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UTILIZATION OF COMPUTERS IN INDUSTRIAL DEVELOPMENT[1]

Prepared by

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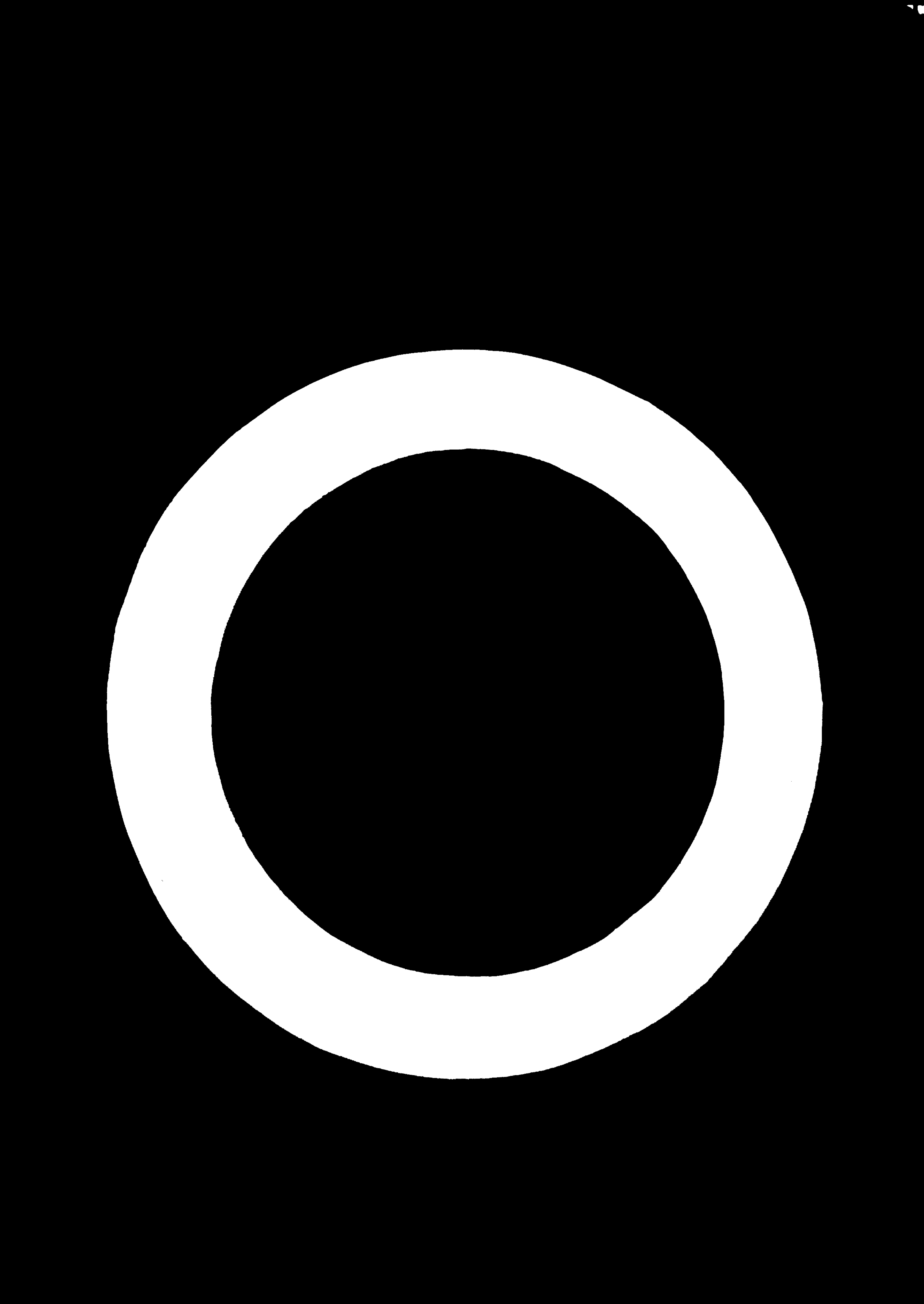

TABLE OF CONTENTS

PREFACE

Beside the introduction of Section 1 and the brief orientation of Section 5 of the technical assistance UNIDO is providing in the areas dealt with here, the present paper has three main sections. Sections 2, 3 and 4.

Section 2 covers the development of both computer technology and application during the last fourteen years. Section 3 attempts to investigate, in a practical way, computer utilization in the various areas of industrial development at the aggregate as well as the micro levels. Section 4 discusses a number of problems developing countries encounter in this regard and offers pertinent recommendations to this effect.

It should be noted that computer science as such is beyond the scope of this paper, as the main issue here is to analyse, as mentioned above, the multifaceted application of computers in industrialization and related problems.

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UTILIZATION OF COMPUTERS IN INDUSTRIAL DEVELOPMENT

1. INTRODUCTION

It became necessary to consider the upheaval which is taking place in development activities from planning, through implementation, to operation and control as an "information revolution" in which people from different disciplines using various techniques and procedures are engaged.

The development process, for a considerable part, involves the collection of data, processing of this data, i.e. carrying out computations on it according to some models or techniques, transferring the resultant information to its users, storing information and retrieving information whenever needed. This is evident in each stage of the development process: in preparing plans or programmes of development, in implementing these programmes and their constituent projects, and in operating and controlling projects or plants.

In order to cope with the ever-increasing demand for information, it was inevitable that attention should be given to more accurate, reliable and faster handling and transfer of information. In this regard a number of techniques and systems have been developed.

Manual computing systems were the first to be developed. The primary drawback was the inability to perform more than one function at a time. Equipment was then developed which was capable of performing computing and recording, such as the desk calculators or the cash registers. The latter, for example, provides computing and recording, issues receipts to customers and gives helpful management information. Errors in computation due to the human element involved coupled with slowness of operation were unavoidable.

Even after developing the machines combining computing, sorting, distributing and recording, these functions were not really integrated. A human operator had to transcribe from the documents generated during each data processing step and to transport the punched cards from one machine, after performing one or more functions, to another machine to perform other functions. The punched card equipment (tabulating machines) were then developed in order to ensure more compatability among machines of the same brand (such as IBM or Remington Rand). Punched card systems, however, could not obtain the degree of accuracy nor speedy operation required. This was attributable to the necessity of the operator having to move the punched cards from one machine to another in a sequence of operations and having to initiate each processing step as well. Added to this was the slowness of operations due to the fact that the machines used mechanical and electro-mechanical parts for performing their functions.

The mechanical and electro-mechanical parts mentioned above were then replaced by electronic parts and thus electronic computers and the electronic data processing (EDP) systems were developed to provide automatic control[1] and high-speed processing.

