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AIMS AND SCOPE OF *INDUSTRY AND DEVELOPMENT*

Industry and Development attempts to provide a link between practitioners and theorists working on economic and related aspects of industrialization. The focus of the journal is on applied economics, particularly in areas emphasized in the Lima Declaration and Plan of Action on Industrial Development and Co-operation.

The journal is published as an integral part of the work programme of the Industrial Policy and Perspectives Division of the United Nations Industrial Development Organization. It is prepared under the general guidance of a Supervisory Panel, composed of staff members from the Division, with the Head of the Global Issues and Policy Analysis Branch as its Chairman. Responsibility for the detailed supervision of a specific issue is rotated among the members of the Panel. The member responsible for this issue was J. Cody.

The Supervisory Panel of *Industry and Development* welcomes readers' opinions and comments and will be glad to consider for possible publication articles relevant to the aims and scope of the journal (see "information for contributors").

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References to dollars ($) are to United States dollars, unless otherwise stated.

The term billion signifies a thousand million.

In tables:

Totals may not add precisely because of rounding.

An em dash (--) indicates that the amount is nil or negligible.

The following abbreviations are used in this publication:

ADNOC	Abu Dhabi National Oil Company
CAD	computer-aided design
CAM	computer-aided manufacturing
CIM	computer-integrated manufacturing
DUBAL	Dubai Aluminium Smelter
EYE	employment-output elasticity
FMS	flexible manufacturing systems
GCC	Gulf Cooperation Council
GDP	gross domestic product
GNP	gross national product
MIS	management information systems
RAM	random access memory

Computers for industrial management in Africa: an overview of issues*

Eoin Gahan**

A. Computers and industrial management

1. The evolution of computer systems

The role of computers now pervades all aspects of economic society. In manufacturing industry, it is most often associated in the public perception with (in increasing order of complexity) process control, CAD/CAM automation,*** robotization, the development of flexible manufacturing systems (FMS) and computer-integrated manufacturing (CIM).

However, there is another, more traditional type of computer usage which may be equally important, even though it does not receive as much attention in the usual analyses of the changing nature of industry. This "business" use of computers occurs in industry as in any other sector of the economy. By this is meant the use of computers for tasks such as the automation of office work, accounting and stock control.

According to a French source, between 1.6 and 1.8 per cent of turnover on average is spent on informatics [1]. Companies can generate significant benefits by "re-engineering" their businesses before automating or computerizing [2]. The real benefits of informatics

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*This paper is based upon the UNIDO document "Computers for Industrial Management in Africa: an overview of issues" (PPD.187). The study carried out also included a number of case-studies of individual African countries. The following are available as UNIDO documents: Algeria (PPD.181); Côte d'Ivoire (PPD.154); Ethiopia (PPD.176); and Nigeria (PPD.126). The document PPD.187 also contained a number of annexes giving more detailed findings. Mathias C. Nadohu provided research assistance at an early stage of the study.

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***CAD: computer-aided design; CAM: computer-aided manufacturing.

come not from the automation of tasks previously done manually, but from a reconsideration of the task itself. Is it necessary? Can the desired effects (reduction in costs, increase in speed or accuracy) be achieved by a more fundamental reconsideration of the need for the task itself and the way in which it can be carried out?

The development of management information systems (MIS) as a department of an enterprise, and the job classification of MIS manager, can be seen as qualitative steps beyond what is called data processing. MIS systems are an attempt to process and make available in a structured and up-to-date form the information needed by decision makers within the enterprise. The MIS manager there has a role beyond the merely passive one of providing a set of computer printouts giving the result of calculations or reconciliations of standard data: the task is that of providing a system of information which can answer relevant questions that meet the requirements of such staff members as the chief financial officer, the sales manager or the production manager.

The evolving use of computers in enterprise management has a long history. In developed countries such use is commonplace, even if "leading-edge" systems are rare. The "systems" (often just simple computer programs to record the totals of some elementary information) may in fact be very old. There may in fact be a reluctance to innovate on the part of the computer staff, especially if the old system is working reasonably well and is handling data that is crucial for the enterprise. The decision may be taken not to improve the system because of the risk of disrupting the essential flow of data. It may even happen that, because of poor documentation of the original system, the reason for not improving it is that the way it works is imperfectly understood. However, these are extreme cases, cited to highlight some of the forces at work that, in general, cause the development of systems to take place at a pace slower than that of technological change.

2. The computer market in developing countries

The acceleration of technological change in software as well as in hardware is a force affecting systems development in the opposite sense. The increased availability of newer and cheaper equipment and software means that there is considerable pressure in developed countries from sellers ("vendors"), always seeking to encourage the company to place new orders for what are called enhancements, upgrades, or entirely new products. Indeed, it is only by offering new products or improved versions of old ones that hardware and software producers can continue to survive; demand for what is regarded as out-of-date equipment is

negligible, and most of it is sold for scrap, even if it was very high-level equipment only a few years ago.

Perhaps understandably, there are sometimes doubts about the returns on the large investments some companies make in information technology, and these doubts can be severe: "There is absolutely no correlation between the level of investment in IT* and performance". [3] Yet the pressures of the hardware and software markets, together with real needs for information systems to improve the quality and speed of response in highly competitive world markets will continue to drive companies' information-technology strategies, even if they become more cautious about individual components of those strategies.

In developing countries, the same conditions are not found. In place of the dynamic and creative competitive pressures which have led to the increased importance of MIS, the enterprise often faces very difficult and intractable obstacles to bringing its production goals to reality. The goals may be realized only through protection afforded by the Government, or by exporting at an unrewarding price. More likely, however, is the non-achievement of the goals. In the face of shortages of supplies and of spare parts, communications disruption and a variety of environmental and political difficulties, the average factory manager may not immediately see advantages in installing a computer. Again, the computer markets of, for instance, most African countries are not sufficiently developed to encourage the introduction or the upgrading of computers into enterprise management. The developed-market-economy countries typically have very competitive markets, in which the computer purchaser is offered a complex and not easily analysed mixture of hardware, software service and support. In the developing country, no such system may exist. Even if suppliers and maintenance are available, there may be no sales pressure which can lead the company to make a purchase decision, no one to convince the company of its necessity or usefulness, no one to demonstrate the virtues of the hardware and software, no one to reassure the company by offering maintenance agreements, guarantees, user groups, telephone advice and support services etc.

In spite of the negative forces at work, such as to inhibit the introduction of computers in many cases, and in spite also of the many practical difficulties, specific to developing countries, in the actual use of computers for management, there are nevertheless good reasons why the issue is worth pursuing. The fact is that computers can be a means of increased efficiency, and it therefore has to be considered to what extent the absence of computers, or the incorrect or insufficient use of them for

*Information technology.

industrial management in Africa, is a factor contributing to the difficulties faced in manufacturing growth in that region. More positively, an investigation of the factors at present obstructing a wider and better use of computers in industrial management in Africa can suggest areas for policy action. These may be in such areas of government responsibility as trade regulations or foreign exchange control, but they may also be in areas of international action such as technical assistance, training, supply of equipment etc.

3. The role of management information systems in industry

The effect of a computer, used properly, is to improve the accuracy and timeliness of information. The more important the information, the more useful is the computer to the activity in question. But it is important to distinguish between data and information. At least in computer terms, information might be defined as structured data. Thus, the statement that "customer 2974 has ordered 50,000 units of part No. 7890" is data, something analogous to what computers actually work with. It is only when there is a numbered list of customers and a numbered list of parts and of units, that the data becomes useful information, in other words when it is part of a structure whose design is related to the needs of the user.

This is not a discussion of database design, although the language used may suggest it. A simple traditional data-processing "production run" can convey information if the basic parts of a structure (different reference lists, for instance) are available to the reader of the printout. Thus, the interactive querying of databases is not the only kind of MIS, by any means.

Information that is accurate and timely can obviously be important if the subject is money: hence accounting systems have always received particular attention from computer system designers. The owner of the small firm expanding on borrowed money is just as interested in timely accurate financial information as is the treasurer of a large transnational corporation who trades in 10 or 20 different currencies every day.

The two essential characteristics of management information, that it should be accurate and timely, are obviously more likely to be achieved with a computer than without. Accuracy of itself could perhaps be achieved by other means: adding up figures, for instance, can be done manually, and if the task is repeated several times, the possibility of error can be reduced to an acceptable minimum. Hard manual work can achieve accuracy in many management information tasks, but sufficient speed to make the information useful is not usually possible. Thus, clerical workers can be set to examine thousands of paper records or cards

in search of a particular piece of information, or in response to a need to find, for instance, all customers who have ordered a certain article more than once. If the question is changed and a different criteria is given for the search, it will probably take the same amount of time again, and this is likely to deter the manager from asking for the information unless it is absolutely necessary.

This deterrent effect can have an important dampening influence on the way in which management decisions are taken. The types of decisions taken are affected, since they are determined by the range of information produced as a routine matter. This could be the weekly sales totals, the monthly total of machine-hours in operation, or whatever. This information is collected regularly and is available to the manager to help him or her decide what is to be done. But both the nature of the information and the detail (the breakdown it gives of the variables in question) have already been established. Thus, the kind of decision as well as the correctness of it are very much predetermined. The possibilities for looking at things differently are very limited: especially restricted is the scope for a more experimental and creative approach to problem-solving and to the development of new strategic directions for the firm.

In industry, the importance of flexibility in management thinking is increasingly recognized. Manufacturing technology continues to undergo pervasive change. Markets become increasingly internationalized, and new materials and new tastes cause changes in product composition and design. The manager is constantly exhorted, mostly with justification, to be aware of the strategic challenges facing the industry in question, and strategic planning in business is a recognized discipline.

The decision-making process in a developing country may be qualitatively different to that in a transnational corporation, but it is not necessarily less complicated, nor are the penalties for failure necessarily less severe. For a manufacturing industry, the process of transforming materials (usually by means of machines and labour) involves the manipulation of material as well as financial information. Moreover, this information is conceptually linked. For instance, financial information could yield an estimate of cash flow, which in turn determines borrowing requirements. But what can be called materials flow can also be measured, and to the extent that it determines, for instance, the required level of inventories needed, it also determines the borrowing requirements. The planning of production levels for the future also needs a sense of existing levels and of what is influencing them. Again, monitoring the actual and projected levels of stocks allows one to detect possible constraints on capacity utilization, with consequent direct or indirect impacts on the profitability of the firm. The flow of orders can also be monitored, which allows estimates of required stock levels. With

respect to the machines used, maintenance scheduling is an important task in itself, and it also affects the machines' availability and thus the potential capacity utilization.

These examples are given in order to emphasize the interrelatedness of various information requirements for industrial management, and to show the way in which such information is useful both for immediate decisions and for longer-term planning. The point to be made is the general desirability of up-to-date and accurate information and the importance of computers in handling it.

Once the possibility of a beneficial use of computers is admitted it is still necessary to establish that, in practice and on balance, the computer can bring practical advantages. There are costs involved, including those of acquisition, but also in establishing the use and in continuing with it. Once again, these steps will be dealt with in detail at a later stage: here it should be noted only that the processes of system design development, implementation and maintenance, that is, the formal stages of a computer application life cycle, are again only part of the story. This work has to be done, of course, but the environment in which it is carried out is equally important and may result in a number of other costs. At the design stage, there is the disruption of the work of existing staff as they negotiate with the system designer; at the development stage there is the further disruption, for instance, in the interaction with prototypes; at the implementation stage the possibilities for further costs are already very diverse; and the system operation and maintenance phase can present its own problems, especially if external hardware and software support is hard to come by.

The question then arises: granted that computers can be useful, are they worth the trouble and expense? Clearly the trouble and expense are determined partly by the environment. The benefits are a (positive) function of (among other things) the complexity of the task to be computerized, and not of the number of people involved. A one-person business, if it is for instance a shoe-shining operation, cannot expect benefits from computerization of the administrative tasks associated with it, for these are simple in the extreme. It is a different matter, however, if what is in question is a one-person manufacturing business, perhaps involving different suppliers, processors and customers. This can still benefit from computerization provided that the information task is sufficiently complex, that is, it is one involving sufficient information to be manipulated sufficiently often.

As was pointed out earlier, the effects of technological change do not only affect the way things are manufactured: they also affect the management of the process. This has its implications for computer systems as much as for management skills. One summary of conventional computer requirements in a manufacturing system is as follows:

> "A well-structured system may be broken down into four subsystems, namely requirements planning, bills-of-material processing, manufacturing stock control and work-in-progress monitoring" [4].

However, the introduction of just-in-time techniques, associated with a degree of flexibility and automation in the production process itself, cause equally significant changes in the information systems requirements. Many, if not all of the things in the list are changed. "Traditional" materials-requirement-planning (or manufacturing-resource-planning) logic has to be "efficient and streamlined" because an environment requires constant balancing. Process documentation is simplified. Stock control and purchasing become tighter but more simplified ([5], pp. 71-76).

4. Special problems in Africa

The environmental conditions under which computers can effectively operate are usually specified by the manufacturer. For instance, an Apple Macintosh IIcx has an operating temperature of 10° C to 40° C, a storage temperature of -40° C to 47° C, a relative humidity of 5 to 95 per cent (non-condensing), and an operating altitude of up to 3,048 metres [6].

The introduction of computers to industry for use in MIS and administrative tasks faces special difficulties in Africa. Some of these are found also in other developing regions, but are nevertheless to be found in Africa in what are probably extreme forms. What follows is a short list of problem areas.

(a) Temperature

Average temperature in developed countries where computers are usually developed are much milder than in many African countries. Extremes of heat can have a variety of damaging effects on computer equipment, including errors in micro-electronic components distortions of metal parts (such as in disk drives), warping of plastic components, etc. Most of these problems can be resolved at the design stage, or by replacement of particular parts of the computer system with more resistant components. Alternatively, air-conditioning can be used, if the cost is acceptable. But there are still extremes to which no easy response can be found: a computer left out in the noonday sun in desert conditions will probably be irreparably damaged.

Different types of computers (mainframes, minicomputers and personal computers) have different requirements and tolerances in terms of temperature, humidity and other atmospheric characteristics. However, the typical data processing system (excluding personal computers) requires a space temperature of 70° to 72° F (21° to 22°C), with the temperature at each specific element of the system not varying by more than a few degrees over time, relative humidity having to be controlled at about 50 per cent in order to maintain the dimensional stability of tapes and paper and to minimize the generation of static electricity, and the circulating air having to be well filtered [7].

Large installations will require elaborate air conditioning systems. At first sight the requirements of personal computers or personal-computer networks may appear to be less. But the operating conditions needed may in some cases not be found in certain areas of Africa without specific measures being taken, which may include air-conditioning. This adds further to the cost and is a further complication since there is one more thing to go wrong.

(b) Humidity

The combination of high temperature and proximity to water leads to highly humid conditions in some African countries, particularly in coastal regions. The effect on computer equipment (and, indeed any electronic or electrical equipment) can be serious, in that moisture in the air will cause spurious circuit contacts which can lead to faulty operation and, in extreme cases, permanent damage to some of the circuitry through reversal of polarities etc. Again, the problem is best tackled at the design phase: effective insulation and extra protective circuitry can be helpful.

(c) Dust

Computer systems still have a considerable mechanical component, and are thus vulnerable to dust. A keyboard usually has moving keys, since typing seems to be easier than with the thermal contact type. Floppy disk drives operate by moving the read/write head very close to but not touching a spinning floppy disk, which is in a plastic cover and can be removed from the drive. In floppy disk drives, research has shown that 85 per cent of read/write malfunctions are caused by contaminated heads [4].

Floppy disk drives and similar forms of magnetic media such as tapes are an essential way of entering external information into the computer, or of handing over information from the computer to another computer or to keep as a reserve in case of damage to the information in the computer. Disk drive mechanisms, and the diskettes also, are highly

sensitive to dust. Printers of almost any kind are also vulnerable. Because of this, the use of computers, large or small, in the dusty conditions of many African countries has special difficulties. They can again be overcome to some extent by design, for instance by special "doors" on the diskette drives, but a change in the working environment may be necessary.

It can sometimes be the case that the solution of one problem exacerbates another. Thus, in Somalia, the need to reduce the dust in a computer installation led to corridors being closed off, thus reducing draughts which had cooled the building, and causing room temperatures to rise [8].

(d) Power supplies

The generation of electrical power for public consumption in some African countries is frequently inadequate. A power cut-off has of course the effect of making the computer unusable until power is restored. But it can also mean that whatever data the computer was handling has been lost, because it had been entered at a keyboard and not yet stored in a permanent form. Again, the power may have been cut off at the closing stage of a long process (such as searching through magnetic tape, for instance, which can be very slow). The power cut can mean that the whole work has to be restarted from scratch. Physical damage may also take place, for instance, to disk drives if they lose power while reading or writing. As well as the damage caused by loss of power, there is other damage caused by uneven power. This may affect the operations of disk drives and thus the reliability of the data contained in them.

Again, sudden surges of power ("spikes") can damage micro-electronic components. As well as this they can introduce less obvious flaws into data and programs: "Power surges and sudden spikes can write random bits to your disk." However, since it is better to have the hard disk spinning all the time rather than to switch it on and off, it is advisable to have software that can park the disk head, or move it to an unused part of the disk rather than a part holding data [9].

The remedies for those problems are various. A secondary generator, which automatically switches on with the failure of the public electricity is one approach. But its cost may be prohibitive for a small company. Careful design of computer systems, for instance, so that they make frequent storage of intermediate results of a calculation, is also a partial solution. Surge suppressors and various filters and voltage stabilizers fitted to the power supply can also, at a cost, eliminate some of the problems. Again, the low power consumption of microcomputers using complementary metal-oxide silicon technology means that there is a certain scope for rechargeable battery-powered systems. It should be

noted, however, that power consumption of peripheral devices (printers, larger hard disks etc.) is still quite high and battery-powered solutions are not feasible for many kinds of computer systems.

Between a fifth and a tenth of the African population is not supplied with electricity. In general, most countries suffer from outdated equipment, inadequate and badly joined networks, frequent cuts and high prices [10].

Uninterruptible power sources represent an obvious answer to the problems of poor quality public electricity supplies. These are devices which automatically provide electricity should the public supply fail. This can be from a battery or from a generator that is started up as required. It is almost as important however that the public supply, when working, should be of good quality. A varying voltage may damage the computer, especially if it contains extreme variations in the form of surges or "spikes". The devices range from low-cost line conditioners or surge suppressors that cost about $30 each and prevent disk drives from being damaged to elaborate systems costing thousands of dollars [11].

An installation in Somalia illustrates a number of these points. A nominal 220 volt power supply was found to vary between 180 and 200 volts, with occasional spikes of over 300 volts. The computer system was protected by a series of measures: a fused on-off switch (to protect against spikes), a transformer (to increase the mains voltage), a voltage regulator and an 11-ampere uninterruptible power source [8].

Uninterruptible power sources were originally for industry and the military, but now 60 per cent of revenue comes from the data processing market (with industry now representing 10 per cent of the demand and military markets 3 per cent). The tendency is for prices to fall and features to increase. There are two market segments, that of under 10 kilovolt-amperes for microcomputers, and that of 10 kilovolt-amperes and over for minicomputers and mainframes [11].

It is reported from Senegal that "An unstable voltage supply wreaks havoc with the equipment and represents the major single cause of hardware failure ... A voltage stabilizer was bought but has not really proved effective in smoothing the power supply. It is probably not of a sufficiently high quality to handle the vagaries (sic) of the electricity supply" [12]. This suggests a need for caution in choosing power supplies. It also indicates a pressing need for technical assistance coordination in electricity generation.

The country surveys carried out as part of this study report a variety of conditions with regard to electricity supply. In Algeria, the public supply is very stable, with cuts being rare. The normal surge suppressors are recommended and are assembled locally [13]. In Egypt the power supply is reliable with cuts once or twice a month. Uninterruptible power sources are recommended and are available locally at reasonable

prices [14]. By contrast in Côte d'Ivoire there is considerable voltage and frequency instability, and the necessary equipment to counter it costs easily as much as or more than a microcomputer [15]. In Ethiopia, although blackouts are infrequent, the power supply is subject to wide and recurrent voltage fluctuation. Voltage regulators are essential but not locally available [16]. In Nigeria also the erratic supply is the most acute infrastructural problem faced by computer users, and again the necessary countermeasures cost more than a personal computer [17].

(e) Telecommunications infrastructure

The use of public networks to link computers together, or to allow remote access to computers is commonplace in developed countries. The purpose of the link might be, for instance, for branches of a company to check on the company's centralized data, or to update it. Again, a salesman in the field might wish to report on an order received, or to check on the availability of a product, by connecting with the company's computer using a telephone line. Apart from telephone lines, a common means of linkage is to have a dedicated line, usually rented from the telephone company for exclusive use. Such linkages are not common in developing countries, partly because the applications are not as sophisticated but also because the facilities are not available. The telephone company may provide a public service that is limited and unreliable, meaning failed or garbled transmission of data. Dedicated lines may not be available at all. There are no easy answers to these problems. Satellite communications may be one solution, and this has been followed in several countries. A possible alternative is radio linkage, which is practicable over shorter distances. This has been used for data transmission in Sudan ([16], p. 29). Radio links are used in Côte d'Ivoire as part of the Sytran network system [15].

Africa has a very low level of telecommunications. The number of telephones is 0.7 per 100 of the population. This is one hundredth of the ratio in the United States of America, and of the telephones, between 30 and 40 per cent are estimated to be out of service at any one time [18].

In general, African telecommunications equipment is not of the latest type: electromechanical switching systems, rather than the latest electronic type, predominate. It has been suggested that a principal reason for this is the desire of the telecommunications equipment manufacturers to sell systems of a type no longer saleable in developed countries [19].

African countries (not including South Africa), spent 658.1 million United States dollars ($) on telecommunications equipment in 1986. This represents 0.7 per cent of world total spending in that year. The total figure for Africa covers a few large spenders: Algeria, Côte d'Ivoire

Kenya, Libyan Arab Jamahiriya, Morocco, Nigeria, Tunisia and Zimbabwe, together account for over two thirds. The North African countries alone account for over 40 per cent. Algeria is the fastest-growing market. It is expected to increase its telecommunications spending from $109.4 million in 1986 to $590 million in 2000 [20]. Among the new technologies under active investigation are satellite communications: there is a $7.5 million feasibility study under way on the Regional African Satellite Telecommunications System [21].

(f) Repair and maintenance of hardware

Any piece of machinery needs to be maintained regularly and can need outside assistance to repair it. A computer system is a combination of electronic, electrical and mechanical equipment and usually includes the central processor and main storage (all now micro-electronic), one or more video display units, one or more printers, and magnetic storage devices such as hard disks, floppy disks and magnetic tapes. Sometimes, these are supplied by a manufacturer, sometimes by a system house, the latter having perhaps put together a package of equipment from different makers. The manufacturer will give a guarantee, but this will not usually extend to anything near the expected life of the computer system, being typically for 6 months only. The usual practice with larger systems is to enter into a maintenance agreement with the supplier or with a third-party maintenance firm, and such an agreement is usually continued during the whole life of the computer system. The system is sufficiently complex and the range of skills needed to repair it are sufficiently diverse to make it impracticable for even the largest companies to undertake their own maintenance.

Arrangements for repair and maintenance are usually regarded as essential. The loss of the computer could mean that necessary information is unavailable or that large repetitive calculations have to be done manually on a scale no one is willing to contemplate. Moreover, the availability of the computer may mean that tasks are undertaken (such as selections, sorting, cross-referencing and merging of data) for which no manual methods previously existed. So crucial can the application be that sometimes a second computer is kept in readiness to be used should the first one fail. There has been considerable success recently in developed country markets for what are called fault-tolerant computers. These usually have more than one central processing unit, and indeed most of the internal hardware is duplicated, and this is automatically invoked in the event of failure of the primary hardware. Such computers are widely used in applications such as banking, where continuous connection between the different branches is regarded as absolutely necessary.

The problems in developing countries include those attached to the use of any sophisticated and imported machinery: the level of help available in repair and maintenance may be inadequate or non-existent. In Africa, there may well be no branch of the manufacturer in the country, and support may be available only from some independent system house or engineering company, whose links with the manufacturer of the equipment may be tenuous. There are particular difficulties if the equipment is obsolete, which is more likely to be the case than in developed countries: in this case the manufacturer, if finally contacted, may well say that the product is no longer supported. This is sometimes for very practical reasons: such is the speed of technological change in this industry and the turnover of staff that it is not unlikely that no one is readily available to diagnose faults in equipment produced even as little as five years ago.

Positive aspects of recent trends in the industry, however, include the falling price of hardware: it is no longer inconceivable that a company should have two computers, treating one as a spare to be used when the first breaks down. But the question remains as to how the first one is to be repaired if local support is not available. Again, increased integration of the circuitry means that some repairs can be carried out simply by replacing a defective chip. Falling prices for other parts of a system, even disk drives and video display units, mean that replacement rather than repair could be considered in certain cases. But in developing countries there may well be foreign exchange shortages which make such a practice undesirable even if practicable, and the prices to the end-user in an African country may be very much higher than those paid by the consumer in the United States, for example.

On the face of it, therefore, the repair and maintenance issue is likely to be the most intractable of those facing the computer manager in a developing country. Certainly, equipment is more reliable than it used to be, but what is being used may be far from the latest type, and the climatic and environmental hazards outlined above will also contribute to the incidence of breakdowns. The newer developments in repair and maintenance, such as remote diagnostics and expert systems, are probably also inaccessible to the developing country. The preventive aspects are thus very important, together with the building-up of an emergency stock of replacement parts and components. Special training schemes to build up the individual company's maintenance capacity are probably impossible, since instruction is usually available only outside the country.

In view of the widespread shortage of spare parts and the lack of technical skills, there is certainly a high degree of down time due to unrepaired faults. In Nigeria, it has been noted that in extreme cases systems can be out of action for months or even years for such reasons [22]. The problem of maintenance can sometimes be

exacerbated by a proliferation of brands of computers: this may make the problem of a supply of spare parts more difficult and it may make the task of fault diagnosis and repair more difficult also. The problem of proliferation has been noted in Kenya, where the tying of donated computers to a particular brand is also negatively perceived [23]. Government policy formulation in Côte d'Ivoire is directed towards a reduction in the number of foreign suppliers [15].

(g) Software support

The question of software support is an even more difficult one. The software used may be entirely supplied by the manufacturer of the computer, in which case the remedying of a fault in it, when discovered, is at least as difficult as coping with a fault in the hardware: it is necessary to find the manufacturer or a competent agent. But, just like the hardware, the software may be obsolete. The manager may eventually learn that the fault he has discovered was first observed many years ago, and connected in subsequent versions of the software for which he is unable or unwilling to pay. The problems are, of course, compounded if the software has come from different sources: unlike the computer manufacturers, the software houses, even the largest ones, will almost certainly not be represented in any African country. Many software problems are difficult to resolve: it is in fact the more subtle errors which remain the longest. Some of them arise through unexpected interactions between different pieces of software, or as a result of incompatibilities between, for instance, the applications software and the operating system, or between the operating system and the hardware, especially peripherals. The latter kind of problem is especially disagreeable. Any computer manager will have stories of a problem for which the different hardware and software suppliers all disclaimed responsibility, each blaming the other as the source of the difficulty. But at least in developed countries the computer manager has the opportunity to confront each of the suppliers with the problem in question: in a developing country he is unlikely to be able to do so. Another class of problem arises with custom software, which has been developed by programmers within the company or written specially for it. The problems with this kind of software are probably no different in developed and developing countries: it is likely to have errors (because it will not have been used as much as a commercial product, which will probably have been sold to many different customers), it will probably be inadequately documented; and the people who wrote it may have left the company.

Recent trends in the software industry are likely to alleviate some of these problems. The tendency for packaged software to be more powerful, flexible, and easy to use means that traditional custom

programming could see a decline. Computer managers could increasingly find that a package could meet their needs, and, also, that the number of different software packages needed to give the necessary tools was reduced. But because packaged software cannot meet all requirements, there will be a continuing need for programming. The work will, however, take new forms. Most of the most successful packages, whether spreadsheets such as Lotus 1-2-3, word processing software such as WordPerfect, or database software such as dBASE, incorporate their own programming languages (sometimes called macro facilities) which allow the use of the package and its facilities in new ways to meet special needs. Thus, while traditional programming skills will help in the mastery of these facilities, there will be a need for new abilities, especially those of understanding the capabilities of the package software in question and the needs of the user in such a way that an efficient solution can be found with a minimum of programming in the traditional sense. Only in this way can the demand for new applications be met, especially if it is fuelled by an ever-increasing supply of personal computers.

Computer programming is undergoing considerable change, and it is sometimes difficult to separate fashion from the underlying trends. There is a considerable degree of unresolved conflict between academic researchers (who develop new programming languages and techniques), software producers (who need new products to promote), and commercial computer users (who are more concerned with what is tried, tested, and known to be reliable). However, there are some emerging principles which have relevance to computer users whether in developed or developing countries. They are in fact particularly important for developing countries because these are often in the position of computerizing from the very beginning. There are no old systems to be replaced, no legacy of perhaps ill-considered or at least outmoded programming to be painfully preserved. The emerging principles are as follows (although principles may be too strong a description):

(a) Good programming is a discipline, and a good programme is not unique, but the result of applying established rules and procedures;

(b) Any computer program is a temporary solution to the problem: improvements will be needed. The program should make it easy to find mistakes or to incorporate improvements;

(c) Some computer languages embody these principles explicitly, and thus are more likely to yield good programs.

These principles are not particularly noteworthy in themselves, and it is more the absence of others that should be remarked. There is no mention of minimizing the need for main memory, or of reducing the time for the program to run, or of optimizing the disk access pattern.

This is because trends in hardware costs and power have steadily reduced the importance of such questions. For some applications such considerations are, of course, still important, but they no longer belong to the set of general principles that must always be followed. Such concerns belong to the period when machine time was much more expensive than human (for example, programmer) time. This is not true any more.

Given the low levels of computer usage and the late start made in many cases, African countries have concentrated on relatively recent developments in the computer field, especially through the use of personal computers and package software.

This means that the African company concerned may not be lumbered with clumsy and expensive and out-of-date software written for a mainframe 10 or 15 years ago and shakily updated from year to year. But it also means that the applications probably suffer from the typical characteristics of systems based on personal computers alone. Such systems are stand-alone and can be used by only one person at a time. They are reliable to the extent that they use a well tried commercial package such as a spreadsheet or database package. However, the specific application may be undocumented and when faults are discovered they may be difficult to correct. Personal computers are not usually designed to be shared, and adequate provision may not have been made for security and backup.

In general also, there may be unreasonable expectations of what can be achieved with the new technology, and even user-friendly software cannot be properly used without a basic appreciation of its capabilities and the techniques that it embodies. This appears to have been the experience in Sierra Leone, which has made a concentration on information technology training [24]. Experience in Uganda has suggested that a major need is to help managers evolve realistic expectations of what computers can and cannot do for them [25].

