SOCIO-ECONOMIC IMPLICATIONS OF NEW INFORMATION TECHNOLOGY

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A survey of current thinking on impacts, issues, and options in support of possible research activities

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FORWARD

John Page, Fritz Lechleuthner, and Loretta Hervey have set out to "survey current thinking on impacts, issues, and options in support of possible research activities". They have done that and more. *Socio-Economic Implications of New Information Technology* provides not only an exploration of the relevant literature and some guidelines for further, more detailed research, but also some stimulating insights into a host of issues raised by the communications revolution.

This Working Paper has a wide compass both in terms of coverage--from industrial opportunities to social challenges--and of treatment--from technical to philosophical. Its discussion of several issues are prescient, indeed. (See, for example, Section III - 1., particularly the passage on "Reduced Working Hours and Job-Sharing", a matter currently at the core of industrial conflict in many countries of Western Europe.)

To those like myself whose backgrounds have been influenced more by the pursuit of the liberal arts than quantitative analysis, the sections addressing Education and Learning (III - 4.) and Culture and Values (III - 5.) pose some troubling questions: To what extent is "information" displacing "knowledge" as a goal in education? To what extent is the demand for "computer literacy" crowding out the need for continuing or expanding more traditional (more relevant?) forms of literacy? In the "Information Society" what happens to the historians, the philosophers, the writers, and the poets? In short, will the Information Society be strong on What, but weak on Why and Whither?

Whether or not some of the issues raised in *Socio-Economic Implications of New Information Technology* are delved into further at IIASA or elsewhere, this paper, on its own, is a valuable contribution to the literature and will be read with profit by anyone concerned about the implications of the communications revolution.

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PREFACE

During the early months of 1983 a continuing program of policy-oriented conferences (The International Forum) was initiated at IIASA. One possibility for such a Forum was some aspect of the social and economic impacts of information technology; in order to provide a focus for defining the scope and content of a possible IIASA activity in this area, it was decided to carry out a brief preliminary reconnaisance to identify suitable topics.

It soon became apparent that the available material merited a more in-depth review of the socio-economic issues arising in the emerging information society and of the corresponding policies under discussion, in order to establish the directions in which IIASA might move. However, staff and program changes at IIASA rendered it impossible to complete a formal feasibility study at the Institute. Instead, the authors--encouraged by the interest of IIASA management in the results of the survey--continued on their own to review the material collected and to structure the findings about the issues on hand for further action. In the authors' view, the evidence collected and analyzed in this paper clearly justifies the relevance for IIASA of further work in this field.

A few words about the background of the authors of this paper will indicate their motivation for the study.

- *John Page*: after a career in operational research, science policy, and administration, he was appointed director of scientific information and education in what is now the European Space Agency, from which he retired in 1973; he served IIASA in several consultative capacities, including membership in the earlier Computer Science and Informatics Groups and more

recently as a researcher in the Information Technology Task of the Management and Technology Area.

- *Fritz Lechleuthner*: after fifteen years of management consulting with McKinsey and Company, Inc., he was the initial manager of the IIASA International Forum Program and in the process became personally interested in conducting research on the information society.
- *Loretta Hervey*: after completing an interdisciplinary program in public health and sociology at Columbia University, she served as a research assistant in an early IIASA project on Planning and Management of Regional Energy/Environment Systems and later as a member of IIASA's Publication Department.

The authors are indebted to Prof. Tibor Vasko for his kind permission to include his draft proposal for a study on the "Economic and Social Impacts of Modern Electronic Technology" as an appendix to this paper. It is provided here because it contributes an additional perspective on current thinking at IIASA.

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SOCIO-ECONOMIC IMPLICATIONS OF NEW INFORMATION TECHNOLOGY

John Page, Fritz Lechleuthner and Loretta Hervey

I. INTRODUCTION

The impact of the current diffusion of information technologies has been compared to the societal transformation accompanying the industrial revolution. In the view of observers like Daniel Bell, however, a crucial difference lies in man's current awareness that such a transformation is occurring, in his attempts to predict its long- and short-term consequences, and in the formulation of national policy responses.

> It is a rare moment in cultural history when we can self-consciously witness a large-scale social transformation. Few persons realized, when the industrial revolution was beginning, the impact of what was taking place... Today with our greater sensitivity to social consequences and the future... we are more alert to the possible imports of this technological and social change; and this is all to the good, for to the extent to which we are that sensitive, we can try [to] estimate the consequences and decide which policies we should choose, consonant with the values we have, in order to shape, accept, or even reject the alternative futures that are available to us (Bell 1980).

The "Information Society" of the Future

The complex of social and economic changes resulting from widespread application of new information technologies is often referred to as the "Information Society". This phrase, however, is just one way of labeling the series of rapidly developing economic and social changes which have emerged in varying degrees in both market-economy and socialist countries since the 1950s. Other labels which have been coined include "the post industrial society" and the "third wave". It seems reasonable to suggest that all these phrases refer to the same series of phenomena, starting perhaps from different points of entry, and emphasizing one aspect over others. The "information society" label focuses attention on what many believe to be a root cause of the phenomena we observe: the growth of electronics, computers and telecommunications, in a word, the microelectronics revolution.

If we were mainly concerned with the economic phenomena, we might interpret the same phenomena in terms of cycles of innovation or "long waves". If we were particularly interested in the changing lifestyles of the "third wave", we would take the microelectronics revolution as given, and discuss the new freedom it granted from the total work synchronization of industrial civilization. In this paper, the chosen point of entry is the effects of new information technology, but as will become clear when we discuss issues and impacts, the choice of entry does not seem to determine the shape of the landscape.

There is a large and growing volume of literature on the information society. Futurologists, social scientists, and technologists have focused on the forms a completely computerized society could take by the early twenty-first century. They have looked as well at shorter-term issues associated with the transition to this future--including employment, restructuring of the educational system, and the maintenance of national economic competitiveness. The scale of analysis ranges from the global to the individual enterprise, and methods are as varied as trend extrapolation, case studies, and econometric analysis. The diversity of approaches reflects the pervasiveness and diversity of the new information technologies themselves.

