done, so the focus has to be on simple and effective remedies to the worst problems.

Group work, checklists, and participation by workers seem to be the methods for design and redesign recommended by most practitioners (ibid., p. 100-101 & 103-104).

6. INFORMATION SYSTEMS ERGONOMICS IN DEVELOPING COUNTRIES

It appears that only physiological aspects of computerized work have this far been studied in developing countries by ergonomists (ibid., p. 96-97). It is correct that physiological-ergonomic aspects of the working-place ought to be attended to first, and much work remains to be done here. However, as mentioned above, systems-level aspects are also important.

Even low-level ergonomic enquiry can give valuable insights. Maciel [26] notes that the back pains and other problems of the data entry operators of a Brazilian service bureau cannot be solved by improving the physical environment only. Job stress due to the psycho-social environment seems to be the most important factor influencing the operators' subjective impressions. It is caused by a Tayloristic division of labour, together with lack of the workers' influence on working conditions (ibid., p. 288).

Maciel's study indicates that the lack of trained personnel must not be used as a pretext for exporting bankrupt Taylorism to developing countries. Furthermore, straightforward goals for design can be drawn: Systems must be designed in such a manner that data entry is not divided into a separate job. Users should have the power to participate in designing the work organization and technology.

Representatives of other disciplines have also used what I have called the macroergonomics perspective, even on information systems in developing countries. Agbalajobi [2] deals with computer systems in health care. According to him, foreign computer systems are not usually suitable as such to users and conditions of developing countries (Nigeria in this case). He suggests that the systems must be adapted through a deliberate procedure.

"Adapting technology to the needs of users" - that is just what ergonomics is all about. Agbalajobi also stresses the importance of high-level needs analysis and large scale participation, in the very sense of macroergonomics.

Some research on information systems from a macroergonomic perspective thus already exists in developing countries. A more conscious relation to the ergonomics tradition might still be useful. There exists solid ergonomic methodological knowledge, together with a body of research results and practical experience, which can be applied (see figure 5).