The development of the electronic computer, which is capable of carrying out the information handling and transfer process more accurately, reliably and a million times faster than the speed of the human being, must have a great impact on the work involved in economic and industrial development as well as on the structure or set up within which this work is undertaken. This is true due to the following main consequences:

1) Recipients of information, as for instance unit or section heads in an organization, can get only the information they need and no more. The computer can print this part of the information in the way or form required and ensure that up-to-date information is always transmitted in "real time"[2] to the recipient of information. Add to this the possibility of rapid simulation of alternatives of action for optimisation which will urge decision-makers or management to:

   a) determine at the outset the information they really require to discharge their functions and hence no time and effort is wasted in collecting and reviewing unnecessary information;

   b) benefit from the computer speed in transmitting information to them through becoming more capable of making decisions and taking action considerably faster.

1/ Automatic control means that the instructions to be given to the computer, which are in the form of an operating or control programme, are stored together with the data to be processed in the memory (the storage) of the computer. Accordingly, a "stored programme computer" denotes a computer which is controlled by a list of instructions stored in its memory or storage area to which it refers in a specified sequence when the application programmes (the programmes put on the computers for processing and solving, such as programmes related to investment planning, resource allocation, inventory control and payroll problems) are being executed.

2/ "Real-time" implies that information concerning some situation is transmitted fast enough to the information user so that he can make a decision or take action in time.

2) In an organization, the impact of the computer on the information system or information flows is profound. Since the design of an organization structure is the design of an information system, the computer assists in establishing what has become to be called integrated management information systems, which implies that in an organization hierarchy each organizational unit is interrelated to other units at the same or other hierarchical levels and accordingly the management structure is likely to change.

2. DEVELOPMENT OF COMPUTER TECHNOLOGY AND APPLICATION

Although actual application of computers started only 14 years ago, great strides have been taken in computer technology during this rather short period. Three computer generations have been successively developed and used for commercial as well as scientific or technical application. Each computer generation is characterized by certain improvements in computer design, size, capacity, speed of processing and operating costs over computers of the preceeding generation. Annex I compares these computer generations in terms of computer design, main functions, storage capacity, storage cost and average computation speed. While the 4th computer generation[1/] is expected to be on the market early in 1971, some computers such as the IBM System 3 have been developed as a transition between the 3rd and 4th generations.

It is interesting to mention that the cost of computers, in terms of storage cost: $\frac{\text{computer price (Purchase)}}{\text{storage capacity}}$ has been reduced by at least 80% within the last 10 years, while the cost of the software has been steadily increasing and this will be the prevailing trend. The latter is attributable

1/ Electronic data processing systems (computers) consist of hardware, i.e. the equipment (central processing unit, auxiliary memory or storage, and input-output units) and software, i.e. the programmes. The 4th computer generation is expected to bring about a number of improvements in both the hardware and the software. For the hardware it would probably be based on large-scale integrated circuits. As can be seen in the last column of the table in Annex 1, further development of computation speed would be of insignificant value. In addition, improvements in auxiliary capacity, magnetic tapes and discs would be made. As regards software it is expected that this would include improvements in programmes, better price/performance ratio and last but not least greater improvements in man-computer systems where a tight interactive relationship between the user and the computer would be achieved. Man-computer systems make it possible for the user to communicate with the computer in the human language rather than in computer language. The latter involves a process of translation from the first.

to various factors such as the excessive varieties of reporting systems and the development of the capability of the hardware through the development of programmes for time-sharing (time slicing), on-line processing and the like.1/

The above-mentioned development in computer technology has contributed to the increase in the number of computers installed as well as to those on order from above 1,000 in the entire world 14 years ago to over 85,000 today, of which about 6-8% are in developing countries. Moreover, the number of computer applications has considerably increased. In the highly industrialized countries the ratio of commercial (payroll, invoicing, billing, etc.) to scientific (marketing, distribution, production, engineering programmes, planning and control including modelling at macro and micro levels) computer application could be estimated on an average at 70:30. The latter, i.e. planning and control including modelling, investment analysis and operation research amounts only to a very small percentage of computer applications which might be in the order of 5-7%. This percentage may be even less in developing countries. However, there is enough indication for a remarkable growth in computer applications in this area in the years to come. This is true as (a) planning and control are now widely accepted as a prerequisite discipline for the industrialization process, and (b) there is an increasing demand for establishing computer-based government and management planning and control information systems.

1/ Time-sharing allows many users to share a computer at the same time, in such a way that each user seems to have the computer's exclusive attention. This is important since the central processing unit, which performs the arithmetic operations, has a considerably higher speed than the input-output units. The central processing unit would therefore be idle during a good part of the time needed to execute a single programme. Thus time-sharing aims at keeping the central processing unit as occupied as possible.

On-line processing provides the possibility of entering or retrieving data into or from an electronic data processing system respectively from a remote location through a communication terminal similar to an office typewriter or telephone line.

3. COMPUTER APPLICATION IN INDUSTRIAL DEVELOPMENT

In reviewing the process of industrial development it becomes clear that computers would be urgently needed at both aggregate and micro levels in a great number of developing countries. This section therefore deals with the likely computer application at these two levels as related to the various areas of development activities.

3.1 Aggregate level

3.11 General

This level is mainly related to the domain of development planning. It is therefore commendable that this part be concerned briefly with the techniques and methods used in national, sectoral and regional planning and their respective computational problems and requirements. Before going into this subject it seems appropriate to define development planning.

Development planning is used for identifying short- or long-term problems and bottlenecks that would impede development efforts, selecting the most appropriate investment projects, allocating limited resources to projects, coordinating development activities undertaken by various agencies at various levels of the country's planning and implementation hierarchy, and formulating consistent short-, medium- or long-term plans of development. Development planning is being practised in both centrally planned and market economies despite the prevailing difference in the constitutional structure of both systems.

In this regard the techniques that are worth mentioning are those related to mathematical model building.

3.12 Model building techniques for development planning

These techniques mainly encompass the development of econometric mathematical models for describing the quantitative interdependence of the economic variables of an economic system. Mathematical models could be regarded as growth models or normative models. The first are developed to identify the future behaviour of the system, giving certain information *a priori*. The second are centered on an objective function and thus provide the most favourable decision regarding the maximum or minimum level of the objective function within the conditions (scarcities, limitations, constraints) imposed on the system.

As a useful tool in economic and industrial planning models should have some degree of detail and by doing so they become more complicated for development and application. The level of detail (number of sectors included) of a mathematical model depends on the data available and the data processing system used. Data limitations and/or inadequate data processing would inevitably impose substantial modifications on the model which frequently make it of questionable value. This is true since the application of mathematical models in development planning involves not only theories to describe the relationship between economic variables but also excessive data retrieval, rapid and reliable data processing and a large number of trials during the various stages of model building and application which could be briefly discussed as follows:

(a) Determining the model system of equations involves an arduous iterative procedure even if the model consists only of a few equations whereby the relevant variables (exogenous and endogenous) are determined and the appropriate mathematical shape of each of the equations comprising the model system of equations is established.