Views of the future. Masuda (1980) has traced the evolution of information technologies from post-World War II applications in national defense and space exploration programs to business and public service applications in the 1960s and 1970s, and finally to increasing use of personal computers hooked up to computer networks in the 1980s and beyond. Visions of the final product of this evolution--a completely computerized society--vary from the utopian to the deeply pessimistic.

Masuda looks forward to an age of "computopia" beginning in the early twenty-first century. In his "universal society of plenty", information and knowledge replace goods and services as primary societal products. Masuda predicts that the center of production will shift from the factory to the "global information utility"--a computer-based public infrastructure consisting of information networks and data banks, to which all citizens will have access. Freed from the need to labor for subsistence, man will have time for leisure, self-improvement and community activities; with the aid of the global information utility, education will be greatly expanded, accessible to all, without income, time and place restrictions.

Although Masuda points to the danger that computerized management systems and centralized data banks could become powerful instruments of social control, he is optimistic that changes in human values will curb this tendency. He believes that as information values replace material values, emphasis will be laid on the expansion of individual cognitive capabilities rather than material consumption, and competition will be replaced by cooperation.

In contrast, analysts such as Nora and Minc (1980) survey the future computerized society with less confidence. They agree that it will be highly productive and much less labor-intensive, but are unsure if society can adjust to the new work situation without conflict. They ask what will happen when work is no longer a central value underlying social organization, and whether the problem of distributing the tasks and rewards of the remaining work will produce confrontation between competing groups. They wonder as well if the varying ability of individuals to adjust to "processed" computerized language could exacerbate

social inequality. The title of the final chapter of Nora and Minc's book *The Computerization of Society*, "Will a Computerized Society Be a Society of Cultural Conflicts?", reflects these questions.

Shorter-term perspectives. Despite their differing views, both Masuda and Nora and Minc emphasize the element of choice in the form that the computerized information society will take. Japan's 1972 "Plan for the Information Society" is designed to move the nation toward Masuda's "computopia" by testing some of its components (including community communications information systems, regional remote control medical systems, computer-oriented education, and regional pollution prevention systems) (Masuda 1980). Nora and Minc's assessment of the impacts of information technology is explicitly presented as a spur to Government decision-makers to devise policies to avoid potentially negative socio-economic consequences.

Thus forward-looking perspectives on the information society should not, in our view, be regarded as deterministic models of the future. Policy issues now confronting decision makers are not concerned with how to get from a known present to a (more or less) defined future state. Instead we suggest that the shorter-term impacts and issues (to be reviewed in Section III) should be considered in the light of a transition towards a continuously evolving information society. Still, not all scenarios for the future are equally probable, and the longer term scenarios already discussed will provide guidelines for the analysis of shorter-term issues and policies, which in Daniel Bell's words, allow us to "shape, accept, or even reject the alternative futures available to us" (Bell 1980).

Today's Information Society

Whether or not "computopia" is cast as a faraway vision or a realizable future, there is a body of research describing, in quantitative terms, what may be regarded as the existing information society. Parker (1976) provided the key paper in this area, as he examined trends in the distribution of the US labor force, in the composition of the national income, and in personal consumption. The best-known section of his analysis

concerns changes in labor force composition. Following Porat's scheme (1974), Parker adds a forth category to the traditional division of employment into the agriculture, industrial, and service sectors--namely the "information sector", consisting of all employees in the original three sectors whose main activity is associated with information processing. This new aggregation showed that in the mid-70s, the predominance of the service sector was declining; in turn, the information sector was rapidly taking over as the main constituent of employment. These findings were relatively insensitive to the use of conservative or liberal assumptions in the classification of occupations.

The conclusion that perhaps more than half the total labor force in the United States is employed in the information sector has since been confirmed and extended by other authors--for example, Porat and Rubin (1977) and Rubin and Sapp (1981). In their analyses it is important to distinguish between the "information sector" and the "service sector". Previous work clearly demonstrated simultaneous growth in the service sector and decline in the agricultural sector and, later, in the industrial sector. When the information sector was separated out as a new component, it became clear that the service sector had in fact begun to decline as a result of the replacement of personal services by information-related services.

These trends in labor distribution are paralleled by similar trends in distribution of US national income and personal consumption. Parker therefore seems justified in concluding that if a society may be characterized by its predominant areas of work, economic activity and personal consumption, then indeed we are already living in an information society. The continued rapid growth in the information sector was evidenced by Strassmann (1982), in his examination of the US market for such products as office automation equipment and personal computers. He states that in 1981 the total market amounted to 9,850,000 units, projected to rise to 40,700,000 by 1986.

Parker (1976) points out that the information society has important qualitative, as well as quantitative characteristics. Machines which significantly enhance and extend man's information processing capability could potentially offer new possibilities of economic growth independent of finite physical and energy resources. But in order for the information society to develop in directions favoring human values, structural and institutional adaptation may be required. For this reason implementation of effective policies in the next few decades is crucial.

IIASA Activities in the Field of Information Technology

Earlier IIASA work in the area of information technology was executed largely within the province of the "Impact of Information Technology Task", initiated in 1980 and drawing on previous IIASA studies involving computers and management, and informatics. Over a period of five years, the "Impact of Information Technology Task" aimed to identify significant applications of information technology, and then to assess their present and future impacts in such areas as work patterns, demands for education and vocational training, and lifestyle. Its ultimate objectives were to provide input to the process of developing policies to minimize the drawbacks and maximize the benefits of information technologies.

In practice, only a beginning could be made on the planned work due to budgetary constraints and organizational changes. During the early 1980s studies were carried out on six applications of information and telecommunication technologies, and preliminary assessments were made of several discrete socio-economic issues.