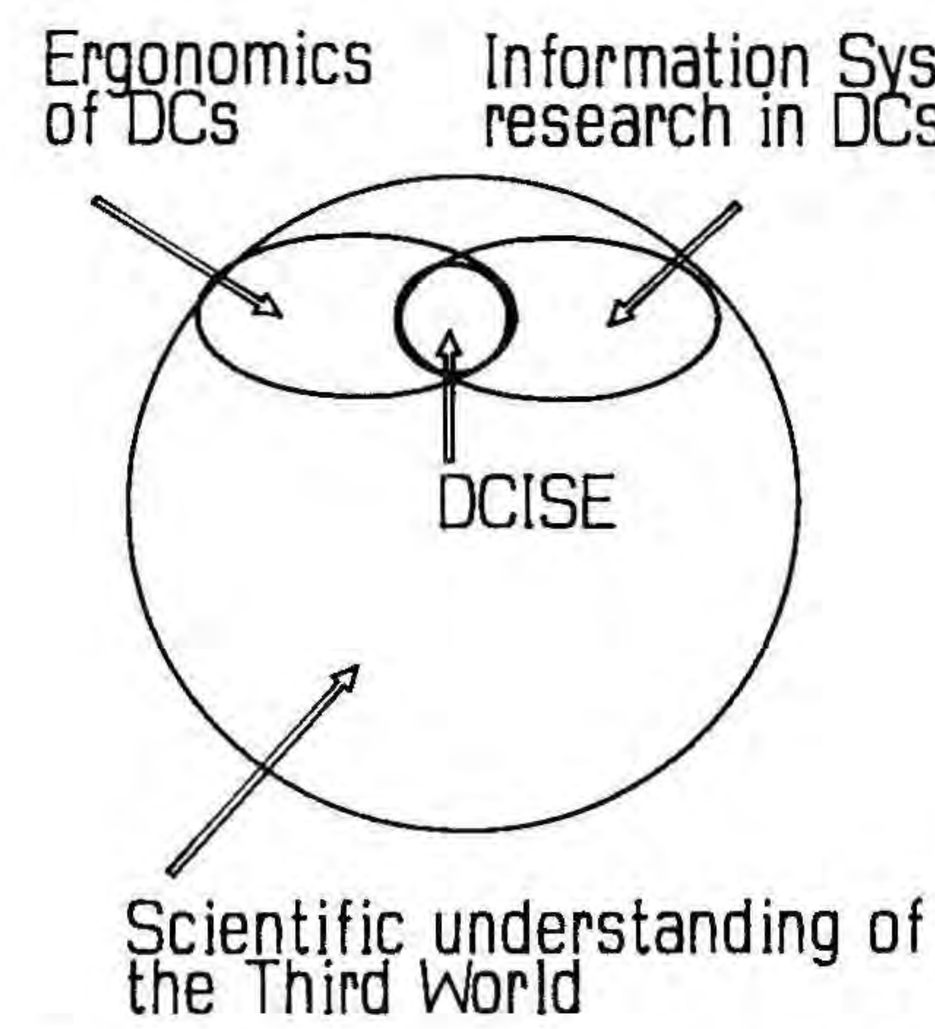


Figure 5: DCISE and Third World studies

I would suggest that there are two things to start with. First, the "low-level" ergonomic aspects should be checked. If tables are too high or the users are sweating or shivering with poor air conditioning, the overall system cannot work either. Second, formal and informal ways should be found to secure collective participation for developing the working environment and machinery.

The special aspects of the ergonomics of developing countries were classified into seven wide groups in the previous section. The results and methods from groups 2 (climate) and 3 (anthropometry) should be applied in basic ergonomic inspection of the working-place, group

6 (preconditions of industrialization) in designing hardware and maintenance aspects, and groups 5 (experience) and 7 (culture) in software systems design, organizational design, and implementation procedures.

7. CONCLUSIONS

Computer technology is one of the most important elements in today's production machinery - the lathe or electric motor of today. Information systems development is part of modern heavy industry due to its role in national economies. But contrary to most conventional machines, the bulk of computer based systems are means or environments for cooperative, collective work [21] even if they are not designed from that standpoint, and may serve their purpose badly.

Consequently, macrolevel approaches are needed. Adapting the quote from Chapanis in section 5, information systems science should be made robust enough to cope with national and cultural variables.

Human-centered systems design, macroergonomics, and the ergonomics of developing countries are all new disciplines, but combining their perspectives seems to be possible and fruitful. There already exist many good summaries on various design aspects in literature [27,17,18,25], but the purpose of this paper is not to go into too much detail. Rather than a bagful of turn-key tricks, what the existing literature can offer us is an approach, inspiration, methodology, and attention to what is important.

At this early stage of understanding, the most important features of this approach can be grouped into five points.

(1) The starting point is the analysis of the actual work activity to be supported by a computerized information system - not as a formal taxonomy, but as a process and as social relations, serving some social need [38]. Investigation of work activity should not be confined to the tasks of individual workers, but should include the complex of cooperating tasks as a whole.

(2) The existing experience of the working collective must be discovered, taking into account that people might have experience in areas unfamiliar to the computer expert and thus difficult for him or her to comprehend. Systems development must be supported by this experience.

(3) I would propose that the analysis of the work activity should be complemented by an analysis of the personal life settings of the workers. This is to ensure that aspects like cultural values, housing, transportation conditions, etc. are taken into account.

(4) The most important guarantee for including all important aspects is participation - or more properly, cooperative design of the computer-supported work activity by a group consisting of users as well as computer experts. It is important that concepts and media for a common language are created through mutual learning and teaching.

(5) In introducing foreign technology, attention must be paid to total transfer - including maintenance, systems support, etc.