(h) Other problems

It has been remarked in Mauritius (which is relatively advanced in the application of computers) that much of the existing computer installations are under-utilized [26]. This is believed to be the case in Nigeria also, especially in the public sector. [22]

Capacity (machine) utilization in Africa is in general about 30 per cent. But for computers it can nevertheless be in certain cases remarkably high: in Gabon the installations at Air Gabon, Comilog and Comuf function perfectly in extreme conditions. The contrast with machinery is striking, and one cannot say that computers have been sold in the same way as machines [27].

B. Present levels of computer usage in Africa: evidence and issues

1. National policies

(a) General issues

African governments, like those in other countries, recognize the potential benefits of widespread computer applications in industry as in other fields. But the selection of strategy elements imposes hard choices. The equipment has almost entirely to be imported, whether hardware or software is in question. Faced with severe foreign exchange shortages, the question arises as to whether the resources available are best spent on computing rather than on some other pressing need. It should be recalled that of the 41 countries classified by the United Nations as Least Developed Countries no fewer than 28 are in Africa. Many of these face pressing problems in other sectors, and the need to assist industry in reaching a greater level of efficiency is only one of many priorities with which policy makers are confronted.

Even given the availability of equipment for the computerization of industrial management activities, there remains the need for trained staff for the tasks of system analysis, operation and maintenance. Typically there will be a severe shortage or absence of such staff. The choices between expanding education at secondary or university level, or setting up some more specific training schemes, are additional and complicated decisions which face the policy maker, and also involve resource allocation. The improvement of the infrastructure, especially in terms of electricity supply and telecommunications, are among many other intractable problems. The importance of telecommunications for the wider development of an industrial society which allows a full use of the information processing capabilities of computers has, however, already been recognized in a few African countries, which have or soon will have public data networks of the Transpac type: Côte d'Ivoire has Sytranpac, Cameroon has COMPAC, and Gabon has GABOPAC [28]. Algeria has also planned for operation in 1990 a Transpac-type network, [13] and Egypt has insituted the EGYPTNET network, with six major packet switching networks and other nodes. Tendering is being prepared for an X.400 system also [14]. In Nigeria network development is carried out by the oil companies, with Shell having its own network based on leased lines, and a subsidiary of the Nigerian National Petroleum Company having installed a network said to be the largest in Africa [17].

A problem such as that of education and training will be subject also to frequent redefinition, as a consequence of technological change. As noted above, the rapid changes in technology that have taken place in the

world of computing mean that latecomers have had an opportunity to skip some of the less efficient stages and to move directly into more advanced fields. The reduced costs of equipment and the increasing user-friendliness of software mean that the possibilities of using the technology in a productive way have increased. But there are several problems also. The personal computer is leading the computerization process in Africa. Personal computers can be relatively easily maintained. However, maintenance from the constructor is less likely to be available [27]. Thus, the skills required may have decreased in level, but the volume required has increased very much. Repair and maintenance of thousands of personal computers is not the same as repairing one or two mainframes.

There will remain also the question of whether there are specifically national or regional solutions to be sought and roads to be taken. Some opinion would suggest, for instance, that Africa should turn to software specific to its countries, and there should be computer service companies, for which a market exists [27]. But the market may be in many cases a potential one, needing many steps before it becomes a real consumer market, ready and able to pay for hardware, software and services to meet specific requirements. Again, the idea of software production for local requirements has to be defined more precisely: there are undoubtedly specific language needs, or, for instance, accounting needs resulting from particular social security or taxation systems, and these can and should be met by specially tailored software. But the standard solution will usually be quicker and more appropriate: a straightforward database or spreadsheet application will meet the majority of requirements and it will be a great deal cheaper. A protected national software industry, for instance, may lead more quickly to the development of programming skills. But this will be at the costs of the increases in efficiency foregone by all the companies that are deprived of tried and tested software packages available on the world market. Protectionism will usually also have the negative effect of cutting off the domestic software industry from world trends and the latest advances.

Such protectionism, whether active through trade restrictions or merely passive through foreign exchange shortages, may bear particularly hard on the public sector, which will be more inclined to follow the official policy, and may be compelled to take its software from a national software company. The private sector may seek to evade this, especially through the use of pirate software copied from best-selling packages from the world market. However, the use of pirated software could lead to virus infection. Piracy of expensive software has been described as "common" in developing countries, as is shared use of machines and lack of security ([29], pp. 81-82).

(b) The effects of import policies

As noted, the import policies adopted by a country will have important effects on the spread of technologies within the country. Sometimes these effects are unforeseen, and they may be quite opposite to what the policy maker intended. A sample of duties and other tariffs in 1985 showed that, for 24 African countries, the average rate of duty (which sometimes included fiscal tariffs etc.) was over 34 per cent [30]. By contrast, developed country tariffs on computers are very low. The most-favoured nation tariff rates on computer central processing units in 1987 were 5.4 per cent for the European Community, 4.9 per cent for Japan, and 4.3 per cent for the United States of America. Tariffs on computer peripherals and computer parts were of a similar order, although some peripherals attracted duties of up to 13.8 per cent in Japan [31]. Given the intense levels of competition between the three, the low rates of duty are striking. They of course partly reflect the general openness of the world trading system, but also the strong demand for such products among industry and the services sector in developed countries.

The choice of such high duty levels in African countries may have been made with one or several objectives in mind, such as:

(a) To discourage foreign exchange expenditures in general;

(b) To encourage capital expenditure on other types of machinery;

(c) To increase government revenues;

(d) To encourage local manufacture of computer equipment.

However, analysis has shown that computer use is highly sensitive to computer price, with a price elasticity of about -1.5. This means that a policy which doubles price will reduce usage by two thirds. Protectionist policies which attempt to foster the domestic production of hardware will do so at the cost of significant reductions in the application of computers in the national economy [32]. In the case of Africa, there are few if any domestic industries to protect, which makes a policy of high import duties on computer equipment even more difficult to understand. Nor is the government revenue significant, since the tariffs are usually so high as to deter any imports at all, except those from government departments, or through aid programmes not subject to duty anyway.

Nevertheless, import restrictions may encourage the formation of domestic industries, in certain circumstances. It seems to have been the effect in Kenya, for instance, although it may not have been foreseen: it can only work if the components can be bought at a lower cost, which is not always the case for certain products for which bulk discounts are

available only to very large-scale purchasers, if the tariff structure is such that it is cheaper to import the components rather than the finished article, if demand is high enough, and if the skills are available locally. These conditions in fact apply in several African countries, but by no means in all.

In Ethiopia, a corporation or factory wanting to acquire a computer must obtain Ministry of Industry approval before seeking foreign assistance or requesting a foreign exchange allocation [16]. In Ghana, a manufacturing firm has to apply for an import licence from the Ministry of Trade (on the recommendation of the Ministry of Industries, Science and Technology). These procedures are not as time-consuming as they used to be, but they are now a first step before competing in an uncertain foreign exchange auction, where a full deposit in local currency is necessary. Customs duty and sales tax on computers and electrical and electronic equipment generally are fixed at 50 per cent of the c.i.f. value. Importers with their own foreign exchange resources are reported as being charged an additional 50 per cent [33]. In Zambia, by contrast, trade policies for electronics are reported as being progressively made more stringent. Except for governmental and infrastructural needs, which are given special consideration, all other users have to obtain permission to import and also queue up for foreign exchange. Data processing machinery attracts a 30 per cent *ad valorem* customs duty and also an import sales tax of 25 per cent, making an effective landed value 55 per cent above the import value. To this is then added a local sales tax of 10 per cent. Imports of automatic data processing equipment amounted to $3.1 million in 1986 [34].

(c) National computer centres

Under this general title, a wide variety of different bodies can be found in African countries. Often, the national computer centre will represent the only major initiative so far taken at the national or governmental level to encourage computing and the diffusion of skills. The terms of reference, mandates, responsibilities and the scale and scope of activity varies very much. In some cases, these institutions are at a formative stage and their role is confined to the preliminary formulation of national informatics policy, sometimes being essentially the secretariat of a national committee dealing with this subject, or having some coordinating function. The tasks of a national centre may include:

(a) Formulating national informatics policy;

(b) Developing informatics plans;

(c) Implementation of selected aspects of informatics plans;

(d) Systems development and implementation, usually for the public sector;

(e) Maintaining a centralized computer service;

(f) Investment promotion;

(g) Providing training in informatics skills;

(h) Approval of imports of hardware and software;

(i) Drawing up import guidelines;

(j) Standard software development.

Country examples include Congo, for instance, where there is a body that deals with informatics coordination. In Guinea, there is the CNIG. In Mozambique there is a special commission on informatics founded in 1980 but it has not yet published a national policy. There is however the body CTD for informatics coordination. Nigeria has the CCC for informatics coordination [35].

More elaborate structures are also found, notably in Algeria and Côte d'Ivoire, for instance. Algeria has the *Entreprise nationale des systèmes informatiques*, which executes national computing projects, as well as a number of national informatics institutes (for training) together with national sectoral computer services companies [13]. Côte d'Ivoire has a national informatics commission and an executive body [15]. Ethiopia has a National Computer Centre under the National Science and Technology Commission [16].

Tunisia has also developed a sophisticated framework for government action, with a National Informatics Commission and a National Informatics Centre. The former has planning and policy functions, the latter a more executive role. The Centre participates in the elaboration and follow-up of policy, gives advice, designs and implements systems, and promotes training and retraining. Its opinion is required on all imports of equipment or services by the public and private sectors. As for systems houses and advisory firms, there were 25 in 1987. Training of analysts and programmers at university level is provided by six different institutions. In addition, the *Institut régional des sciences de l'informatique et des Télécommunications* has been proposed as an international organization for informatics in the Arab region and Africa. Further evidence of a positive climate for the growth of computer applications is found in the existence of a number of other centres for informatics and many computer clubs [36].

The National Informatics Centre itself in Tunisia had two regional subcentres and 250 staff in 1987, of whom 151 were technical staff. It has carried out work for a number of public enterprises, including many manufacturing enterprises. It has also produced general-purpose

software, including accounting and stockkeeping software for small- and medium-scale enterprises. It is also involved in arabization and telecommunications projects [37].

(d) The role of official development assistance

The role of official development assistance in the development of computing in Africa is a significant one, although there are some grounds for believing that it is largely an unconscious one. Many projects for improved public administration involve the computerization of information systems. Equally, there have been a number of activities targeted at the development of human resources in the informatics field. For instance, significant training is provided in the United Kingdom of Great Britain and Nothern Ireland by industry. Students are sponsored by the British Council and the Overseas Development Administration on courses run by manufacturers and training companies [38].

However, other projects not directly in the computer field have had an important impact. There is an increasing tendency for computers (mostly personal computers) to be acquired in the course of a technical cooperation project, whether this is in the agriculture, health or education or industry sector, and for it then to be added to the stock of equipment and software in the country. The demonstration effects as well as the explicit training in the use of the computer that may take place within the life of the project are other important considerations that make the indirect boost to informatics due to other projects both significant and at the same time difficult to assess with much precision. Perceptions of the impact are nevertheless high. A Wang regional sales director is quoted as saying that "Half the African market is someone's foreign aid" [39].

Another sector in which donor interest is high is telecommunications. This has even more impact on the computer side because, as well as the indirect effects of the introduction of computers already mentioned, there may be specific electronics skills upgrading. Again, there will be an important contribution to the infrastructure needed for distributed information systems, as well as international linkages. The particular attention of bilateral donors with respect to African countries partly reflects the strong international competition among companies from developed countries in this field. Such cooperation is normally linked to the supply of equipment and training for telecommunications systems. For instance, in Guinea-Bissau, there is a joint venture with the Portuguese company CPRM to develop the telecommunications system [40]. Telecommunications in Zaire are being developed in conjunction with Alcatel through the use of satellite systems [41] and Italy is supporting rehabilitation of the cable networks. Japanese cooperation in the same field is also under discussion [42].

Telecommunication systems in Mozambique are the subject of cooperation with two Portuguese companies in seven projects to a total value of $12.5 million [43].

2. *Levels of progress*

(a) Markets

Ethiopia has been mentioned as the first African country to acquire a computer (in 1960) [44]. Since then there has been progress, but by world standards Africa is still in the initial stages. The total present market for informatics products in Africa has been estimated at no more than 2 billion French francs (less than $400 million), about one-thousandth of the world market [45]. This contrasts with an African share of world industrial production of between 1 and 2 per cent. Trade data for 1986 suggest a total of $170 million of informatics electronics, with an estimated total of $60 million of passive components and software of about $80 million [46]. No detailed or comprehensive figures are available that describe either the installed capacity or the potential for computers in Africa. However, estimates are sometimes made at the country level. What follows is a summary of some selective evidence on the spread of computers in certain African countries.

In Botswana, middle-sized companies are one of the two current growth areas for computer usage (the other is the media). The estimated number of personal computers in 1986 was 600, growing to 880 in 1987 and 1,000 in 1988 [47]. In Cameroon, the numbers of microcomputers rose from 850 in 1984 to 2,135 in 1985 and an estimated 14,000 in 1989 ([35], p. 85) In Côte d'Ivoire, the number of microcomputers rose from 1,400 in 1984 to 3,150 in 1985 and an estimated 20,900 in 1989 ([35], p. 85) but the same source gives another estimate of 11,600 for 1990.

Côte d'Ivoire has already been mentioned in terms of its strong government policies in informatics. It is described as being 30 per cent computerized, while in Abidjan, the capital, one office in two has a computer. Microcomputers account for 60 per cent of the total, and are growing at 60 per cent each year [48]. The projected growth in minicomputers is 20 per cent, and 5 per cent in mainframes [49].

In Gabon, the numbers of microcomputers rose from 400 in 1984 to 1,083 in 1985 and to an estimated 4,100 in 1989 ([35], p. 58). In Morocco, in 1985, there were 3,500 microcomputers, 80 per cent in the private sector, 11 per cent in the semi-public sector and 9 per cent in Government. Most were used for management: notably payroll and accounts [50]. In Senegal, the number of microcomputers rose from 696 in 1984 to 1,780 in 1985 and rose to an estimated 5,540 in 1989 [35].

In Sierra Leone, by 1987 virtually every major organization owned a computer. Furthermore, a significant proportion of smaller businesses now possesses microcomputers and uses these machines in their day-to-day operations [12].

In Tunisia, the Second National Plan for Informatics (1987-1991) envisages between 8,770 and 10,585 computers for 1991, depending on to what extent the principal plan objectives are met. Strikingly, the envisaged role of mainframe computers is very small, with a maximum number at 85 [51].

(b) Use of computers by the manufacturing sector

As part of a series of studies of rehabilitation of industry in Africa, UNIDO surveyed a number of companies in the agro-food sector in Zambia. All of the companies visited suffered from lack of adequate information systems for the routine tasks such as accounting, administration, purchases and sales [52].

A summary of minicomputers and medium-size mainframe installations in some francophone African countries indicate that in 1989 the overwhelming majority of these were in the services sectors, especially in banking, insurance, transport and communications. Companies clearly identifiable as manufacturers were very few in number.

As against this there is evidence of the use of computers by larger manufacturing firms. In Benin, *Société béninoise de brasserie* is computerized for management purposes. In Côte d'Ivoire, *Société ivoirienne de raffinage*, Abidjan, uses computers not only for management but for maintenance planning also. In Niger, SONITEXTIL is computerized for management. In Nigeria it is estimated that more than 50 per cent of all industry is using computers for accounting, either in-house or using external services [17]. More detailed information is available for Tunisia. These statistics derive from the Second National Informatics Plan (1987-1991), which gives the number of manufacturing enterprises in Tunisia as 2,368 (almost 52 per cent of all enterprises). The number equipped with computers was only 176. The year of data collection was the end of 1984, covering enterprises with more than 10 employees [51]. The number of staff engaged rose from 2,600 in 1981 to 4,500 in 1986, and is expected to grow to 9,700 in 1991. Manufacturing industry had 10 per cent by value of the total installed base of computers. However, less than 10 per cent of manufacturing establishments had a computer in 1986, compared to between 10 and 20 per cent in agriculture and fisheries, energy and mining and transport and communications. In the banking and insurance sector, the figure is given as over 75 per cent. Of manufacturing enterprises which have computers, all use them for payroll, 80 per cent also for accounts, 70 per

cent also for stockkeeping, 50 per cent for sales, 20 per cent for production management, and less than 10 per cent for analysis [36].

The use of computers in the production process itself is even less common. In Egypt, computers are used in control of blast furnaces in the iron and steel company, Halwan, in process control in the Delta Steel Factory, in process control of aluminium manufacturing, in other chemical industries, and in the control of the crystallization process in chemical industries [53].

(c) Local manufacture of computers

Although the assembly of personal computers is now undertaken in several African countries (such as Cameroon, Zimbabwe, and Kenya), there is a view that "true" manufacturing is not possible [27]. However, this is to take a very narrow view of manufacturing, and it does not recognize the specific changes that have come about in the computer industry as a result of the introduction of the personal computer. In 1982, when IBM entered the market, for the first time the company went to outside suppliers, using Intel for the microprocessor chips, and other suppliers for printers, screens, disk drives etc. The nature of the activity increasingly involves the assembly of products produced by others. The choice of components and the way in which they are put together (logically and physically), in other words the design elements, are the bases of competition. For this reason "assembly" can have a number of different meanings.

Personal computers of the IBM compatible type are produced in Cameroon. The company INTELAR first launched its Intel 8088-based computer in 1988 and now offers a range of machines including ones based on 80386 processors, video graphics array etc. All the machines are described as being resistant to heat, dust and humidity [54].

Côte d'Ivoire is also to engage in the assembly of microcomputers in conjunction with a company from Taiwan Province of China [35], and Kenya assembles a personal computer clone, the Neptune. By so doing the company KML (Kenya Microcomputers Ltd.) pays 35 per cent duty and 17 per cent sales tax instead of 80 per cent duty and 35 per cent sales tax [55]. Other assembly is undertaken in Kenya. A new company, Microsolve is to join Kenya Microcomputer and Micropower in importing kits and assembling them for the local market and for export. Software packages are imported and tailored to local needs. Because of lack of in-company resources, this is a common approach on the part of sellers [56].

In Morocco, the company SBI produces Atlas personal computers. Its capital comes 30 per cent from the national development bank [50]. An example of computer-related equipment production may come from

Nigeria, where a project to manufacture uninterruptible power sources in Lagos has been identified and is under consideration by United States investors [57]. Computers and local area network stations are being manufactured in Zimbabwe by Transafrica Computer Services [58]. Also in Zimbabwe, C.F. Tulley Associates and Plessey Zimbabwe have a joint venture to assemble clones (Olivetti and Bulgarian Isotimpex). They will assemble about 600 a year (expected demand: 1,200-1,500 a year) [59].

(d) Software and services

The production of software increasingly seems attractive to developing countries. The reasons for this are many. They can include a desire for import substitution, for export promotion, or for mastery of a key new technology. In Africa, the skilled labour force needed for a successful software industry is not available, apart from the absence of other necessary factors. There is however a common feeling that if African countries are to make a start in the informatics fields, they should do so first in software, because the capital equipment costs are lower than in other industries and because there may be domestic market opportunities for software to meet African conditions.

However, this latter point in particular needs careful consideration. The language differences obviously open up certain possibilities. This may be particularly so when there are different character sets involved from those in English, the language in which most commercial software interfaces are written. The arabization of software is the principal issue under this heading. The difficulties arise partly from the fact that characters in Arabic differ in form depending on whether they are at the beginning, middle or end of a work or are stand-alone. Again, Arabic is written right to left. More than simple modifications of the keyboard are called for. Of 31 companies or institutions reported in 1988 as working on Arabic software and systems and equipment, the majority (20) were in France. The only African Arab countries were Tunisia (2), and Morocco (1) [60]. However, there is considerable Arabic software activity in Egypt, and the use of Arabic predominates [14].

With respect to issues other than those of language, the demand position is not so clear. As mentioned, different tax and regulatory systems may create certain opportunities, but it is not certain that specially written software that caters for these peculiarities can find a wide enough market. Wider opportunities may be found in applications written using standard packages such as the well known spreadsheet or databases. Many thousands of small companies in developed countries have already entrusted their accounts to these packages, and the arguments for using well-known, tried and tested packages are often

conclusive. The opportunities in African as in other countries may derive from applying the package to special business situations, providing a mixture of design, development and advisory services.

In Botswana, for instance, computer services are a major growth area. One recent survey gave 10 major companies offering consultancy, supply, repair, assembly and training. One of these companies (Ngami Data Service) offers a specialist program for hunting licences [47]. In Côte d'Ivoire there are about 20 computer services companies, and competition is keen. The largest is Cieria (*Compagnie ivoirienne d'études et de réalisation en informatique et automatisme*) which has an annual turnover of about 600 million CFA francs [49].

In Egypt there are around 100 active software houses, with about 10 of these working on mainframe software and the remainder working on personal computer applications [14]. A software package specifically for small and medium sized African building contractors has been designed in Gabon [61].

In Mozambique there exist already 20 groups capable of joint serious work in informatics, and there is talk of some specialists forming a cooperative [62]. Business applications for MS-DOS machines are written in Zimbabwe by Micropac (Pvt) of Harare and supported in Malawi, Zambia and Zimbabwe [58].

3. Education and training

The shortage of skills is often the implacable obstacle to a wider use of computers. Technological change is such as to redefine the skills required on a frequent basis. Many of the difficulties can be overcome by better choices of equipment and software. Nevertheless there will continue to be a need for trained staff who know what a computer can do and who can analyse a business problem and implement a solution to it that will improve the efficiency of the organization concerned. These abilities, to make the right choices, to bring the application to an operational stage and to make sure that it is used to best effect by those whom it is intended to assist, derive partly from training and partly from experience. It is the task of training policy and activities to make sure that the two are complementary and in line with technological change.

The special problems of computers in Africa are such that the experience component of skills development is likely to be imperfect. This is inevitable in a situation where the latest technology is not available, where pirate copies of software are being used, where staff resources are limited so that design, testing and documentation are neglected in favour of rapid system development, and where the absence of a computer culture means that uncritical attitudes persist, better ways

to do things are not known, and poor examples of computerization fail to convince newcomers of the potential benefits.

Moreover there will be a tendency for those who do have initial skills to migrate to countries where they can not only earn more money but upgrade their skills in line with the latest technological developments. For the best of these the latter may be the dominant motivation. The phenomenon of skilled nationals of developing countries finding a living abroad can be observed in the computer field as in every other advanced sector [63]. Nevertheless in countries such as Algeria, Côte d'Ivoire, Egypt and Nigeria there are few shortages of staff. The real problems are the potential ones, and the explosion of usage in personal computers will create significant shortages in the future in a number of African countries. This is not only because there will be an increased need for staff to give support to personal computer users as well as to develop specific applications, even using standard software packages. The problem is also that the normal processes of self-education among computer staff, especially in the personal computer field, will be severely hindered without access to information as to the latest trends and practices in software. It remains true that most of these still arise from developed countries.

With respect to education, it has been pointed out that there is often a confusion between the subject of computers in education (i.e. as a tool for learning) and education in computing, in which computing becomes a part of the curriculum like other subjects. Nevertheless there have been significant steps in the encouragement of computing through several attempts to supply different levels of the educational system with equipment. Egypt has perhaps the most elaborate plans, with the intention to apply computer-assisted learning techniques. The approach being adopted is a fully integrated one, with cooperation with external firms in the importation of personal computers in kit form and in the training of technical staff for the construction of the personal computers. Training of the Egyptian computer-assisted learning instructors is to be carried out in France, and the software is to be produced entirely in Egypt, although there may be a supply of software tools from France for this purpose [64].

Evidence at the country level on the position with regard to education and training is as follows. In Botswana there are commercial computer schools [47].

In Côte d'Ivoire there is a training centre in Abidjan for officials [27]. No fewer than 95 per cent of analyst/programmers and 55 per cent of engineers are nationals [49].

In Gabon, the *Institut africain d'informatique* provides training in informatics on a regional basis ([35], p. 54). In Kenya training is

provided for instance by Kenya Polytechnic, with a three-year diploma course which includes industrial experience. The University of Nairobi Institute of Computer Science has a postgraduate course. About 20 schools have computers with at least three using them in teaching [47].

Morocco has planned to have 400 secondary schools equipped by 1990, but in 1989 there were only about 60 so supplied. In Algeria the numbers of computers available to the educational system seems very high: there appear to have been at least 10,000 in 1989, although perhaps half of these are older eight bit machines that are nevertheless adequate for basic computer-literacy purposes. Again there has been a concentration on computer clubs which flourish under the auspices of youth centres, especially in Algiers. In Morocco, in 1985, there were 12,500 computer staff (56 per cent operators, 28 per cent programmers, and 16 per cent analysts). The majority were trained by the National Institute of Statistics or the office for professional training. [50]

In Nigeria, at least 26 firms undertake training [65]. In Senegal, there is a *Centre de formation à la micro-informatique de Dakar*. This is in connection with the chambers of commerce and industry in Dakar and Le Havre, the latter having the *Centre normand de recherche en informatique* (Cenori) [27].

In Sierra Leone, the Institute of Public Administration and Management at the University of Sierra Leone provides training in information technology, based on the realization that "Accounting and computer could not be treated as independent subjects. They were inextricably linked" [15].

The role of computer-assisted learning seems to have been taken quite far in Tunisia, where, along with the usual mechanisms of national informatics plans and national commissions for informatics, there has also been an emphasis on voluntary activity. In particular, there has been an emphasis on encouraging the formation of computer clubs, which can be a very important ingredient in encouraging a "computer culture" of the kind referred to earlier [64]. Tunisia is one of several countries which have made forecasts of their skill requirements in the informatics field. The Second National Plan for Informatics (1987-1991) envisages a number of personnel needs totalling between 8,500 and 9,700 by the end of the plan period, depending on to what extent the principal objective is met. This is a target of at least 1 per cent of gross domestic product (GDP), and preferably 1.2 per cent accounted for by informatics, in order to reach a take-off level [51].

Much training is carried out directly by the manufacturers of computers or their agents, usually of customers or their employees. ICL, for instance, has training centres in Egypt, Kenya, and Zimbabwe among other countries. Where possible it arranges for courses to be held in the

countries concerned but many employees and customers also go to ICL in Britain, perhaps as many as 1,500 from Africa each year [8].

In parallel with the State-run educational sector, commercial computer training activities are common in both developed and developing countries. In some cases however, the kind of training offered may not be particularly useful. Sometimes people can be led to pay for courses in BASIC, for instance, with the expectation that this will of itself lead to a well paid career. Even more structured courses with more focus on actual commercial applications may nevertheless not lead to employment as a data processing professional, since experience in the industry still counts for more than any paper qualification. The effect of a shortage of experienced people in computing in developed countries has often been to bid up the wage levels, rather than to allow new entrants to the market. There have been very practical reasons for this. The systems in operation in computing have been painfully constructed and have become central to commercial operations. Computing staff will not be willing to jeopardize these systems by allowing inexperienced staff to participate in their maintenance and further development. Nor, in the light of the heavy backlogs of work that typify the level of applications development in modern computing, will they be willing to release their experienced staff to undertake the practical training of inexperienced staff, whether in a structured or unstructured way.

4. Producer presence

(a) Presence of computer firms

The presence or absence of individual companies in African countries is difficult to determine in practice. Yet it is important in providing support and access to new technology, together with the assurance to the potential buyer of a computer that help in its maintenance and use can be counted upon. Traditionally the major computer companies provided this support along with their sales. Although maintenance and other services were charged for, there was nevertheless a good deal of free advice and suggestions as part of the sales procedure. The psychological underpinning provided by a strong supplier presence was significant. Now the tendency is increasingly, for all except mainframe computers, for the manufacturer not to sell the product to the final user but rather to a distributor, sales agent, systems house, value-added reseller or some other intermediary. In many cases these provide the same services as the manufacturer did in the past, although there is a limit to the kind of free advice to be expected with the purchase of a personal computer costing around $1,000.

Another factor militating against the presence of the large computer firms was market size. Only the biggest and most advanced African countries were likely to attract the large firms. The other countries were supplied through appointed or independent agents. This is not necessarily a bad thing in terms of individual services provided, but it is nevertheless the case that the direct presence of a large computer firm in the country contributes to the confidence of the potential computer market and thus has a role in helping it to grow.

A number of large firms are directly present in some African countries, although coverage is far from complete. Thus, for instance, IBM has agencies in its biggest markets: Cameroon, Côte d'Ivoire, Gabon, Morocco, Senegal, Tunisia and also in Algeria. In 1989 IBM sold 6,000 personal computers and about 200 minicomputers. However the turnover of IBM in Africa is only 60 per cent of that in Portugal. Bull and Unisys are important also [45]. IBM has recently opened representation in Uganda through Business Systems Limited [66].

Computerland, the worldwide retailing company, which has 28 per cent of the United States market, 18 per cent of the world market and 10 per cent of the European market, through 900 franchises of which 100 are in Europe, now has four franchises in Africa (Cameroon, Côte d'Ivoire, Gabon and Senegal) [28].

In Tunisia, the Ministry of Industry and Commerce checks on the provision of after-sales service and tries to limit a proliferation of brands. In spite of this, there were six minicomputer and medium computer and mainframe distributors in 1987, together with 32 microcomputer and peripheral suppliers, the latter handling 27 different brands [36].

Côte d'Ivoire illustrates that while links with former colonial powers are important, within those there is flexibility. S.M.T. Goupil has only 10 per cent of the French market but 40 per cent of that in Côte d'Ivoire [67].

Kenya has many dealerships but it has also been the focus of direct action by major manufacturers, whose involvement is in the form of subsidiary companies, such as ICL Kenya and NCR Kenya [68]. In Morocco, there were 37 suppliers in 1986, employing 800 people. Bull and IBM each had 35 per cent of the market, Burroughs 10 per cent. [50] In Zambia, it has been noted that the market for computers is very skewed. A survey of computer usage in late 1986 noted that of a total of 116 computers covered in the survey, the top two companies had supplied 97 of them [69]. In Zimbabwe C.F. Tulley Associates has a staff of more than 300, and has franchises for Goupil, Epson, Isotimpex, Ferranti and Compaq. It also provides regional support for Data General in Eastern Central and Southern Africa. [59]

The question of second-hand equipment would bear closer examination in the African context. Technological change is so rapid that

in developed countries perfectly usable equipment is often described as obsolete. In some cases the opportunity is being taken to export it to developing countries rather than scrapping it. For instance, the system of "cartes grises" for the Ministry of Transport in Benin has been computerized with (second-hand) IBM equipment by the company Paris Computer Exchange, which specializes in the sale of second-hand computer equipment. The equipment was thoroughly overhauled and a technician was sent. [50] In other cases proximity to a more advanced computer market of itself will facilitate such transfers. Thus in Botswana the situation was summarized in saying that "80 per cent of the installations there are ex-Johannesburg" [70].