(b) Determining the values of the coefficients in equations is based on manipulating time series data for the past 5, 10 or 15 years by certain statistical methods such as the least squares method for regression analysis or the simultaneous equation method. The former is less complicated than the latter. However, it only allows one variable in an equation to be designated as dependent (endogenous) on other variables in the system. As mathematical models frequently have more than one dependent variable in an equation, the simultaneous equation method could then be used. For the latter, even if a modified version is used for simplicity, it still is a complicated and burdensome method involving computational limitations which are impossible to deal with by manual computing systems. The situation is further aggrevated when the model is detailed rather than aggregated. It should be noted that using data and parameters of past periods may be misleading in this respect in a developing country as they were related to the situation which the effort towards development aims at changing. Since the purpose is to change the existing structure embodied in past trends, other data and parameters have to be incorporated in the model.

(c) Projecting the future values of the economic variables. The solution of the system of equations to determine the values of the endogenous variables for certain estimated levels of the exogenous variables (which would be the main body of the quantitative data comprising the development plan or programme) is a cumbersome job where reliability, accuracy and speed of computers are, in the majority of cases, essential requisites..

(d) Testing the adequacy of the model by using all available data and information in order to find answers to such questions as:

(i) Does the model work?

(ii) Does it describe the future behaviour of a system superior, though far from perfect, to any other available method which can be economically used?

To arrive at a satisfactorily improved system of equations of a model a large number of trials (computer runs) have to take place, a process which generally requires adequate data processing facility in order to cope with the vast quantity of data, the speed of processing and the accuracy of output.

(e) Updating of models. In the course of time, conditions inevitably change thus necessitating adjustments to be made in the variables and structural relationship of the model. The rate of updating of the model definitely depends on the system of planning. Frequent updating of models is, for instance, clearly needed with medium-term plans (3-5 years) supplemented by annual plans. This necessitates the establishment of reliable computer-based information systems with adequate electronic computing facilities to monitor those critical variables and parameters in order to: detect in time any changes in their current values; to communicate the necessary information on the change to the correct person in the planning system at the correct time; to simulate the model rapidly and reliably using the new input data to determine whether the utility of the model will be significantly affected by the change to warrant its modification; and, if so, to up-date the model.

Main models currently used are:

3.121 Comprehensive models

3.1211 Simple aggregate models

In this type of model the economic activities of a country are aggregated into one or a few categories and frequently the models only consider one factor of production.

The aggregate Harrod-Domar production function serves as an example. It is mainly used to determine the capital requirements for various levels of production corresponding to alternative investment plans; as an aid in comparing demand with supply of capital and hence modifying the plan. Both ECAFE and ECLA used the Harrod-Domar[1/] production function in projecting the economy of the countries in their respective regions. In addition, a number of countries applied the Harrod-Domar model, such as India, in the preparation of her second Five-year Plan where the economy was divided into four sectors.

The well-known Cobb-Douglas production function[2/] is another example of aggregate models. It describes production as a function of two scarce factors of production, namely labour and capital while assuming perfect substitution between them.

3.1212 More detailed models

Here two models are included; static input-output models and simulation models:

(a) Input-output models

Input-output analysis deals with various empirical problems for which national income and partial equilibrium analysis

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1/ In addition to the production function which describes the various technological possibilities, the model system of equations would include other equations or functions including variables such as consumption, import, net factor income coming from abroad and balance of payments. Initial values and coefficients of the model are to be determined from current data and past time series. The variables in the system will be determined at the projected period (time t) either as exogenous parameters, such as export, which is to be determined (given) outside the model, or endogenous, as gross national product inside the model, i.e. the outcome of the solution of the system of equations.

2/ It is worth mentioning that although the Cobb-Douglas production function is for certain applications superior to the Harrod-Domar production function, the latter is used more especially when statistical data is inadequate or in the case of long-term projections when capital is scarce and is a limiting factor to development.

techniques are inadequate. It deals in detail with the interrelationship or interflow of commodities and services among the economic sectors of the whole economy, a sector or a region.

In an input-output table each entry therefore indicates a transaction of commodities or services during a certain period of time - usually a year. The entries may represent transactions in physical units but usually this is done in monetary units using the price of a base year. Since it is widely used more will be said below on input-output analysis; its computation requirements as related to its main uses.

The main uses of input-output analysis are: structural analysis of the economic system; policy guidance; and projections of the economic system.

Among other things structural analysis involves:

(i) The calculation of the quantity of each primary input (e.g. the import content) which is directly and indirectly required to satisfy the final delivery of one unit of output of one or more sectors. Here the inverse coefficient matrix is to be derived from the input coefficient matrix and is used to trace the ultimate origin of the inputs absorbed in the final output of a particular sector.

(ii) The undertaking of market-type of analysis as and when it is desired to find the ultimate destination of the output of a particular producing sector(s). For this purpose the rows of the inverse coefficient matrix are used instead of the columns. This kind of information is valuable to the establishments constituting the sector under study and shows how the output of other sectors affect their ultimate markets.

(iii) The determination of component factor costs of the price unit of the final output of a sector or sectors. Here computations would involve a transposed inverse coefficient matrix, multiplication of a specified sector row of this matrix by the different classes of primary input coefficients and then the placing of quotients in rows.

As regards policy guidance, sensitivity type of analysis could be undertaken with the help of a detailed input-output table and laborious computations when input-output analysis is used (though with limitations) as an aid in simulating the various government price policy alternatives.

As a predictive model, input-output analysis can be used in the projections of the economic system.1/ In other words it is used to determine the future levels of output of the different sectors for both short and long terms. Computations here include the projection of final demand and input coefficient matrix and then the calculation of output levels by multiplying projected final demand by the inverse of the projected matrix. Since the computation of an input-output table might take as long as 3-5 years, input-output projection models may have to be based on previously prepared tables. However, as new input-output data becomes available, frequent iterations are deemed to be necessary to update the input coefficient matrix and render it more consistant. Computations required are related to the degree of complexity of the projection approach used which may vary from a simple extrapolation of past trends of coefficient changes (using coefficients from two past tables) to the formulation of a linear programming problem where the changes in the original coefficients are the solution to the problem.

From the aforementioned, a number of points can be noted. In order to be meaningful and of value to the planner the input-output models should include a relatively detailed industry breakdown. It should be pointed out, however, that as the size of the matrix increases the input-output table becomes more complex, burdensome in computations, time consuming and subject to a very high probability of error. In order to visualize the order of

1/ An 83 x 83 input-output table for the United Arab Republic in 1954 was developed and used for the projection of primary input requirements for the UAR economy for 1960/61.

magnitude of the difficulty involved, it may be of interest to mention that the preparation of the inverse of a small input coefficient matrix of, for example, 16 sectors takes by manual computing systems on average not less than 300 man-hours. Moreover, by its very nature as a static system, the timing of the table and the speed with which it is prepared is extremely important since its usefulness tends to diminish with time to the extent that its value to developing countries has been frequently questioned due to the high opportunity cost of the process involved.