This approach also has implications for national policies. Humanistic, ergonomic education must be provided for designers. Potential users must be encouraged to cooperate and employ their powers at the work-place. To do that, they need education in informatics. Furthermore, foreign computer systems cannot be adapted without indigenous software development, which should thus have a high priority. Finally, the application of informatics should be considered as an acquisition, and not as a transfer of technology. This is of course a message to the industrialized as well as the developing countries.

As indicated earlier, ergonomics is not a neutral tool: it can be applied to facilitate different, even conflicting interests of profit, quality of work, and social needs. In developing countries

the last mentioned interest is especially important. Ergonomic improvements can mean better health care systems, more productive agriculture, less bureaucracy, and so on. The designer has great social responsibility at the forefront of the challenges of national development. Colleagues in industrialized countries should share that responsibility.

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CONCLUSION

Information Technology in Developing Countries - For Better for Worse?

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INFORMATION TECHNOLOGY IN DEVELOPING COUNTRIES - FOR BETTER FOR WORSE?

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This epilogue offers a highly personal kaleidoscopic summary of the conference with an attempt to systematize some of the recommendations under the headings impact, design, implementation and government policies.

1. INTRODUCTION

- Did less industrialized countries (LICs) try to run with computers before they could walk? (Quarshie)
- Is quick, quick, quick possible, when managers do not have familiarization with information technology? (Mohan)
- What kind of social meaning is it that information technology carries? (Gupta)
- Is transfer of information technology to LICs really transfer of knowledge? (Odedra)

These and many more questions were raised and addressed during the first IFIP conference sponsored jointly by Technical Committee 8 and 9, where earlier versions of the papers in this book were presented and discussed.

To answer these questions, less industrialized countries (hereafter called LICs) often look to the industrialized countries (ICs) for solutions. Surely the material standard of living is higher in ICs. Surely life expectancy is much higher. And surely information technology (IT) has played a major role in facilitating these improvements. But is it equally certain that quality of life is better in ICs?

In a resent book by the dutch professor Tjerk Huppes called "Western Edge", Huppes argues that the comparative advantage of the Western societies (over and above especially Japan and the Far East) is *individualization.* Three statistical indicators are given in the book as a proof of the high level of individualization, (1) the *divorce rate* (average number of adults and children in a household in Denmark is expected to come down from 2.3 today to 2.0 around the turn of the century!), (2) *crime rate* (especially theft has more than doubled in this century - if you can not get what you want, you steal!), and (3) *suicide* (the ultimate expression of individualization that one takes charge of when to end ones own life). Indeed a frightening flip side of the high material standard of living.

Perhaps, as one of the participants remarked, "what LICs are really after is not technology transfer or appropriate technology on these premises. What we need is a technology which will allow us to keep the siesta!"

What right does ICs have to preach the Western gospel, and tell LICs what is right and what is wrong? Many computer vendors and consultants from Western countries are "peddling snake oil" they are is not solving any real problems, they are simply fulfilling their sales quota.

As a bank clerk once told me when I asked her whether she was for or against the new computer systems: "How can I be against the computer system, it is progress is it not??"

Computer vendors have come a long way if they manage to convince the world at large that technological progress is equal to human progress.

It is clear to me, and it is also the impression I got from most of the papers that the participants feel that LIC should try to avoid making the same mistakes that many of us in ICs have made. This includes the difficult process of contextualizing the information technology to the conditions in LICs.

Mohan argued at the conference that there were many experiences in the ICs which LICs could learn from. She indicated that is was the same law of gravity that causes the apple to fall to the ground in Dehli and in Washington DC. Yes, it is the same law, and it could even be the same (type of) apple, but the *ground* is different, the *reason* why the apple falls is probably different, and the likely *consequences* of the apple falling is different. For one thing it will probably be picked up in Dehli!

And that is what the conference and indeed the book is about, *context*. Not the context of the apple but the context of IT. The chip, the keyboard and the communications protocols are the same, but the context is different and calls for different measures.