In the applications sphere Bararie, Fick and Lee focused on artificial intelligence and on decision support systems as a methodology for associating computers with the solution of management problems. Page undertook work on electronic text transfer and electronic publishing, from the point of view of policies for professional information transfer. Sebestyen surveyed remote data processing facilities and procedures in several Eastern European countries. In addition, Page discussed the potential of broadband satellite communications for scientific and technical exchange. Sebestyen looked at the use of teleconferencing in an

international environment and, with Maurer and Rauch, investigated existing and future applications of videotex as a new information medium.

In regard to socio-economic issues, the original research planning had foreseen in-depth studies as a second phase of the overall information technology project. With available resources, it proved possible to undertake only preliminary work in the selected areas. Merians and Sugiyama provided overviews of general issues, while Vasko focused specifically on telecommunications policy. Cifersky, Costello, and Lee looked at the roles of computers in organizations. Page undertook studies on applications of information technology to respond to developing countries' problems. As well, energy and resource consumption associated with new information technologies were researched by Maurer, Sebestyen, and Rauch. Papers were prepared on certain employment implications of information technologies by Dell'Mour, Fleissner, and Sint, and by Goldberg. Costello made a contribution in the area of training and employment policy. Finally, Sebestyen, as well as Stadler and Herzog, dealt with questions of transborder data flows and data protection.

Titles of papers and other contributions describing the work outlined above are listed by topic in Appendix I. It is to be hoped that any future IIASA activity in the area of information technology would build on this substantial body of work.

The Need for Research

The socio-economic impacts of information technology are a subject of concern to reseachers, practitioners, and the political world itself. In fact, such prominent personalities as the late President Andropov, President Mitterand, and Prime Minister Thatcher have all made key policy statements underlining the necessity to optimize the application of information technology in their countries. The need to develop effective policies at the industrial and Governmental levels to deal with the issues (and opportunities) of the emergent information society suggests a consequent requirement for analysis and research. Even a cursory look at

some issues policy makers face in such areas as employment and the organization of work, industrial development, education and retraining, and public investment in information technology infrastructure indicates a level of complexity making it difficult to identify practical policy options. Indeed, some policy issues are concerned with questions of social or cultural values, rather than more objectively perceived factors.

Apart from the complexity of these matters, it appears that events--in the shape of actual impacts of new information technology--are beginning to move so rapidly that individual *ad hoc* policies are becoming increasingly inadequate for dealing with real situations by the time such policies are ready for implementation. While research itself cannot provide automatic solutions, it seems that a carefully co-ordinated effort in policy-oriented research, taking into account impacts at the enterprise, national, and international levels, could provide a much needed background against which practical policies could be devised and implemented by concerned authorities.

The Role of the Present Survey

Following a background discussion of the nature of information technologies in Section II, current perceptions of short or medium-term impacts and issues associated with the future evolution of the information society are surveyed in Section III. A criticism which may not be side-stepped is that the "information society" and its socio-economic implications are subjects far too broad to tackle. Yet a preliminary review of perceived impacts and issues is a task facing every policy-maker attempting to frame national responses to the diffusion of information technologies. As well, a wide-ranging review of issues may serve to identify areas where IIASA could contribute to the policy-making process, and to identify topics on which the Institute could undertake original research. A summary of possible topics is provided in Section IV of this report.

II. INFORMATION TECHNOLOGY, APPLICATIONS AND SOCIETY

The potential threats and benefits inherent in changes resulting from the new information technologies have been articulated in countless papers and scholarly exchanges. Study of its influence on society has been typically approached from a technological perspective. That is, the likely developments of a given technology were projected and its probable social impacts were then derived. Or, more creatively, various future forms of a technology were conceived with subsequent attempts to assess the beneficial and harmful effects of each on society.

Both approaches have increasingly been rejected as too deterministic and, in the face of actual experience, often wrong (see Godet 1983a and 1983b). Instead, scholars have concluded that "the focus should not be on the technology itself, but on the social policy options and the probable consequences of those policy choices ... We should focus our attention on social problems and institutional analysis in order to keep the technology in appropriate perspective" (Parker 1976). However, since we shall later be discussing issues which policy makers and the public are facing in the evolution towards the future information society, it is as well to indicate broadly the technologies with which we are concerned and to relate these to applications having or likely to have socio-economic impacts.

The Technologies

According to Sugiyama (1982), the technological basis of the information society may be viewed as having three main elements:

- *Communication technology* (for transmitting and receiving information)
- *Computer technology* (for processing, storing and retrieving information)
- *Control technology* (for guiding operational processes through the use of information)

The continued rapid growth in all three technologies does not need stressing, but it may be noted that an equally important factor is that many novel, highly significant applications are offspring of the marriage of two or more of the above technologies. For example, the development of computer time sharing on the one hand and computer control of telecommunications (packet switching) techniques on the other, made possible such applications as electronic fund transfer and airline reservation systems. Another combination of computer and communications technology (in the shape of TV) resulted in videotex. In the immediate future, broadcast satellite systems, combined with computerized text and image processing, will find immediate application in the direct transfer of broadband digital data, information and pictorial images from source to individual user. This will add a challenging new dimension to the transborder data flow problem.

The Applications

Masuda (1980) suggested that applications of computerization could be considered as occurring on three levels: a local scale, a national or regional scale, and finally a global scale. For any particular application the three different levels could also be considered sequentially--local applications would normally precede national applications, and the latter would precede global applications. Thus different applications would not necessarily be at the same stage at any particular point in time. Masuda suggests, for example, that at the second level, communications features are added to the products of computer technology to create "telematics", while satellite communication is added to telematics to reach the third level. He also groups applications into four classes: those directed towards science, business, the public, and the individual. This seems a convenient framework in which to list applications in a perspective relevant to societal impacts and implications.

LEVEL I - Stand Alone Systems

Science. Scientific computation in, e.g., space research, high energy physics, radio astronomy, etc.

Business. Inventory, stock control, payroll systems, process control and management information systems, etc.

Public. Social security and health records, library systems including simple information retrieval, computer-assisted training and education.