It should be further noted that aggregate tables do not always mean to be less complex. Problems similar to those mentioned above are still to be faced particularly when more detailed sector classification is adopted (which is frequently the case) in preparing the aggregate table, since, at such a level of detail statistical data can easily be found; and in addition to the fact that generally speaking working at a more detailed level improves the quality of the results.

From the analysis so far it is needless to over-emphasise the necessity for large-scale computers in this area.

b) <u>Simulation models</u>

The above mentioned mathematical models are not truly dynamic, although the variables included have a time dimension. This is due to the fact that all variables are of the same period, which is different from the actual path of development during which, for example, various amounts of investments at different points in time with different gestation periods take place.

Simulation, on the other hand, is supposed to aim at more realistic models to work with, which are neither normative nor optimisation models. Having formulated a simulation model which comprises relations similar to those developed in econometric studies, input-output analysis[1/] and some others resulted from

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1/ The industry breakdown included in simulation models would not be as detailed as the one used for input-output analysis.

certain qualitative observations, attempts will be made at a more realistic development of the time paths of variables beginning at a certain point in time, under some given conditions, through a quasi-continuous process of computation. In it the computations proceed in intervals of time throughout the planning horizon. In the MIT simulation model[1] the computations progressed in steps of one-twentieth of a year, which provide a fair approximation to a continuous process during overall periods of 5 to 25 years. The amount of data and the complexity of computation clearly necessitates that the application of simulation models be geared to the utilization of large-scale computers, which renders further argument in this regard irrelevant.

Having put the simulation model in the form of a computer programme any necessary modifications should be made to ensure that the model yields satisfactory results. In using the model, a comparison is made between alternative development programmes as well as instruments of economic policy, assuming different time paths of variables. For example, at early stages of development this could take the form of some computer runs including emphasis on the development of consumer goods industries and then later emphasis would be on capital goods industries or the establishment of new export products - - - and a host of other possibilities and problems.[2]

Apart from the two models discussed above it would be worthwhile to cite another example on a detailed model. This is related to the long-term manpower planning in the United Arab Republic (UAR).[3]

The objective here was to determine the manpower requirements for all sectors of the UAR economy for the period 1960 - 1985 and to develop accordingly an education and training plan. Manpower requirements have been related to the needs of the economic development programmes and an economic development forecast of the production level of each sector was

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1/ Edward P. Holland, The American Behavioural Scientist, Principles of Simulation, September 1965, Vol. IX, No. 1.

2/ Simulation model of the economy of Venezuela developed in 1963 can be used as an example.

3/ Mostafa H.A. Hamdy "Manpower Requirements for the UAR for the period 1960 - 1985", The Institute of National Planning, Memo No. 431, 26 May 1964.

thus made during this period. Having determined these production levels, sectoral changes in labour productivity have then been predicted in order to estimate the aggregate sectoral employment during this period. Projected demand by category of manpower was then determined with the help of a manpower occupation structure for 1985 which was developed for this purpose. After projecting the manpower supply for the period 1960 - 1985 from existing education and training systems, projected supply and demand were compared and expected deficits by category of manpower were determined. The education and training plan was then developed to make up for these deficits gradually. Due to the lack of data and particularly computer facilities a number of assumptions and modifications were made in order to reduce the number of variables to a manageable number which have limited the value of the model. Foremost were:

(a) Estimation of sector variables or parameters used for economic forecast, projection of labour productivity and expected changes in the occupation structure for manpower from 1960 - 1985 were based on inter-country comparisons. This involved both time-series analysis as well as cross-section analysis. For the first, both the number of countries included and the number of post years covered by the data were limited. For the second, the number of countries was reduced.

(b) Occupation categories of manpower dealt with were relatively small.

(c) Projection of labour productivity disregarded the effect of important factors, such as, technological advance, improvements in organization and management, improvements in manpower performance through training and upgrading and structural changes of production, during the period of planning.

(d) A sketchy assumption implying that graduates from a certain educational discipline or training programme would occupy posts involving the areas they were trained in.

(e) No effective reallocation of available qualified personnel was considered.

3.122 Sectoral models

Models are also used in sectoral planning, sectoral plans can be developed as an integral part of, or independent from, a national plan. The former is the case of centrally planned economies. A sectoral plan would be more detailed than the component of the same sector in an over-all plan. A sectoral plan may consider all the sector activities or may concentrate on one or a small number of activities which are considered critical or limiting to development.

3.123 Regional models

A country's economic system could be considered as consisting of a number of sectors or it could be divided up into a number of regions.1/ A regional plan could be a part of, or independent from, a national plan. Regional planning is of particular importance when a region's development has a direct impact on the development of other regions or on the development of the country as a whole. For the latter, selection of potential regional as well as national projects that would be implemented in the region would be of essential importance.

Mathematical models, similar to those previously discussed could be also used for regional planning. In addition mathematical models have been successfully used for some specific activities of regional development such as in the programming of industrial complexes. Examples of regional planning activities include the regional development programmes in the various regions of the North East of Brasil, particularly that of the State of Bahia and the regional development programme of Aswan, United Arab Republic.

1/ The extent to which a region in a country would undertake, by itself, regional planning, is a function of a number of variables. Foremost are, availability of resources in the region and the responsibilities assigned by the federal or central government to local or regional governments in terms of taking political and administrative decisions.

Problems relating to lack of data and inadequacy of electronic computing systems, as previously discussed, have also been encountered within both sectoral and regional models where simplifying assumptions limiting the value of the model had to be made.

3.124 Integrated (or multi-level planning) models

The coordination or integration of sectoral and/or regional plans in the national plan presents a problem. For example, economy-wide investment models give the overall optimum investment programme indicating the optimum investment levels in the economic sectors. At this point no projects are specified for implementation in each sector. What is then required is for sectoral planning bodies to select a number of projects according to certain specified criteria within the level of investment in each sector previously specified by the national or central planning body. Coordination here is of importance in order to select those projects which provide complementarity among the sectors of the economy. In the absence of a well established system to this effect, coordination would not be possible.

For more integrated or multi-level planning the application of mathematical models of a reasonable degree of detail should require the utilisation of large-scale computers due to the vast amount of data used and the iterative procedure which is frequently employed.1/

1/ This would be appreciated by citing briefly one attempt towards more integrated planning.

Two-level planning technique* was developed to deal with planning at the national and sectoral levels. The Central Planning body draws up an initial investment programme on the basis of its shadow price system. After deriving their sectoral optimum programmes, according to the investment allocations in the programme of the central planning body, sectors feed back their programmes, as well as their corresponding shadow price systems, to the central body, together with their recommendations, which might include proposals for changes in investment allocation. Accordingly, the central planning body modifies its overall optimum programme and consequently each sector derives its modified programme. This iterative procedure continues until an optimum solution is found.