In this summary, I can not possibly do justice to the many insightful comments presented in the articles and made during the conference in the presentations and the often lively discussions that followed. Furthermore, I can not possibly present a *consensus* view -- we do not agree on a solution, we probably do not agree on the description of reality, and we might not even agree on the problem definition.

But, I believe, we agree that there is a set of vital problems or perhaps, as the French say, a large set of *problematiques*, concerning the exploitation of IT in developing countries, which need to be more thoroughly explored.

2. PERSPECTIVES.

Several presenters, eg Wood-Harper stressed the value of perspectives in the introduction of computers in LICs, arguing especially for a multi-perspective. This point was also expressed by Kluzer who suggested that there was solid evidence which would suggest that information technology in developing countries should be viewed from the following perspectives:

- *stages*, i.e. think of information society as the third stage, where the first two stages are the agrarian state and the industrial stage
- *business* as usual (i.e., creating new dependencies of the old colonial powers)
- *multinational* (i.e., dumping ground for surplus production or perhaps even obsolete technology
- *enlistment* (i.e., tool for development)

Which is the correct one? All or none? Probably a little of each, but it is hard to know until we establish some baseline for evaluation.

This is why *cross-comparisons* and *comparative studies* are so useful, and group meetings and resulting volumes of articles like the present one are fruitful.

I have chosen to structure this summary into four areas, regarding informations technology for LICs,

- impact
- design
- implementation
- policy making

With this introduction, let me proceed to the snippets of knowledge/insights that I found especially useful in the conference.

3. IMPACT OF INFORMATION TECHNOLOGY

Whether we need technology assessment of IT in LICs, was not one of the most difficult questions. The many studies from all parts of the world reporting upon disappointing results of the introduction of IT in LICs makes it abundantly clear that there are many pitfalls. Costs are often underestimated especially for the organizational implementation phase. Benefits are overstated, and most of the time, benefits are argued on the basis of insufficient insights into the local contexts in a LIC. Lack of vendor support, lack of education, lack of continued support for further development were most frequently mentioned.

As Odedra pointed out, to the 200 multinational companies represented in Kenya, technology transfer did not mean transferring of knowledge or skills in any real sense of these words, it meant simply the transfer of boxes!

It was also argued by several participants that the foreign aid institutions was pushing national brands from the donor countries which made it extremely difficult for the recipient LIC to establish a coherent IT-policy. Greater awareness about this type of problem should help funding agencies and recipient countries develop more coherent strategies.

But the *potential* is there to do a better job. "IT can be seen as the multivitamin, which is more important to the poor that the rich. Computers are the multivitamin of effective administration" (Natarajan). But, with the risk of over interpreting the metaphor, some vitamins are poisonous in larger quantities!

We should not focus on solving administrative data processing tasks which use IT as a labour saving device. As Goonatilake stressed, there is much more to be gained from looking at the potential strategic importance of information systems in LICs. Mohan gave several good examples of how that could be achieved with relatively simple means.

At any rate, "IT will certainly lead to a transformation of the work culture" (Seshagiri), and indeed that might be the solution that Avgerou was looking for. She argued that if the public sector of Greece was to become more effective, nothing short of a revolution would be required.

4. DESIGN

The biggest flaw in systems design for organizations in LICs is probably problem definition (i.e. solving the wrong problem) even though it sometimes is done with great elegance and sophistication! The use of the Critical Success Factors Approach for identifying the important problems was cited (Mohan). Requirement analyses and *context analyses* are often carried out in less than adequate ways. *Appropriateness studies* should be carried out before major investments are embarked upon, because resources are extremely scarce and potential risks are more damaging.

Bhatnagar and Rao stressed *modeling skills*, Davis and Wood-Harper *participation,* Korpela *ergonomics* on a macro level, Heeks *4 generation languages*, Walsham, Simon and, Weema the necessity of applying a *socio-political perspective*, and Subramanian the importance of *security* in developing systems for LICs. All of which would no doubt contribute to the successful design of computer systems in the context of developing countries.