Individual. Electronic calculators, electronic games, personal computers.

LEVEL II - Computer plus Telecommunications (Telematics)

Science. Computer networking for joint database creation and use, distributed processing, electronic invisible colleges, networked early warning systems.

Business. Electronic fund transfer, credit checking and electronic banking, airline and hotel reservation systems, commercial time-sharing operations, coordination of management information in geographically dispersed enterprises, locally interconnected all-electronic offices.

Public. On-line information retrieval information systems accessible to all, electronic mail, integrated urban traffic control, regionally-integrated air traffic control, remote systems for medical diagnosis and treatment, electronic publishing and full-text transfer, use of TV and computer networks for education, etc.

Individual. All forms of video text services (information, electronic shopping, electronic mail order, etc.), cable TV and other individual manifestations of the "wired city".

LEVEL III - Global Teleinformatics Plus Broadband Facilities

Science. Real-time delivery of data from high energy physics experiments, relay communication satellites for onboard data handling for earth resources satellites, etc.

Business. Integrated voice data facsimile and TV teleconferencing facilities for international business, interconnected all-electronic offices.

Public. Intercontinental text transfer, regional educational satellite systems (e.g., PEACESAT for the Pacific Ocean region), TV broadcast by satellite directly to domestic TV sets on an intercontinental scale, etc.

Individual. A global information utility.

In practice, there will be other applications, particularly in Level III, which cannot now be foreseen. It should also be noted that technological development in the specific areas of robotics and computers may produce applications of information technology not listed above. For example, robotized factories (already far advanced), practical applications of artificial intelligence, and the successful development of a "thinking machine" in the shape of the fifth generation computer would have far-reaching consequences worth close observation.

Society and Technology

Returning to a sociological, rather than technological perspective, one must note the absence of successful attempts to provide a systematic methodology describing the complex relations between technology, particularly information technology, and society. At IIASA, one such effort resulted in a "Framework for Information Technology-based Innovation" (Sugiyama 1982). Sugiyama's paper points to the importance of information as a resource, comparable to material and energy. It then describes technological innovations, arriving at four broad categories of "impacts on society": economic, social, political, and cultural.

Apart from the problem of semantics, groupings of this kind are largely a product of the author's imagination and conventional thinking. There is no way to prove exhaustive coverage, mutual exclusivity, or uniform levels of conceptualization. Unfortunately, similar deficiencies occur in other, often excellent, materials. For example, Parker (1976) provides his own particular "list" of economic questions, social issues, application areas, and (shorter-term) policy questions. Also, in their report about the 1982 Conference on the "Information Society", the FAST editors encountered similar problems in their attempt to provide systematic coverage (Bjorn-Anderson 1982).

The FAST editors explain that they are unable to offer a comprehensive, systematic model of the society/information technology interplay in all its facets. Nevertheless, the information society develops ceaselessly. Bold experiments are underway in many countries, rules and regulations are being devised, and policy matters are dealt with on the basis of whatever advice, insight, or instinct is available.

III. IMPACTS AND ISSUES

It has been stated "that even scientists render their work coherent, progressive and manageable by embodying shared social/intellectual filters in their disciplines. These socially buttressed frameworks determine what are relevant and important goals and questions, what are valid techniques and explanatory systems, and what counts as relevant and meaningful information" (Wynn and Otway 1982). This recognition underlies our attempt in this section to break down and organize various articulations of concern into packages suitable for descriptive treatment in this survey and for subsequent evaluation in future research.

Our choice has been a grouping of seven broadly defined issue areas for which we have assembled relevant ideas concerning the implications of the new information technologies. A first glance at the list will make it obvious that the issue areas are not mutually exclusive; rather each represents a point of departure from which several phenomena and changes in society could be seen and analyzed.

The seven issue areas are the following:

1. Work and Employment
2. Business and Management
3. Developing Countries: Challenges and Opportunities
4. Education and Learning
5. Culture and Values
6. International Regulation for Social Benefit
7. The Economic Value of Information

I. Work and Employment

That the penetration of information technologies in the industrial and service sectors will have an enormous impact on the numbers and types of jobs available is generally accepted. According to Rada (1980), a consultant to the International Labour Organisation, "the argument is not whether jobs will be lost, but whether other jobs will be created elsewhere. This question is debatable and and the answers are largely a metter of speculation".

In the industrial sector, the large-scale introduction of robots is expected to rapidly eliminate jobs in machine shops and assembly lines. Though national level projections are lacking in the literature surveyed, quantitative estimates of job losses have been made at the enterprise level in several cases. For example, General Electric's plans to introduce up to 1000 robots in its appliance plants between 1980 and 1990 are expected to result in the replacement of 50% of its 37,000 assembly line workers (Norman 1980). In Norman's view, "jobless growth" increasingly characterizes many manufacturing industries, as productivity per hour improves while staffing is reduced. He cites a study undertaken in the Federal Republic of Germany which indicates that employment among printers decreased by 21.3% between 1970 and 1977, while productivity per hour increased by 43.5%.

Although declining employment opportunities in industry have been offset until now by expansion of the service sector, many observers doubt that this compensation will continue. Norman refers to predictions that "the most far-reaching impacts of micro-processors will be felt in offices and in such service activities as retailing and maintenance work." He suggests that "in most areas of the tertiary sector, micro-electronics is likely to lead to slower rates of employment growth and even to job losses". Rada concurs that "in the short run, in developed countries, the information revolution will have much the greatest socio-economic effect through the automation of offices". He cites a study which predicts that automation could eliminate as many as 2 million of the 5 million existing secretarial jobs in the Federal Republic of Germany. Similarly, Norman points to French study findings indicating that as many as 30% of jobs in banks and insurance companies could be eliminated by computers by 1990.

But both investigators emphasize the difficulty of accurately forecasting the dimensions of computer-induced job displacement in the service sector at this point in time. According to Rada, "the full consequences on employment will be felt only on completion of the new investment cycle in manufacturing and services... full-scale development of office automation, for instance, is expected to take place in the 1980s". Norman agrees that "the full impact of the flood of new office technology will only be felt when the machines are linked in far-flung networks through which information is transported, stored and processed".