* Kornai and Liptak, "Two-Level Planning", Econometrica, Vol. 33, No. 1, January 1965.

The above mentioned analysis of the mathematical models for development planning and related computational requirements would suggest the following simple comparison between the various computing systems, bearing in mind the difference in speed and cost of data processing and retrieval among them.

It is not impossible:-

(a) for simple aggregate models consisting of about 10-12 sectors to obtain the solution by means of manual computing systems, although they need laborious work of computation, checking, recomputation and listing or tabulation;

(b) that punched card systems such as IBM/602A or 604 could undertake the processing of models of 12 - 16 sectors;

(c) that first generation computers such as the IBM/650 could carry out the processing of 16 - 20 sector models;

(d) that second generation computers such as IBM/704 could process models of 20 - 25 sectors.

For models having more than 25 sectors third generation computers such as the series of IBM/360 would be sufficient.

3.2 Micro level

3.21 General

The last fifty years have witnessed profound changes in the tasks and responsibilities of the management of enterprises and, in most cases, has made computer-aided management decision-making essential. This is attributable to a number of factors. Organizations grew rapidly in size and comprised a bigger number of interrelated components (departments or plants, etc.) Technologies available became more complicated and need considerable effort in the area of research and development and this manifested itself in design, production and maintenance. Products have been diversified and the range of products within organisations is widened. Timely information and reporting by the organisations to outside bodies is tremendously increased. More effective formal decision-making techniques have been developed. And last but not least, electronic computers have been developed which can process data and information much faster, more reliably at less cost per unit of information than any other data processing methods. In the meantime the pressure on the management, mainly to stand competition, has been considerably increased to develop their ability in order to respond rapidly to changing conditions and to take timely decisions.

Accordingly, in order to let an organization or enterprise function smoothly and achieve its objectives, management has to appreciate the ever-increasing complexity of data handling activities. Masses of data and information from the different organizational departments, as well as from outside the organization, have to be collected, processed according to certain models based on some decision-making techniques, transmitted through the communication channels to the various decision points in the organization hierarchy, and stored and retrieved whenever needed. It is therefore needless to over-emphasise the role of computers in helping management in making reliable decisions and controlling the implementation of these decisions.

The decision-making process comprises two components: information as well as management techniques. Since data processing and information needs vary with the management techniques used it is therefore essential when dealing with data handling, to consider both information needs and management techniques in the context of the various functions of management and to consider how computers can improve management ability in carrying out these functions.

3.22 Management functions and the computer

Basically, management has two main groups of functions; planning of future operations and control of operations.

Planning or strategic planning 1/ involves the determination of organisation goals, any necessary changes in them, allocation of resources.

1/ Robert N. Anthony, "Planning and Control Systems; A Framework for Analysis", Boston, Harvard University, Graduate School of Business Administration, 1965.

to these goals and definition of policies for acquiring and using the resources. Strategic Planning decisions are those one-of-a-kind decisions which commit capital resources, such as those related to whether a new plant shou d be built, which of several available technologies should be adopted, how the distribution of a product can be improved to provide faster service to customers, etc.

Control functions are of two main types; management control and operational control. Management control involves the establishment of procedures to assure the effective utilisation of the resources to accomplish the goals according to the policies set up by strategic planning. For example, programming and scheduling of project implementation and formulation of budgets require management control decisions and although a good part of management control is planning, yet it differs from the strategic planning mentioned above. Operational control comprises the day-to-day decisions that are necessary to carry out the projects or enterprise operations according to the objectives and resources prescribed by both strategic planning and management control. For example, production scheduling and control and inventory control require operational control decisions; day-to-day decisions on how to handle special jobs, what to do in case of material shortage, how to schedule material and manpower, how to complete a rush job at the promised time, etc. are to be taken.

In order to carry out these functions, management should be provided with the necessary information which is generated within and outside the organisation. Information required should be up-to-date, accurate, set in the proper format relevant to the issue at hand, and received in real time by the recipient or user of information. It should, in addition, highlight significant variables, indicate out of line conditions and be the only information needed by its user. Knowing that computers, as previously stated, are capable of processing, transmitting, storing and retrieving data and information more accurately and rapidly than any other data processing method, the question is what management functions could be carried out by the computer. In general any decision that is based on rational factors can be made more efficiently by the computer. Furthermore, decisions based on logical operations can be more favourably made by the computer provided that all the required information is available to the computer and the logic for obtaining the decision is known. In other words, electronic computers can so far take over those management functions which do not involve judgement and creative thinking.

3.23 Management problems and related techniques used

Management areas and related problems are numerous. It is not within the scope of this paper to cover all of them. It is only attempted to deal rather briefly with some of them together with relevant problem-solving techniques used with the help of computers. Due to the complexity of these problems and the importance of finding satisfactory solutions, managements have been sactioning the ever-increasing application of systems analysis and operations research techniques for problem solving. Since the advent of computers these techniques have been successfully applied in solving management problems.

3.231 Cost analysis and control

This involves a number of problems and problem solving techniques such as:-

3.2311 Cost-effectiveness analysis

In an enterprise, many decisions can only be solved if the various alternatives which can achieve a certain goal are studied and compared.

Cost-effectiveness analysis can be defined as "being that procedure by which the costs of alternative means of achieving a stated effectiveness or, conversely, the effectiveness of alternative means for a given cost are compared in a series of numerical indices 'The objective of the analysis is to isolate the alternative, or combination of alternatives, that either gives the greatest expected effectiveness for a given, or least expected, cost."[1] For example, if the goal is to increase the performance of a certain engine and if there are a number of engine types that can achieve this goal, a decision should be taken as to which engine type should be adopted. This is based on relating the cost and effectiveness of the alternatives and comparing them together. Cost will include cost of capital resources and the time required for a successful production. The effectiveness criterion or scale used might be taken to be the difference of fuel consumption for the same engine size, weight, etc. compared to that of the existing model.

3.2312 Resource allocation for minimum cost

This group of decision problems is mainly dealt with by the linear programming technique.[2] It is a mathematical technique used to determine the optimum allocation of resources which satisfies some specified objective, for instance minimum costs, when there are alternative uses for resources. As an example take the case of a manufacturer who will produce a number of products at the same time. He should know the production size (number of units to be produced) of each product that should be produced so that he would be able to satisfy his goal or, in mathematical terms, his objective function; minimum cost, maximum profit etc. The solution to the problem is to find this optimum production policy taking into account the limitations and constraints imposed on the manufacturer's operations such as limited production resources, etc. The graphical method to solve linear programming problems is only possible for problems with not more than two variables (such as two products in the example mentioned

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1/ Karl Seiler, 3rd, "Introduction to Systems Cost-Effectiveness", Wiley-Interscience, A Division of John Wiley and Sons, New York, 1969.