(b) Producer perceptions

For the present study a small survey was undertaken of the major world computing companies, to see what was their involvement in African markets and what were their plans for the future. The companies in the DATAMATION 100, a list compiled annually by DATAMATION magazine, were circularized with a questionnaire that attempted to obtain an overview of the situation. The companies covered include not only hardware and software producers but also systems companies and in some cases purely financial companies involved in leasing computer equipment. In other cases the companies are primarily concerned with military markets. The survey is based on responses towards the end of 1988. The response was not high, with 37 completed questionnaires out of a possible 100. However, it was possible to say that most of those companies in any way active in Africa did reply.

Adaptation of products to the African markets has taken place in certain cases, notably in software and in services. For both of these commercial practices were the commonest cause of adaptation, followed by language. Hardware changes were occasioned most frequently by the power supply (five cases) followed by operating temperature and humidity (three cases each). Other causes for adaptation cited were altitude, packaging, keyboard cables and local telecommunications requirements.

As is to be expected, given the small share of Africa in world informatics markets, the share of revenues arising in Africa for any of the companies surveyed is also very small. The highest share quoted was less than 5 per cent for a personal computer manufacturer, with a disk drive manufacturer quoting less than 4 per cent. The most frequent answer was zero (11 responses), with 10 other responses from 0 to 2 per cent.

The expectations of how the share would evolve over the period 1988-1992 were, for 13 firms, that their share would increase, with 12 expecting it to remain the same. As many as 16 firms expected to take

specific action in the African market. There were 16 planning to appoint distributors or local agents, 8 planning to adapt their products to the market, 6 planning to open representative or sales offices, 6 planning to take an interest in local companies, and 4 intending to establish manufacturing or service facilities. The overall impression conveyed by these figures is that the major firms have modest but positive expectations of the market possibilities, and plan fairly conservative action to exploit what is seen as a rather limited potential. It should be stressed that no computer firm expressed themselves in this manner, nor were they asked to compare the potential in Africa with other developing regions. However, given that eight of the firms whose share of world revenues from Africa was zero stated that they expected this to remain the same, it seems that the market is not regarded as especially promising.

What are the major obstacles to increasing activity on the part of computer companies in Africa? A number of possible difficulties were listed and the companies were asked to rank them as very important, fairly important, or not very important. The clearly most important obstacle was currency restrictions and payments difficulties, which were ranked as very important by 16 of the respondents, and as fairly important by 5. This was followed by a lack of demand for computer products, which was perceived as very important by 12 firms, with another 7 regarding it as fairly important. Inadequate telecommunications then was followed by non-tariff barriers, lack of suitable local agents, and lack of market information. Tariff barriers should be mentioned especially, because although only 5 companies thought they were a very important obstacle, 11 others thought they were fairly important. The remaining possible obstacles were unreliable electricity, unsuitable climatic conditions, competition from low-cost producers and language difficulties, which only two firms thought were very important. It is however noteworthy that all of the potential suggested obstacles were regarded as very important by at least two companies. One company suggested another obstacle as being very important, the financing question.

C. Markets as they are (field questionnaire)

1. Data collection

In order to collect data on some of the questions discussed in the preceding section, a questionnaire was designed and sent to staff of UNIDO or the United Nations Development Programme (UNDP) in each African country. Since the primary objective was to obtain as complete

a picture as possible, the questionnaire was designed to be short and to cover the main issues. It is reproduced in the annex to this article. The first two questions dealt primarily with the human resources aspect of computer usage, intending to collect information as to the availability of trained computer staff, and the skill levels and the source of these.

The third question, on software production, is a significant one, because it asked whether the respondent was aware of package software producers, custom (made to order) software firms, or package software suppliers, agents or sellers. If the answer to the first part is positive, it means that the country concerned has already established itself at a certain level of computer development which is analogous to that of a developed country. The production of software as a package involves a level of commitment and investment which can only be attained with the simultaneous presence of a skilled and creative software staff, but more importantly the existence and availability of an appropriate market for the product. The presence of custom software firms, writing programs to order, indicates a less advanced level, but still one which is significantly more than a country still in the initial status of informatics development. The presence of agents or sellers of software shows that a market exists, of some kind. It also shows that a minimum level of support may be available to the purchaser of software, and thus at least part of the necessary "environment form" for the use of computers may be present.

This last point is explored further in a series of questions on the presence of software support, suppliers of equipment, availability of computer consumables (such as magnetic media, paper, replacement chips). Some of the supplies mentioned in this question in fact contain indicators as to how up to date the industry is in the country in question. Thus, for instance, 8-inch diskettes are now obsolete in developed countries and 3½-inch diskettes are rapidly replacing the 5¼-inch diskettes. Similarly, punch cards are also obsolete, and magnetic tapes, while they are not exactly obsolete, are very much associated with old-style computing, and very inefficient for normal use. Question 8, on the repair of equipment, also deals with the general question of the support available to a computer user. The following question on local sources of information on computers refers also to support availability, but in a wider context, that of a general climate of awareness of computers within the country. The presence of computer societies, magazines and shops (as distinct from specific supply companies) can be taken as an indicator of the developed computer market. Questions 10 to 13 collect information on the present use of computers for industrial management in the country and also on the degree of sophistication and the degree to which the approach used is a modern one. Thus, question 11 asks about the age of the equipment, question 12 attempts to gather information on whether the computer is used on an on-line basis or in the older way of batch-

processing. More up to date forms of package software, such as database and application generators also provide by their use an indication of how up to date is the operation in process.

Finally, question 14 reviews some of the issues in terms of environmental factors such as temperature, humidity and dust, as well as infrastructure variables such as the public power supply and telecommunications. Within this question, the issues of support as perceived by the respondents are again examined.

2. Human resources

The questionnaire began with two questions attempting to assess the availability of human resources for computerization. The first question asked how difficult it was to find locally computer staff who were fully trained and experienced, with a separation into system analysts, programmers and operators. It should be noted at the outset that this is a very rough categorization. The effect of technological change is such as to reduce the importance of the computer operator. There are two main causes. The first is the increasing importance of the personal computer, for which no operator is needed. The second is that even on mainframes and minicomputers, the traditional work area of the computer operator, the operating system software itself has become so sophisticated that the actual number of operators needed per machine has been dramatically reduced. Many minicomputers are now sold which are claimed to require no full-time operator. Again, the sophistication of the operating systems means that the work to be done by the operator is increasingly routine and his or her intervention with the computer is less often needed.

A further development as a consequence of technological change is that the programmer has also experienced a redefinition of role. The wider use of software packages, which are sufficiently generalized and flexible enough to be used for many business tasks without any direct programming on the part of the user, means that the programming task is somewhat reduced in importance within the traditional work area in business (programming, on the other hand, is very much on the increase in the development of application software, which is much more sophisticated than it used to be). The effect of these two changes is to increase the importance of the systems analyst: the traditional programmer has both more time and more opportunity to develop new skills in defining the use to which the computer system will be put. Again, the proliferation of distributed computer power and the growth of networking means that the design task becomes a much more complicated one than it was in the past.

Given these facts, the human resource supply situation in African countries does not look encouraging. System analysts are either difficult or impossible to find in 26 out of 39 countries. The 10 countries which describe it as impossible comprise the following: Botswana, Chad, Congo, Equatorial Guinea, Mauritania, Mozambique, Nigeria, Rwanda, Sao Tome and Principe and Somalia. Most of these countries are least developed countries, and many are also small in population size. However, the list contains some surprises in that Botswana and Nigeria have relatively advanced industrial sectors.

The 11 countries which do not experience difficulties in this regard include Algeria, Côte d'Ivoire, Djibouti, Egypt, Kenya, Morocco, Seychelles, Sudan, Togo, Tunisia and Zaire.

The situation with respect to the supply of programmers is better than that for systems analysts. For 14 countries it is not difficult to obtain them, as against 25 where it is difficult or impossible. In fact, in only two cases, Congo and Rwanda, is it impossible. For operators, the supply situation is even better, with 25 countries saying that it is not difficult to obtain them and 12 reporting as difficult. In no case is it said to be impossible to find a computer operator.

The responses to this question have to be seen together with those for the second question, which dealt with the formal training and qualifications of the staff. This is because information on availability of staff does not of itself indicate whether the reason that the staff are available is because there is no work for them or because there is a good local system of training which produces more candidates than can be absorbed.

According to the information supplied in the questionnaire, the source of training for trained computer staff of all types is very evenly distributed between in-company training, computer manufacturer or supplier training, and university qualifications with technical qualifications coming somewhere behind. However, the distribution of training sources differs sharply once the total of computer staff is broken down into systems analysts, programmers, and operators. Systems analysts are preponderantly university-trained or trained by the computer manufacturer or supplier, with in-company training and technical qualifications being infrequent. Programmers also have preponderantly university qualifications but in-company training and technical qualifications are more frequent than are computer manufacturer or supplier training. In contrast to this, operators have in-company training as their most usual training source, with computer manufacturer or supplier training being second. Fairly few have technical qualifications or university qualifications. This pattern is derived of course from the aggregate results and the situation may differ markedly in individual countries. For instance, in Tunisia, the majority of all three groups,

systems analysts, programmers, and operators are described as having technical qualifications. In addition, all three groups have university qualifications to the extent that these have been available. In the case of systems analysts, since 1975, in the case of programmers, since 1972, and in the case of operators, since 1970. The response from Nigeria, while saying that programmers had in-company training, also indicated that some had university qualifications also. For Angola, the comment "there are very few" was supplied in connection with programmers, about whose training no general statement could be made.

3. Software markets

At the world level, the software market is a complex one, the complexity of which is accentuated by the diffusion of hardware and technological advances. The typical example is that of the development of so-called "user-friendly" software which is easy to use, flexible, and responsive to the needs of the individual. The spread of personal computers has meant a corresponding spread of the use of such software in the field of industrial management as everywhere else. However, this tends to exist side by side with the older type of centralized application, characterized by a mainframe computer run by a data processing department of a company. One reason why a merger does not take place or takes place over a long period of time, is that the existing applications running on the mainframe are so important to the life of the company concerned that they cannot be disrupted in any way.

All the evidence suggests that at the company level in Africa the position is very different. There the typical pattern has been a spread of personal computers in advance of any mainframe and minicomputer application. This means that the African company concerned may not be lumbered with clumsy and expensive and out-of-date software written for a mainframe 10 or 15 years ago and updated from year to year. But it also means that the applications probably suffer from the typical characteristics of personal computer software that is oriented towards a single user and does not come with much in the way of support from the seller.

The general technological trends are such as to increase the emphasis on packaged software and to reduce the relative importance of the individually written program or suite of programs. This notwithstanding, the presence of a software company, producing software to order, suggests at least some level of development of a computer market within the country since if there were no such market, one would envisage the presence only of isolated computer installations relying on their own expertise and that of the original supplier. Again, the presence of

package software producers is an indication of a more elaborate computer market within the country, since in this case the producers of the packaged software are doing it in the expectation of being able to sell it afterwards, rather than merely fulfilling a contract for a particular customer.

The results of the questionnaire indicate that 12 African countries appeared to have package software producers. These are Algeria, Cameroon, Djibouti, Egypt, Ghana, Libyan Arab Jamahiriya, Morocco, Senegal, Somalia, Tunisia, Zambia and Zimbabwe. This list is somewhat surprising with the inclusion of Somalia and the fact that Côte d'Ivoire, for instance, is not included. With respect to custom software firms, 19 respondents indicate the presence of such firms in the country, and with respect to suppliers or agents of software the response was even higher with 30 of the countries being reported as having such sellers. The nine countries without such basic commercial activity as the sale of software are Angola, Cape Verde, Chad, Congo, Equatorial Guinea, Ethiopia, Sao Tome and Principe, Sierra Leone and United Republic of Tanzania.

The main conclusion to be derived from the above figures is that the relatively high number of countries in which software suppliers are to be found indicates a fairly high degree of market activity. This, however, does not necessarily mean that the market as such has fulfilled its second role, that of providing support and general information in case of difficulties to software users. This can be seen in the fact that the responses to question 4, in which it is asked whether a user would be able to find assistance with a commercial software package within the country, paint a fairly discouraging picture. In only 15 cases was the answer "usually" given. The answer "sometimes" was given in 18 cases and the answer "never" given in six cases. The latter included Cape Verde, Chad, Equatorial Guinea, Mali, Sao Tome and Principe and United Republic of Tanzania. In the case of Sierra Leone it was pointed out by the respondent that such help was not available except from other users of the package.

The results indicate a real difficulty and a clear obstacle to wider use of computers, whether for industrial management or any other purpose. In general, a computer user is likely to have more problems with the software than the hardware, especially with the increasing integration of electronic components. Hardware problems may be the result of faulty chips or bad connections, but the number of possibilities is by no means as large (nor in most cases are occurrences so frequent) as in the case of software. Problems with software may arise from a lack of understanding of the purposes for which the software was derived and the problems may arise also from a mismatch between the capabilities of the software and the purposes for which it is intended to be used by the purchaser. It

should also be noticed that the initial stages of the use of software are most precarious. A problem at this stage effectively disables the software altogether. A potential user can be blocked by some simple mistake such as pressing a "return" key instead of an "enter" key just as if the software itself contained some obscure flaw. The availability of help or advice on an informal and frequent basis is usually the only way in which useful progress can be guaranteed. The support of other users is as critical to this process as that of the original seller of the software, who may in any case be simply selling a packaged product off the shelf and not have used it at all.

Question 5 of the questionnaire asked about the presence of computer or equipment suppliers in the country. However, question 5 gives an overview, at least of the perceptions of the questionnaire respondents, although the results are unlikely to be completely accurate. As is to be expected, the presence of distributors or sales agents is much more frequent than that of branches of the equipment manufacturers. Thus, while mainframe manufacturers are represented in 12 countries, 23 countries have distributors or sales agents for mainframes. By contrast, minicomputer manufacturers are represented in only 10 countries, with 29 countries having minicomputer distributors or sales agents. The largest number of distributors or sales agents is found for microcomputers and personal computers, where 36 countries report distributors or sales agents. In this case only 11 countries have a branch of the manufacturers. This is not, however, surprising, because personal computers are much more likely to be distributed through what amounts to retail channels and in many cases the manufacturer does not sell to the public at all. The 11 manufacturers represented may be mainly those computer companies which also produce other forms of computers, mainframes and minicomputers, and the sale and service of these may be the main reason for the manufacturers to have a direct presence in the country. The position with respect to printers is very similar to that of microcomputers and personal computers, as is that for tape and disk drives. While many printer companies exist which do not produce computers, and are quite likely to be present in an African country in their own right, the same is not true of tape and disk drives. The large producers of disk drives sell to computer manufacturers, and it is probably these who are referred to by the respondents of the questionnaire. Finally, the position with respect to visual display units and terminals should be noted: 26 countries report the presence of distributors or sales agents, with only nine having the presence of a manufacturer of such equipment. Again, these manufacturers are probably the same diversified computer equipment companies that produce everything from mainframes to personal computers and peripherals.

Question 6 dealt with the supply of computer consumables in the country. That is the magnetic media such as diskettes, the paper needed for printers, the small but vital electronic components occasionally needed for replacement purposes etc. Some of these items, such as paper for printers, may not be very sophisticated technologically and yet represent an essential need for the useful operation of the computer. Floppy disks, also known as diskettes, are in general divided into 3½, 5¼, and 8 inches. (a new standard, 2 inches, is beginning to appear but has met with limited acceptance). The priority appears to be the getting of more and more data on the existing 3½-inch size [71]. The world market for diskettes in 1989 was around 3 billion units, made up of 2 billion 5¼-inch, 800 million 3½-inch and 200 million 8-inch units [72]. The supply position with respect to each of the items mentioned in the questionnaire is as follows:

(a) *8-inch diskettes.* Surprisingly, in view of the rapid disappearance of these from the markets of developed countries, they were still described as easy to obtain in 14 countries, compared with difficult or impossible in 16;

(b) *5¼-inch diskettes.* Still the most common magnetic media. these are described as easy to obtain in no fewer than 28 of the countries of Africa. In two countries it is impossible to obtain them, and because these are perhaps the most essential supply for the personal computer user, it is perhaps interesting to notice which countries are in question: Sao Tome and Principe and Equatorial Guinea;

(c) *3½-inch diskettes.* These appeared to be rapidly becoming widely available, being so in 22 countries, still difficult to be obtained in eight and impossible in five. In view of the better protection (for instance, against dust) afforded by 3½-inch diskettes, it is to be hoped that their use will become more widespread;

(d) *Magnetic tapes.* These are described as easy to obtain in 14 countries, and difficult in 14;

(e) *Continuous printer paper.* Is easy to obtain in 27 countries, difficult in nine and impossible in three. Continuous printer paper is a fairly high-quality product, demanding reasonable feedstock and relatively new equipment for its manufacture. The opportunities for local manufacture should be considered, since it is unlikely that many of the 28 countries where it is easily available in fact produce it. This would also reduce transport costs;

(f) *Printer ribbons.* These are less frequently available than printer paper, even though they are equally essential to the operation of a computer printer. They are easy to obtain in 20 countries and difficult in 14, while being impossible in five. These are Cape Verde, Equatorial Guinea, Sao Tome and Principe, Sierra Leone and Sudan. Given the

necessity for printer ribbons, there may be some recycling of existing ones through reinking. This is not unknown in developed countries either;

(g) *Punch cards.* This subject received the highest number of "impossible" responses, which strongly suggests that the tendency for this media to become obsolete is prevalent in Africa as much as anywhere else. It also received the lowest score for being "easy" to obtain, being so in only seven countries, while 12 reported it as difficult. The high number of "don't knows" (eight) in this context again points to its rapid obsolescence;

(h) *Toner for photocopier (laser).* Sixteen countries report this as easy and only 11 as difficult. Thus although it is certainly not widespread, the technology has begun to make an impact. The response from Angola was that the laser printer was just being introduced;

(i) *Cables and connectors* were easy to obtain in 14 cases, and difficult in 17. Again, the problems may be simply low levels of demand, perhaps with a sale of cables and connectors with the original equipment and few requirements for any additions thereto. This means that the equipment then is probably used in its original configuration, with little change in terms of extras being added or swopping of printers, for example;

(j) *Fuses for electronic equipment.* These were easy to obtain in 18 cases and difficult in 14. The essential nature of these items means that the supply position is rather disturbing;

(k) *Standard random-access-memory (RAM) chips.* Apart from punch cards, the supply of standard RAM chips is the least satisfactory. In only 10 cases are they described as easy to obtain, difficult to obtain in 19, with impossible to obtain in six. The demand for RAM chips in developed countries is in general of two kinds, as far as existing computer users are concerned:

(i) The first is the replacement of defective chips in the personal computer. It should be noted that a RAM chip can be defective in subtle ways which cannot be detected unless suitable software or hardware is present. The defect may be such as to cause only occasional crashes of the system when that particular area of memory represented by the chip is accessed. Unless a thorough diagnostic analysis is carried out, the origins of the fault may not be detected and it may be attributed instead to some other cause, perhaps electric current failure or a bug in the software;

(ii) Again, another source of demand is for expansion of the existing memory by adding more RAM chips. The most common operating system MS-DOS allows only 640K to be addressed in a personal computer. However, some personal computers are sold with 512K fitted as standard, or even 256K, and frequently the demand in developed countries is to bring up the memory available to its maximum. Increasingly, software available for personal computers demands the full 640K to work efficiently. It is possible that in some African countries the skills are not available to allow for installation of extra chips. If indeed the poor supply position is due to a lack of demand, it may partly be due to unexploited expansion possibilities or even to unrecognized chip failure.

To summarize, the supply position in respect of computer consumables in African countries cannot be described as satisfactory for any of the categories considered. Even to obtain the most basic requirement of a computer user, a 5¼-inch diskette is still difficult in eight countries and impossible in two, with a similar situation holding for continuous printer paper. Doubtless in situations of limited supply, it is possible to use what is available more economically, and thus all available space on a diskette can be used and ordinary writing paper can be put in the printer. The supply position with respect to the printer ribbons was already noted as providing an opportunity for reinking. Nevertheless, it should be stressed that these solutions impose their own costs. Given the existing shortage of skilled staff already noted, the fact that they should have to spend their time concentrating on economizing computer supplies, rather than on applying the computer to the problem it was intended to solve is regrettable.

The last items mentioned in the previous question, fuses for electronic equipment and standard RAM chips, are very much related to the question of repair and maintenance, since in many cases these are essential spare parts. In this sense there is an overlap with the following question which dealt with the availability of repair and maintenance services for central processing units, hard disk drives, floppy disk drives, printers, and visual display units and terminals. Perhaps surprisingly, no enormous differences were found as among these categories. Central processing units were easy to have repaired in 10 countries, difficult to have repaired in 19 countries and impossible in 8 countries. This relates very much to the question of mainframes and minicomputers, because the repair of a central processing unit in a microcomputer or personal computer is not in practice possible, given that the entire processing is on a single chip. The number of cases where it is easy to have a central

processing unit repaired is almost that of the number of branches of mainframe manufacturers present (see question 5), and in practice it is difficult to envisage that mainframe or minicomputer central processing units could be repaired by anyone else. The next category, hard disk drives, is the most problematic. It received the lowest number of "easy" and the highest number of "impossible". This is because of the complexity of the technology evolved. A hard disk drive is a sealed air-tight unit in which the reading head of the drive is positioned extremely close to the spinning disk. Floppy disk drives, however, are in principle slightly easier to repair, and this is borne out by the responses obtained, where in 13 cases it was "easy", in 15 cases "difficult", and in 9 cases "impossible" to obtain repair and maintenance. For printers the position is not dramatically different, although impossible in a low number of cases, while for visual display units and terminals the situation is roughly similar.

In general, the conclusions to be drawn from these results are that the repair and maintenance position is very unsatisfactory. This can be seen clearly by comparing it with the supply position in terms of the responses to question 5. Here the number of supplies of the different types of equipment can be seen to be quite extensive, but the number of countries reporting an easy repair and maintenance position is very low in comparison. Thus, on average 23 countries report the presence of a distributor or sales agent, while, on average, only seven countries report an "easy" availability of repair and maintenance facilities. In fact, this group is almost the same as that of the group reporting the presence of branches of manufacturer. Repair and maintenance of any equipment is obviously a major problem in many developing countries. However, it is clear that in this case the situation is worse because there is a local sales activity in some countries which is presumably encouraging sales of equipment which it is then unable to support. Again, by comparing the results for question 8 with those of question 3 we can see that in fact, on average, the repair and maintenance position of hardware is worse than the support position for software, although informal support for software from other users is easier to envisage than for hardware.

Question 9 attempted to assess the position with respect to the presence or absence of the "computer climate", that is, a strong enough user community and wide enough acceptance of computers to encourage newcomers to enter into the use of computers and to encourage those already using computers to develop more sophisticated applications, install new equipment and implement new software systems. In a rather specialized sense, personal computer hardware and software have become consumer goods, in which fashion and trends play a part, and software tends to be discarded long before the end of its useful life, if a more powerful and technically superior product appears. The presence of a

user community in a country will, of course, encourage this trend also, which to some extent is regrettable. However, on balance, it is clear that a user community will have a positive influence on the use of computers. The responses indicate that 21 countries, or more than half the sample, have a computer society or club and 17 have not. This is again a rather disappointing result, which may represent an underestimate since amateur groups are not necessarily interested in very wide publicity for their activities. The numbers are similar for magazines and journals, but here the question has been interpreted by the respondent as whether such magazines or journals are available locally and not necessarily that they are locally produced. The question was not precise enough to make this distinction, but it is doubtful if, with the exception of Nigeria, any of the countries responding produce computer magazines of any kind, although a local business or technical magazine may indeed provide articles dealing with computers and their uses.

4. Industrial applications

The questionnaire attempted to determine, using only the judgement of the respondent, what percentage of factories used computers for industrial management. The respondents were asked to estimate the extent in connection with factories which in developed countries would certainly use computers for management purposes. The results are quite striking. Eighteen, or about half the sample, of the countries are reported as having a figure of 5 per cent or less. A further 14 are reported as being between 5 and 25 per cent, 4 between 25 and 50 per cent, and 1 between 50 and 75 per cent (in fact, this one, Kenya, was given by the respondent as between 25 and 75 per cent).

Since the yardstick of comparison was developed countries, the figures indicate a very striking level of underdevelopment, as far as computer usage is concerned. There are only four countries in which between 25 and 50 per cent of the factories use computers. As a matter of interest, these countries are Botswana, Malawi, Seychelles and Zambia (the case of Kenya has already been mentioned). There is no obvious correlation with country size or with levels of development of the economy as a whole or the manufacturing sector in particular. For instance, Zimbabwe, although it has one of the most elaborate manufacturing sectors, has low usage. The same is true for such large and relatively wealthy countries such as Nigeria, and also for Côte d'Ivoire, which has been making a particular concentration on national informatics policy.

Another question tried to gather information on the typical age of the computer equipment used. Perhaps because of the relatively recent

introduction of computers into Africa, and certainly into management use in industry, the typical age was given as mostly less than five years old, this being true in 30 countries. Some of the equipment is 5 to 10 years old, this being true in 16 countries. In only one case is the equipment mostly over 10 years old, although in four cases, Algeria, Ethiopia, Libyan Arab Jamahiriya and Nigeria, the equipment is described as being mostly 5 to 10 years old. In six cases (Cameroon, Côte d'Ivoire, Djibouti, Mozambique, Sierra Leone and Tunisia) the statement was made that there is none over 10 years old. This is a relatively encouraging result but it has to be seen in context (the previous question indicated that, at least as far as industrial management is concerned, the use of computers is very limited). Accordingly, the fact that what equipment is there is new is all very well, but the number of cases where new equipment is being used is very small.

Another question tried to obtain an impression of the general type of use of the computer that was being made in terms of batch processing versus on-line processing. Batch processing represents a traditional view of computing in which a "job" is carried out at regular intervals or as required, for instance a payroll being run or a total being made of some accounting records. It is linked to a type of hardware and software which is not designed to be used directly by the end-user of the computer, but in which the operator, or the operating system, scheduled the jobs to be run. By contrast, the on-line approach means that the user runs the programme concerned directly from a terminal. This, however, is only part of the difference: the real contrast with batch processing is that the use of the computer is no longer seen as a discrete series of jobs but as a continuous process. The rise of the database as a concept is closely linked to this. In any case, on-line processing needs different equipment and has overheads in terms of process requirements. A further complication in definitional terms is that the use of a personal computer could be described as mostly on-line processing. Thus, although the question seeks to establish to what extent modern techniques of computer usage have spread, it may be of use only in establishing to what extent traditional techniques are still in operation.

The results were: 8 countries being reported as having only batch processing, 10 with some on-line processing, and 8 with mostly on-line processing. For some respondents, this question was difficult, and for others it may have lead to misunderstandings. Certainly the countries which are reported as having only batch processing include some surprises. These are Cameroon, Cape Verde, Ethiopia, Nigeria, Sao Tome and Principe, Sudan, Uganda, and Zaire.

The next question again attempted a summary picture of the modernity of the computer systems used by checking for the presence or absence of up-to-date types of software. These were database,

application generators and fourth generation languages, teleprocessing monitors and optimizing compilers. The most frequent positive response was for database software, which is used in 34 cases and not used in 2, these being Cameroon and Equatorial Guinea. The first of these, at least, is very surprising. Application generators and fourth generation languages are typical products of the mainframe and minicomputer world, and not so much for personal computers. This may partly account for their low score of 18 (although some common database software for personal computers does include an application generator). The use of teleprocessing monitors is low, although in fact these are a central component of on-line processing on a mainframe, and, given that 24 countries use some or mostly on-line processing, the fact that so few are analysing this use is surprising. The last category of software mentioned, optimizing compilers, drew 9 positive and 10 negative responses with 15 "don't know". In fact, many modern compilers nowadays could be described as optimizing compilers and the lack of response may be due only to the lack of appreciation of this technical detail.

5. Environmental and infrastructure problems

The last question dealt with the respondent's perception of a number of important problems for computer usage, following along the lines covered in section A of this article.

Temperature is described as a minor problem in 22 countries and a major one in 12, being no problem in 5 countries. It thus shares with humidity almost the same score of major problems. Dust, however, is a major problem in 22 countries, and a minor problem in 14. In only 3 countries is it described as no problem. These are Swaziland, Tunisia and Zimbabwe. The public power supply is, however, the most commonly cited problem. It is described as a major problem in no fewer than 25 countries in Africa, and a minor problem in 13. In only one country, Ethiopia, is it described as "no problem". By contrast, public telecommunications are not as much of a problem, with 18 countries having a major problem and 13 a minor problem. The reason for this may be that the typical use of computers in African countries does not call for as sophisticated a telecommunication system, with networking and the linking of computers being relatively little known. On the other hand, the availability of a public telecommunications body to supply dedicated data links to computer users would mean that more reliance would have to be placed upon the public telephone network for data transmission, should this be necessary. Returning to the themes of questions 4 and 8, software and hardware support, these are explored again in question 14 from the point of view of the perception of the respondent. The conclusion already

arrived at was that hardware support is in general inferior to software support. This is to a certain extent borne out by the fact that it is seen as a major problem in 21 cases for hardware support, whereas in 19 cases only is software support a major problem. In only three cases is it no problem, namely Botswana, Egypt and Tunisia.

Finally, the question of shortage of suppliers is examined and this is regarded as a major problem in 19 cases and a minor in 12. This again contrasts with the fact that the replies to question 5 suggested strongly that at least for personal computers and printers and disk drives most countries had at least distributors or sales agents, and mainframe and minicomputer suppliers were present in the majority of countries.

D. The scope for technical cooperation

In this concluding section there is a brief review of the main areas in which technical cooperation in the field of computer usage for industrial management in Africa could take place, in the light of the evidence collected in the previous pages.

1. National policy issues

(a) Trade policy

As noted, many countries in Africa, as in other regions, have recognized the importance of informatics technologies, and have adopted plans and set up institutions to cope with the problems raised in more detail. Nevertheless the single most important area affecting the likelihood of the technologies being rapidly absorbed in the country concerned is the degree to which informatics products are affected by trade policy. The structure of tariff and non-tariff barriers is a question which needs careful examination in the context of industrial and trade policy formulation. It would be advisable in particular to adopt a trade policy with respect to the imports of informatics products which took account of all the factors involved, as set out in section B, subsection 1 (b), above. The need to increase the efficiency of industry by increasing the diffusion of computerized information systems is an important task which may not necessarily be at the forefront of discussions on trade policy and may nevertheless require low or reduced tariffs on individual products if the hopes for greater computerization are to be fulfilled. A further consideration is that the choices made cannot be regarded as final ones. They have to be kept under almost continuous review, both because of changes in world industry and technological change which can render

successful products obsolete quickly. Trade policy that does not include careful monitoring of these trends will quickly be out of date, and will push domestic industry and technological development in wrong directions.