In parallel to their discussion of information technology-induced job losses, labor market analysts have identified a number of strong growth sectors, both in manufacturing and services. Expanded production of computers and electronic equipment of other types (including games) is expected to create substantial numbers of new jobs in industry. At the same time, increased interest in tourism and entertainment as well as growing needs for health, education and social services are predicted to spur new job opportunities in the tertiary sector.

In the face of these diverse trends, and given the paucity of hard data, the net impact of new information technologies on the availability of jobs remains unclear. In Rada's words, "a comprehensive framework and explanatory variables which would assist in an assessment of particular technological developments is not available." Like other investigators, he identifies a need for cooperative research and open debate.

Despite uncertainties about the ultimate impact of information technologies on the labor market, there is widespread agreement that action policies are needed urgently to deal with short- and medium-term labor displacement. In the opinion of Norman, "the transition to the electronic age will ... require policies to deal with technological unemployment in addition to those that support high-technology industries. Simply hoping that the unemployment problem will disappear in the white heat of technological revolution does not constitute a viable employment policy in a period of relatively show growth and rapid technological change".

The literature surveyed suggested three types of employment policies under discussion or implemented to varying degrees in industrialized countries: reduction of working time and work sharing, government support for expansion of high-technology businesses, and creation of new employment opportunities in the service sector. A fourth policy, execution of large-scale retraining programs, is discussed in another section of this paper.

Reduced working hours and job-sharing. As formulated by Norman, "the time may have come to consider how to share work in a high-productivity society", to permit "lighter workloads and higher living standards for many", rather than "higher profits and earnings for a few". Mechanisms suggested for achieving more equitable sharing of available work include a shorter working week, longer vacations, sabbaticals, and reduced opportunities for overtime.

The advantages of such strategies are that they would reduce unemployment at least on the short-run, and would avoid sudden extreme reductions in work availability for individuals. Arguments against the shortening of working hours include increases in labor costs with

associated inflationary effects, damaging of international competitiveness, the uncertain practicality of enforcing statutory provisions and international agreements on standardized working hours, and possibly detrimental effects on Third World development.

But despite uncertainty about its effectiveness as an employment policy, many observers regard the progressive shortening of working hours as inevitable. As Rada has noted, "the evidence seems to suggest the beginning (or for some the continuation) of a shift from a society with unemployment to one in which increased leisure is regarded as normal". Mitterand, in his 1982 speech before the Versailles summit, agreed that "the rapid substitution of new jobs for old ... will be accompanied by a profound evolution in the content of work and its organization. It will give another meaning to the shortening of work-time".

The prospect of increased sharing of available work itself raises a host of questions concerning organization and personal adjustment. Rathenau (1982), a Swedish expert in information technology policy, states "how to distribute work among people, but also how to distribute work, study, and recreation over the duration of a person's life, how to find the link-up between wages and needs ... these are so many problems demanding radical solutions in the foreseeable future". Mitterand (1982) emphasizes similarly the "need for research on the organization of work... the effects of new technologies on the length of work and its possible reduction".

Government support for expansion of high-technology businesses. Although deferring the introduction of new technology is sometimes suggested as a means for circumventing unemployment, most analysts concur that such a policy would seriously harm a nation's competitive strength in the world market, would result in the loss of certain manufacturing activities to other countries, and would prevent the labor force from benefiting from job creation in the micro-electronics sector. For these reasons, world leaders have soundly rejected this option, calling instead for government investments in micro-electronic technology and for the support of demand to promote the development of markets for new goods and services. Mitterand stated at the Versailles summit,

"We must respond to the technological revolution by encouraging industrial investments in the private and public sectors". Johannson (1982), a Swedish analyst, has noted that OECD countries have shown general agreement on the need to subsidize R&D and initiate public procurement policies favorable to the diffusion of micro-electronic products.

Norman noted in 1980 that the government of the Federal Republic of Germany is investing about 25 million dollars per year into R&D projects in support of the computer industry. Similar investment strategies have been documented for France, Japan and the USA. Prime Minister Thatcher of the United Kingdom has stressed the need to promote competition between firms in the micro-electronics sector, noting that British Government policy is to put nationalized industries into private hands, and to break up monopolies (Thatcher 1982).

Creation of employment in the service sector. As noted above, several analysts feel that creation of new employment opportunities in the service sector can compensate for job losses in other areas caused by the diffusion of information technologies. Trends which could lead to an expansion of jobs in the service sector include (1) the aging of populations, associated with increased need for labor-intensive health and social services; (2) increasing amounts of leisure time and rapid turnover in technologies, creating a desire and need for continuing education; (3) rapid social change, including increasing unemployment and divorce, associated with a need for counselling services of all kinds; (4) the possibility of a backlash reaction to the widespread diffusion of information technologies, producing a demand for more human contact in activities of daily living; and (5) the demand for specialized personnel such as programmers and electronic engineers in the information technology branch itself. As well, Rostow (1983) has noted that a great backlog has evolved in recent years in regard to the renovation of public service infrastructure. The broadest view of the potential of the service sector as a source of jobs is provided by Strassman (1982). He describes a framework for a new social economy based on new services, pointing to the opportunity for expansion of operating personnel who can deliver services tailored to the needs of clients.

2. Business and Management

Business enterprises and prevailing management practices have been praised and blamed--by varying constituencies--as both the cause of, and the cure for, many of the "problems" and "benefits" associated with the new information technology. Millions of jobs and billions in equipment have been or will be rendered obsolete and uncompetitive by the new technology, at a rate and on a scale never before encountered. At the same time, technical breakthroughs and marketing successes in the information technology sphere have created millions of new jobs and hope for increasing levels of societal wealth in the future (Masuda 1980, Strassman 1982).