2/ Linear programming is applied to a variety of management problems.

above). For more variables the algebraic method of solution should be used. The most common method used is called the Simplex Method. It is an algebraic procedure which progressively approaches the optimal solution through a well-defined iterative process until optimality is finally reached. Due to the considerable number of variables which are frequently included and the nature of the iterative process involved computers are being used in this field to great advantage. Consequently, computer manufacturers provide computer programme packages or standard programmes to the users to put these problems on computers and to save them the effort of writing their own programmes. In such a case the users only need to prepare the input data for the computer.

3.2313 Inventory control (control of stock)

Since stock levels fluctuate according to market demand the objective of inventory control is to achieve an optimum stock level at the lowest total cost. The total cost comprises; the cost of carrying inventories, the cost of incurring shortages and the cost of replenishing inventories. Inventory control involves decisions which mainly relate to; the quantity required to replenish the stock, i.e. how much to order and the determination of the minimum stock level, i.e. when to order. The solution to the inventory problem is achieved when values of these parameters can be found which give the lowest total cost mentioned above. Inventory problems are commonly solved by building a mathematical model from which optimal decision rules are derived. For this purpose methods of mathematical statistics are used due to the uncertainty presented in predicting the volume of sales as well as the replenishment time in many cases. Accordingly, the expected demand and expected replenishment time are taken from some probability distributions.

The computer is used to great advantage in solving inventory models. One of its big advantages is to simulate a probability distribution by a sampling process which otherwise would be time consuming. Once a certain inventory policy is established the computer is capable of tracking the current inventory situation and proposing action when change or follow-up is required.

3.2314 Transportation problem

Problems of this type arise when many plants are geographically separated from their warehouses or the markets they serve, and thus the optimal shipping pattern is to be sought in order to minimize transportation costs and to meet market demands. The technique usually used to solve transportation problems is similar to the general linear programming technique. In fact the transportation problem is a special type of linear programming problem.[1] This technique is again an iterative one, involving a great amount of data processing, and hence computer utilization. Computer manufacturers have developed programme packages designed to solve transportation problems. One well-known package is the "stepping stone method" which is an iterative procedure. This involves the development of an initial distribution as input which is any allocation of shipments that satisfy the requirements without regard to the total cost. In each iteration the computer constructs a new distribution with a smaller total cost than the previous one. This continues until a reduction in total cost is no longer possible which implies that the solution, i.e. the resultant total cost, is optimal.

1/ This technique is also used in some situations which do not involve transportation such as allocation of new products to plants in order to minimise total manufacturing costs.

3.232 <u>Project implementation</u>

Project implementation is the phase where major problems impeding the industrialization of the developing countries take place. In most countries failure to attain the intended development has frequently been failure to achieve successful or even satisfactory implementation, to the extent that project implementation has fallen short of expectation due to lengthy delays and overrun of cost. Delays of three to five years in project completion are not unusual. This is mainly attributable to scarcity of resources and lack of necessary expertise required to deal satisfactorily with the complicated tasks of implementation.

Network analysis techniques are now the most effective discipline which is widely used for programming, scheduling and controlling project implementation. In implementing a project it is not practical nor possible to attempt to work with the entire project as a single entity. It should be sub-divided into its component activities or operations such as project detailed design and engineering, bidding and contracting, construction of plant, erection of machinery and equipment, and start-up of production as well as the de-bugging of the managerial and the production processes. Project implementation programming is thus used to indicate the rightful chronological place of these different activities and to identify their interrelationship.[1/] According to the methods that are to be used to undertake each activity, an estimate of time duration required for the carrying out of each activity is to be made in order to arrive at the time schedule for each activity as well as that of the project as a whole. The result of programming and scheduling is a time-phased plan for implementing the project taking into account available capital,

1/ Considering the relationships between the various activities or jobs constituting a project is of essential importance since in implementing a project some activities have to precede others, some have to follow others and some have to be undertaken at the same time with others.

manpower and material resources. The plan[1] in this form is a very useful management tool as it detects the order of magnitude of potential bottlenecks that would hamper project implementation and determines the time periods during which they would occur. Consequently management would be in a better position to take corrective action ahead of time and direct its efforts and resources where they fit best. In the absence of these techniques implementation problems are only known when they occur and hence delays and cost increase.

Control of implementation involves; the coordination of the work of all parties (the enterprise, contractors, government departments, .. etc.) participating in implementing the project, the feed-back of actual performance to be compared with estimates of the plan and the taking necessary corrective measures.

For projects of medium and large size the application of computer-aided network analysis techniques is of great value to management. Since this subject is relatively new it seems appropriate to consider it in more detail than the others.

The difficulty in project implementation is not so much the process of programming and scheduling at the outset, but it is, in fact, how to exercise effective project control during the various phases of project implementation based on efficient feed-back or reporting. This area of work is directly related to the so-called management information systems.

1/ Both basic as well as advanced network analysis techniques are applied to a number of management problems; project time planning and control, cost analysis and control, time-cost trade off, and resource allocation. The time-cost trade off problem arises from the fact that most of the activities of a project can be undertaken by alternative methods which require different time durations, amount of resources and expenses. If the initial schedule for implementing the project is beyond the desired project completion date which may have been specified by some external controls, these techniques attempt to find the project schedule that meets the deadline, with the lowest total direct or variable cost. On the other hand, if these techniques are applied to determine the most favourable completion date, then they find the schedule that gives the lowest combination of direct and indirect costs, hence the lowest total cost.

A project of a short duration in the order of six months, for instance, with follow-up reporting every two months, can be dealt with economically by manual methods. The same could be said of relatively small-sized projects where all the activities are the responsibility of one department in an organization or one person and hence are well known to him.

However, most of the industrial development projects in developing countries have a duration of two to five years and, in addition, they are complex in nature. The latter partly stems from the fact that the projects are new to a country where prior relevant experience is lacking. These projects need a more elaborate organization of work, than what has been so far practiced, in order to carry out the various project components chronologically at the right time and in the right place. Furthermore, as conditions change in the course of implementation, frequent collection of data and information, periodic evaluation of progress and revision of strategy seem to be imperative. The situation is further aggravated by the fact that progress reporting and periodic revision may be necessary every two weeks if not weekly.

With large projects a decision might be taken at a certain level in the organizational hierarchy, which is responsible for implementation, concerning some part or portion of a project, which might not be based on sufficient knowledge of the situation in other parts of the project. Such a decision, which may be effective for this particular part of the project, may have detrimental effects on other parts or on the speed or cost of completing the project as a whole. Therefore, it is essential to determine rapidly and reliably the impact of individual decisions on the various activities of the project. Computer utilisation in this respect is of great value.

On the other hand, not every agency participating in implementing the project nor every manager of a part of the project is interested in following up the progress of the entire project. Follow-up reports should contain only the information needed by the recipient of the report. Such information should reach the right person at the right time so that effective control can be achieved. In this regard computers are of essential importance as they are capable of processing huge amounts of data and arranging the results in a great variety of orders through sorting and selective printing of information. Furthermore, alternative solutions to problem projects which are behind schedule can be more easily and rapidly simulated and compared by computers, than by any other alternative.