Thus, trade policy, industrial policy, and technology policy are closely interrelated. Especially in the key issue of computerization, where change is rapid and where mistakes can be very expensive, there is a need for speedy and up-to-date policy advisory services. These would cover, *inter alia*, the desirable path of computer policy generally, the steps towards building up domestic capabilities, the human resource development implications and the policy instruments needed to bring about the desired effects. The wish or the need for "planning" in the traditional centralized sense may have disappeared, but there will be a continued requirement for external resources such as experience in industrial strategy formulation, knowledge of technology and market trends, trade policy, institutional development, technology acquisition and diffusion strategies etc. These are broad issues which include at a detailed level some of the most complex and decisive issues in determining the evolution of world industry. African countries are geographically and to some extent informationally remote from the areas where these issues are being decided. Technical cooperation has an important role to play in improving decision-making with respect to many-faceted problems such as those which arise in connection with the use of computers for industrial management in Africa.

As was seen in the survey, and can be confirmed by the trading experience of African and foreign companies, the most important obstacle was currency restrictions and payments difficulties. These obviously can derive from many sources, ranging from collection difficulties, late payments, foreign exchange controls and the like. No simple solution can be found in the frequent situation in African countries of high fixed exchange rates and trade deficits and heavy external debt. Even with moves towards a more liberal economic regime and in some cases sharp devaluations, exchange controls are usually still needed, either to give the changes time to have their intended effects, or for other reasons to control capital flows.

(b) National promotion and informatics policy

Pragmatic plans are needed for two sets of reasons. The first relates to the rapid process of change already referred to: an inflexible plan with enormous detail will quickly be outdated and, even without this, cannot be implemented without a system of controls which cannot work properly and which will serve only to stifle economic activity. The second set of reasons relates to the fundamental link between good information flows

and efficient markets. A good information system helps a company manage its development and respond to change. With proper systems, a company can develop as an independent actor in the economy. Attempts to specify in advance what information systems it should have and when it should have them are usually irrelevant to this process of organic growth, or else an intrusion into it.

(c) Education and training

Developing countries face difficult choices in every question of resource allocation, but the question of computer-related education and training is especially important and hard to answer. Ideally computing should be introduced into school curricula and into third-level education; there should be computer science, hardware and software engineering and computer professional training; there should be specific technical education for subjects such as programming, hardware repair and maintenance etc. However, since not all this can be done immediately, where should the start be made? Again, rapidly changing technology continues to redefine skill requirements. Equipment becomes obsolete, programming languages become more powerful, software tools for system development become more productive, and package software has more and more features and potentials. The result is, relative to the need for systems analysis and application development, a decreasing demand for traditional programming skills on their own. These issues continue to make more difficult the question of correct strategy choices for education and training.

Technical support may be needed by developing countries in the development of a correct response. Among the tasks to be carried out are the following:

(a) Assessment of global technology trends as they affect training requirements and their expected impact on computerization in the country concerned;

(b) Survey of computerization trends and plans in the public and private sector, together with forecasts of likely future evolution, to give a full picture of likely skill requirements in the short and medium term;

(c) Assessment of potential sources of skills to determine education and training requirements;

(d) Assessment of resource requirements;

(e) Determination of priorities, policy choices and development of implementation strategies, including curriculum development;

(f) Institutional development and specific education and training activities.

In all these stages there may be requirements for international support measures, including specific technical cooperation activities on the part of multilateral and bilateral agencies. It is, however, essential that the end-users, the individual firms and government departments, be closely involved in all stages of this activity, not just through representative bodies but through their specific involvement in the analytical process and the collection of information.

(d) Telecommunications

Inadequate telecommunications were identified as the second obstacle to increased activity in Africa by major computer companies in the survey undertaken. Difficulty in telephone communications is obviously the most crucial in terms of the consequent absence of the most basic instrument of modern marketing and distribution. However, the telephone network is increasingly relied upon for facsimile transmission, as well as for data exchange. Thus not only is there an absence of the basic tools needed to carry on business activities, but an essential building block of distributed computer systems and of information exchange between systems is missing. Public infrastructure projects should increasingly focus on the telecommunications sector in Africa, as well as in other regions. It has already been the subject of much attention from the multilateral financing bodies as well as bilateral donor agencies. It can be assumed that this will continue to be so, but the special needs of industry and its computerization need to be continually emphasized at the level of national economic and industrial policy formulation. However, in the absence in many African countries of a fully functioning modern system of telecommunications, there will be a need for action at a more detailed level in specific support of industrial needs. This is discussed further below.

(e) Copyright

Without adequate safeguards for their intellectual property there will be an increasing tendency to avoid the more uncontrolled markets. Thus, a software company will not develop products for a market that it knows will not yield a fair return. Support for these markets will not be set up, so that the genuine purchaser in an African country will not be able to secure local advice and help. Moreover, were the country to enter world software markets at some stage, it could face restrictions on exports were it not seen to respect the intellectual property rights of software companies from other countries. Accordingly, there will be a need for assistance in the field of intellectual property rights development,

including legal systems, patent and copyright registration procedures and administration, etc.

(f) Standards development

Industrial standards are important both from the point of view of attempts to enter international export markets and also with respect to domestic issues such as quality and reliability. Many de facto standards, propagated by manufacturers in strong market positions, also have found wide acceptance. This is very much the case in the field of computer hardware and software, in which, as computer systems grow more complex and possible suppliers of individual parts more numerous, the need is for detailed specification of the components behaviour and interfaces in a recognized form. The importance of international standards diffusion in national policy cannot therefore be underestimated. It is especially significant at a nascent stage of computerization, when, for instance, a rapid expansion is likely to take place before a mature stage is reached. National policy issues related to the standards question concern foreign exchange scarcities: there may be advantages in setting national standards to reduce a proliferation of brands and consequent diverse service and spare parts requirements; there may be advantages also in bulk ordering of a single product; and, most importantly, there may be significant benefits if computer systems and personnel all speak the same language. Assistance may therefore be needed in specific fields of informatics standards development and diffusion. In general, the strategy will be to adopt international standards in the informatics sphere, but even then there are complex technical questions on which external assistance will be needed. Moreover, there will be a very great task in encouraging the adoption of the standards in the country and in meeting requests for assistance in this field from individual firms. In the absence, for instance, of a national standards body and the involvement of industrial associations in the standards process, the task will be more difficult. Thus, as well as the development of an informatics standards strategy, there will be the work of integrating it into the overall standards process in the country. In this field high-level international support will be needed, especially in the areas of:

(a) Enhancing the informatics capabilities of national standards bodies, including their work in promoting and diffusing appropriate standards;

(b) Supporting the activities of subregional and regional standards and technical bodies (especially the African Regional Standards Organization);

(c) Specific technical assistance to individual enterprises in meeting standards and quality requirements.

(g) The information environment

A more general but powerful method of encouraging computer applications and the efficiency of the operations in which they are carried out is to facilitate the free flow of information on the subject within the country. This can be done, for instance, by making available literature on the subject, and by encouraging the formation and activities of professional societies and amateur clubs in this field. A selective imports policy, as referred to earlier, will also allow for some autonomous diffusion of informatics products.

Specifically with regard to technical cooperation, there will be a need for international support in several fields. In the first place, professional societies will benefit very much from participation in the activities of the main international societies in the informatics field. Again, these international societies could increasingly be involved in technical cooperation activities through direct provision of expertise in individual projects and through involvement in the processes of programme and project development by the main multilateral agencies in the field of finance and technical assistance.

A second area where support would be needed and could yield significant benefits is in the expansion of the capabilities and responsibilities of industry organizations. Chambers of commerce, chambers of industry and manufacturers' associations are often directly involved in advising their members on a wide variety of administrative, economic and technical issues in connection with the success of the business. Their potential role in encouraging and assisting the successful application of computers to industrial management is very considerable. But their own capacities are at present limited, and external support is often necessary for them to play a wider role. This can take the form of the provision of advice on strategy formulation, surveying their members' requirements, the supply of expertise for an initial period, arranging international contacts etc.

2. Managerial issues

At the level of the individual firm, the role of technical cooperation is necessarily constrained by the need to deal with a potentially large number of enterprises, able or willing to benefit from improved information systems through the application of computers to the management of industry. It will never be possible, at the international

level, to provide support to more than a tiny fraction of the enterprises which could theoretically benefit from it. The needs of the individual firm will have to be met by the provision of broad support to the development of indigenous capabilities, so that institutions, whether government bodies or industry organizations of various kinds, will have the primary responsibility of trying to meet the needs of the individual enterprises for support and for advice.

It should be noted also that there is a related resource question: the direct financing of improved information systems will come from the firms themselves. They are the ones which will benefit from the speedier response times that ensue, as well as the greater accuracy, higher productivity and waste reduction that are the objectives of improved systems. The role of government and of international action is primarily an educational, promotional and supportive one, to make it clear to firms the advantages of computerization, to make it easier for them to carry it out, and to ensure that they reap the maximum benefit from it. Thus resources at a central level are intended only to supplement those to be mobilized at the firm level, and those at an international level only to assist in overcoming resource gaps in the country concerned.

From this perspective, the scope for direct action at the firm level is limited. Firms are best supported by the kinds of institutional development referred to above. But there will be special cases, such as those of large enterprises, public or private, where the benefits of direct intervention would be significant, either because of the importance of the enterprise in question to the economy as a whole, or because of the expected demonstration effect of a successful computerization project, in that it would encourage other industrial firms to undertake similar systems development.

Management training is an area where the needs in Africa are recognized to be very great. Training programmes are operated by many institutions at the national and subregional level, and in some cases, management training is also provided through the initiatives of the manufacturing or commercial sector itself. These activities provide a further point of intervention with respect to technical cooperation, which is often involved with management training activities. Programmes to bring better awareness among managers of the benefits of computerized information systems, and to thoroughly familiarize managers with the computerization process, are essential if computers are to benefit industrial management in Africa. Most important is the ability to master enough of the details of the process to be able to negotiate with suppliers, to recruit the necessary staff, to assess the critical areas of intervention and to derive the best returns from the hardware and software investments to be made. Thus technical assistance might be needed in the areas of curriculum development, training of trainers, and preparation of

training materials, together with regular updating of these in the light of technological developments.

An extension of the topic of training materials is that of the development of standard solutions and guidelines for the computerization of information systems. Here there would be perhaps particular benefits in concentrating on the following fields:

(a) Standard management information requirements definition;

(b) Guidelines for computerization of management information systems;

(c) Standard software applications packages.

3. Technical issues and production implications

(a) Hardware

The encouragement and support of electronics activity in a country is an essential part of any strategy of enhanced computerization. This is because of the repair and maintenance skills needed for computer equipment, but also to have the flexibility to make simple adaptations of standard equipment or to make new products from standard components. With respect to improved use of computers for industrial management, the former is the more important aspect, in which the spread and successful application of computers will be very much influenced by whether there is someone who can repair them or not. But it should also, in the industrial field, be recognized that the presence of computers and the availability of skills to adapt them means that a wide variety of applications in the field of industrial process control are in principle open to the industrial firm, even if it begins its computer usage with the applications of computers to management information systems.

Thus, technical assistance activities in support of the electronics industries, and related activities in the field of education, training and research, have important secondary effects in encouragement of computer usage, and thus industrial management usage, in general. However, there are a number of detailed areas in the electronics and electrical engineering industries which could be specially encouraged and could make explicit contributions to the acceptance of computers as a workable tool in the country. These include the following:

(a) *Fault-tolerant hardware.* This involves manufacturing activities based on the incorporation of reserve components and internal structures in computers. Principally personal-computer-based, these activities would mirror at a simplified level, the ideas of fault-tolerant computers

used in developed countries in essential high-volume transaction processing systems;

(b) *Dust protection.* This requires development and application of filters and control systems to guard against breakdowns and consequent down time and loss of data due to dust;

(c) *Electricity protection.* The quality of the public power supply in African countries being frequently bad enough to endanger information systems and to damage the equipment, there is a need for standard solutions to the problem. In some cases this can be done by infrastructural development, but in most cases there will be a need to fit some form of protection. Accordingly, assistance in the manufacturing of uninterruptible power sources and filters of various kinds will be an important field for technical cooperation, as well as raising the general level of skills in the electrical and electronics engineering industries;

(d) *Cooling and humidity control.* The need to retain component operating conditions within tolerable limits in spite of severe climatic conditions creates a demand for technical cooperation activities, especially in the field of design and electronics manufacturing. Suitable modifications to existing equipment will be the first types of activity undertaken, but there will also be a need to develop new approaches to the assembly of machines;

(e) *Repair and maintenance.* This is a general issue which concerns many other activities besides computerization. Development of national capabilities and skills in electronics-related fields is a task which involves action at the levels of education and training, and the development of electronics industries, as noted, will have particular impact in this regard. However, there will be also specific skills, such as disk-drive repair, for which specialized skills will be needed, as well as general training in computer diagnostics and fault finding. Here the role of the private sector will be a leading one, but it can still benefit by specific government action and external assistance in training activities and in the encouragement of local institutional support measures, such as involving universities and polytechnics in the training activities. Other measures in the field of repair and maintenance, especially in situations of severe foreign exchange shortages, should perhaps include assistance in the building-up of reserves of selected spares to keep systems going and minimize down time. Here the role of external assistance would be particularly important both in determining the requirements in terms of standard components and also in financing the holding of stocks;

(f) *Data networks.* Closely allied to development of computing is the question of the telecommunications infrastructure. Technical co-operation activities that foster the development of telecommunications systems will of themselves help the spread of computing: they can do so

more effectively if the needs of the computer information systems, actual and potential, are taken into account. This relates not only to the planned future information activities of existing companies in the country with dispersed manufacturing, distribution and administration facilities; it also relates to the need for an attractive infrastructure to encourage new investors to set up industries in the country. This is a particularly important consideration for foreign investors, but it will also be relevant to more ambitious local investors. However, in the absence of general improvements in the telecommunications network, especially for data communications, there is a need to investigate the possibilities of special solutions to particular data exchange problems. These can include measures to overcome the perceived disadvantages of the existing system, through data compression, extra validation, automatic repetitive data transfers etc. It can also include measures to substitute for the public network, especially through the use of radio frequency transmissions for the exchange of data between computers, or between remote terminals and a central computer. Applications of this technology are not common, and special development may be needed to encourage its more widespread use, including the development of suitable conventions, data compression, error checking and validation. It might nevertheless provide a flexible and elegant solution to certain data exchange problems. Technical cooperation might find this activity a useful focus;

(g) *Assembly*. As already noted, several African countries are engaged in the assembly of personal computers, naturally using components imported from outside the region. The question of how much design is done locally varies from country to country, but there can be no doubt that even pure assembly activities are nevertheless of value in spreading experience and skills in the fields of testing, repair and maintenance. Technical cooperation activities could be of value in encouraging the adaptation of equipment to meet special requirements of the country (including dealing with the climatic problems referred to earlier), or to use better or cheaper components.

Technical cooperation may also have a potentially wider role in the hardware field: this is in the area of investment promotion. Some of the possible research and development activities, as well as the production possibilities, covered in this section of the paper might be of interest to foreign investors seeking new opportunities, or existing manufacturers, in both developed and developing countries, seeking a competitive advantage in entering new markets. For this reason it should also be a focus of international support measures to promote suitable joint ventures, whether from developed countries or in the context of economic cooperation among developing countries. Here the role of sub-regional organizations in promoting projects could be important.

(b) Software

Development of software capabilities in the country, together with the training activities needed and the formation of skills to meet national requirements has been addressed above in sections 4, subsections 1 and 2, where it is clear that international cooperation and technical assistance programmes have an important role to play. There remain, however, several areas where there would be a need for specific support at detailed stages of software production:

(a) *Development of software companies.* This would require technical assistance to individual firms developing software either to meet local needs or for export. In either case advice may be needed on market research, design methodologies, development techniques, testing and debugging, packaging, documentation and marketing;

(b) *Security software.* In view of the difficult conditions in some African countries, a number of hardware developments have been discussed in preceding paragraphs, intended to overcome the climatic problems, poor electricity supply etc. However, there is a role for software also in attempting to compensate for these problems. Developments might include software that is fault tolerant, including the modification of existing packages to improve their level of backup procedures and data validation. As well as this there will be an important role for software directly involved with some of the hardware developments outlined. Finally, there is a potentially important software activity in the diagnosis of hardware faults and the monitoring of computer activity and information systems performance which could provide further opportunities for local software production. It is likely, however, that development of such software solutions will need external support and technical assistance.

Annex

QUESTIONNAIRE*

FIELD STAFF SURVEY

UNIDO: Study of the use of computers for industrial management in Africa

Your name Project number Duty station

.....

1. How difficult is it to find locally computer staff who are fully trained and experienced?

	Not difficult	Difficult	Impossible
System analysts	☐	☐	☐
Programmers	☐	☐	☐
Operators	☐	☐	☐

2. In your opinion, do computer staff in the country generally have formal training and/or qualifications?

	In company training	Computer manufacturer or supplier training	University qualifications	Technical qualifications
System analysts	☐	☐	☐	☐
Programmers	☐	☐	☐	☐
Operators	☐	☐	☐	☐

3. Are you aware of any of the following in the country?

	Yes	No
Package software producers	☐	☐
Custom (made to order) software firms	☐	☐
Package software suppliers, agents or sellers	☐	☐

*Due to a misprint, no question 7 was included in the original questionnaire. Since references to the questionnaire are based on the original text, the questions have not been renumbered.

4. If there is a problem with a commercial software package, would a user company be able to find help, advice or technical support within the country?

Usually	☐
Sometimes	☐
Never	☐

5. Do you know of any computer or peripheral suppliers within the country?

	Main-frame	Minis	Micro/ PCs	Printers	Tape/disk drives	VDU terminal
Branch of manufacturers	☐	☐	☐	☐	☐	☐
Distributors or sales agents	☐	☐	☐	☐	☐	☐

6. How easy is it for a computer user to obtain the following supplies locally?

	Easy	Difficult	Impossible	Don't know
Diskettes 8"	☐	☐	☐	☐
Diskettes 5 ¼"	☐	☐	☐	☐
Diskettes 3 ½"	☐	☐	☐	☐
Magnetic tapes	☐	☐	☐	☐
Continuous printer paper	☐	☐	☐	☐
Printer ribbons	☐	☐	☐	☐
Punch cards	☐	☐	☐	☐
Toner for photocopier/laser	☐	☐	☐	☐
Cables and connectors	☐	☐	☐	☐
Fuses for electronic equipment	☐	☐	☐	☐
Standard RAM chips	☐	☐	☐	☐

8. How easy is it for a computer user to obtain repair and maintenance of the following:

	Easy	Difficult	Impossible
CPUs	☐	☐	☐
Hard disk drives	☐	☐	☐
Floppy disk drives	☐	☐	☐
Printers	☐	☐	☐
VDUs, terminals	☐	☐	☐

9. Do you know of any local sources of information on computers?

	Yes	No
Computer society/club/user group	☐	☐
Magazines/journals	☐	☐
Shops	☐	☐

10. In your judgement, what is the extent to which factories in the country use computers for industrial management? (By this is meant factories of a size and type which in developed countries would certainly use computers in this way)

%	
5-25%	☐
25-50%	☐
50-75%	☐
75-100%	☐

11. In your judgement, what is the typical age of such computer equipment?

	Mostly	Some	None	Manufacturer(s)
Less than 5 years old	☐	☐	☐	.....
5 to 10 years old	☐	☐	☐	.....
Over 10 years old	☐	☐	☐	.....

12. Is the typical usage

On batch process	☐
Some on-line processing	☐
Mostly on-line processing	☐

13. Is any of the following software used?

	Yes	No	Don't know
Database	☐	☐	☐
Application generator/4GLs	☐	☐	☐
Teleprocessing monitors	☐	☐	☐
Optimizing compilers	☐	☐	☐

14. In your judgement, to what extent are the following a problem for computer users in the country?

	Major	Minor	No problem
Temperature	☐	☐	☐
Humidity	☐	☐	☐
Dust	☐	☐	☐
Public power supply	☐	☐	☐
Telecommunications	☐	☐	☐
Lack of hardware support	☐	☐	☐
Lack of software support	☐	☐	☐
Shortage of suppliers	☐	☐	☐

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Industrial development in the United Arab Emirates

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In the pre-oil era manufacturing activities in the United Arab Emirates were limited to small traditional handicrafts for the local market, such as wooden ships, fishing nets, salted and dried fish and skins, earthenware, and silver daggers and ornaments. Some of the small handicraft makers worked alone, but more often the master-artisan was assisted by family members or two or three skilled craftsworkers or apprentices.

The petroleum industry prompted the growth of service and ancillary industries together with some import-substitution industrialization. Small, privately owned factories producing carbonated beverages, furniture and building materials such as concrete blocks, tiles, asbestos-cement and plastic pipes, aluminium doors and windows began to spring up to cater for the growing population of manufacturing communities. Various fabrication and maintenance workshops also started to appear.

The Governments of the emirates then decided to enhance the role of the public sector in the development process by investment in the manufacturing sector associated with oil and gas, such as refineries, fertilizer plants and aluminium smelters, as well as other industries requiring large investments, such as cement factories. In Abu Dhabi, the largest and richest emirate, the public sector industrial projects are shared between the Abu Dhabi National Oil Company (ADNOC), which is the main organ for implementing Abu Dhabi policy regarding oil exploration, production, marketing and processing, and the General Industries Corporation, which undertakes non-petroleum-related projects. Table 7 in the annex shows that the share of crude oil and gas in the gross domestic product (GDP) dropped from 66.5 per cent in 1975 to 37 per cent in 1987, while the share of manufacturing increased from 0.9 per cent in 1975 to 9.4 per cent in 1987.

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A. Oil-and-gas-related industrialization

Like other Persian Gulf countries, the United Arab Emirates began giving importance to oil-and-gas-related processing industries, such as oil refining, gas liquefaction, petrochemicals and aluminium smelting, after the oil price increase of 1973-1974, which enabled the country to accumulate considerable capital. The oil industry also began producing the materials needed in the oil industry itself, such as drilling fluids and chemicals.

Although the oil industry contributes considerably towards the gross national product (GNP), its employment figures are quite small. Moreover, the oil-and-gas-related downstream projects are capital-intensive, and the necessary technology and labour skills are both imported.

1. Oil refining

Local refining of oil meant that the value added by the refining process could be captured domestically. It also secured a supply of refined oil products for the country. McHale [1] considers that many emerging countries make a priority of having their own oil refining capability as a symbol of their industrial independence. However, such a capability is also one of the most obvious factors in the industrialization process.

There are two oil refineries in the United Arab Emirates, both in Abu Dhabi. The first one, situated at Umm Al-Nar, started production in 1976 with a capacity of 15,000 barrels per day, and this was raised to 75,000 barrels per day in 1983. The other refinery at Ruwais, about 245 kilometres west of the city of Abu Dhabi, started production in 1981 with a capacity of 120,000 barrels per day. Together the two refineries can refine about 200,000 barrels per day, or less than one fifth of the total oil production of the United Arab Emirates. All the remaining oil production is exported as crude.

2. Gas liquefaction

In the past most of the associated gas produced during the extraction of oil was wasted by flaring. In 1974 the United Arab Emirates produced about 500 billion cubic feet of gas, of which the oil companies utilized about 1.5 per cent in the fields, and about 1.5 per cent was used by the city of Abu Dhabi for the generation of electricity and desalination of water. However, over 93 per cent had to be burned.

Gas liquefaction projects were undertaken to stop the wastage of gas and make its export possible. By 1980, about 49 per cent of the gas was being exploited by liquefaction for export, or by utilization in industry and bottling for domestic use [2]. By 1983, nearly 92 per cent of the gas in Abu Dhabi, the main producer of United Arab Emirates gas, was being exploited [3]. This reflected the growth in gas sales from 2,430 million dirhams (Dh) in 1980 to Dh 5,272 million in 1984.* Moreover, in 1983 gas accounted for 8.8 per cent of the total exports of the United Arab Emirates [4]. More significantly, gas was also regarded as an important vehicle for industrialization. In the United Arab Emirates it is a cheap source of energy for energy-intensive industries like aluminium smelting. It is also the main raw material for many petrochemical industries.

The construction of the Abu Dhabi Gas Liquefaction Company, 51 per cent owned by ADNOC and the rest owned by foreign oil companies, was completed in 1977. The storage tanks were built on Das Island. The project produces liquefied natural gas and liquefied petroleum gas. The two liquefaction trains are designed to produce annually 2.3 million tonnes of liquefied natural gas, 0.65 million tonnes of propane, 0.52 million tonnes of butane and 0.22 million tonnes of pentane plus.

ADNOC has a majority share in Abu Dhabi Gas Industries, which came on stream in 1981. This project, which is larger than the Abu Dhabi Gas Liquefaction Company, collects associated gas from three onshore fields. In 1983 total production was over 2.5 million tonnes of propane, butane and pentane plus. ADNOC is also the sole owner of THAMAMA, which collects non-associated gas from the Thamama C structure of the onshore fields. Sweet gas from the processing plant is supplied to Ruwais and Abu Dhabi for use as fuel and feedstock for utilities and industries.

The Dubai Government is the sole owner of Dubai National Gas Company, which was inaugurated in April 1980. By September 1986 the company had produced 5 million tonnes of products (propane, butane and condensate). Gas from offshore fields is separated from the crude oil produced at an offshore separation plant and the resulting natural gas liquids and dry gas are pumped to the Jebel Ali fractionation plant. Residue gas is used to supply most of the requirements for fuel refinement at the Dubai Aluminium Smelter (DUBAL) and some of the requirements of the Dubai Electricity Company. Most Dubai gas is associated gas, but some non-associated gas is also obtained from the offshore Rashid field.

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*1 United States dollar ($) = Dh 3.675.

The Sharjah Government is the majority shareholder of SHALCO, the liquid-petroleum-gas plant at Sharjah. Construction began in 1984 and production in 1986. The company uses gas from the onshore Sajaa fields. The capacity in the early stages was 7,500 barrels per day of propane and 6,000 barrels per day of butane, plus some condensate. Gas has played an important role in the development of industrialization in the United Arab Emirates both as a feedstock for petrochemical and gas liquefaction industries and as a source of energy in industries such as aluminium smelting.

Petrochemicals represent a field of industrialization in which several Persian Gulf countries have been concentrating their efforts. However, in the United Arab Emirates, diversification into petrochemicals has been rather limited. Nevertheless, oil-related processed products accounted for over Dh 3.5 billion of the total exports of the United Arab Emirates, which in 1984 amounted to over Dh 58 billion. The main petrochemical industry has been a fertilizer plant (FERTIL), a joint venture between ADNOC, which holds a two-thirds share, and *Compagnie française des pétroles* (DFP-Total). The factory is situated in the Ruwais industrial zone. The location of this industrial zone, which is 245 kilometres from Abu Dhabi, was dictated by several considerations, including closeness to the export terminal for onshore oil at Jebel Al-Dhanna and the fact that it is conveniently placed for several major onshore fields providing associated gas for use as fuel and industrial feedstock. FERTIL has a design capacity of 1,000 tonnes per day of ammonia as well as 1,500 tonnes per day of urea. The first shipment from the plant was in January 1983. Most of the production is exported to places such as China, India and Japan, but some is sold in the local market and to other countries belonging to the Gulf Co-operation Council (GCC).

ADNOC is also the sole owner of National Chlorine Industries, which uses the brine from the power stations at Umm Al-Nar near Abu Dhabi to produce salt, hydrochloric acid, chlorine, caustic soda and distilled water. The industry takes advantage of cheap energy available in Abu Dhabi, of an easily available feedstock, namely the brine, which is essentially concentrated sea water, and of the ready market in the local oil and other industries. The plant has a capacity of 52,700 tonnes per day. About 75 per cent of production is sold locally and the rest mainly in other Arab countries.

Various other oil-related industries have been more recently under consideration. In the different emirates, however, several of these projects have been shelved following the drop in oil prices in the second half of the 1980s, which resulted in a decline in funds and made the gas-based petrochemical industries of Persian Gulf countries less competitive compared with oil-based petrochemical industries in the European Community. Moreover, even before the decline in oil prices, the

petrochemical products of a country such as Saudi Arabia were facing marketing difficulties in Europe owing to tariff barriers. In addition, several Persian Gulf countries have been undertaking similar projects in basic petrochemicals, producing mainly ethylene and methanol from gas. This duplication, which is partly dictated by the type of feedstock used, could make the Persian Gulf countries compete fiercely with one another over a very limited number of basic products. The question of opening up developed market economies to petrochemicals from the Persian Gulf has been the subject of various negotiations between Persian Gulf countries and the European Community in recent years.

3. Aluminium smelting

In recent years the aluminium industry has been passing internationally through a period of structural readjustment, with production becoming concentrated in areas where cheap energy is available, since energy is a substantial component of total costs in this industry. Thus, the availability of cheap electricity from gas was the main reason behind the setting up of DUBAL, the aluminium smelter in Dubai, even though all the other raw materials are imported.

The viability of the plant, which is linked to the Dubai National Gas Company processing plant, is enhanced by the tapping of the hot exhaust gases by means of heat recovery boilers for the desalination plant, which provides Dubai with over 60 per cent of its drinking water requirements. In fact, DUBAL is one of the most energy-efficient smelters in the world because of this link. Instead of working at an average of about 27 per cent thermal efficiency, the overall efficiency is much higher because the desalination plant makes use of the exhaust heat. Moreover, DUBAL has recently installed back-pressure steam turbines to achieve even greater efficiency. DUBAL produces its own electricity, but is linked to the Dubai electricity grid for the mutual security of the factory and the Dubai Electricity Company.

DUBAL has an installed capacity of 135,000 tonnes per year. The plant came on stream at the end of 1979, but since September 1981 it has been producing at more than nominal capacity. Cast metal production in 1985 reached 150,252 tonnes, of which 62 per cent was in premium products, that is, 99.9 per cent pure aluminium. Production in 1986 reached 155,065 tonnes. Modifications are under way to increase the capacity of the plant to some 170,000 tonnes per year without installation of additional pots. The strategy of DUBAL has been to produce more and more high-purity value-added products such as billets for high-technology users, and fewer commercial-grade remelt products. Almost three quarters of the production is now of the higher-grade products.