Traditional management practices have themselves come under scrutiny and are changing as new "info-technical" possibilities become more widely available. Thus, as a cause, a cure, and a case in point, the issues surrounding the impacts of new information technologies on the "business community" are pervasive--as numerable as the variables which can be used to describe business institutions and managerial actions and as varied as existing views about the roles of businesses, entrepreneurs, and managers in an economy.

Growth of informatics as an industry. One question which must be raised at the outset is whether the development of the informatics industry is following patterns set earlier by other industries. If this seems to be the case, retrospective study of the behavior of emerging industries could provide insights about strategies for supporting and guiding the information technology industry. If the development of this industry is an unprecedented phenomenon, however, policy formulation becomes the more uncertain.

One may identify a number of intriguing features characterizing the evolution of the informatics industry. First, there is the dramatic shift in the importance and value of hardware relative to software, with some software products costing nearly as much as the computers on which they are run. Secondly, a tremendous range of labor and capital intensities are found in subsectors of the informatics industry; the capital

investments needed to develop microchips may be contrasted with the demand for labor to execute such tasks as data input. This range is reflected in the varied composion of the labor force working in the informatics industry: highly skilled persons are required for software programming, while minimally trained persons can handle data entry tasks.

One must also take note of the range in the scale of activities undertaken in the informatics branch. The capital intensity of hardware technology has produced the "bigger is better" approach taken by mainframe producers. In the case of production of communications equipment, aggregation into large industrial units has been a national practice for many years, due in part to the preference of national telecom administrators for single source equipment supply arrangements. However, analysts have noted that a "bigger is better" philosophy acts to curb innovation in the communications equipment sector. In recent years, new products in the areas of peripherals, personal computers, games, and other devices have shown the market potential for innovative small-scale ventures. Mitterand (1982) has concluded that "technical innovation essentially remains the achievement of small and medium-sized firms".

Attention must also be focused on increasing trends toward technical convergence of hardware products. The emergence of "telematics" has begun to blur the distinction between the communications equipment industry and the computer industry. It will also become increasingly difficult to draw the line between the production of machine tools and robotics. In some cases such structural changes are spurring competition between subsectors; for instance, following the break-up of AT&T, the residual company is joining forces with Olivetti in an attempt to compete with IBM and the Japanese.

Another feature of the informatics industry is the variation in industrial norms at the enterprise, national, and international levels. Rada (1980) stresses the multi-national, even global, effort needed to ensure coherent guiding principles for the emergent global information society, both in terms of infrastructure and operations. Development of a joint industrial policy among Western European countries--to permit

successful competition with Japanese and American electronics/communications industries and to reverse their position as net importers of technology--is the *raison d'entre* of such efforts as the FAST program. Yet, some authorities believe that achievement of industrial convergence on a continental scale will prove insufficient in the future; in their opinion, even larger units will have to cooperate to carry out the research and development necessary to operationalize the fifth generation computer concept. A salient issue in this context is to identify the level of aggregation at which policies should be formulated (global, regional, international) and to determine how high-level policy measures can be implemented while ensuring fair corporate behavior by the participants in a global industrial effort, as well as to provide an adequate level of public control.

The friction between the perceived need for international cooperation and the desire for national self-sufficiency also emerges from the current discussion about the informatics industry. Many governments consider it essential to maintain a national capability in every sector of the economy, and thus support domestic information technology industries to assure that they remain competitive in the international market. In this context, self-sufficiency in information products is treated as a matter of national security. Some decision makers, however, consider that isolationist approaches create a wasteful duplication of effort. They strive to develop workable international agreements to reduce international confrontation in the sphere of informatics systems.

Effects of the penetration of information technology at the enterprise level. Investigators such as R.M. Lee (1983) and Wynne and Otway (1982) have examined new forms for and limits of applying information technology in bureaucracies and other managerial settings. One argument is that there will be more "power" for middle management in a decentralized, yet electronically interconnected mode of operation. A countervailing view is that use of new information technologies will strengthen the position of managers at the center.

Clearly, employees' access to a central source of information will change the corporate environment, in terms of power and hierarchy. It is possible that a greater amount of teamwork will emerge, with a horizontal (rather than hierarchical) structure organized around the access to a common source of information.

Strassman foresees significant improvements in administrative productivity through task simplification (or elimination) in a quantitative sense and enhancement of value added of enterprise activities in a qualitative sense. If new office technology is used to transform organizational processes rather than just to mechanize existing office procedures, employees' work will take on new significance; departments' missions will change, with more value being placed on customer service and greater responsiveness being introduced into smaller units of service delivery. In Strassman's view, introduction of information technology could permit the lagging service sector of the economy to achieve new levels of productivity and wealth creation.

According to Strassman, however, new conventions on cost accounting and investment evaluation will be required for such redirection of managerial priorities. Increased attention will also have to be given to individual learning and to adaptation to changes in power and the organization of information. The receptivity of management and workers to new information technologies and the creation of management structures responsive to the new technologies thus become major issues at the enterprise level.

3. Developing Countries: Challenges and Opportunities

We can consider the impacts of information technology on developing countries from two points of view, the strategic and the tactical. The strategic is mainly concerned with changes in the North-South situation likely to be induced by the spread of information technology, particularly its concentration in the industrialized countries. On the tactical level, it is necessary to consider how information technology can actively assist the development process.

Strategic impacts. Certain developing countries have hitherto found it profitable to undertake the manufacture of electronic components for export, thus providing new employment possibilities for semi-skilled labor at costs which cannot be matched in the industrialized countries. This is perhaps a special case of a more general pattern of trade between North and South: the North tends to export certain types of jobs to the South, and to import finished or semi-finished products; this supplies the South with foreign exchange to pay for needed imports of capital goods, equipment, and other goods. As the possibilities and extent of production automation develop in industrialized countries, however, the competitive advantage of developing countries' lower labor costs could be reduced. In one sense, therefore, factory automation could result in a loss of jobs in both industrialized and developing countries, and at the same time push the balance of trade against developing countries, reinforcing a trend which may harm both. Both Mitterand (1982) and Rostow (1983), from their different standpoints, come to the same conclusion: the application of information technology as an innovative force in industrialized societies requires an increase in the funding of development in the developing countries, both internationally and bilaterally.