3.233 Production control

Here production control implies both planning and control. Due to the complexity of the manufacturing process, an enterprise controls its production at the plant's operational level to meet sales requirements. This involves the integration and coordination of the utilization of manpower, machines and materials for the efficient production of goods. In short, production control determines how, where and when work is to be done and follows it up for control. Consequently it mainly includes material planning, scheduling and machine loading as well as shop progress control. The recognition of the managements of the value of applying operations research techniques to production control problems which require the use of computers and the development of the third generation computers with their high speeds and storage capacities have greatly succeeded in solving production control problems. For example production scheduling and machine loading involve the optimization of the sequence of operations and the development of a smooth work load. This frequently necessitates the application of operations research techniques such as the queuing technique and the utilisation of computers.

4. PROBLEMS OF COMPUTER UTILIZATION IN DEVELOPING COUNTRIES AND PERTINENT RECOMMENDATIONS

The foregoing sections analyzed the great value computer application has in a variety of areas of industrial development. However, a word of warning in this regard seems appropriate. Without adequate knowledge of computer requirements, related problems, factors discrediting computer application and proper approaches to alleviate them, the potential success of computers would simply become an expensive failure. These are briefly dealt with below.

4.1 Utility and economy are not fully considered in using computers. The consequence is limited use of computer systems and hence high cost per unit of information provided and lack of coordination between computers established. Experience indicates that decisions related to the utilisation or installation of computers in many developing countries are for some, if not a great part, subject to many irrational factors or based on inadequate knowledge of what a computer requires and can do. The latter frequently stems from the fact that most of the managers or executives in developing countries who would decide on whether to use or install computers lack the necessary knowledge in this respect. This is true, since computers practically came into being fourteen years ago when most of these high echelon people had already completed their education. The situation is further aggrevated due to the complexity of this decision which is based not only on knowledge of the field of computer science but also on knowledge of other areas, such as systems analysis, econometrics and operations research.

For this purpose a detailed feasibility study is to be undertaken to investigate the actual needs of the organisation concerned and whether computer utilisation or installation warrants its cost. Although feasibility studies are of essential importance, experience shows that managements having inadequate knowledge in this field might not be able to understand or appreciate the importance of analyzing the present system nor the detail that should be put in the proposal and consequently might not agree on the resources, time and cost required to carry out these studies. The undertaking of this type of feasibility studies requires:

considerable knowledge of the activities concerned and the structure within which they are undertaken, analytical skill and knowledge of computer technology. Electronic data processing systems analysts are to be assigned this task.

4.2 The fallacy in most developing countries is to believe that the changing data processing systems towards more mechanisation follows a certain sequence such as changing manual systems first to punched-card systems and then to electronic data processing systems. Following this order unnecessarily would effect delays and an increase in cost in shifting to the most appropriate system. The system redesign should be solely based on the present and future needs of the organization. Based on the feasibility study mentioned above, a direct change from manual systems to even large-scale computer systems could be suggested. It should be noted, however, that this does not mean that any attempt of system redesign should suggest a change from manual systems to other systems. At a certain level of data processing, redesign might not be anything more than maintaining of a manual system with some improvements regarding a better organization of input and output data at the various organisational levels. Though lack of high speed, reliability and accuracy of data processing would still be prevailing.1/

4.3 There is a variety of computers of different brands available on the market. Since they could do the job equally well at comparable cost, the important point to be considered in installing a computer is the selection of the computer manufacturer. Here factors such as; the manufacturer's system design, the kind of supporting services he can provide; his research and development programme and the reliability of the software he can furnish should be considered. The latter is of

1/ It should be borne in mind that cost of processing with manual systems will increase as the data processing load increases. This is true since increasing the work load beyond a certain capacity of the operators, carrying out the processing functions, will affect their productivity, reduce supervision on the work they do and perhaps require overtime work at a higher cost and less efficiency. This definitely limits the data processing system in coping with additional processing functions to meet pressing needs.

essential importance as the effective utilization of a computer system does not only depend on the computer but it also depends on the software provided with it.

4.4 When substituting computer systems for manual systems, utilization of the former should not be limited to the computations that were carried out manually so that computer applications would not be restricted and hence higher marginal costs. Further applications and additional functions should be studied and included such as using the computer in decision-making, selective data sorting and reporting, etc., at the various levels of the organizational hierarchy. In an enterprise priority to utilize the computer should be given to those problems involving a vast amount of data and information as well as those which are mathematically complicated.

4.5 The utilization of computer systems definitely increase the speed of computations. This, however, is but one of their numerous benefits over manual systems, as previously mentioned. It should be emphasized that these benefits would not be automatically realized by the establishment of such systems. Certain measures should be taken and implemented in order to gain these benefits. For this purpose it is of essential importance to gear the establishment of a computer system to the establishment of a well structured information system with well defined boundaries. A small number of developing countries have so far recognized this prerequisite and even those which did, have dealt with it on a rather partial basis.

4.6 Future expansion of computer systems frequently presents some problems. All too often a computer is installed to replace an existing manual or punched-card system and to carry out the limited work which was done by the old system. The computer selected in this case could be the smallest one in the manufacturer's computer line. Soon the organisation realizes the potentialities of the computer system and new and more complex applications will be put on the system. Accordingly, the existing system will cease to be sufficient to meet the needs at hand and hence the problems of "conversion" from a present to a larger system will be faced. One of the problems is the compatibility of the software or programmes. Not every programme written for a small computer can run faster or even can run at all on a bigger computer, although many computer manufacturers claim this attribute in what they sometimes call "upward compatability". Therefore, in case of conversion from a smaller computer system to a bigger one the necessity of rewriting the programmes should be seriously considered.

4.7 When they need computers many organizations would acquire small computers. This stems from a number of reasons. Foremost is cost. Soon, as was mentioned before, the need would exceed the capacity of the computer and a bigger computer will be sought. Experience has shown that when a small computer is installed, before long an additional storage capacity of 8, 16 or 20 K[1/] would be acquired. If such expansion has been provided for in the initial configuration, the additional capacity would cost much less than if it has to be added at a later date.

4.8 The delivery period of computers is between one and two years. Many developing countries which acquire computers do not effectively utilise this time period for computer programming, i.e. preparing programmes to run on the computer. This of course will require extensive work in identifying problem areas that warrant computer utilisation, putting them in a well structured form, applying some mathematical techniques to solve them and preparing the computer programmes for processing.