About 5 per cent of the production of DUBAL is sold locally to companies such as Gulf Extrusion, an aluminium extrusion company situated at Jebel Ali. The bulk of the production is exported to some 25 countries, particularly to China, Japan, the Republic of Korea and the United States of America. Prices of aluminium have been subject to great fluctuations in recent years. The price increased in March 1988 to $2,350 per tonne, which enabled DUBAL and other aluminium manufacturers to make good profits. The depression of metal prices in 1985 prompted the company to make efforts to cut costs, which included reducing the workforce from 1,362 to 1,314.

Another important aluminium smelter in the Persian Gulf area is ALBA, which is located in Bahrain. It came into operation in 1971 and produces about 180,000 tonnes per year. DUBAL and ALBA have been cooperating in certain fields, such as the joint purchase of some raw materials, particularly alumina.

B. Manufacturing outside the oil sector

Outside the oil sector industrial development has been mainly connected with the construction boom (for example, in the cement industry and its related downstream industries, polyvinyl chloride pipes and furniture) and with the food industry, as a result of the large increase in population.

As the non-oil industrial sector consists of a large number of medium- and small-sized factories, consideration will be given to non-oil-related manufacturing activities, with an examination of the results of the three industrial surveys carried out since 1978, particularly the latest one based on 1985 data.

1. Results of the industrial surveys

The first industrial survey in the country was undertaken by Arthur D. Little in 1968 on behalf of the World Bank. In more recent years the Ministry of Planning has carried out two general industrial surveys. The results, known as the 1978 and 1981 Annual Industrial Production Statistics, were published in 1980 and 1983, respectively. The latest comprehensive United Arab Emirates industrial survey was conducted by the Industrial Department of the Ministry of Finance and Industry, with the help of various federal and local establishments including the Ministry of Planning, the Federation of United Arab Emirates Chambers of Commerce and Industry, the local chambers of commerce, industry and agriculture in the various emirates, the Emirates Industrial Bank, and

some of the municipalities and the local departments of planning or economics. The 1985 survey was published in 1988.

According to the 1985 survey there were 622 industrial establishments in the United Arab Emirates employing 10 persons or more and 7,519 industrial establishments employing less than 10 persons. The survey attempted to cover all the factories employing 10 persons or more and to use sample surveys for industries employing less than 10 persons. Survey questionnaires were filled in by 483 factories employing 10 persons or more, 77.7 per cent of that category, and 537 establishments employing less than 10 persons, 7 per cent of that category.

A comparison of the number of establishments employing 10 or more persons, the value of gross output, and value added by industry in the three surveys of 1978, 1981 and 1985 is given in table 1. These comparisons include all the manufacturing establishments that existed at the time of the survey, and not only the establishments that filled in the detailed questionnaires.

The table shows that manufacturing industrial establishments employing 10 persons or more in the United Arab Emirates increased from 423 in 1978 to 658 in 1981, then decreased to 622 in 1985. These figures indicate that manufacturing activity has been affected by the general economic situation of the country, which went through a boom between 1978 and 1981, and which started to decline during the period 1981 to 1985 owing to a decrease both in prices and in the quantities of oil exported.

The gross output values, on the other hand, more than doubled between 1978 and 1981, increasing from about Dh 2,388 million to about Dh 5,570 million in 1981, and then increased by a further 15 per cent to about Dh 6,423 million in 1985. The main reason for the increase in gross output between 1981 and 1985 was the effect of the creation of the basic metal industries. The 1981 survey did not register any basic metal industries, while the 1985 survey indicated six industries in that category, of which two were iron and steel producers contributing Dh 49.4 million to gross output values and 4 non-ferrous metal industries contributing a further Dh 1,067 million to output values (see table 1 and the annex). Another reason for the increase is the expansion in the food industry, the gross output of which increased from Dh 196 million in 1978 to over Dh 1,000 million in 1985.

Although gross output increased between 1981 and 1985, the net value added (in producers value) in fact decreased slightly from Dh 1,923 million to Dh 1,911 million over the same period. The main factor contributing to the drop reflects the decrease in value added in non-metallic mineral products other than petroleum products from about Dh 581 million (33.1 per cent of gross output) in 1981 to about Dh 276 million (19.1 per cent of gross output) in 1985. In fact, net value

Table 1. Number of establishments employing 10 or more persons, gross output and value added by industry

Manufacturing industry	1978			1981			1985		
	Number of establish-ments	Gross output values	Net value added	Number of establish-ments	Gross output values	Net value added	Number of establish-ments	Gross output values	Net value added
		(thousand dirhams)			(thousand dirhams)			(thousand dirhams)	
Food, beverages and tobacco	49	195 879	78 454	73	717 588	211 136	80	1 006 205	277 124
Textiles and wearing apparel	43	23 703	16 711	67	64 021	37 146	47	40 287	22 250
Wood, furniture, wooden products	61	136 144	64 356	86	335 351	145 198	52	182 567	17 594
Paper, paper products, publishing	43	148 399	41 210	65	363 125	153 251	64	346 301	141 223
Chemical, plastics, petroleum products	30	445 749	141 643	61	1 133 712	366 862	74	898 059	308 911
Non-petroleum non-metallic minerals	95	728 083	294 213	135	1 758 967	581 479	136	1 337 090	276 116
Basic metal industries	1	3 508	1 553	–	–	–	6	1 116 145	152 233
Metal fabrication, machinery, equipment	99	699 453	334 611	165	1 034 845	389 822	148	1 283 589	613 006
Other manufacturing industries	2	6 771	3 416	6	158 356	38 244	14	102 890	49 000
Total	423	2 387 689	976 167	658	5 569 965	1 923 102	622	6 423 404	1 911 457

Source: Ministry of Planning, *Annual Industrial Production Statistics* for 1978 and 1981 data; and Ministry of Finance and Industry, *1985 Industrial Survey*.

added was over 40 per cent of gross output in that category in 1978. The main reason for the drop of value added in this category was the very sharp drop in net value added in the cement industry. The value of gross output of the cement industry in the 1985 survey was Dh 695 million whereas the net value added was less than Dh 25 million, only about 0.35 per cent of gross output. This is because the cement industry from the early 1980s until late 1988 suffered severely from the decline in construction and the overcapacity of cement factories in the United Arab Emirates, the production of which was mainly aimed at the limited local market rather than at export.

A more detailed picture of the gross output values and net value added by type of industry for 1985 is given in table 8 in the annex, which also shows the number of establishments and the number of workers in each industry. As the table is self-explanatory, only some of the results will be commented upon.

Out of 80 establishments in the category of industries concerned with the manufacture of food and beverages, 36 are bakeries, 13 deal with milk and dairy products and another 13 produce non-alcoholic beverages and mineral water. Together, these industries employ 5,254 workers or 13.5 per cent of the total industrial workforce. There are only two mills for cereals, but they are the largest concerns in this category, employing 243 workers with a gross output value of nearly Dh 280 million. The ratio of value added to gross output varies from a minimum of 15.9 per cent in the one fat and oil factory, which depends on imported raw materials, to a maximum of 43.7 per cent in the one fodder products plant.

There are 47 establishments dealing with textiles and wearing apparel, but they are generally small, with a total employment of 808 persons. Most of these establishments are small concerns with a gross output seldom exceeding Dh 2 million or Dh 3 million per annum. Forty-one of these establishments are small clothes manufacturers. The ratio of value added to gross output in this category is on average over 65 per cent because workmanship constitutes a large part of the cost. There is a large number of small tailor shops which are not included in this list because they employ less than 10 persons. This category includes one small shoe factory with only 30 employees.

There are 22 small furniture factories employing a total of 964 persons and another 29 shops mainly of makers of wooden products such as doors and other products for the construction industry. This category also includes makers of small wooden boats. The percentage of value added to gross output in this type of industry is about 40 per cent. In the 1981 survey there were 31 furniture establishments and 55 factories producing wooden products other than furniture. The decrease in the number of wood and furniture establishments between 1981 and 1985 is explained by the significant contraction in the construction industry.

The chemical industry is an important contributor to industry in the United Arab Emirates, the fertilizer factory FERTIL being the largest plant, with a gross output of over Dh 100 million, a workforce of 500, and a ratio of value added to gross output of over 34 per cent. Gulf Pharmaceuticals, with 220 employees, is the only pharmaceuticals factory in the United Arab Emirates. This is the only factory with a negative value added tabulated in annex table 8, indicating that the factory was going through difficulties. There are 38 factories, most of which are quite small, producing plastic pipes and household plastic goods and employing 2,158 persons, with a ratio of value added to gross output averaging 32.6 per cent. There are a further seven factories producing basic chemicals other than fertilizers and employing 543 persons, one of the most important of which is the chlorine factory, National Chlorine Industry, owned by ADNOC. There are also seven paint factories employing a total of 236 persons.

The second largest group of industries within manufacturing is concerned with non-metallic mineral products other than petroleum products. The largest of these are the nine cement factories with a gross output of Dh 695 million, a total employment of 2,326, and a ratio of net value added to gross production of only 3.6 per cent. One of the important industries in this category is the rock-wool factory at Fujairah, which produces insulation material from locally available rock. There is also a large number of smaller factories which produce building materials such as building blocks and tiles. A factory for ceramic products at Fujairah, with a capacity of 750,000 square metres, is working to full capacity, and a second factory with a capacity of 600,000 square metres to meet orders from Europe and America has been recently under consideration.

The survey indicates that there are six basic metal industries, two of which produce reinforcement steel bars from scrap metal. The gross production of these two factories is nearly Dh 50 million, and they employ 218 persons with a ratio of value added to gross production of 30.1 per cent. There are four other factories producing non-ferrous metals. The most important one among these is DUBAL, which at the time of the survey employed 1,314 persons out of the 1,675 persons in the four establishments. The total gross production of the four industries was over Dh 1,000 million. The ratio of value added to gross output for these factories was on average only 12.9 per cent.

The most important industrial group in the United Arab Emirates, employing 12,798 persons, covers establishments producing engines, equipment and metallic products such as steel structures. Of the 148 factories in the group, 82 produce mainly steel structures for the oil industry, factories and buildings. The gross production of these 82 factories is Dh 944 million, and they employ 9,883 persons. The ratio

of net value added to gross production for these factories exceeds 50 per cent on average. There are another 38 establishments dealing with metal products other than machinery, with a gross production of Dh 171 million and an employment of 1,369 persons. These include the larger machine shops. There is a large number of small machine shops and garages employing less than 10 persons, and which are therefore not included in the above figures. According to the 1985 survey, there were seven ship repair shops employing 785 persons with a total gross production of Dh 76 million. The largest among these is the ship repair dockyard at Port Rashid in Dubai, which has the largest dry dock in the world, capable of handling a ship with a rating of 1 million tonnes.

The distribution of establishments employing 10 persons or more, by emirate, is given in table 2, which also shows the number of employees, the gross production, the net value added and the physical capital cost. Dubai, with 215 establishments, is the emirate with the largest number of factories employing 10 or more persons, followed by Abu Dhabi and Sharjah, with 154 and 151 industrial establishments, respectively. Ajman comes next with 45 establishments. Its proximity to Sharjah and Dubai, which have good seaports and airports and are important markets, attracts foreign firms and local industrialists to set up factories in the emirate, where rents, moreover, are appreciably cheaper. Ras Al-Khaimah comes next with 21 establishments, cement factories being the most important.

The employment data show a similar pattern. Dubai employs 16,694 persons in industries employing 10 or more persons, followed by Sharjah with 7,127, Abu Dhabi with 6,747 and Ras Al-Khaimah with 5,141. Of the total employment in industrial activity, the number of persons engaged in actual production, as distinct from other activities such as administration and sales, amounts to 67.7 per cent on average.

It is interesting to note that there are variations in capital-intensity from one emirate to another. The average employment per establishment varies from a minimum of about 34 in Umm Al-Quwain to a maximum of about 245 in Ras Al-Khaimah, with 49 in Abu Dhabi and 78 in Dubai.

The gross output values are highest in Dubai at Dh 3,141 million, followed by Abu Dhabi and Sharjah at about one-third these values. Ras Al-Khaimah gross output is Dh 611 million, followed by Umm Al-Quwain at Dh 511 million, although this emirate has only 11 industrial establishments employing 10 or more persons. The ratio of net value added to gross output is nearly 30 per cent in the four emirates with the highest gross output, but it decreases to 8.3 per cent in Fujairah and to only 3.2 per cent in Umm Al-Quwain.

As mentioned earlier, there are variations in capital-intensity among the emirates. The total fixed capital value is highest in Dubai at Dh 8,473 million, with Abu Dhabi a distant second at Dh 1,765 million. Abu Dhabi, however, has made large investments in the oil refineries and

Table 2. Data on industrial establishments employing 10 persons or more, by emirate

Emirate	Number of establishments (a)	Employment: Production (b)	Employment: Total (c)	(b)/(c) (percentage)	Average employees per establishment (c)/(a)	Gross output values (d) (million dirhams)	Net value added (e) (million dirhams)	(e)/(d) percentage	Fixed capital value: Equipment (f) (million dirhams)	Fixed capital value: Total (g) (million dirhams)	(f)/(g) percentage
Abu Dhabi	154	4 480	6 747	66.4	43.8	1 066	330	31.0	1 049	1 765	59.5
Dubai	215	11 299	16 694	67.3	77.6	3 141	994	31.6	5 391	8 473	63.6
Sharjah	151	4 557	7 127	63.9	47.2	1 054	294	27.9	560	1 046	53.5
Ajman	45	1 566	1 940	80.7	43.1	338	71	20.9	184	337	54.7
Umm Al-Quwain	11	212	370	57.3	33.6	511	16	3.2	60	97	61.7
Ras Al-Khaimah	21	3 794	5 141	73.8	244.8	611	193	31.6	912	1 484	61.5
Fujairah	15	603	1 025	58.8	68.3	163	13	8.3	360	481	74.8
Total	622	26 441	39 044	67.7	62.8	6 423	1 911	29.8	8 517	13 683	62.2

Note: Values of (d), (f) and (g) are rounded, with ratios calculated before rounding.

Source: Ministry of Finance and Industry, 1985 Industrial Survey.

gas liquefaction industries. Ras Al-Khaimah comes next at Dh 1,484 million because of investment in industries such as cement, followed by Sharjah at Dh 1,046 million and Fujairah at Dh 481 million. In general, the share of machinery and equipment, virtually all imported, is 62.2 per cent of the total fixed capital value for the seven emirates.

Besides the 622 industrial establishments employing 10 or more persons, the *1985 Industrial Survey* shows that there were another 7,502 industrial establishments that employed less than 10 persons. The total employment of these 7,502 establishments was 22,490 persons, or 36.6 per cent of the total employment in the manufacturing sector.

The number of establishments and workers in industrial concerns employing less than 10 persons by emirate is given in table 3, which also indicates the gross output values and the capital values. Although Dubai had the largest concentration of the larger factories, Abu Dhabi had a greater concentration of the smaller establishments, 2,112 compared with 1,870 in Dubai. Sharjah had 1,606 small establishments, followed by Ras Al-Khaimah with 828 establishments. The total capital value of establishments employing less than 10 persons was Dh 83 million in Dubai and around Dh 77 million in Abu Dhabi and in Sharjah. Abu Dhabi had a gross output from these establishments of about Dh 215 million, followed by Dh 211 million in Sharjah and about Dh 136 million in Dubai.

Table 3. Data on industrial concerns employing less than 10 persons, by emirate

Emirate	*Number of establishments*	*Number of workers*	*Total wages*	*Gross output values*	*Capital formation*
Abu Dhabi	2 112	6 023	91 180 391	214 609 212	76 207 047
Dubai	1 870	6 639	80 031 528	135 759 519	83 556 218
Sharjah	1 606	4 957	56 872 978	211 119 392	77 931 868
Ajman	110	1 654	18 155 904	50 243 469	48 437 419
Umm Al-Quwain	615	354	3 798 567	24 834 309	6 328 343
Ras Al-Khaimah	828	2 210	18 572 003	60 846 428	51 768 446
Fujairah	362	653	5 398 001	[illegible]	838 848
Total	7 503	22 490	274 009 372	71[illegible]	[illegible]0 068 189

Source: Ministry of Finance and Industry, *1985 Industrial Survey*.

The number, activity and employment of these concerns are summarized in table 4. As the table shows, small-scale industrial establishments employed on average three persons per establishment. The output and productivity of these industries was small, their output accounting for about 10 per cent of the gross industrial output, even though they accounted for 3 per cent of total industrial employment, indicating their labour-intensive nature. Of the 7,503 small establishments, 4,299, or more than half, were concerned with making clothes, weaving and leather goods, most of them being small tailors' shops.

Table 4. Number of small establishments employing less than 10 workers and employment levels, by activity

Activity	*Number of establishments*	*Number of workers*
Clothes, weaving, leather	4 299	12 673
Furniture, wood products	1 186	3 035
Machine shops, workshops	965	3 080
Food and drinks processing	442	1 365
Products using mined products other than metal and oil	322	1 310
Paper products and printing	38	174
Chemical and plastic products	38	166
Other manufacturing industries	213	687
Total	7 503	22 490

Source: Ministry of Finance and Industry, *1985 Industrial Survey*.

C. Closer examination of some manufacturing industries in the United Arab Emirates

Three sample manufacturing industries have been selected for a closer examination. These are the cement industry, the plastics industry and the beverages and food industry. They have been chosen because they are among the more important or the more ubiquitous manufacturing activities, and because their problems are typical of the difficulties faced by the manufacturing sector. One of the most significant problems is the duplication of projects owing to the lack of government planning and of

coordination between the emirates. There has also been a lack of imagination on the part of many in the business community who have tended to concentrate on copying successful projects and given insufficient consideration to the effect of new projects on the industry.

1. The cement industry

Cement has been the most prominent material used in the construction industry in the United Arab Emirates in the post-oil era. Most buildings in the Gulf are now constructed from reinforced concrete and cement blocks. However, when the oil prices jumped in 1973, there were still no cement factories in the United Arab Emirates. At that time the country imported all of its cement primarily from Belgium, Germany, Federal Republic of, Japan and Kenya, and when requirements increased sharply in 1974, other countries including Egypt, Greece, Pakistan, Philippines, Republic of Korea and Romania also exported cement to the United Arab Emirates. The desperate situation of cement demand and supply in those days in the Gulf has been described as follows: "Less than 10 years ago demand for imported cement in the Gulf was so extreme that, in the face of appalling port congestion, fleets of helicopters were used to shuttle back and forth between ship and shore carrying loads of urgently needed cement" [5]. The use of such an expensive means of transport shows the magnitude of the boom in the construction industry in the Gulf at that time. An asbestos-cement pipe factory established in Dubai in 1973 continued for two years to depend on imported cement until locally made cement became available.

The Union Cement Company of Ras Al-Khaimah was the first to start in 1975 with an annual capacity of 550,000 tonnes. One of the main reasons for setting up the cement industry in Ras Al-Khaimah was the availability of limestone from the Hajjar mountains suitable for the production of good-quality cement. The capacity of the plant was expanded later to just over 1 million tonnes. This factory, as well as the other factories set up after it, produce ordinary Portland cement as well as sulphate resisting cement that is supposed to be more suitable for the salty soil of the Gulf.

Several cement factories thereafter began to appear in the various emirates. As a result, in December 1986 the annual cement production capacity of the United Arab Emirates was estimated at about 8 million tonnes, 2.6 million tonnes of which were used locally and 2 million tonnes exported [6]. More recent developments in the industry have thus tended to be shelved because of market saturation. In fact, after trial runs in 1987, a new factory in Umm Al-Quwain was kept closed until the end

of the recession which began to weaken with the cease-fire that terminated hostilities in the war between Iraq and the Islamic Republic of Iran.

The cement industry the world over is often a problem industry, beset with uncertain returns on heavy investment. The industry has also been suffering from the problems of plenty in the past few years. In the United Arab Emirates, demand started to fall in 1984 with the decline in construction activities as the infrastructure became largely completed and oil income decreased. The development of cement production and prices between 1981 and 1984 is reflected in table 5. Production has been on the decline since 1984, but prices started to fall earlier in 1982, while gross output in money terms has declined since 1983.

Table 5. Annual production and average prices of cement in the United Arab Emirates, 1981-1984

Year	*Production (thousand tonnes)*	*Price (dirhams per tonne)*	*Gross output (million dirhams)*
1981	3 276	314	1 030
1982	4 758	262	1 247
1983	5 746	210	1 208
1984	5 137	193	990

Source: Journal of the Emirates Industrial Bank, December 1986, p. 11.

Despite the availability of plentiful local cement, some imported cement continued to find its way into the market until recently when prices fell to such a level that foreign cement could no longer compete with local production, which is generally of high quality and has the advantage of being fresher than rival imports. Moreover, some of the factories are able to cater for special requirements of customers. For instance, Union Cement is able to produce a special plain cement for the asbestos-cement pipes factories. It can also produce special cement for use in the oil wells. Gurdon [7] claims that despite the quality of the domestic product, which conforms to the highest international standards, until recently there has always been a preference for imported cement. The reason was that some countries were dumping cement at lower prices than the local product. The cement industry does not enjoy government

protection, but since 1986 it can benefit from the 10 per cent price preference margin in purchases by the federal government agencies.

According to the general manager of the General Corporation of Industry, which is an Abu Dhabi public sector organization and which owns the Al-Ain cement factory, the price of cement in the United Arab Emirates dropped at the beginning of 1988 by another 20 per cent compared to the price a year earlier to reach Dh 4.5 per bag, or Dh 3 below actual cost price, making cement in the United Arab Emirates the cheapest in the world [8]. However, due to high costs of production the industry could compete easily in world markets and thus make greater use of its capacity, which would lead to a reduction in production costs. The industry tried to find a solution for its predicament by suggesting that the Government should buy the surplus output to use as aid-in-kind in its aid programmes with other countries, but this did not materialize.

The price of local cement has been gradually increasing since the end of the Gulf war and the gradual revival in construction. The problem of overcapacity has been evident since the beginning of the decade. For instance, in 1983, the Dubai National Cement Company saw its cement production decrease to half of what it was in 1982 because the local market for building material was static and total cement production in the country was well above the demand [9]. Nevertheless, more factories have been built, since some projects were planned earlier when demand was high and supply limited. In fact, five of the United Arab Emirates cement factories came on stream after the construction boom had peaked up.

Abduljabbar [10] states that one reason for the overexpansion has been the desire of each emirate to have its own cement supply for local construction plans. Gurdon [7] supports this view. He suggests that the political and economic competition between the various emirates has led to much unnecessary duplication of airports, harbours and numerous other projects including cement plants. However, he also states that the cement industry appeared during the construction boom of the 1970s as an important and obvious import substitution industry which could act as a catalyst for other industries. Sakr [4] explains the expansion in the cement industry as typical of the way in which local investors have misjudged the extent of demand, assuming that the exceptional circumstances of the construction boom of the 1970s would continue into the 1980s. In all circumstances, it is clear that the problem could have been averted had there been a coordinated national industrial policy and plan.

In the mid-1980s the cement industry tried to reduce its losses by resorting to a cartel arrangement. Repeated attempts were made, but arrangements did not last because of undercutting by one factory or another. One way for the industry to surmount its predicament could be through increasing exports. However, most of the factories are not

situated close to the ports. In fact, the Sharjah factory is so ill-sited that it is neither near the source of raw materials, nor the centre of consumption, nor a port.

Oman, which in 1984 imported about 40 per cent of its cement from the United Arab Emirates [10], now produces its own cement. However, the GCC countries could be an important potential market. For instance, Saudi Arabia imported 7 million tonnes of cement from Europe and South Asia in 1985 [7]. Cement consumption per capita in GCC countries is one of the highest in the world, reaching 2,370 kilograms per capita, whereas world average consumption is only 189 kilograms per capita [6]. The possibility of exporting cement by road to the GCC countries and the existence of tariff protection of at least 4 per cent against cement imported from outside the GCC are advantages from which the United Arab Emirates cement industry is benefiting. However, organizations like the Emirates Industrial Bank believe that to be able to penetrate the GCC market on a larger scale the cement industry requires government incentives, particularly cheaper electric power, as this constitutes at present more than 35 per cent of the total cement production costs [6]. However, electric power is already heavily subsidized.

The high cost of electric power was the reason why the cement factory of Dubai decided to change its technology, at a cost of about $50 million, from the wet process to the dry process which consumes less electricity, just a few years after the start of the plant. This is really not an example of the wrong choice of technology by the United Arab Emirates industry, because the planner of the project could not have anticipated that the price of electricity to industrial consumers would increase in 1977 from 7.5 fils* to 25 fils per kilowatt. In April 1980, the price of electricity was restored to 7.5 fils per kilowatt.

The Gulf Organization for Industrial Consultancy (consisting of GCC countries plus Iraq) has recommended to its member countries that the further installation of cement factories should be so regulated that their existing factories, including those in the United Arab Emirates, would benefit rather than suffer. Meanwhile, cement factories in the United Arab Emirates are running at a loss, and the less competitive ones might not be able to survive. Most of the factories, however, have the financial backing of the Governments of their emirates.

The cement industry has helped the development of a downstream building materials industry such as asbestos-cement pipes and sheets and cement building blocks and tiles. There are two asbestos-cement factories in the United Arab Emirates, a pipe factory established in Dubai since

*Dh 1 = 100 fils.

1973, before the development of the local cement industry, and a pipe and sheet factory at Umm Al-Quwain installed in the late 1970s. The first factory was doing very well and often running full capacity before the appearance of a competitor. As the local market cannot sustain two factories, the two are now running at well below capacity, even though a sizeable part of the production is exported to GCC countries and Yemen.

There were 41 tile factories in 1986 with a production capacity of 11.6 million square metres, but the actual production in that year was about 5.62 million square metres, less than half the full capacity. Prices of tiles fell from more than Dh 22 per square metre in 1982 to Dh 14 per square metre in 1985 and 1986 [11]. A GCC agreement and a drop in the price of tiles have led to a substantial increase in tile exports to GCC countries in recent years.

Block manufacturing in the United Arab Emirates goes back to the 1950s when blocks were made with simple hand-operated machines. By 1987 there were 91 block factories inclusive of the simple hand-operated plants. Production peaked in 1982 at 121 million blocks costing about Dh 2 per block, but gradually dropped to 97 million blocks in 1986, the price also dropping sharply with the drop in cement prices to about Dh 0.95 per block (for the large-sized blocks) [12]. Nearly one third of the factories work at less than half capacity. Some of the smaller hand-operated plants are beginning to find it too difficult to survive in the face of competition from larger automated factories.

In conclusion, it may be said that the main problem that has plagued the cement industry and its downstream industries is overcapacity and duplication of projects owing to insufficient coordination between the emirates in industrial development and the limited powers of the federal authorities in the approval of new projects.

2. Manufacture of plastic products

The production of basic petrochemicals such as ethylene and methanol has grown in recent years in some Persian Gulf countries, particularly Saudi Arabia. However, no such industries have been established in the United Arab Emirates, one reason being to avoid duplication of projects in Persian Gulf countries that could lead to self-destructive competition. Nor does the United Arab Emirates have intermediate petrochemical industries, which constitute the first step in downstream activities after basic petrochemical industries.

Plastics industries relying on imported ethylene and propylene derivatives have, however, mushroomed in the United Arab Emirates, and the *1985 Industrial Survey* indicated that there were 38 factories employing 10 or more persons producing plastic products. Although there

are six factories in Saudi Arabia and one in Qatar producing plastic raw materials such as polyethylene, polyvinyl chloride, polystyrene and melamine, the plastics factories in the United Arab Emirates depend mainly on non-Persian-Gulf sources for raw materials. The reason is said to be that imported materials are more highly refined than those currently produced by Persian Gulf refineries [4]. However, another report [13] points out that the plastics raw-material industry in Persian Gulf countries does not currently have suitable policies and strategies for marketing to the existing plastics factories in the GCC. For instance, the prices of raw materials have been high, reflecting international trends, without taking sufficiently into account the drop in production costs in the Persian Gulf factories as productivity has increased with improved training and salaries have fallen in recent years. In fact, this is a field where proper policies at GCC level could lead to greater integration and better linkages in the industrialization efforts undertaken in the Persian Gulf.

The journal of the Emirates Industrial Bank [14] states that plastic products in the United Arab Emirates consist of the following: 41.8 per cent of polyvinyl chloride, polyethylene and glass fibre pipes for water supply drainage and irrigation; 25.5 per cent of moulded products, mainly household goods; 16.4 per cent of polyethylene film for industrial and consumer use such as bags for supermarkets and household garbage; and the rest of various other products such as expanded polyurethane, ropes and water tanks.

Production of plastic goods increased from 18,000 tonnes in 1982 to 43,500 tonnes in 1986. The Emirates Industrial Bank [14] believes that there is a potential for developing new product lines such as semi-finished products that could be used in other countries. The industry is meeting local demand to a large extent, but a variety of plastic products are still imported.

Plastics factories have spring up so fast that exporting has to be a serious consideration. In the early 1980s over a quarter of the production was exported to other Persian Gulf countries. However, many factories have been established in these countries, and exporting has become more difficult. Moreover, because the production units are usually small in size, economies of scale are not possible, and the production costs tend to be higher than those of foreign manufacturers with huge automatic units. More recently, the idea of amalgamation of small industrial units in the Persian Gulf countries has been advocated by organizations like the Gulf Organization for Industrial Consultancy. To be more competitive, perhaps no new small units should be licensed, and existing units should consider amalgamating into fewer and larger units to benefit from economies of scale.

3. Food processing and beverages

The *1985 Industrial survey* showed that there were 80 establishments employing 10 or more people dealing with food processing and beverages, with a gross output value of over Dh 1,000 million. This was more than five times the gross output value in 1978, when the number of establishments was 49. The large increase in gross output relative to the increase in the number of establishments is due to the fact that establishments set up in recent years have tended to be generally on a much larger scale.

The growth of income and concern over hygiene in the past two decades, stimulated by contact with a large foreign community and the penetration of the food market by international processed-food companies, have wrought a change in dietary habits, as reflected in a greater propensity to consume processed food. Sensing these changes, local industry began to expand into food processing.

The activities of establishments in food processing are reflected in table 6. The units making bakery products constitute the largest number of establishments. Practically all the flour used is milled locally from imported wheat. The local macaroni factory, however, imports flour from Canada, Italy and France, as local flour is not suitable for macaroni production, which requires hard wheat [15].

The canning of tomatoes, of which a large surplus is produced during the season, has been started recently. The canning of fish has also been started on a small scale. However, it is surprising that exports of this industry have so far not grown on a large scale, given the rich fish and marine food resources in the waters of the Persian Gulf and on the eastern coast of the Gulf of Oman.