Rada (1980) stresses that the concentration of the electronics industry in the industrialized countries serves only to reinforce the existing imbalance of trade and the industrialized countries' lead in the application of science and technology. Electronics apparently account for over 30% of manufactured goods exported from the developing countries, but it is often claimed that, as such countries are merely one link in a chain of a process of distributed manufacture controlled by multinational corporations, they have no influence on the operation as a whole; their contribution to the finished product does little to assist development of their own industry. Indeed, as already noted, once the cost of process automation falls to levels matching the labor costs in the processing country, automation is applied in the industrial-country point of the production chain, not at the developing country end. Thus the developing countries lose not only their export earnings but also the possibility of applying any new know-how.

These impacts suggest that policies and strategies for broad-based technical assistance and development-aid programs could be formulated at both the bilateral and international levels. However, there seems to be little sign of agreement on the form, scope, and content of such North-South programs.

Rada (1980) notes policy trends in the developing countries themselves in respect to computer technology. The countries mentioned (Argentina, Chile, Brazil, and India) are at the richer end of the development spectrum and the policies mainly concern the relaxation or imposition of import controls either to stimulate certain types of computerization, or to favor the development of a home EDP industry. For instance, India has developed elaborate policies and regulations governing the purchase and use of computers: there is a home industry and foreign investment in it is regulated. Rada considers that other developing countries will wish to adopt the Indian pattern of regulating both markets and use.

Tactical issues. From a tactical viewpoint, a key question is how to apply existing information resources to the development process itself and how to identify and develop the necessary kinds of information, if they do not already exist. Page (1982) has reviewed some existing information transfer technologies in the light of their applicability to the general requirements for professional information in developing countries. While access to scientific, technical, medical, economic, and other databases and databanks offered by on-line information services is important in industrialized countries, much of the material is irrelevant to developing countries' problems. Existing mini- and micro-computer techniques would, however, facilitate the development and operation of simple, cheap, and easy-to-use information systems. This would often include local information, not readily accessible by other means but highly relevant to development needs. New mass storage systems developed for electronic office applications in industrialized countries are very suitable for providing access to full text information. A mainframe computer is not needed to process the material contained by the storage systems and they are therefore suitable as vehicles for the

distribution of full texts to local information systems for local retrieval, a convenient way of improving South-South cooperation.

In this respect, the need for better and cheaper telecommunications as a basis for cooperation and information exchange, both on a North-South and a South-South basis has often been stressed. Regional communication satellites, working with smaller local research stations are now state-of-the-art: these make it unnecessary for developing countries and regions to repeat the development of a complex, costly and difficult-to-maintain terrestrial telecommunications infrastructure such has been built up over the last century in industrialized regions.

There are economic, political, and structural obstacles to the application of these technologies. Their identification and further study to suggest practical policies is a primary issue. In the field of improved telecommunications facilities and the use of regional satellites, for example, the problems are mainly political and economic (how can the infrastructure be financed?), but also regulatory. Current international regulatory and tariff machinery may be more suited to the operations of telecommunications administrations in industrialized countries than to the different priorities in accelerating the pace of development through telecommunications in the South.

4. Education and Learning

New educational media. As many commentators note, new educational hardware and software--including home computers, video cassette courses, and innumerable forms of programmed instruction--will vastly extend education opportunities outside the formal school system. Rada (1980) can imagine a "sort of 'knowledge factory' producing kits in a variety of disciplines". Individuals who obtain the new products will be able to receive instruction at virtually any location, at any time, in any field, and at any pace they wish. Concurrently, changes in the locus and mode of instruction are expected to affect the roles of teachers. Although Nora and Minc (1980) do not foresee that the new media will replace teachers entirely, they speculate that "specialization will fade

away and levels of teaching will become diversified... education will see its function distilled to one of coordination".

New demands for education and training. There is consensus that in addition to these structural impacts, advances in information technology will necessitate a great increase in educational activity--an increase associated with retraining as a response to unemployment, with the need for continuing education to keep abreast with technological progress, and with expanded interest in education as a leisure-time activity. As the Swedish Minister for Civil Service Affairs and Chairman of the Swedish Data Policy Commission notes, "the need for massive investment in education and training ... is a point on which all parties are in agreement" (Johannson 1982). Mitterand, addressing the Versailles Summit Conference in June 1982, called for an "immense" training effort, to enable all sectors of the population to operate in a world transformed by information technology.

The potential effects of information technology on modes of instruction and on the volume of educational activity will confront decision-makers with a plethora of issues during the 1980s. One central concern is the quality of education. Stressing positive features, Nora and Minc (1980) suggest that "computers will enable students to deal with complex problems that are closer to reality" by permitting complex statistical analyses and large-scale simulations. On the negative side, Johannson (1982) has asked if the new education media might not instead "condition youth toward learning as entertainment, unsuitable for serious academic work".

A second issue arises from the question of access to the new educational tools; if self-instruction outside the public school system assumes increasing importance, persons lacking prerequisite economic resources will be severely disadvantaged--not only in obtaining a basic education, but in learning vital vocational skills. Yet another issue concerns modes of pedagogical training, both in terms of the substantive knowledge that teachers will have to master and their orientation to new professional roles.

Organization of training facilities on a very large scale raises another cluster of issues. One must ask, for instance, how the volume and types of training requirements can be forecast. How should a new education infrastructure be designed to provide the services? How can these be financed and staffed? A crucial determinant of education and training programs would seem to be the future structure of the labour market. There is a need for analysts focusing on structural unemployment and new employment opportunities to explicitly link their projections to education and training needs.