Since it is possible to learn (something) from examples, this volume is rich with excellent examples of how systems have been successfully designed to meet the specific requirements in a LIC. Valuable design criteria like *user involvement, flexibility, ownership and commitment* (Bhatnagar and Rao) are discussed.

It is important not to try to make one-to-one mappings of successes. Borrowed solutions will always have to be remodeled to meet the real requirements, tailored to fit the industrial sector, modified to be congruent with the organizational culture, and developed to reflect the societal contexts.

5. IMPLEMENTATION

Even though there were islands of very effective use of IT in the context of LICs, most of the examples pointed to less than optimal use and sometimes even tragic applications which fell short of meeting their promises. Businesses, organizations and government all seems to suffer, even though it is the problems in the public sector which seem to be to most spectacular. To a large extent this is the result of implementation plan being given too little priority. "Once the PCs are in place, who cares what they are used for" is unfortunately far too often the attitude of vendors, funding bodies etc.

A lot of implementations fail due to *technical problems* as illustrated especially by Okuwoga in his report from Nigeria. Often unusual remedies will have to be applied. For example Norsk Data now requires that their hardware in central India is vacuum-cleaned inside once a month due to the very dry and dusty conditions that most of their computers are confronted with.

Other implementation problems relates to *resistance to change*. Several participants mentioned for example that managers were not prepared to touch keyboards. This phenomenon is also found in the West, but the relatively larger disparity in status found in many organizations in LICs means that it is even more difficult to get managers to touch the keyboard.

Finally the biggest implementation problem seems to be *training*. Training is often too little, too late, and too technical. Furthermore it is often aimed at the wrong people and is based on an inadequate model of learning. No doubt a very large part of the problems with IT in LICs are due specifically to the poor quality of training.

6. GOVERNMENT POLICIES

One of the main purposes of this volume has been to report on experiences with government intervention and government policies in LICs. There are many interesting reports ranging from

- *confident* reports on effective policies from India (Seshagiri, Subramaniam, Moni), Zimbabwe (Zwangobani), Nigeria (Okuwoga)
- to *less optimistic* reports from for example Bangladesh (Siddik)
- and *disconcerting* reports from Black Africa (Odedra, Kluzer), Greece (Avgerou), Ghana (Quarshie) who gave a ruthless critique of inadequate policies in the public sector in his country, and Sanwall, who gave the "secondopinion" as regards Indian policies especially seen from the periphery.

Everybody agreed that there were problems of adequate policies, especially integrated policies. Several suggestions, which were believed to be generally applicable were:

- governments should be promotive and not restrictive, i.e., they should not limit development (Bhatnagar)
- decentralization should be the overriding policy (Sanwal)
- appropriate applications like for example production management should be supported rather than payroll and CAD/CAM/Expert systems applications (Goonatilake)

But policy making is one thing, implementation of these policies can be very difficult (Avgerou), and from most countries there were reports about the glamorous espoused-theories and the dismal theories-in-use. There is still a lot to be learned from others having had similar experiences!

7. CONCLUDING REMARKS

It is not always easy and straightforward to learn from the experiences of others. As Sanwal pointed out in his insightful remark: "Perhaps we are making fundamental mistakes by

- learning from mainframes and generalizing to micros
- studying aid programmes and generalizing to all general administration
- focussing on linking/networks when the most urgent problems in a less industrialized country context may be that of stand alone equipment".

Once again we are reminded about the crucial importance that context and contingency views play in determining the proper policies, plans, designs and implementations of IT in less industrialized countries.

IT can no doubt be a significant - and perhaps even the most significant tool - in achieving administrative effectiveness as we have seen from many examples in IC as well as in LICs. But it can also be used to exploit, to dequalify, and to monitor people, and in this way deprive human beings of their fundamental right to work and a good quality of life. The choice is ours.

Our attitude should be humble. Nobody has the right answer! But if we engage in constructive dialogue, I believe we can move one step further in the direction of understanding the problems, perhaps even in defining the problems, and just maybe approach the solution to the problems.