The latter are very time-consuming factors which should be seriously considered before acquiring the computer itself. Although the computer manufacturers can provide some help in programming, developing countries should depend for a great part on their staff in writing and modifying their programmes. It is understood that training of programmers will take time and directly after training is completed, it is unlikely, due to lack of experience, that they will be able to do the job rapidly or effectively. In this regard it is worth mentioning that those training courses in programming commonly held for a few weeks can hardly cover programming as such. They mainly cover simple coding. Managements should know that a programmer needs a longer time to be trained and to

1/ K denotes 1024 bytes. One alphabetic or numeric character can be stored in one byte.

acquire experience before he would be able to prepare a well conceived programme although writing computer programmes has been recently simplified.[1] Although this has resulted in wider computer application, the following should be borne in mind:-

(a) The resulted simplification in writing computer programmes is responsible for the tendency of the management in many developing countries to under-estimate the complexity of programming.

(b) When complex problems are to be put on computers, package programmes are unlikely to be of much value and thus programmes to be used directly for those specific problems have to be written anew.

4.9 Computer staffing also presents a problem. Computer systems require three main categories of personnel: systems analysts, programmers and operators whose numbers could possibly have the ratio 1 : 1 : 0.75 as recent surveys have shown. Appropriate training programmes should be provided. For this purpose, it is of essential importance to know the functions of each category. Since the difference in the functions of systems analysts and programmers is frequently not appreciated in developing countries, a brief analysis of their respective functions seems appropriate:-

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1/ Writing computer programmes has been steadily simplified. This manifests itself in the following:

1. The development of the so called "assembly languages" which render programme writing a simpler task in logical expression rather than in detailed cumbersome machine instructions.

2. The development of standard programmes for common activities such as payroll, inventory control, project implementation programming and the like.

3. The development of the so called high-level languages such as Fortran, Cobol, Algol and P.L.I. which have greatly simplified programme writing to the extent that those trained in other disciplines such as mathematics, engineering, etc. can now rapidly be proficient in writing computer programmes in their own field.

(a) Systems analysts

In an organization systems analysts:-

(i) define, develop or improve the system of work; determine the information needs and flows required to plan, implement and control the activities of an organisation; and establish the system in the form of flow charts and reports.

(ii) Adapt the system worked out in (i) above to a computer, i.e. design the data processing system.

(iii) Determine, in consultation with the management of the organization what activities are to be processed first by computers and what activities are to follow, and develop some guidelines for programming these areas.

(iv) Supervise the implementation of the work in (i), (ii) and (iii) above.

These functions might call for two types of systems analysts. One would be concerned with the functions under (i) above, whose main training and experience would be in the fields of organisation, management and operations research. The second is what could be termed computer systems analysts, whose training and experience would be in computer science and technology and who would take care of (ii), (iii) and most of (iv). Nevertheless both have to cooperate together to establish a sound system.

(b) Programmers

After the design of a data processing system, programmers:-

(i) put the activities or problems to be processed into operational steps and code them in a language acceptable to the computer;

(ii) Verify the accuracy of, and test the completeness of, the programme.

Programmers should work in cooperation with the systems analysts. In case the systems analyst, besides his other functions, would undertake a good part of the function under (i) above, the programmer's functions would be only confined to coding as well as verifying and testing the programmes.

4.10 A common practice is to establish a computer system as a "Computer Centre", i.e. as an entity or department in the organizational hierarchy. Training of staff who will run and manage it should be considered during the awarding of the contract to an equipment supplier who should provide a good part of computer training in the early stages of the "Centre's" development. Due to the scarcity of computer personnel and cost of training and installation, not every enterprise in a developing country can afford to establish its own computer centre. Therefore, the possibility of having an inter-firm computer centre or computer service bureau with on-line terminals and time-sharing programmes1/ may be considered.

4.11 A computer centre should be effectively structured. One way to do this is for the computer centre to have two divisions or sections. One includes the hardware and may be called "Data Processing Division ". It could comprise two units: one is for the computer and its operation and the other for dealing with the input and output. The second may be called "Systems Analysis Division" which comprises the specialists in systems analysis and operations research. Furthermore, for the effective running of a computer centre, its location in the organisational hierarchy should be carefully determined.

4.12 Although the resistance to computers has been recently reduced, quite a number of government executives and personnel in developing countries still think of computers as the "mysterious black boxes" which take over human activities and judgement and affect the level of employment and create manpower displacement.

1/ See footnote 1 on page 6 of this paper.

One should know that it is the human judgement and experience which instruct the computer, the individual should therefore still be recognised as the ultimate decision-maker. He can accept or reject the computer output. He is the one to put his knowledge and judgement in designing the system and the details of its operation. According to this the computer can carry out this operation with a superior speed and reliability and manual systems will never be its equal. It is the computer which enables the decision-maker to effectively utilise his capabilities. Here some orientation round-table discussions or seminars would be very useful. Furthermore, one should not always expect a considerable drop in the level of manpower due to the application of computers. As has been previously mentioned, the establishment of computer systems implies the increase in number of processing functions and information uses than with manual systems and hence more jobs are created. In case manpower displacement would be the result of computer systems, suitable jobs for those affected by the change should be found. The ideal case would be when the majority of them could be upgraded in time so that they would acquire the necessary new skills.

5. UNIDO TECHNICAL ASSISTANCE PROGRAMME

Taking into account the aforementioned and bearing in mind the pressing urgent needs of the developing countries, UNIDO has long devoted its attention to providing technical assistance in this field. This comprises both direct technical assistance and training in all the areas which this present paper includes. In addition a series of publications and documentations on the subject have also been established.

Annex I

DEVELOPMENT OF COMPUTER TECHNOLOGY

Computer generation	Year	Type	Main functions	Storage capacity in number of characters that can be stored (magnetic core)	Storage cost in $ = computer price/storage capacity	Average speed of computation in micro seconds to add two five digit numbers
1st generation	1954-1959					
Main characteristics based on vacuum tubes. Big machines, much dissipation of heat	1950	IBM 650	Commercial	No magnetic core storage		700
	1956	IBM 702/704	Scientific	24000-192000	0.1	
	1956	IBM 705	Commercial (Simple application, e.g. commercial application was mainly concentrated on simple business data processing application (pay-roll, simple book-keeping))	20000-40000	0.125	
2nd generation	1959-1964					
Use of transistors and ferrite cores. Smaller, bigger memory, more reliable, faster and better price/performance ratio and lower energy input and heat generation than 1st generation computer		IBM 7070	Commercial	5000-49990	0.136	
		IBM 1401	Commercial	16000	0.131	
		IBM 1440	Commercial	16000	0.081 (same speed as 1401)	
		IBM 1460	Commercial (Many new applications)	16000	0.14 (faster than 1440)	
3rd generation	1964-present					
Use of integrated circuits as logic elements. New memory types (plated wire, thin film), better price/performance ratio		IBM 360/20 /40 /65	Commercial and scientific applications	4000-16000 32000-512000 256000-1024000	0.032)	1
As a transition between 3rd and 4th generations	October 1969	IBM system 3	Commercial scientific equipment would be available on the market early 1970	32000		
4th generation	Expected early 1971					

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