Table 6. Food and beverage industries in the United Arab Emirates

Activity	*Units with 10 or more workers in 1985*	*Total units in 1986*
Slaughtering, preparing and preserving meat	4	20
Manufacture of dairy products	13	25
Canning and preserving fruits and vegetables	--	1

continued

Table 6 (*continued*)

Activity	*Units with 10 or more workers in 1985*	*Total units in 1986*
Canning, preserving and processing fish etc.	--	1
Manufacture of vegetables, animal oils and fats	1	1
Manufacture of mill products	2	4
Manufacture of bakery products	36	90
Manufacture of cocoa, chocolate and sugar confectionery	--	19
Manufacture of food products not elsewhere classified	10	8
Manufacture of prepared animal feed	1	4
Soft drinks and carbonated water industries	13	14
Total	80	169

Sources: For 1985 figures for factories employing 10 persons or more, see table 8 in annex; for estimates of 1986 total food processing units, see [16], p. 74.

In addition to bakeries the food industry is concentrated on dairy products, soft drinks and mineral waters. The expansion of the industry has been restricted by the fact that most of the primary inputs have to be imported. Such inputs are generally perishable, and since most processing entails weight reduction, there is the further consideration of additional high freight costs.

One of the main reasons for the comparative success of soft drinks is that the major part of the product is water, a local raw material. Moreover, the hot climate of the United Arab Emirates makes it necessary to consume liquids to compensate for loss through perspiration, and this helps increase demand for soft drinks. Concentrates, which represent about 40 per cent of the cost of inputs, are, however, imported [17].

The beverage sector nevertheless suffers from duplication of projects and consequent overcapacities. A study by the Ministry of Finance and Industry [18] showed that the capacity of factories producing carbonated beverages during the period 1980-1985 ranged between a maximum of

48 per cent in 1982 and a minimum of 37 per cent in 1984. There are eight carbonated beverage factories in the United Arab Emirates, four of which are in Dubai. The newest is Coca Cola, which started production in Al-Ain in 1988 after being removed from the Arab boycott list. Five of the factories also produce juice drinks. There are a total of eight factories producing juice drinks, three long-life and five short-life varieties. There are no factories for dilute drinks or drink powders. In addition, six factories produce natural mineral water, a popular product since the municipal drinking water, which is desalinated water, groundwater or a mixture of the two, is not so palatable. In fact, there is considerable scope for marketing such high-quality products in the GCC countries. Sparkling water like Perrier is imported, but remains an exlusive minority taste. It may be noted that no sparkling mineral water is produced locally.

The study by the Ministry of Finance and Industry [18] states that utilization of capacity in mineral water factories between 1980 and 1985 ranged between a maximum of 74 per cent in 1983 and a minimum of 55 per cent in 1985. Despite the overcapacity and the drop in price by about 7 per cent since 1983 [19], there were net imports of carbonated beverages, fruit juices and mineral water into the United Arab Emirates worth Dh 70 million. However, since 1983 the United Arab Emirates has been a net exporter of non-alcoholic beverages as a whole, mainly to GCC countries. After reaching Dh 76 million in 1984 (about 30 per cent of total production), exports dropped to only Dh 87,000 in 1985, owing to the installation of new factories and the modernization of old factories in other GCC countries [20].

According to the *Journal of the Emirates Industrial Bank* [19], a questionnaire investigating problem areas was sent to the beverage manufacturers, nine of whom responded. All (100 per cent) of the respondents agreed that stiff competition in the local market was a problem, and 89 per cent complained of a shrinking product market. Surprisingly, however, only 44 per cent thought that overcapacity in local production was a problem.

Mineral water is bottled in lightweight transparent polyvinyl chloride bottles manufactured locally. Fruit juices are usually sold in paper containers or non-returnable glass bottles. Carbonated beverages used to be sold in returnable bottles, but in recent years tin-plated cans and non-returnable bottles have become the more usual form of packaging. Some factories have their own units for the production of the required tins or bottles, but some import empty bottles from outside, usually from other GCC countries.

There are about 20 dairy processing establishments in the United Arab Emirates, 7 of which process fresh milk and the rest depend on imported milk powder. There is also a number of small fresh milk

processing units owned by small farmers. Idle capacity averages 40 per cent [21]. This is due to a shortage of local fresh milk and, in the case of reconstituted milk, to insufficient demand for the product. To improve plant utilization, some factories have started to export at low profits or to introduce new products such as fruit yoghurt.

The first dairy processing plant in the country was an ice-cream factory which started in Dubai in 1961 using imported ice-cream mix. Several other plants using imported raw materials followed, before the first factory marketing fresh milk was set up in 1979. Locally prepared milk is marketed in paper containers, not in bottles. Competition in dairy products is severe from both local and foreign producers, and one ice-cream factory has already closed down. The industry does not receive government subsidies except in the form of free veterinary services to farmers. Meanwhile, it has to compete against the products of Saudi Arabia, which subsidizes fresh milk products, and against imports from European countries, which export their surplus dairy products at highly competitive prices. The Emirates Industrial Bank suggests that the Government should protect the industry and also help small dairy farms by establishing milk collection points [21]. In conclusion, if growth in this sector of industry is restricted, overcapacity would probably be absorbed with the increase in population, the rise in the standard of living and the expansion of exports.

D. Industrial zones in the United Arab Emirates

Industries in the United Arab Emirates have been largely concentrated in industrial zones. In recent years some of the industries in Dubai have been moved from their original location to the Jebel Ali Free Zone. The Governments of the various emirates usually provide factory land in these areas at reasonable rents, and ensure that the industrial zones are connected with good road networks and supplied with the various utilities. The concentration of industries in large industrial zones enables some of the services to benefit from economies of scale. Moreover, the towns are spared congestion and pollution. The existence of industrial zones also makes it possible for private maintenance workshops to be set up to serve a large number of industries, which tends to lower the cost of maintenance services. In addition, the establishment of industries in areas away from the towns reduces any sociological ill-effects of the small indigenous population being a minority amongst the expatriates.

1. Abu Dhabi industrial zones

The industrial zones in Abu Dhabi are controlled either by the municipality or by ADNOC. The Ruwais industrial zone, about 235 kilometres west of Abu Dhabi, houses ADNOC projects such as the refinery, the gas liquefaction plant and the petrochemical fertilizer plant. The industrial zone at Musafah, 25 kilometres from Abu Dhabi, has a fertilizer plant that uses the town refuse, fabrication shops supplying the oilfield with some of the mechanical structures and equipment, vehicle repair shops etc. Al-Ain has an industrial area in which various industries such as a cement factory and a block factory are situated. There is also an industrial zone at Tarif in which a refinery is situated and another zone at Sadiat.

Industrial zones under the municipality lease land to factories at Dh 0.1 per square metre and provide electricity at Dh 0.01 per kilowatt, gas at Dh 7.25 per 1,000 cubic feet and water free of charge.

2. Dubai industrial zone

The newest and most important industrial area in Dubai is at Jebel Ali, 35 kilometres south-west from Dubai. Jebel Ali houses several large establishments, such as the aluminium smelter DUBAL, the gas liquefaction plant (Dubai National Gas Company) and the electric cable factory DUCAB.

A Free Zone was created at Jebel Ali by an official decree of the Government of Dubai in February 1985. By April 1989 there were already 221 companies operating in this Free Zone with a total workforce of about 6,000 and a total investment of over Dh 2,000 million. About 40 per cent of the above-mentioned companies are manufacturing concerns. The rest are trading and service companies. By February 1991 the number of companies in the Free Zone reached 310.

Of the total investment, United Arab Emirates companies account for over Dh 1,000 million, United States companies for over Dh 680 million and United Kingdom companies for Dh 126 million, the rest being accounted for by investors of various other nationalities. Dubai puts high hopes on the Jebel Ali Free Zone, which is expected to play an important role as a location for companies and factories engaged in the reconstruction of Kuwait after the 1991 war in the Persian Gulf.

The Free Zone has the largest artificial harbour in the world, with efficient cargo handling facilities, modern communications and a well-developed infrastructure. Rents of factory land vary between Dh 5.38 and Dh 32 per square metre, depending on distance from the quayside. An industry or business in the Free Zone can be of 100 per cent foreign

ownership, whereas the law of Dubai does not permit this outside the Free Zone. Moreover, there are no requirements for a local sponsor for expatriate workers. There are corporate tax holidays for 15 years from incorporation, renewable for a similar period. Furthermore, industrial projects are able to benefit from the subsidized electricity. To sell within the United Arab Emirates, however, firms in the Free Zone must have a local agent, otherwise they are required to obtain the necessary operating licence from the municipality or equivalent authority. One of the main advantages that Dubai derives from the Free Zone is the increased utilization of its ports and other services. Another indirect benefit to the country is that landlords benefit from renting to the more senior personnel working in establishments in the Free Zone, but who live in Dubai and not the Free Zone area. Similarly, shopkeepers benefit from selling to expatriates working in the Free Zone and who often shop in Dubai. There could also be long-term benefits from externalities as the country becomes more industrialized. For instance, the Government may one day stipulate that a certain percentage of the local population be employed in Free Zone factories. Taxes might also one day be generated in the Free Zone.

Dubai has nine other areas with a concentration of factories. Some of these areas are on the outskirts of Dubai, and some are within the town itself. One of these areas is in the suburbs of Dubai at Al-Ramoul. It contains over 200 establishments, including a large asbestos-cement pipe factory, a paint factory and a foam factory. As the Port Said area, which also has over 200 small industrial establishments, is in the heart of Dubai, the Government has been shifting these industries gradually to other industrial areas. In fact, it has shifted some of the larger factories such as the McDermott factory, which builds rigs for the oil industry, to Jebel Ali Free Zone.

3. Industrial zones in the other emirates

The main industrial zone of Sharjah is to the west of the town. An area of 26 square kilometres has been allocated for the purpose and divided into 16 areas, each for a category of industrial activity. Factory land rent is kept nominal as a means of encouraging the setting-up of industries at Sharjah.

There are industrial areas in all the other emirates. The main industrial zone of Ras Al-Khaimah is at Khor Khuair, where the rock, cement and marble industries are located, and at Rams, which has industries such as those producing steel reinforcement bars and nails.

E. Conclusions

Industrial development in the early days of oil consisted in the establishment of small factories to produce substitutes for imports such as carbonated beverages, building blocks and furniture, and, in the absence of good roads between the different emirates, to serve the particular emirates where the factories were located. In the early 1970s larger factories, including an asbestos-cement pipe factory, were built, and soon after the mid-1970s major projects such as cement factories and an oil refinery began production. The boom of the 1970s, resulting from the rise in oil prices and output, produced an upsurge in project activity generally related to the construction industry and the expanding population. Owing to a lack of coordination between the various emirates, poor planning at emirate level, and lack of experience and foresight on the part of the investors, considerable duplication of activities took place.

In the late 1970s and early 1980s, the Governments of the various emirates, particularly those of Abu Dhabi and Dubai, began to promote industrialization through the utilization of gas which until then had been flared. Thus export-oriented projects, such as a fertilizer plant and an aluminium smelter, came to life.

The drop in oil prices and the recession of the 1980s had an adverse effect on project activities, particularly the duplicated or less efficient ones, some of which had to close down. Meanwhile, coordination between the emirates on industrial affairs began to improve with the delegation of broader powers to the Industrial Department in the Federal Ministry of Finance and Industry. Local entrepreneurs, mainly from the merchant class, have become more experienced in industrial investment. A well developed infrastructure including special zones for industrial development has also been established.

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Annex

STATISTICAL TABLES

7. Contribution of the various industries and economic activities to gross domestic product at factor cost, 1975-1987

(Percentage)

Activity or industry	*1975*	*1980*	*1984*	*1987*
Agriculture, livestock and fishing	0.8	0.7	1.3	1.8
Mining and quarrying				
Crude oil and gas	6.5	63.3	45.2	37.0
Other	0.2	0.2	0.3	0.3
Manufacturing	0.9	3.8	9.7	9.4
Electricity and water	0.5	1.2	2.0	2.4
Construction	10.9	8.8	9.8	8.4
Wholesale and retail trade, restaurants and hotels	8.2	8.2	8.4	10.0
Transport, storage, communications	3.2	3.3	4.2	5.2
Financing, insurance, real estate				
Financing and insurance	1.6	1.9	5.1	6.0
Real estate	4.0	3.6	5.1	5.2
Other services	1.0	0.7	1.3	2.1
Imputed bank charges (deducted)	(1.4)	(1.3)	(2.4)	(1.6)
Government services	3.4	5.4	9.8	13.5
Household domestic services	0.1	0.2	0.2	0.5
Total	99.9	100.0	100.0	100.0

Source: S. M. Ghanem, "Industrialization problems in the United Arab Emirates with particular reference to the shortage of indigenous skilled manpower" (author's unpublished Ph.D. thesis).

Note: Figures in parentheses are negative.

Table 8. Industrial survey, 1985

ISIC	Industry	Number of establishments	Gross output values (a) (thousand dirhams)	net value added (b) (thousand dirhams)	(b)/(a) percentage	Number of workers
3111	Animal and poultry meat	4	77 614	19 288	24.9	368
3112	Milk and dairy products	13	159 652	62 527	39.2	1 271
3115	Vegetable and animal fats and oils	1	25 681	4 082	15.9	94
3116	Milling of cereals	2	279 538	52 582	18.8	243
3117	Bakery products	36	134 981	52 297	38.7	1 498
3121	Other food products	10	43 497	18 986	43.6	267
3122	Fodder products	1	23 579	10 296	43.7	41
3134	Non-alcoholic beverages and mineral water	13	261 662	57 065	21.8	1 472
31	Total foods and beverages	80	1 006 205	277 124	27.5	5 254
3221	Wearing apparel except footwear	3	6 814	1 978	29.0	60
3222	Weaving and sewing	41	27 509	18 046	65.6	685
3233	Leather products except footwear	2	2 163	1 471	68.1	33

continued

Table 8 (*continued*)

ISIC	Industry	Number of establishments	Gross output values (a) (thousand dirhams)	net value added (b) (thousand dirhams)	(b)/(a) percentage	Number of workers
3240	Footwear other than plastic, rubber and wood	1	3 801	755	19.8	30
32	Total textiles and clothing	47	40 286	22 250	55.2	808
3311	Wood products other than furniture	29	93 997	36 254	38.6	1 066
3320	Furniture other than metal	22	84 190	33 664	40.0	964
3322	Upholstery	1	4 380	1 676	38.3	34
33	Total wood and furniture	52	182 567	71 593	39.2	2 064
3412	Paper and cardboard	8	94 612	26 388	27.9	434
3419	Printing and publishing	2	15 014	4 901	32.6	86
3420	Other paper products	54	236 674	109 934	46.4	2 637
34	Total paper and publishing	64	346 301	141 223	40.8	3 157
3511	Basic chemicals others than fertilizers	7	142 293	60 330	42.4	543
3512	Fertilizer and pesticides	1	102 549	35 310	34.4	500

continued

Table 8 (*continued*)

ISIC	Industry	Number of establishments	Gross output values (a) (thousand dirhams)	net value added (b) (thousand dirhams)	(b)/(a) percentage	Number of workers
3513	Plastic raw materials and synthetic fibres	1	18 403	3 580	19.0	87
3521	Paints and varnishes	7	81 817	28 352	34.7	236
3522	Pharmaceutical products	1	26 226	(4 720)	-18.0	220
3523	Soaps, detergents, perfumes, cosmetics	3	22 893	5 685	24.8	96
3529	Other chemical products	9	69 081	28 483	41.2	260
3540	Oil and coal products	6	92 104	39 218	43.0	264
3551	Tyres and pipes	1	1 226	1 007	82.2	17
3560	Other plastic products	38	342 466	111 666	32.6	2 158
35	Total chemical products	74	898 059	308 911	34.4	4 382
3620	Glass and glass products	1	1 868	719	38.5	43
3691	Building materials from clay	1	10 871	6 098	56.1	103
3692	Cement and lime	9	695 081	24 714	3.6	3 326

continued

Table 8 (*continued*)

ISIC	Industry	Number of establishments	Gross output values (a) (thousand dirhams)	net value added (b) (thousand dirhams)	(b)/(a) percentage	Number of workers
3699	Other non-metallic mineral products	126	739 270	248 585	33.6	5 500
36	Total non-metallic mineral products	137	1 447 090	276 116	19.1	7 972
3710	Iron and steel basic industries	2	49 353	14 831	30.1	218
3720	Non-ferrous basic industries	4	1 066 792	137 402	12.9	1 675
37	Total basic metal industries	6	1 116 145	152 233	13.6	1 893
3813	Metallic furniture	5	7 010	2 415	34.4	67
3813	Fabricated metal products	82	944 404	475 282	50.3	9 883
3819	Metal products other than machinery	38	171 217	59 807	34.9	1 369
3821	Prime movers	1	2 408	1 150	47.7	24
3824	Equipment other than for metal and wood working	1	2 385	420	17.6	20
3829	Other non-electrical equipment	7	43 883	19 722	44.9	352

continued

Table 8 (*continued*)

ISIC	Industry	Number of establishments	Gross output values (a)	net value added (b)	(b)/(a) percentage	Number of workers
			(thousand dirhams)			
3831	Industrial electrical engines and appliances	1	2 649	572	21.6	18
3833	Domestic electrical appliances	3	13 042	5 736	44.0	146
3839	Other electrical appliances	2	18 690	11 396	61.0	116
3841	Shipbuilding and repair	7	76 121	35 794	47.0	785
3852	Photographic and visual products	1	2 050	712	34.7	18
38	Total metallic products, engines and equipment	148	1 283 859	613 283	47.7	12 798
3901	Jewellery	4	21 178	2 283	10.8	187
3909	Other manufacturing industries	10	81 711	46 717	57.2	530
39	Total other manufacturing industries	14	102 890	49 000	47.6	717
	Total	622	6 423 404	1 911 456	29.8	39 044

Notes: ISIC = International Standard Industrial Classification of all Economic Activities. Gross output values and net value added are in producers values.

Source: Ministry of Finance and Industry, 1985 Industrial Survey (Abu Dabi, 1988).

Promotion of small-scale industry in India

*S. Nanjundan**

The comprehensive, multi-institutional and wide-ranging small-industry development programme of India is well-known around the world. Many countries drew upon and emulated the experience of India from the 1960s to the mid-1970s, but with the emergence of other more successful developing countries India has acquired a new role, that of sharing its experience to enable other countries to decide what to choose and what to avoid among their various policy options. At the same time, India itself needs to evaluate the effectiveness and efficiency of its small-industry programme, to rationalize and streamline it, along with the policies, mechanisms and programmes relating to the manufacturing sector as a whole.

A. Context of the programme

Many past studies have considered the small-industry programme, without relating it fully to policies and developments in manufacturing

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*This paper has been adapted by the author from his contribution to a workshop organized by the National Council of Applied Economic Research and the Frederick Naumann Foundation, and held at New Delhi on 10 December 1990. The purpose of the workshop was to formulate issues for an in-depth national analysis of the promotion and structure of small-scale industries.

The author was deputy director and director, during its initial stages from 1955 to 1964, of the small-industry development programme undertaken in India with the support of the Ford Foundation, and subsequently a senior official and Deputy Director of UNIDO, retiring in 1985. During 1986-1987 he was one of the three core consultants involved in preparing the thematic evaluation of rural small-industry development, sponsored by the International Labour Organisation, the United Nations Development Programme, UNIDO and the Government of the Netherlands.

and other sectors of the economy. The administrative system, cultural and moral factors, and work ethics are equally important. The following factors are especially relevant:

(a) The continuation, as a legacy from the colonial era and earlier monarchical days, of the *maa-baap* system of dependence on the government to provide a solution to every problem;

(b) Encouragement and support of the above-mentioned system, through the bureaucratic development of the most regulated and complicated system of administrative controls for operating an enterprise or engaging in a vocation, except perhaps agricultural activities, bonded and child labour (both illegal), and unreported and unrecorded black market and parallel market activities (illegal). The Indian system is unique in combining the most regulated official economy with an unintentionally (though almost totally) free parallel economy. The extent of the latter is not known, but could range from 20 to 50 per cent of value added in different non-agricultural activities;

(c) The growing nexus between big business and politicians is bound to affect the nature and content of development and the efficiency of the economy, which may be countered to some extent by the countervailing power and influence of trade unions, farmers' organizations, consumer groups, the small-business lobby, organizations supporting the backward classes and other social groups etc.;

(d) Inadequate training and motivation of blue- and white-collar workers resulting in low efficiency and poor work ethics (absence of "zero-defects culture"), on the one hand, and poor business ethics (corruption, failure to maintain quality standards, no code of conduct) and lack of self-reliance (secured through additional government incentives, facilities and subsidies to reduce prices or expand exports) of entrepreneurs and managers, on the other;

(e) A matter of deep concern which has emerged only recently is the growing indifference on the part of the political leadership to questions of economic policy, including medium- and long-term development strategy, economic efficiency, resource availability, human resource development and bilateral and multilateral negotiations. It seems to be assumed that *kulak* agriculture and reservation of government jobs will take care of all other problems. The neglect of economic development by the political leadership may in the long run prove a blessing in

disguise, provided it leads to liberalization, gives more scope to market forces, and induces self-reliance on the part of business and industry.*

B. Objectives and purpose of small-industry development

When considered in the context described above, the stated benefits of small-industry promotion, such as labour-intensiveness, capital savings, spatial dispersion and quick responses to demand generated by income growth, may be more apparent than real. Past studies ranging from Dhar and Lydall [1] to Sandasera [2], Little, Majumbar and Page [3] and Suri [4] have examined the extent to which small-industry promotion has helped to achieve these aims. In reality, the policies pursued (continuous increases in the capital investment ceiling,** reservation of product types, allocation of scarce resources, subsidization of capital, advice on technology etc.) have promoted capital-intensive industries, often using more labour and capital per unit of output produced. The capital investment ceiling taken together with the type of technology adopted has restricted the employment of additional labour and expansion into healthy labour-intensive medium-sized enterprises. Research studies (for example Little, Majumbar and Page [3]) have indicted the Indian industrial structure for the inadequacy of its medium-sized enterprises employing 50 to 500 workers (which are more labour-

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*The programme of reforms begun by the Government in July 1991, if continued vigorously, will mitigate this factor (see annex).

**The new industrial policy introduced by the Government in 1990 included the following increases in investment limits: for small-scale industry, from 3.5 million rupees (Rs) (fixed by the Government in 1985) to Rs 6 million; and for ancillary enterprises and industrial units exporting 30 per cent or more of their output, from Rs 4.5 million to Rs 7.5 million. The limit for the tiny sector was increased from Rs 200,000 to Rs 500,000. In keeping with the Indian penchant for hierarchization and total government regulation, the National Confederation of Small Industry - one of the small-industry lobby groups - proposed in January 1991 the creation of the following new categories and investment limits: light medium industry, Rs 15 million; medium sector, Rs 50 million; and large sector, above Rs 50 million. The exchange rate between the United States dollar and the Indian rupee has recently been unstable. It was $1 = Rs 19 in March 1991, $1 = Rs 26 in July 1991, and $1 = Rs 23 in February 1992.

intensive in some other countries, both newly industrializing and developed).

The de facto *raison d'être* for the promotion of small-scale industry is the building-up of countervailing power by the middle classes (industrial democracy). Assistance in the form of product reservation, extension services, capital and credit allocation, factory accommodation, import licences, raw material quotas, tax rebates and subsidies etc. is meant to offset similar or greater facilities available from government and public institutions to large industrial enterprises. To this extent, it contributes to equitable treatment of large- and small-scale enterprises in the provision of physical and financial inputs for industrialization. This is inevitable in an economy as regulated as that of India. To the extent that liberalization affects the large-scale sector and market forces come into fuller play, there will be similar effects on the small-scale sector. This approach and the system of industrial licensing and regulation have given rise to the lobbies of small-scale industries (similar to the more powerful lobbies of large-scale industries). The danger recently posed by increasing the capital ceiling for small-scale industry - under the new industrial policy - is that of interlocking between large and small firms, or the ownership of small enterprises by large industry.*

Note should also be taken of the "tiny" sector or the sector of household and cottage industries, also known as the microsector (in United States and World Bank terminology). It is believed that only an infinitesimal part of assistance under the small-scale-industry programme** goes to the tiny sector, which probably receives more substantial assistance under State government and rural employment programmes such as Khadi and Village Industries, or the Integrated Rural Development Programme.

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*The Minister of State for Industry has stated that in the production of many of the 836 items reserved for the small sector, large industries have encroached dangerously, subcontracting manufacture to small enterprises (often linked by ownership) and selling the products under their brand names. Examples include toothpaste and shoes. It has been reported that combinations of small enterprises or of small and large enterprises through interlocking ownership are to be prevented by legislation [5].

**A Minister of State has remarked that only 10 per cent of the small-scale sector constitutes enterprises other than those coming under the tiny category, and yet they were "ruling the roost" because they were "very vocal". He stated that the industrial policy of the Government would be to protect the tiny sector, even while promoting small industry [6].

C. Demand-push (policies) versus supply-side measures (institutions)

In a more liberalized and market-oriented economy, policies to stimulate the demand for industrial products and thereby the establishment of industries should take precedence over - or at least precede - supply-side measures of direct assistance. Such macroeconomic policies relate broadly to agricultural and rural development, more equitable distribution of income and export orientation. There is some evidence that the green revolution in India (and Pakistan) stimulated the growth not only of agro-processing industries (direct linkage), but also of consumer-goods industries based on the increased demand generated by growth in incomes [7]. The increase in procurement prices of agricultural products, incomes generated through the Integrated Rural Development Programme and rural employment programmes, as well as trickle-down effects, with a reduction of poverty through *Kulak* prosperity, may be assumed to have stimulated the development of industries. This question merits further research, which might also throw light on the benefits accruing through the establishment of tiny and household industries in rural areas, and small-, medium- and large-scale industries in rural or urban areas.

Besides policies relating to agriculture, infrastructure and social services, other macroeconomic policies involve tariff protection, exchange rates, interest rates, credit and prices of factors and products. Macroeconomic policies could be designed to alter the pattern of demand in favour of labour-intensive industries. Industrial and trade policies will again assist in achieving a desirable size distribution of industry. Whether and how such policies have affected small-industry development may be worth further research.

While policy measures often have widespread and non-discriminatory (within group or classes) effects, the benefits that could be derived from them may be limited by inadequate access to resources or insufficient ability or preparedness of the potential small entrepreneur. Herein lies the case for supply-side programmes of direct assistance, which form the crux of the Indian programme.

An immediate limitation of supply-side programmes is that they benefit only a small number of enterprises, usually at the upper end of the administrative definition of small-scale industry. This is especially so in India, where the institutional mechanism is overcentralized, the small-scale category is widely heterogeneous, and the target group is imprecisely defined. Moreover, in terms of cost-benefit ratios, direct assistance programmes are seldom successful; usually the benefits are hardly commensurate with the costs incurred. Earlier studies in India have indicated that non-assisted enterprises are generally more efficient than

assisted enterprises ([2] and [8]). The issues raised in this paragraph merit further research (see section 3 below).

Supply-side programmes may be broadly reviewed under the following functional categories: financing; industrial estates; industrial extension services; technical training, technology and research; marketing and subcontracting; and entrepreneurial and management development.

1. Financing

Given the proper economic environment through appropriate policies, the small-scale entrepreneur prefers to operate independently, with some help from family and friends, in establishing, financing, operating, marketing and developing his or her enterprise. The typical small-scale entrepreneur resents unwarranted intrusion from outside. Nevertheless, the one - and often the only - form of assistance which the entrepreneur expects is the provision of adequate and timely financing of capital and credit requirements. Financing through institutional channels - mainly the development banking system, the Unit Trust of India and the Life Insurance Corporation of India - has expanded considerably. However, it has mostly benefited large enterprises which could be, and often are, established and operated with as little as 10 to 20 per cent of equity. On the other hand, the small enterprises - the smaller they are, the worse off they are - are often hardly able to obtain 10 to 20 per cent of financing from banks and institutional sources. The system of capital and credit allocation together with interest rate ceilings - a regime of financial repression - favours large-scale and discriminates against small-scale enterprises. Despite the recent establishment of the Small Industry Development Bank of India, which has in fact taken over functions relating to small-scale industry hitherto carried out by the Industrial Development Bank of India, the small-scale industry sector has been considerably disadvantaged in recent years, particularly as compared with large industries, as a result of the following developments:

(a) The nationalization and subsequent expansion of banking, accompanied by centralized direction and controls, has snapped the previously close banker-client relationship. The growing inefficiency of the banks, including bureaucratic delays and corruption, has further exaggerated the risk and cost of small loan transactions;

(b) There has been a decrease in the importance of informal credit channels, such as indigenous bankers, moneylenders and financial brokers, as sources of capital and credit for small-scale manufacturing enterprises (informal channels play a greater role in the trade and services sector);

(c) New mechanisms, such as public deposits and stock market issues, are available only to the large-scale sector;

(d) There has been no improvement in payments to small enterprises against subcontract orders by large industries, including even those which are government-owned.

The entire gamut of issues relating to financing of small-scale industries is well worth detailed research. The availability of financing to enterprises at the lower range of small-scale industry, particularly the tiny sector comprising cottage and household enterprises and rural enterprises, could be specifically studied. There is a need to appraise innovative arrangements, where they exist, linking credit to marketing, to savings and to extension services, linking informal and formal credit etc.

2. Industrial estates

There is less need to dwell on the subject of industrial estates than on other aspects of small-industry development, since India has already learnt lessons from its costly venture into construction of industrial estates, starting in the mid-1950s, as an instrument for enterprise location or for development of complementarities. The policy has rightly shifted to the development of suitable sites with provision of zoning and utilities by local authorities or industrial development corporations, leaving construction to be done by enterprises themselves or by cooperatives, associations or construction firms.

3. Industrial extension services

The experience of general-purpose small-industry development organizations has not been a happy one, especially when the target group is not appropriately identified. Small-industry development organizations tend to centralize their operations in the capital cities or large towns. They are often not operationally linked to small enterprises, apply a rigid set of rules and regulations, suffer from bureaucratic inertia and inability to innovate and to take risks. Their outreach becomes limited. They are able to provide extension services to very few enterprises, and their impact is more on the upper end of small-scale (or medium-sized) enterprises than on average small-scale enterprises. The better-off enterprises which are not the most in need of assistance are the ones to benefit from such services. There is greater ineffectiveness or inappropriate use of resources when the small-industry development organiza-

tions function as a government department and when services are provided free.

The provision of extension services through financing institutions (small-industry financing organizations) has often proved more successful than through small-industry development organizations. Small-industry financing organizations combine the provision of financing with pre-loan and post-loan extension services. While the small-industry financing organization ensures more effective use of limited resources, what may be lacking is the provision to enterprises of technological and technical services.

A multiplicity of agencies are involved in the provision of extension services. During the 1970s a network of State technology consultancy bureaux sponsored by the Industrial Development Bank of India was, together with the Entrepreneur Development Programme at Ahmedabad, superimposed on the central and state government network of Small Industries Services Institutes, State Directorates of Industries, State Small Industries Corporations etc. The government later established the District Industrial Centres. There is also a network of rural agencies linked to agricultural community development, integrated rural development and rural employment.

It may be worthwhile to undertake area-specific studies, under different conditions and circumstances, of the effectiveness of the following types of institution in three or four districts of India: central Government; state Government; central parastatal; state parastatal; central financing; on-location or decentralized financing; cooperatives or savings and loans; social target-group development programme; enterprise associations; and non-governmental or private voluntary organizations.

The received wisdom from other studies is that a successful institutional mechanism is one that has effective linkages with a defined target group, which itself participates in the programme. The successful institution is usually non-governmental rather than governmental. It could be a non-governmental or private voluntary organization, an association, a society, or rarely, a large private enterprise, or a technology or training institute. The target group is usually cohesive and not too heterogeneous. One or two functions rather than a comprehensive range of functions is tackled through the institutional mechanism, which develops links with the nearest resource institution for assistance in other functions. This received wisdom could be verified through the comparative studies suggested in the previous paragraph.

Another question to be considered is the role of private consultants and firms, some of which specialize in small-industry schemes and studies. The extent to which services are provided by private agencies against payment, in preference to free services provided to small enterprises by government agencies, will be pertinent.

4. Technical training, technology and research

Skill upgrading through training programmes is certainly useful. In general, however, small-scale enterprises rely on worker training on the job, under some sort of apprenticeship scheme. It may be more useful to reorient and upgrade the basic educational and vocational system than to create special training programmes or institutions for small-scale industry. Such training programmes often become too specialized, and may in fact provide highly skilled workers and supervisors to large-scale industries. Training institutions specifically related to the small-scale industry programme - at both central and state government level - may be reviewed in this light. Do they provide training or retraining to workers in small-scale industry, or do they help such workers obtain better-paid jobs in large-scale industry? Do they make up for lack of vocational education of small-industry personnel? Do they substitute for or complement trade schools, and do the trainees qualify for national trade diplomas?

Technology upgrading through research into appropriate technology and its application could be carried out through sector- or product-oriented institutions or research and development facilities of large enterprises. India has a country-wide network of institutions for designing appropriate farm equipment, encouraging its manufacture, and disseminating its use. There are also institutions for machine tools and mechanical and light metal equipment, as well as leather, food-processing, wood and furniture, ceramics, chemicals, design, fashion etc. Is there effective interaction between such research institutions and small-industry extension agencies?

Often it is a question of organizing technical information, identifying research carried out elsewhere under similar conditions, and adapting the design or process to local requirements. An industrial extension service linked to a central industrial documentation facility could carry out this function, provided its outreach is effective. Extension services provided to clusters of enterprises in similar trade or product groups could be an effective means of technology upgrading. An example is extension services to the leather industry provided by the Central Leather Research Institute at Madras.

5. Marketing and subcontracting

Small-scale manufacturing and large-scale marketing under the brand name of the distributor represent a successful strategy for the marketing of small-industry products. Marketing of handloom and handicraft products is undertaken in this manner. Private traders also

market small-industry products, such as leather goods and garments. A considerable amount of small-industry products is traded through large-scale exporters or export houses.

Government purchase programmes, product reservation schemes and tax relief or differential tax rates are other market stimulatory programmes. Government purchase programmes provide assured markets and initial stimulus for new products. Reservation of products for manufacture by small and microenterprises is feasible under total industrial licensing and could be beneficial in the case of infant industries. Tax relief compensating for cost advantages of large-scale industry could perpetuate the cost disadvantages of small enterprises. All these measures should be temporary in nature; in the long run, small enterprises should have comparative cost advantages to be able to compete successfully in the market.

There is a growing and permanent role for small-scale industry working as subcontractor to large-scale industry. Subcontracting involves linkages between lead and linked enterprises, thus making possible integration of industrial production and fostering a self-reliant industrial structure. Subcontracting relationships benefit the economy through reduced production costs and better allocation of capital, labour and other resources, thereby improving economic performance. As differentiation and hierarchization of industrial structure develop, opportunities for such linkages increase.

Industrial subcontracting has been developing apace in India. It is not necessarily and always between large and small enterprises. It is often between large enterprises and between small enterprises. There could be small assemblers and large parts manufacturers, large assemblers and small component manufacturers, small assemblers and small parts manufacturers.

Much subcontracting takes place on the basis of information available in trade and industry circles. The role of government is important in ensuring the right environment of fiscal, financial and licensing policies to encourage healthy linkages.

The danger of dependency relationships and exploitation of small enterprises (and especially of workers) should be avoided. The encouragement of competition among suppliers and buyers and of linkages between several of them (rather than one to one) is a means of avoiding dependency. The small enterprise could combine subcontracting work with supplying the spare-parts market, as well as making an alternative product line to minimize the impact of fluctuations in demand.

Subcontracting may link rural areas with urban, and work in the home with work in the factory. Computer software production and programming provide the self-employed with opportunities for subcontracting work.

6. *Entrepreneurial versus management development*

Entrepreneurial Development Programmes are the vogue in India as an important means of promoting small-scale industry. The rapid expansion of such programmes calls for a review of their effectiveness. It seems likely that about 50 per cent of the content of such programmes relates to government rules, regulations and procedures for obtaining the resources and know-how for setting up an enterprise, and the other 50 per cent to management topics such as accounting, cost control, marketing, financing and personnel management. Identification and development of entrepreneurs forms perhaps an infinitesimal part of these programmes. What they purport to teach is how to be successful in overcoming governmental and bank bureaucracy, rules and regulations, in order to be able to engage in an enterprise.

The urgent need is not for Entrepreneur Development Programmes. The country has probably too many entrepreneurs and many of them may be over-entrepreneurial. Primary importance should be given to business ethics inculcating a code of conduct, with an awareness of productivity, quality and cost, optimization of resource use, a zero-defects culture and the pursuit of excellence. All these form part of modern management-development curricula. They should be learnt and inculcated in schools and colleges, before one becomes an entrepreneur.

D. Closing thoughts

The evaluation of the Indian programme needs to focus on the medium- and long-term role of small enterprises in the economy, and not strive for solutions to short-term problems. There is a permanent long-term role for small-scale industry. It is the seedbed for entrepreneurship. Some enterprises grow into medium and large ones, some fail and disappear, and new ones emerge in innovative areas. There is no room in a healthy dynamic economy for permanently sick enterprises.

Enterprises of different sizes coexist in most economies, since labour, capital and product markets are usually imperfect, and changes in technology, transportation, consumer preferences and lifestyles continuously influence manufacturing. It is not out of context to look at the most developed countries, where the trend towards decline in small-scale manufacturing enterprises (as defined in those countries) has been somewhat arrested. There are both technological and social reasons for the revival of small industry. The technological reasons are the accent on knowledge- and skill-intensive industrialization (as against material- and energy-intensive industrialization) and the shift to new processes of manufacturing based on computerization and automation. The social

reasons are the accent on quality of life, decentralized work centres, individualized consumer preferences, and informal work (self-employment).

The reference to developed countries is not out of place since some parts of a dualistic type of economy reach maturity rapidly. In India, however, the problems of poverty, decentralized development and provision of employment are and will remain paramount for many years. Labour-intensive industrialization through medium-sized industries as well as tiny enterprises in rural and semi-urban locations linked to small-, medium- and large-scale urban industries will have to be emphasized.

While the manufacturing sector in India has been growing rapidly in the 1980s, it is a moot point whether it has been absorbing labour over the long term. In relative terms, employment may have declined in the manufacturing sector. However, there is need and scope for considerable absorption of labour in the services sector in urban and rural areas and for efficiency and productivity improvements. Computerization may well lead to more rather than less employment in the medium term, since productivity improvements should reduce costs and increase the demand for services. The use of microcomputers - both in management and manufacturing - in small-scale industry should improve performance and productivity.

The small-scale services sector could be encouraged by local authorities to organize the provision of extension services through their associations. Banks could also play a positive role in this connection.

The pessimistic note in these observations is occasioned by the critical economic situation and government apathy and procrastination in the economic field. However, both agriculture and manufacturing registered a growth trend from the mid-1980s till 1990, and stock markets have been booming, despite government policy or the lack of it. Such a situation provides an opportunity for small businessmen to organize themselves to solve their problems. There cannot be help without self-help. One may take heart from a recent observation of the economist John Mellor to the effect that "growth is steaming along in Asia with much of it coming from export-oriented small- and medium-scale industries run by rural-based enterprises", and that "development in Asia could no longer be measured by growth in government-controlled heavy industries". The context of this observation is the Republic of Korea, Taiwan Province of China, Thailand and South-East Asia, rather than India or South Asia. However, India can draw lessons from the success story of South-East Asia, achieved through long-term and concentrated attention to macroeconomic policies and human resource development.

Annex

SMALL-SCALE INDUSTRY POLICY REFORM IN INDIA

The new industrial policy package announced by the Government of India in July 1991 marks a radical departure from the past 35 years of a controlled and closed economy dominated by the public sector and by bureaucratic regulation of every aspect of industrialization as in a command economy. The principal elements of the new policy are market-friendliness, privatization and the opening-up of the economy to foreign capital and trade. Industrial licensing has been abolished, except for 18 industries, where security, social or environmental concerns apply. Automatic approval of direct foreign investment of up to 51 per cent of foreign equity will be accorded in 34 priority industries. Foreign technology agreements will also be approved on a liberal basis. The trade regime has been liberalized and the rupee substantially devalued near its open market level. Only eight industries are now reserved for the public sector, compared with 17 industries previously.

A new small-enterprise policy was announced in August 1991. The policy recognizes the inevitable tendency towards expansion in the size of manufacturing enterprises as a consequence of growth in gross domestic product and per capita income in an expanding economy such as that of India. At the same time it takes into consideration the need for employment creation through microenterprises and service enterprises and non-agricultural activities in rural areas. Thus, for both ancillary and export-oriented industries, the investment limit is raised to Rs 7.5 million, and for other small-scale units to Rs 6 million. For microenterprises or tiny units, the limit has been raised from Rs 200,000 to Rs 500,000. The inclusion of services within the ambit of assistance is rather vaguely worded as relating to "all industry-related services and business enterprises irrespective of their location". A major change introduced in small-industry policy is the provision for equity participation of up to 24 per cent of total shareholdings by large enterprises in small industrial units. Another new feature is the introduction of a new legal form of organization for small enterprises, namely restricted or limited partnership, involving the following feature: while one partner has unlimited liability, others could have liability limited to the extent of their investment. The list of over 800 products reserved for exclusive manufacturing in the small-industry sector is being reviewed, and will probably be drastically reduced.

The intention seems to be that the larger-sized enterprises in the small-industry sector receive one-time benefits relating to industrial estate location, facilities for technology development etc., the rest being

integrated or linked with large enterprises in financing, marketing or subcontracting. The reality of the Indian situation in regard to this segment of so-called small industry is thus taken into account, to the advantage of the large-scale sector or big business, which would derive tax and cost (lower wages in small units) benefits through these arrangements.

An attempt has been made to target assistance to the really small through a programme for both tiny and rural industries. The details of the programme are still being worked out, but would cover supply of raw materials, credit arrangements, marketing and factoring assistance, training services, technology, production and quality improvements, use of non-governmental organizations, industry associations etc.

While the new policy marks the beginning of a new market-oriented direction, it will necessarily take time for all parties to adjust from a command economy to a market economy, from reliance on government orders, permits and licences to management responses to price signals. The institutional questions remain paramount: how to debureaucratize and develop privately-operated self-governing institutions. A centralized policy and programme for the tiny manufacturing sector and the service sector would be self-defeating. Besides provision of infrastructure at the urban and semi-urban levels (nodal points), institutional assistance could be most effective at decentralized levels through delivery mechanisms directly linking technical services to the client. These and other issues raised in this paper will need the constant review and attention of business, industry and Government.

In regard to manufacturing proper, the role of small-scale industry - which has been static or declining over the past 25 years - will be constrained in the future by the natural advantages of economies of scale tending towards medium- and large-scale enterprises. The small-scale sector should continue to be the seedbed for nurturing and growth of new entrepreneurship, although there is no sanctity in perpetuation of smallness through government fiat. It should be regarded as natural for small-scale enterprises to expand and grow to medium and large size, or to disappear. The perpetuation of so-called sick enterprises in all sectors of the Indian economy has been a drag on scarce resources and a bane on development.

While the outlook for an expanding role for the small-scale manufacturing sector is thus pessimistic, there is enormous scope for additional income and employment generation in the expansion and growth of, and improvement of efficiency in, the whole range of small businesses and services, covering trade, transport, banking, tourism, food packaging, catering and restaurants, entertainment, construction, computer services, repairs and maintenance, vending, factoring, leasing, design, consultancy, household and cottage arts and crafts etc.

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Labour absorption in industries: some observations from the post-liberalization experience of Sri Lanka*

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Countries differ widely in their ability to successfully implement a new strategy of economic development. They differ even more in their ability to ignite a process of industrialization that also generates large-scale employment. In the 1950s and 1960s, import-substitution industrialization was widely proclaimed to be the sole strategy by which developing countries could create a modern industrial sector through protectionism, economy-wide planning, and other forms of State intervention. But once the easy phase of consumer-goods import substitution ended in the late 1960s, many developing countries were confronted with an inefficient capital-intensive industrial structure, with low rates of labour absorption and increasing dependence on imported capital goods.

The negative aspects led to mounting criticism of import-substitution industrialization among many development economists, who argued that such aspects could be overcome if developing countries switched to a strategy of export-led industrialization that aimed at reaping economies of scale inherent in free trade.**** They further stated that such a policy would enable developing countries to exploit their natural comparative advantage in labour-intensive exports [1]. Thus it was said that export-led industrialization would not only result in an expansion of the process of industrialization, but would also lead to a reduction in the high level of unemployment in developing countries ([1], [2]). The apparent success of the Republic of Korea and Taiwan Province of China in "wisely" switching to an export-led strategy after having reached the limits of consumer-goods import substitution reinforced the case for the mass adoption of export-led industrialization among developing countries.

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****For a lucid discussion, see Krueger and others [1].

As a result, the manufacturing sector has become the focus of policy reform in many developing countries in recent times.

The experience of Sri Lanka since 1977 provides a good case-study of an attempt to use policies of export-led industrialization to create large-scale employment. From 1960 to 1977 the development strategy of Sri Lanka was based on import-substitution industrialization. By the mid-1970s such a strategy no longer produced the desired results, and the level of unemployment reached 20 per cent in 1977 ([3], [4]). The generation of large-scale employment became an explicit goal of the new Government elected in 1977. In a speech to the country the President declared that all his top priorities were in the area of creating employment. The Minister of Finance, even more outspoken, called solving unemployment "the most pressing issue", and said that it would be reduced to 7 per cent by 1984 [5]. A growing manufacturing sector was seen to be essential not only as an engine of growth in the economy, but also to reduce the unemployment problem in the country. Moreover, the example of the East Asian newly industrializing countries* played an important role in the decision to combat unemployment by developing the manufacturing sector. In this context the new government embarked upon the liberalization of the economy and adopted a trade-oriented development strategy - a policy of export-oriented industrialization emphasizing free trade and the market mechanism. As a part of such a strategy, the Government enacted measures such as removing quotas in favour of tariffs, devaluing the currency, introducing export subsidies to compensate for any exchange rate appreciations, encouraging the inflow of foreign direct investment and establishing a free trade zone ([6], [7]).

Eleven years have passed since liberalization began in Sri Lanka, and yet the level of unemployment remains at about the same level as in mid-1977. The latest estimate, for the year 1985, puts the rate of unemployment at 21 per cent ([4], p. 285). Table 1 shows the share of employment and output in the main sectors of the Sri Lankan economy for 1971 and 1981/82.** The agricultural and service sectors together accounted for nearly 86 per cent of total employment in 1981, with manufacturing accounting for only 12.4 per cent. Despite the agricultural

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*The term newly industrializing country is issued extensively to describe developing economies, be they countries, provinces or areas, where there has been particularly rapid industrial growth. It does not imply any political division within the ranks of developing countries and is not officially endorsed by UNIDO.

**These years were chosen because of scarcity of data on sectoral employment.

sector being a large employer, labour absorption in the major tree-crops subsector of the country had been declining from 1950 onwards ([8], pp. 5-6). The paddy subsector which grew rapidly after 1977 also ceased to be a source of employment ([9], pp. 111-112). Furthermore, employment creation in the service sector is sustainable only in the presence of foreign capital inflow; and in the absence of such inflow, it is not suitable without the growth of the tradeable sector. Also worth noting is the fact that the share of the service sector in total employment was lower in 1981/82 than in 1971. Given these facts, it appears that the manufacturing sector is the main source of employment creation in the country. In fact, according to Korale, the manufacturing sector is "the key determinant of employment in the medium and long-run Sri Lanka" ([9], p. 112).

Table 1. Employment and output shares in the Sri Lankan economy for 1971 and 1981/82
(Percentage)

	1971		*1981/82*	
Sector	*Output*	*Employment*	*Output*	*Employment*
Agriculture	28.3	50.1	24.6	51.2
Industry	17.4	9.7	17.0	14.1
Manufacturing	16.7	9.3	13.6	12.3
Mining	0.7	0.4	3.4	1.7
Services and construction	54.3	40.2	58.4	34.7

Source: Employment figures from R.B.M. Korale, "Employment trends", *Sri Lanka Economic Journal*, vol. 1, No. 1 (1986); output figures from Central Bank of Ceylon, *Annual Report*, various issues.

But as the 1985 unemployment figure (21 per cent) suggests, employment creation by the manufacturing sector has been unsatisfactory during the post-1977 period. According to the estimates of the Sri Lanka Industrial Development Board [10], employment in new industries (those which came into production after 1977) increased by 7 per cent between 1977 and 1979, while in old industries employment declined by 16 per cent. Even if allowance is made for the fact that export industries take time to respond to policy reforms, the fact that unemployment increased

to pre-1977 levels by 1985 clearly shows that export-oriented industrialization has not been able to generate employment on a large scale.

Why has this been the case? In this paper an attempt is made to answer this question by examining the labour-absorptive capacity of manufacturing and how it has changed after liberalization. In this context a study of the entire manufacturing sector alone would have limited relevance to policy because different industries have different labour-absorptive capacities. Therefore, an analysis at a disaggregated level is undertaken in order to highlight issues of policy relevance.

The plan of the paper is as follows. In section A, the measurement of labour-absorptive capacity is discussed and the significance of the "employment function" outlined, with a brief survey of the literature. In section B a model is formulated to estimate the labour-absorptive capacities of various industries. In section C the data and estimation methods are discussed and in section D the results are interpreted and their implications scrutinized in the light of the employment policy of Sri Lanka. Finally, some suggestions for policy formulation are presented in section E.

A. Measuring labour absorption and the relevance of the employment function

A useful yardstick of the capacity to absorb labour of any particular sector of the economy is its employment-output elasticity (EYE). For a given sector, it compares the percentage change in employment with the corresponding percentage change in physical output. In general, a sector will be said to absorb less labour when its employment-output elasticity is low, and vice versa. Nevertheless, the basic arithmetical measurement of employment-output elasticity has a major shortcoming, as it is very sensitive to the base and terminal years chosen for the measurement. In addition, this simple measurement ignores the influence of other variables on the demand for labour, such as the size of the capital stock, the user cost of capital, the technology adopted and the wage rate. Any rigorous measurement of employment-output elasticity should incorporate the influence of these other variables. It is in this context that an employment function derived from neoclassical theories of optimum labour input in a production decision become useful.

In recent years, employment functions have been used quite often to estimate EYEs and the determinants of employment in manufacturing industries in developed market economies ([11], [12]). However, there have been few attempts to apply employment functions to manufacturing in developing countries [13], perhaps because industries in developing

countries are still in the early stages of development and the required data are difficult to obtain.

The problems of specification of an employment function will now be considered. The employment function was first used by Brechling ([14], pp. 187-216) to assess the behaviour of manufacturing industry in the United Kingdom. A modified form of his employment function was then used by Ball and St Cyr ([15], pp. 179-196) for the same purpose, and their version remains popular in the literature on the subject and has been used recently for Malaysia [13].

Among simple employment functions, those based on assumptions of cost minimization appear to be the most satisfactory [11]. Here the argument is that the optimum level of employment is such as to minimize a specified cost function, given the state of technology ([11], p. 121). The main assumption is that output is exogenously determined. In general these employment functions take the following form:

$$E_t = f(t, Y_t, E_{t-1}) \tag{1}$$

where E_t = employment, t = time, and Y_t = output.

The models used by Brechling [14], Ball and St Cyr [15] and Raj Kumar [13] attempt to describe the short-run employment decision not the long-run plan. But to use such a model for a time-series analysis produces inaccuracies, since the capital-labour ratio changes continuously with time, in part as a result of changes in relative factor prices. Moreover, an econometric problem arises when a time trend is used as a proxy for technical progress and the growth in capital stock as in equation (1). Raj Kumar [13], for example, employs a time trend to overcome the difficulties of incorporating as variables either the user cost of capital or the capital stock.* The problem with this short cut is that it results in a high degree of multicollinearity to the right-hand side of equation (1), thereby making the coefficient estimates unstable ([16], p. 236). Multicollinearity occurs as the output variable and time move in the same direction.

The problem of multicollinearity is made even more acute in the model of Raj Kumar's [13], because he includes a lagged output variable in an attempt to account for stock adjustments. Consider the following equation: $E_t = Y(t, Q_t, E_{t-1}, Q_{t-1})$, which is the basic form of Raj Kumar's modified version of the employment function of type (1). Virtually the entire right-hand side of the model moves along the time trend. In fact,

*Raj Kumar [13] resorts to this method because of difficulties in estimating these variables.

Q_{t-1} is already accounted for by E_{t-1} and as a result Raj Kumar's modification leads to a misspecification of the entire model.*

It is useful, therefore, to explore an alternative solution without ignoring the fundamental concepts behind the employment function, while developing a specification of the model that can stand up to rigorous empirical testing. The nature of Sri Lankan data at the aggregate level does not encourage the formulation of a complex specification which explicitly incorporates all the different types of cost effects. In the next section an attempt is made to formulate a model that is empirically viable and overcomes the econometric weaknesses of the existing models.

B. The model

It is useful to formalize the main assumptions of the model so that the results can be interpreted in the light of the inevitable restrictions on quantitative analysis for Sri Lanka. The approach used here departs from the basic Ball and St Cyr [15] assumption of a fixed capital-labour ratio. The main aim is to determine the long-run EYE from a dynamic equilibrium model.

1. The assumptions

The manufacturing sector is assumed to consist of technologically identical firms, employing labour and capital. The output is assumed to be exogenous to the manufacturing sector although realistically this may not be the case because an industry can adjust output, or because output and employment can be planned jointly. The underlying assumptions on the input decision and the equilibrium state are outlined below.

Normally the labour input in the short run is acknowledged to have the following two dimensions: the number of people employed; the number of hours worked in a given period. In the Ball and St Cyr model [16], the number-of-hours variable is eliminated from the Cobb-Douglas production function, using a quadratic relationship between the number of hours worked and the wage rate. Yet the existence of this relationship seems improbable, since overtime and bonus payments take a discrete form rather than a continuous functional form with the number of hours worked. Roberts [17] has also questioned the rationale behind this assumption. To investigate ways of incorporating or excluding the

*In testing Raj Kumar's model on Sri Lankan data, high multi-collinearity was found among these variables.

number-of-hours variable, it will be examined from the perspective of a single country.

The dominance of the public sector in the Sri Lankan manufacturing sector did not diminish after 1977. Even in 1983, for example, 56 per cent of the output of the manufacturing sector came from State industries ([6], p. 26). Normally, in all Sri Lankan public sector enterprises the working hours per day are fixed and there is some overstaffing.* In the private sector, although some variation prevails in big firms, the working hours are fixed in most cases. Therefore, it would not be unrealistic to take the number of working hours for the manufacturing sector as fixed for the period of analysis, and this variable could be dropped for the industry's employment decision.

Employment in tradeable goods industries is usually a relatively small fraction of total employment. To the extent this is so, the supply of labour to those industries may be perfectly elastic within the relevant range ([1], p. 8). It will therefore be assumed that there are no labour constraints owing to lack of skill and expertise. In a country like Sri Lanka, with high literacy and a surplus of labour, this assumption is not unrealistic. Moreover, for simplicity, it will be assumed that the quality of labour is homogeneous.

The entire capital variable will be incorporated for the input decision. That is to say, both the capital stock and the user cost of capital are accounted for in the employment decision. In the derivation of the model the influence of capital stock on the employment decision (by the cost-minimizing method) will be removed, since it is not possible to estimate the capital stock for Sri Lankan industries (see the derivation of the model). This leaves only the user cost of capital from the capital variable. Calculation of the user capital in developing countries, especially in Sri Lanka, is not an easy task. However, under reasonable assumptions it could be derived using the simple neoclassical formulation (see section C below). Since the Sri Lankan manufacturing sector depends substantially on imported inputs, it will be assumed that the user cost of capital in any import-oriented sector in Sri Lanka is applicable to all industries in the manufacturing sector. The absence of investment deflators for various industries, not to say the entire manufacturing sector, does not permit the construction of an industry-specific index of the user cost of capital. Although not the same for all industries, its variation can be assumed to be small. It will also be assumed that technical progress is disembodied from capital and labour.

Allowance is made for the possibility that, at any given price, each industry's demand for inputs is directly dependent on aggregate demand.

*For details on overstaffing, see Kelegama ([18], p. 78).

Empirical studies have found this to be so, though its explanation is not yet clear.* It will be assumed that there are constant elasticities for the given period of analysis, and use is made of the Cobb-Douglas production function. Moreover, the industry is assumed to be on the production frontier (that is, in a state of equilibrium). While this may not be the precise case, the assumption is that deviations can be taken to be negligible.

2. *The derivation of the model*

Let the production function of the firm be:

$$Y_t = A_t E_t^{a} K_t^{b} \tag{2}$$

where Y_t = volume of output, K_t = capital stock, E_t = employment, and a and b are constants.

Let the cost function of the firm be:

$$C_t = w_t E_t + r_t K_t$$

where C_t = the cost to the firm, w_t = wage per worker and r_t = user cost of capital.

The labour demand corresponding to the cost-minimizing decision of the industry is given by the optimality conditions of the Lagrangian (L^*) where:

$$L^* = w_t E_t + r_t K_t + \lambda(Q_t - A_t E_t^{a} K_t^{b}).$$
$$(\partial L^*/\partial E_t) = O \text{ and } (\partial L^*/\partial K_t) = O \text{ gives}$$
$$w_t/r_t = aK_t/bE_t \tag{3}$$

By eliminating K_t in (3) by using the K_t value from the production function, and taking logarithms of the expression, the result obtained is:

$$\text{Log } E_t = a_0 + a_1 \text{Log } Y_t + a_2 \text{Log } (r_t/w_t) \tag{4}$$

where a_0, a_1 and a_2 are functions of a and b.

*See, for instance, Layard and Nickell [19].

The cost of labour adjustment to the static model (4) will now be incorporated. Labour may be regarded as a quasi-fixed factor along with costs of hiring, firing, training, and non-monetary obligations to workers and unions. This may involve labour hoarding, a situation when labour that is not fully used is kept on for temporary variations in output, or to conform to moral constraints on dismissal. Moreover, the difficulties in the short-run adjustment of other inputs, like capital stock, may involve further labour adjustment costs. This adjustment behaviour can be incorporated by a simple first-order Koyck adjustment process expressed as:

$$(E_t/E_{t-1}) = (E_t^*/E_{t-1})\lambda \qquad (5)$$

where $O < \lambda < 1$, and where E_t^* is the desired level of employment and λ the speed of labour adjustment.

By substituting E_t^* from (5) into the static model (4), one obtains:

$$\text{Log } E_t = c\lambda + c_1 \text{Log } Y_t + c_2 \text{Log } (r_t/w_t) + c_3 \text{Log } E_{t-1} \qquad (6)$$

where $c\lambda$, c_1, c_2 and c_3 are functions of λ, a, and b.

Now c_1-short-run EYE and $c_1/(1-c_3)$ is the long-run EYE.*

C. Data and estimation methods

The user cost of capital was calculated as $r_t = I_t(R_t + d)$, where R_t is the interest rate, d is the depreciation rate, and I_t was calculated as the weighted average of the gross domestic capital formation (GDCF) deflator (i) and the import price deflator (p):

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*Note that c_1 will be biased down. To show this, attention will be focused on equation (4). Now if (4) is written in full, one obtains:
Log E_t = Log (a/b) + (a/a+b)Log (r_t/w_t) + (1/ab)Log Y_t - (1/a+b)Log A_t.
A_t is being consigned to the residual of equation (4) and it is negatively correlated with Y_t thus inducing a downward bias on a_1 (assuming that A_t and Y_t are increasing with time). Also note that a_1 will be biased up, owing to overstaffing of many public industries. Overstaffing implies employment is provided above the cost-minimizing employment levels. Note that the above observations are also valid for c_1 in (6). It is here assumed that the downward and upward bias are neutralized by one another, though strictly speaking this may not be correct.

$$I_t = \mu p + (1-\mu)i$$

where $\mu = m/(m+x)$, m = c.i.f. imports, x = GDCF.

To determine "i" United Nations statistical publications are used [20]. p, m, x and R_t (bank rate of the Central Bank of Sri Lanka) were obtained from the International Monetary Fund statistics [21]. d was given a fixed value of 6.5 per cent.* E_t, Y_t and w_t were obtained from Central Bank of Ceylon sources ([23], [24]). Y_t (real gross output) was estimated by dividing the value of output by the manufacturing sector deflator - both of which were taken from Central Bank of Ceylon reports [23].

The period of analysis is from 1966 to 1985. Autocorrelation did not become a problem as shown by the Durbin [25] H-test statistics in annex table 6. The EYE and the speeds of labour adjustment (λ) are presented in table 2. Tests were performed for the following questions in order to see how labour-absorptive capacity had changed after liberalization:

(a) Had liberalization induced a structural break in the labour demand for the given industries?

(b) Had liberalization contributed towards changing significantly the EYE?

Table 2. EYE and the speed of labour adjustment estimates

Industry	*EYE*		*Speed of labour adjustment*
	Short-run	*Long-run*	*(λ)*
Food, beverages and tobacco	0.375	0.822	0.422
Textiles and wearing apparel	0.247	0.555 a/	0.377
Petrochemicals etc.	0.107	0.266	0.401
Wood and wood products	0.537	0.731	0.735 a/
Paper and paper products	0.381	0.748	0.510
Non-metallic products	0.709	0.873	0.813 a/

continued

*Based on Hughes-Hallet ([22], p. 90).

Table 2 (*continued*)

Industry	*EYE*		*Speed of labour adjustment*
	Short-run	*Long-run*	*(λ)*
Fabricated metal products, machinery and transport equipment	0.393	0.650	0.606
Total	0.232	0.506	0.458

a/ EYE and λ values are significant only at the 10 per cent level. All other EYE and λ values are significant at the 5 per cent level.

The first test was conducted using a dummy variable as an explanatory factor in relation to the function (6). A structural break after liberalization is indicated if the dummy variable is significant (say, at the 5 per cent level). It implies that the constant intercept changed after liberalization while the other coefficients remained constant, or that there was an overall shift in the function after liberalization. The second test was conducted using a dummy variable as an explanatory factor and also a "slope dummy". A slope dummy is used to measure the change in a parameter over time. This is used because during a liberalization period not only can the function shift, but also its slope may change; elasticities may change over time. This change can be captured by introducing a dummy variable with the parameter.* These two tests for the liberalization period were conducted using a dummy variable (D_t) in model (6). $D_t = 0$ for the 1966 to 1977 period, $D_t = 1$ for the 1978 to 1985 period. Regression analysis was also performed for the period 1966-1976 in order to see how the EYEs have changed due to liberalization.

In order to compare the EYE of the Sri Lankan manufacturing sector with those of the East Asian newly industrializing countries, a regression analysis was performed for the Republic of Korea.** The long-run elasticities for the Republic of Korea together with those for Hong Kong are presented in table 3.

*For more details see Koutsoyiannis ([16], pp. 281-284).

**The selection of the Republic of Korea was based mainly on data availability. E_t and Y_t were obtained from United Nations sources [20]. Data on w_t were drawn from the Bank of Korea [26], and on R_t from the International Monetary Fund [21]. I_t was obtained from United Nations sources [20].

D. Interpretation of results

The EYEs and λs presented in table 2 do not shed any light on the employment behaviour of individual firms within these manufacturing industries. A more comprehensive study of labour demand in the Sri Lankan manufacturing sector should include detailed micro-level case-studies of firms in the different industries, studies which also examine the impact on demand for labour of a variety of factors. These factors would include the influence of business cycles, changes in minimum wage legislation, ownership patterns (for example, public and private), trade unions, and transnational corporations that control these firms and influence their employment policies. The estimates do, however, provide useful insights into the employment-generating capacity of the Sri Lankan manufacturing sector as a whole and of its industries (that is, at a macro level).

The short-run and long-run EYEs of the overall manufacturing sector are 0.232 and 0.506, respectively. These figures indicate that the overall manufacturing sector was characterized by low rates of labour absorption that improve, but not dramatically, in the long-run. A comparison of Sri Lanka's long-run manufacturing EYE with that of Hong Kong or the Republic of Korea clearly shows that Sri Lanka has a long way to go before it can match their achievements (see table 3). Moreover, the two tests for liberalization fail to give positive results (see annex 6). Thus it may be inferred that the high capital-intensity that prevailed in the Sri Lankan manufacturing sector during the pre-1977 period did not undergo any significant change after liberalization. The reasons for this can be examined by analysing the EYEs at a disaggregated level.

Table 3. EYEs for selected East Asian countries and areas

EYE	*Hong Kong*	*Republic of Korea*
Period	1960-1970	1966-1983
Long run	0.740	0.618

Sources: For Hong Kong, EYE was obtained from R. Hsia, "Technological change, trade promotion and export-led industrialization in Hong Kong and South Korea", in *Export-led Industrialization and Development*, E. Lee, ed. (Geneva, International Labour Office, 1981); for the Republic of Korea, EYE was estimated as explained in section B of text. Econometric estimates are reported in annex table 6.

The long-run EYE estimates at the disaggregated level indicate that the textile and wearing apparel and petrochemical industries have the lowest EYE values among the manufacturing industries, 0.555 and 0.266, respectively. The short-run EYEs are even more striking at 0.247 and 0.107, respectively. These estimates indicate that labour absorption in these two industries is relatively low as compared with that in other industries in the Sri Lankan manufacturing sector. In addition to having low EYEs, these industries have very low estimates for the speed of labour adjustment (λ), indicating that labour absorption is very gradual. A low value of λ could mean either that employers resort to overtime or use part-time staff, or that they experience difficulty in recruiting labour owing to high skill requirements and long training periods. In the case of the textile and wearing apparel industry the low speed of labour adjustment could be explained by overtime use of labour ([27], p. 40), while for the petrochemical industry the low λ value is more likely to be due to long training periods because the industry is highly dependent on complex imported technology.

The first test for liberalization gives a positive result for the textile and wearing apparel industry, indicating that there had been a structural break in employment generation after liberalization (see annex table 6). This result is consistent with the massive employment increase in this sector after 1977 (see annex table 7). However, the second test fails to give a slope break, indicating that there has not been a significant change in EYE after 1977. The reason for this can be understood by examining employment and output shares of the above industry for the years 1977 and 1985. According to table 4, the employment share (viewed as a percentage of total employment in the manufacturing sector) increased by only 7.2 per cent compared with the output share (viewed as a percentage of total output in the manufacturing sector), which showed an increase of 14.6 per cent. Owing to this disproportionate change in employment *vis-à-vis* output, there was no significant change in the EYE. For the petrochemical industry, however, both these tests fail to give positive results, because of the declining growth of the industry after 1981 as the refineries reached full capacity and the price of petroleum products in the world market declined ([28], p. 66). The output and employment shares given in table 4 for the petrochemical industry for the years 1977 and 1985 further substantiate the above findings.

Table 4. Output and employment shares of the industry sample, 1977 and 1985
(Percentage of total output and employment of the manufacturing sector)

Industry	*Year*	*Output share*	*Employment share*	*Imported raw material as a percentage of total raw material*
Food, beverages etc.	1977	32.8	24.0	..
	1985	27.1	30.1	20
Textiles and wearing apparel	1977	10.0	28.0	..
	1985	24.6	35.2	97
Petroleum and chemicals	1977	35.2	12.2	..
	1981	52.2	15.5	..
	1985	33.9	10.5	98
Wood	1977	3.9	6.5	..
	1985	3.0	3.6	60
Non-metallic products	1977	5.9	8.4	..
	1985	4.8	8.4	53
Fabricated metal, machinery and transport equipment	1977	8.1	3.1	..
	1985	4.1	5.5	59
Total	1985	97.5	93.3	89

Source: Central Bank of Ceylon, *Annual Report* (Colombo, various issues).

Table 5 shows that in 1985, exports of textiles and wearing apparel and of petrochemicals, which together amounted to 91 per cent of total manufactured exports, contributed 48 per cent of total employment in the manufacturing sector. The Sri Lankan data do not give any figures for employment generated by industries categorized as exporting and import-substituting. Yet it could be argued a priori that the export-generated employment of the textiles-and-wearing-apparel and petrochemical industries is much lower than 48 per cent, an indication that these industries generate less employment as compared with their volume of exports.

Table 5. Share of the textiles-and-wearing-apparel and petrochemical industries in output, exports and employment in the total manufacturing sector, 1977 and 1985
(Percentage)

Year	*Output share*	*Export share*	*Employment share*
1977	45.2	84	40
1985	58.4	91	48

Source: Central Bank of Ceylon, *Review of the Economy* (Colombo, 1986).

It would be useful to examine in some detail the labour-absorbing potential of the textiles-and-wearing-apparel industry, as it is the leading non-traditional export in Sri Lanka today. The data in tables 4 and 7, however, show that there has been a marked change in employment in this industry since 1977. The expansion of the textile and wearing-apparel industry after 1977 was largely caused by the wearing-apparel or garments industry that operates mainly in the export processing zone. Thus the marked increase in employment in the overall textiles-and-wearing-apparel industry came from the expansion of the garments industry after 1977. The figure for total employment generated by the garments industry during 1977-1983 is estimated at 35,000.* This increase, however, has to be seen in the context of nearly 40,000 jobs lost between 1977 and 1980 from the unorganized industrial handloom industries [30]. Thus it appears that the labour absorptive capacity of the garment industries was low by comparison with the employment losses in the handloom industries alone.

The relatively low labour-absorptive capacity of the Sri Lankan garments industry is explained in part by its high dependence on imported inputs and, as a result, the absence of linkages with local industries. Between 75 and 97 per cent of its raw material is imported; even cloth, thread, buttons and packaging material are imported.

In the remaining group of industries - wood, paper, food and beverages, fabricated metal products, machinery and transport equipment, and non-metallic products - the long-run EYEs are well over 0.65 and short-run EYEs are above 0.35. These industries have grown much more

*Estimated from Central Bank of Ceylon, *Annual Report* (Colombo, 1983) and [28]. See also Athukorala [29], p. 99.

slowly since 1977, while their share in manufacturing output has been declining by comparison with the pre-1977 period (see table 4). Their export share also fell from 16 per cent in 1977 to 9 per cent in 1985.

The first and second tests of liberalization give positive results for the fabricated metal, machinery and transport equipment industry; while for the wood industry the second test for liberalization gives a positive result (see table 6). Table 7 shows that total employment in the fabricated metal, machinery and transport equipment industry declined by 3,937 between 1977 and 1985. Thus the negative structural break (which is significant at the 10 per cent level) for that industry after 1977 does not come as a surprise. With regard to the second test, a negative slope break (which is significant at the 10 per cent level) is observed. Closer examination reveals the reasons for this. According to the 1966-1976 regression the EYE is 0.83 (significant at the 5 per cent level) with a negative slope break after 1977. Here, too, one observes the EYE falling from 0.588 during the 1966-1976 period to 0.381 during the 1966-1985 period, implying that the labour-absorptive capacity has fallen dramatically after liberalization. According to table 7, employment in this industry fell between 1977 and 1985, and according to table 4 the share of employment fell more sharply than output. These observations clearly explain the negative slope break after 1977 for the above industry.

In all the other remaining industries referred to above the EYEs are observed to decline in value in the 1966-1985 regression in comparison with the 1966-1976 regression (see table 6). These changes are not significant according to the second liberalization test, and some of the EYEs from the 1966-1976 regression are not significant at 5 per cent level. Where, however, the EYE of the 1966-1976 regression is significant, this would suggest that these industries have become more capital-intensive. This fact is supported by Sirisena, who writes that: "Energy-intensive labour-saving technologies were adopted in a wide range of manufacturing industries. This was obvious in the case of wood and wood-processing and of the printing industry. The use of power-driven machinery in timber-sawing and furniture manufacturing reduced the labour requirement considerably. Similarly, in the printing industry there was substantial labour reduction owing to the use of power-driven machinery" ([31], p. 57).

It must be noted here that all the remaining group of industries have stronger backward and forward linkages with the rest of the economy than the textiles-and-wearing-apparel and petrochemical industries. The use of local raw materials by the remaining group of industries is, by comparison with the above two industries, quite high (see table 4), and therefore the multiplier employment effects of these more domestically resource-based industries are also significant. In particular, the food industry, which produced much employment after 1980, provides ample

evidence to substantiate this claim (see table 7). Accordingly, the decline in the share of the remaining group of industries in the overall output of the manufacturing sector, as well as in exports in the post-liberalization period, explains the failure of the manufacturing sector to generate rapid employment after 1977. Their high potential for employment generation is reflected not only in their linkages, but also in the EYEs and the speed of labour adjustment.

In sum, the analysis at the disaggregated level suggests that the employment-generating potential in most high labour-absorbing industries has fallen, and there has been a shift towards more capital-intensive techniques in most industries. The causes of these changes are complex, but the following factors should be emphasized:

(a) A shift in production towards large-scale enterprises in the export processing zone. These industries received substantial incentives from the State ([7], pp. 64-65). Heavy incentives may have worked against the desired employment objectives. For example, in Malaysia and the Philippines, industries in the export processing zone were more capital-intensive than other industries owing to the State provision of heavy subsidies on capital. Consequently, this policy worked against the objectives of employment creation ([32], p. 165). It is extremely likely that a similar development occurred in Sri Lanka. Moreover, large domestic enterprises (outside the export processing zone) had a comparative edge over more labour-absorbing small-scale firms in avoiding export disincentives associated with exchange-rate appreciations;

(b) The preference of local producers for high-quality imported inputs, in order to maintain the quality of the final product and its ability to compete with imports. In effect, this meant a reduction of linkages with the economy;

(c) The increased involvement of transnational corporations in domestic industry. Such corporations usually depend on foreign capital inputs embodying capital-intensive technologies;

(d) The relatively low cost of some imported inputs resulting from the overvalued exchange rate and the anomalies in the tariff structure. In industries such as textiles and wearing apparel, the negative effect of exchange-rate appreciation on profitability may have been counterbalanced, *inter alia*, by the lower cost of some imported inputs. Moreover, low dependence on domestic raw materials insulated them from domestic inflation, to which domestic resource-based industries were vulnerable;

(e) The bias in favour of capital-intensive production inherited from the previous framework of import-substitution industrialization.

E. Conclusions and some notes on policy

Sri Lanka has now had over a decade of experience with export-oriented industrialization, but the legacy of the past remains. The manufacturing sector has not been able to create large-scale employment opportunities for the unemployed. Despite the limitations of the model, the results of the analysis presented in this paper together with other available data indicate that the dominant Sri Lankan manufacturing industries - textiles and wearing apparel and petrochemical products - had relatively lower labour-absorption capacities than the rest. Since the manufacturing sector is the key determinant of employment in the medium- and long-run in Sri Lanka, its low labour-absorption capacity explains why unemployment levels reached 21 per cent in 1985, far exceeding the 7 per cent target that was set for 1984. In fact, the findings suggest that the continued expansion of this sector in its present form would not contribute to rapid employment generation in the future.

This points to a certain weakness in the policy of export-oriented industrialization adopted by Sri Lanka, namely its tendency to focus on trade policy rather than industrial strategy. As pointed out, the trade policy itself had shortcomings such as exchange rate appreciation and anomalies in the tariff structure ([7], [33]). But the negative effects of these shortcomings were more or less offset by export subsidies and tax concessions. In fact, the export bias index for the manufacturing sector remained well above unity during the post-1977 period [29]. Thus, in spite of shortcomings, the trade policy was in tune with export-oriented industrialization. But the trade policy was not supported by an industrial strategy. The Government was of the view that market forces would suffice to identify Sri Lanka's areas of comparative advantage, with the industries so identified taking off thereafter. Thus an industrial strategy was thought to be unnecessary.*

Recent research on export-oriented industrialization has shown that successful industrialization is an interplay between incentives created by trade policies and supply-side factors created by an industrial strategy ([35], [36]). This research has shown that there are widespread market failures on the supply side, involving factor, product and technology markets. Thus in addition to "correct" incentives, selective intervention according to an industrial strategy is required to rectify those

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*For details see Kelegama [18]. Realizing the need for an industrial strategy after nearly a decade pursuing liberalization, the government formulated such a strategy in 1987. See Minister of Finance and Planning [34].

market failures. It is through such a strategy that dynamic comparative advantage can be achieved for successful labour-intensive industrialization.

The absence of an industrial strategy explains the emergence of low-labour-absorbing industries in Sri Lanka after 1977. In fact, Sri Lanka's attempt to use export-oriented industrialization to create large-scale employment provides some useful lessons for other developing countries contemplating its use in the near future. First, trade policy by itself is inadequate to promote high-labour-absorbing industries. Secondly, trade policy alone may not be adequate fully to exploit the comparative advantage of a developing country. In sum, it can be stated that an industrial strategy should not be treated as secondary to trade policy. The objective of the trade policy should be to exploit the comparative advantage of already well-established industries, while the objective of the industrial strategy should be, on the one hand, to rectify market failures on the supply side, and, on the other, to identify industries that are judged to be in line with a country's dynamic comparative advantage and develop them using selective intervention. In practice, those aims are often not realized; one reason being that trading patterns influence the political economy of a country and consequently the choices it makes.

Annex

STATISTICAL TABLES

Table 6. Econometric estimates of the employment function

Item	*c*	*Log* Y_t	*Log* (r^t/W_t)	*Log* E_{t-1}	D_t	D_t. *Log*$_t$	R^2	*SER*	*DH*
Food, beverages and tobacco	3.79 (2.11)	0.357 (1.98)	0.064 (1.50)	0.578 (2.91)			0.64	0.227	0.354
1st test	3.85 (2.08)	0.205 (0.55)	0.072 (1.54)	0.599 (2.87)	0.095 (0.46)		0.62	0.233	0.227
2nd test	5.27 (2.07)	0.035 (0.08)	0.045 (0.79)	0.484 (1.91)	-1.30 (-0.76)	0.633 (0.82)	0.61	0.236	0.585
1966-1976 reg.	2.25 (0.95)	-0.027 (-0.08)	0.131 (2.15)	0.815 (3.40)			0.49	0.189	-0.501
Textiles etc.	3.58 (1.64)	0.247 (1.62)	-0.035 (-0.97)	0.623 (2.72)			0.78	0.186	-1.90
1st test	6.73 (2.76)	0.216 (1.47)	0.008 (0.21)	0.320 (1.29)	0.301 (2.18)		0.83	0.168	-1.90
2nd test	6.82	0.046	-0.015	0.326	-0.086	0.274	0.83	0.166	-1.84
1966-1976 reg.	7.37 (2.13)	0.066 (0.23)	-0.025 (0.39)	0.268 (0.76)			-0.22	0.222	-1.21

continued

Table 6 (*continued*)

Item	*c*	*Log* Y_t	*Log* (r^l/W_t)	*Log* E_{t-1}	D_t	D_t. *Log*$_t$	R^2	*SER*	*DH*
Petrochemicals	3.74	0.107	0.029	0.598			0.87	0.114	1.102
	(2.61)	(1.97)	(1.47)	(3.72)					
1st test	3.63	0.065	0.032	0.616	0.082		0.87	0.115	1.12
	(2.52)	(0.87)	(1.58)	(3.77)	(0.89)				
2nd test	3.42	0.065	0.040	0.641	0.276	-0.070	0.86	0.118	1.06
	(2.13)	(0.85)	(1.33)	(3.52)	(0.52)	(-0.37)			
1966-1976 reg.	0.045	-0.038	0.093	1.03			0.73	0.126	-0.295
	(0.02)	(-0.38)	(1.93)	(3.52)					
Wood	6.77	0.537	-0.015	0.265			0.88	0.216	-1.152
	(3.37)	(2.36)	(-0.323)	(1.20)					
1st test	7.47	0.665	-0.029	0.198	0.115		0.87	0.220	-1.18
	(3.25)	(2.22)	(-0.56)	(0.81)	(-0.67)				
2nd test	9.45	0.948	-0.0006	0.01	-0.422	-0.540	0.89	0.211	-0.647
	(3.71)	(2.78)	(-0.01)	(0.04)	(-1.63)	(-1.53)			
1966-1976 reg.	8.92	0.874	0.028	0.071			0.80	0.279	-1.15
	(2.47)	(1.81)	(0.33)	(0.18)					
Paper	4.42	0.381	-0.021	-.490			0.90	0.127	1.416
	(2.91)	(2.24)	(-0.86)	(2.790)					
1st test	4.55	0.359	-0.019	0.473	0.042		0.89	0.130	1.49
	(2.84)	(1.96)	(-0.77)	(2.53)	(0.37)				

continued

Table 6 (continued)

Item	c	Log Y_t	Log (r^t/W_t)	Log E_{t-1}	D_t	D_t. Log$_t$	R^2	SER	DH
2nd test	5.86 (3.82)	0.559 (3.01)	0.006 (0.24)	0.332 (1.88)	0.265 (1.90)	-0.762 (-2.27)	0.92	0.115	0.116
1966-76 reg.	6.13 (3.09)	0.588 (2.61)	-0.001 (-0.03)	0.299 (1.29)			0.84	0.117	0.355
Non-metallic minerals	6.12 (4.33)	0.709 (3.22)	-0.022 (-0.616)	0.188 (0.97)			0.85	0.197	-0.764
1st test	7.09 (4.18)	0.679 (2.66)	-0.021 (-0.55)	0.191 (0.96)	0.035 (0.25)		0.84	0.203	-0.540
2nd test	7.21 (4.12)	0.716 (2.65)	-0.003 (-0.07)	0.182 (0.89)	0.286 (0.59)	-0.297 (-0.54)	0.83	0.208	-0.743
1966-1976 reg.	7.60 (3.56)	0.762 (2.47)	0.047 (0.83)	0.151 (0.61)			0.77	0.214	-1.78
Fabricated metal, machinery and transport equipment	5.36 (3.77)	0.394 (0.197)	-0.062 (-1.41)	0.393 (2.39)			0.92	0.202	0.864
1st test	5.25 (3.93)	0.405 (2.04)	-0.059 (-1.45)	0.412 (2.65)	-0.152 (-1.76)		0.69	0.191	0.403
2nd test	7.12 (4.39)	0.732 (2.81)	-0.076 (-1.93)	0.187 (0.98)	0.537 (1.37)	-0.971 (-1.80)	0.73	0.179	0.651

continued

Table 6 (continued)

Item	c	Log Y_t	Log (r^t/W_t)	Log E_{t-1}	D_t	D_t. Log$_t$	R^2	SER	DH
1966-1976 reg.	7.70 (3.73)	0.832 (2.56)	-0.034 (-0.55)	0.127 (0.53)			0.77	0.202	0.591
Total manufacturing	4.66 (2.41)	0.232 (1.99)	0.009 (0.62)	0.541 (2.72)			0.93	0.083	1.32
1st test	3.75 (1.90)	0.073 (0.45)	0.021 (1.22)	0.663 (3.15)	0.108 (1.44)		0.94	0.080	0.402
2nd test	3.75 (1.90)	0.073 (0.45)	0.021 (1.22)	0.663 (3.15)	0.108 (1.44)		0.94	0.080	0.402
1966-1976 reg.	4.82 (1.48)	0.141 (0.58)	0.016 (0.45)	0.551 (1.60)			0.72	0.104	0.773
Republic of Korea 1967-1983	11.06 (4.55)	0.575 (4.30)	0.081 (1.16)	0.07 (0.33)			0.99	0.232	0.040

Notes: t - statistics are given in parentheses.
The number of observations for all regressions for which the period is not mentioned = 20 (1966-1985);
DH stands for t - statistics for first-order autocorrelation (Durbin [25] H-test).
The method of estimation is ordinary least squares.
SER is the standard error of regression.
All equations satisfy the F-test at the 1 per cent level.
reg. = regression.

Table 7. Employment patterns in manufacturing industries

Industry	*1977 level*	*Increment 1977-1980*	*Increment 1977-1985*
Food, beverages and tobacco	28 429	3 936	35 453
Textiles, wearing apparel and leather products	33 180	15 793	41 658
Wood and wood products	6 476	2 252	3 285
Paper and paper products	7 650	512	-66
Petrochemicals etc.	14 446	2 750	7 808
Non-metallic and mineral products	9 963	9 960	7 951
Fabricated metal products, machinery and transport equipment	15 513	-437	-3 937
Other manufactures	1 129	668	870
Total	118 576	35 987	93 576

Source: Central Bank of Ceylon, *Review of the Economy* (Colombo, various years).

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SOMMAIRE

L'utilisation d'ordinateurs pour la gestion industrielle en Afrique : examen des problèmes

Eoin Gahan

L'étude présentée dans l'article analyse l'utilisation d'ordinateurs pour la gestion industrielle en Afrique et porte essentiellement sur les niveaux actuels de cette utilisation ainsi que sur les obstacles à une utilisation plus large. Elle se propose de contribuer au développement des programmes d'assistance technique et au renforcement de la coopération internationale dans ce domaine.

L'utilisation des ordinateurs aux fins de la gestion comprend des applications traditionnelles, comme l'établissement de la paie, la comptabilité, la tenue d'inventaires, etc. Dans d'autres pays, l'ordinateur s'est révélé un instrument utile pour accroître la productivité et l'exactitude de ces tâches et contribuer à l'efficacité de la fonction de gestion. Le rôle des ordinateurs dans l'industrie est potentiellement très important en Afrique, mais de nombreux éléments, notamment d'ordre économique et technique, font obstacle à leur plus large utilisation. On s'est efforcé dans l'étude de passer en revue ces obstacles.

On y examine les problèmes généraux que pose l'informatisation ainsi que les obstacles particuliers à l'Afrique. Les informations publiées et les données recueillies lors d'une enquête limitée menée dans un certain nombre de pays africains servent à donner une idée préliminaire de la situation actuelle de l'utilisation des ordinateurs, en général, et de leur utilisation dans l'industrie africaine, en particulier. L'étude se termine par un examen des principales conclusions en ce qui concerne les activités de coopération technique.

Développement industriel dans les Emirats arabes unis

Shihab M. Ghanem

Dans cet article sont examinés les détails du développement du secteur industriel dans les Emirats arabes unis à la suite de l'essor de l'industrie pétrolière. Les résultats de l'enquête sur l'industrie réalisée en 1985 par le Ministère des finances et de l'industrie des Emirats arabes unis sont examinés et comparés aux résultats de deux enquêtes antérieures dont l'industrie a fait l'objet en 1978 et 1981. Ces enquêtes, qui

contiennent les données les plus complètes sur le secteur industriel dans les Emirats arabes unis, couvrent la plus grande partie des entreprises manufacturières employant 10 personnes ou plus. Le rôle des zones industrielles dans le pays est également indiqué.

Absorption de main-d'œuvre par l'industrie : observations tirées de l'expérience consécutive à la libéralisation de Sri Lanka

Sama Kelegama et Ganeshan Wignaraja

Cette communication contient une analyse de la tentative réalisée à Sri Lanka pour se servir d'une politique commerciale orientée vers l'exportation comme moyen de créer à grande échelle des emplois dans le secteur industriel pendant la période 1977-1985. On y trouve les estimations de la capacité d'absorption de main-d'œuvre d'un certain nombre d'industries qui ont été faites grâce à un modèle simple et peu onéreux de détermination de l'emploi. Il ressort des résultats ainsi obtenus et d'autres données disponibles que l'expérience de Sri Lanka ne correspond pas au schéma habituel d'une forte création d'emplois sur la base d'une politique commerciale axée sur l'exportation. Il est suggéré que les changements apportés aux politiques commerciales ne sauraient par eux-mêmes contribuer à promouvoir le processus d'absorption de main-d'œuvre par l'industrie.

Production de la petite industrie en Inde

S. Nanjundan

Depuis l'indépendance, les gouvernements successifs de l'Inde ont cherché à promouvoir la petite industrie, en en faisant un des piliers de la politique générale de développement du pays. Pour promouvoir la petite industrie, on a largement fait appel à des réglementations concernant l'offre, qui avaient la plupart du temps un caractère restrictif et réservant notamment l'exclusivité de certaines activités à la production à petite échelle. Cette communication passe en revue des programmes concernant le financement, les activités industrielles, les services de vulgarisation, la formation et la recherche techniques, la commercialisation, la sous-traitance et le développement de l'esprit d'entreprise. Il y est affirmé que ces programmes ont été rarement couronnés de succès. La nouvelle politique du gouvernement annoncée en juillet 1991 pourrait remédier à certains problèmes antérieurs, en laissant principalement plus de latitude à l'initiative des entrepreneurs.

EXTRACTO

Computadoras para la gestión industrial en África: examen general del tema

Eoin Gahan

Un aspecto objeto de examen es el empleo de computadoras para la gestión industrial en África. El estudio presentado en el artículo se centra en los niveles que ha alcanzado actualmente la utilización de este tipo de computadoras, y considera los obstáculos que se oponen a su mayor difusión. Su finalidad es contribuir al desarrollo de programas de asistencia técnica y a una mayor cooperación internacional en este campo.

El empleo de computadoras para fines de gestión abarca aplicaciones tradicionales como nóminas, cuentas, contabilidad de existencias, etc. En otros países, la computadora ha resultado ser un instrumento útil para aumentar la eficiencia y la exactitud de esas tareas y para contribuir a una mayor eficacia de la función de gestión. Su papel en la industria de África es potencialmente muy importante. Pero son muchos los obstáculos que se oponen a su mayor difusión en África, entre ellos factores económicos y técnicos. En el estudio se intenta dar una visión de conjunto de esos obstáculos.

En el citado estudio se abordan cuestiones generales de la informatización y se examinan los obstáculos concretos con que tropieza en África. Se utiliza información publicada, así como datos reunidos en un estudio limitado sobre varios países africanos para ofrecer una sinopsis preliminar de la situación actual en lo que atañe al empleo de computadoras, en general, y a la industria africana, en particular. El estudio se ocupa, por último, de las principales consecuencias de esas conclusiones para las actividades de cooperación técnica.

Desarrollo industrial en los Emiratos Árabes Unidos

Shihab M. Ghanem

En este artículo se analiza detalladamente el desarrollo del sector industrial de los Emiratos Árabes Unidos tras el auge de la industria petrolera. Los resultados del estudio industrial realizado en 1985 por el Ministerio de Finanzas e Industria de los Emiratos Árabes Unidos se examinan y/comparan con los de dos estudios industriales anteriores efectuados en 1978 y 1981. Esos estudios ofrecen la más amplia

información sobre el sector industrial de los Emiratos Árabes Unidos y tratan de la mayoría de las empresas manufactureras que emplean a diez o más personas. También dan una idea general del papel desempeñado por las zonas industriales del país.

Absorción de mano de obra por las industrias: algunas observaciones sobre la experiencia liberalizadora de Sri Lanka

Saman Kelegama y Ganeshan Wignaraja

En este documento se analiza el intento realizado en el sector industrial de Sri Lanka durante el período 1977-1985 para aplicar una política comercial orientada al mercado exterior como instrumento para generar empleo en gran escala. Se facilitan estimaciones sobre la capacidad de absorción de mano de obra de varias industrias, utilizando para ello un sencillo modelo de determinación del empleo que reduce al mínimo los costos. De estos resultados, y de otros datos disponibles, se desprende que la experiencia de Sri Lanka no responde al esquema clásico de régimen comercial orientado al mercado exterior que genera un gran número de puestos de trabajo. Se sostiene que los cambios de la política comercial no pueden contribuir por sí solos a mejorar los esquemas de absorción de mano de obra de las industrias.

Promoción de la pequeña industria en la India

S. Nanjundan

Desde la independencia de la India, los sucesivos gobiernos de este país han tratado de promover la pequeña industria como uno de los pilares de la política de desarrollo global del país. Para fomentar la pequeña industria se ha recurrido, sobre todo, a la promulgación de disposiciones relativas a la oferta, casi siempre de carácter prohibitivo, entre ellas las que reservan en exclusiva ciertas actividades a la producción en pequeña escala. En el documento se examinan los programas elaborados en materia de finanzas, parques industriales, servicios de extensión, investigación y capacitación técnica, comercialización y subcontratación, y desarrollo de la gestión empresarial. Se sostiene que esos programas rara vez han dado resultado. Es posible que la nueva política anunciada por el Gobierno en julio de 1991 resuelva algunos problemas previos, sobre todo, ofreciendo mayores posibilidades a la iniciativa empresarial.

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