Evidence collected thus far on national education policies indicates that while many Governments are introducing new education and training programs, these are generally on a small scale. Concerted efforts to introduce computers in secondary schools are evidenced by French Government plans to install about 10,000 micro-computers in schools by 1984 (Norman 1980). Similarly, the UK initiated a "Micros in Schools" scheme which aimed to place a micro-computer in every secondary school by the end of 1983 (Thatcher 1982).

As well, innovative vocational training programs are being implemented in several countries. As one example, Prime Minister Thatcher has described ten new 4-year courses of technical and vocational training, "directly related to the needs of firms", which currently serve about 10,000 14-18 year-old youths in the UK. The UK has also established, in cooperation with private industry, 40 Information Technology Centers, to train unemployed young people in computer technology and electronics (Thatcher 1982).

In the U.S.A. the private sector appears to be quickly responding to the demand for technological training. A new column headed "Career Training" has appeared on the classified pages of U.S. newspapers. Through this medium, private institutes offer "electronics career training", including instruction in programming, data processing, and word processing. For children, summer "computer camps" have sprung into existence over the past five years and now include boarding as well as day camps (Gilpin 1983).

Many commentators have called attention to the obstacles hindering large-scale introduction of new education and training programs. In Sweden, Johannson (1982) points to a severe shortage of qualified teachers. An additional factor may be student opposition to new Government policies for higher education, as illustrated by student protests in France (*International Herald Tribune*, 10 May 1983).

What policy makers agree upon is the "massiveness" of the retraining effort needed. What seems to be lacking is movement from the exhortation to the planning stage, from the pilot to the full-scale programme level. Also agreed is the need to produce qualified teachers for such programs as a first priority, and to ensure that all sectors of the population have access to training opportunities. Mitterand voiced each of these concerns during his 1982 address at the Versailles Summit, as he urged all Government representatives present to install "a very large training apparatus" in each of their countries, with priorities for training engineers and technicians, the young unemployed, and workers needing to master new technologies during their careers (Mitterand 1982). The design and dimensions of such an apparatus remain, however, to be specified.

5. Culture and Values

The almost universal adoption of the automobile as a means of personal transport in many industrialized countries and the parallel heavy national investment in improved road systems during the last thirty years have been a major factor contributing both to the growth of suburbia (and a change in life style), and to the decay of inner-city life. The extension of new information technologies into the workplace, the home, and in the social environment generally may still further accelerate this social decentralization. However, it has also been suggested that the new information technology could help to break the isolation of life in the countryside and to bring new possibilities of employment through "electronic cottages" (Toffler 1980).

From another point of view, steps to establish an information utility available to all who are not "computer-illiterate" would perhaps reduce the need for physical mobility, and also perhaps have a negative effect on community life. Godet (1983) points out that the microelectronics revolution might alternatively reinforce centralization and social control: computerization may lead to greater social inequality, leaving a "Lumpenproletariat" excluded from its benefits by economic or cultural inability to cope with the EDP environment. If Masuda's conception of computopia turns out to be a purely middle-class phenomenon, the transition to it might result in social breakdown.

Discussing the impacts of new information technologies on urban civilization, Mitterand (1982) concluded that these impacts were poorly understood, and indeed, it seems that rather little attention has been paid to them in the literature. By analogy with the lifestyle and urbanization consequences of the post-war explosive growth of the automobile and highway sectors, the development of public policy in time to have some influence on the outcome would seem to require greater current emphasis on research.

Cultural uniformity. Mitterand (1982) has pointed out that a negative consequence of some of the current aspects of information technology is the tendency to reduce the possibilities for cultural diversity. He notes that in Western industrialized countries almost all the television broadcasting stations are supplied with their material by only two primary sources, and five international news agencies supply more than three-quarters of the press information. Extrapolating these tendencies, Mitterand concludes that they could lead to control of the world's communications industry by about twenty firms by the end of the present century.

Within the overall issue of reversing the trend towards cultural uniformity, some specific issues may be isolated. For example, direct television broadcast satellites are now a reality: these radiate a TV signal (or a broadband data signal) sufficiently powerful to be picked up by simple rooftop antennas feeding domestic-quality TV receivers, either direct or via a local cable system. Such satellites can cover large regions, for

example the entire Mediterranean basin, so that individual countries would no longer have the possibility of exercising some sort of control over their citizens' exposure to TV programs except by banning the sale or distribution of suitable antennas and receivers. Aside from the tricky problems of propaganda and "cultural imperialism" engendered by these developments, there are policy issues to be faced by national and regional broadcasting agencies and authorities in collaborative actions to optimize the use of such new facilities, while ensuring that national TV facilities and national susceptibilities are not harmed. Thus, the issue has not only technical and political dimensions, but also economic aspects. One may ask how many TV channels can be economically supported in the German-speaking region of Central Europe and how these channels should be allocated between national and transnational facilities.

6. International Regulation for Social Benefit

Numerous issues may be identified concerning the degree to which society can and should regulate the aggregation, flow and access to computerized information and data. While in one sense these problems are by no means new, computerization has added two new dimensions. First, the quantity of data and information which may be stored, and the ability of the computer to manipulate them, result in new possibilities both socially beneficient (e.g., world weather-watch data) and potentially anti-social (unified personal records being used for criminal purposes). Second, the possibilities given by the very rapid and difficult-to-detect transfer of information between distant EDP machines provide a geographical and time dimension to benefits and disbenefits of information flow several orders of magnitude greater than when information and data had to be physically conveyed from one place to another. Many of these issues are of course of concern in many countries and in the international community generally, in particular in the UN and the OECD. They are briefly summarized below.

Ownership of data. While it is generally held that data, whether in a physical or electronic manifestation, belongs to the compiler of that data, there may be some legal constraints to ownership if, for example, the data have been illegally acquired. Some would argue that if the data are descriptive of an individual or some other legal entity, that entity should have rights in it. An oft-quoted example is that of earth resources data collected by remote sensing satellites: from a strictly legalistic point of view, the data are clearly the property of the organization owning and operating the satellite; but many countries, including developing countries relying on their natural resources for their economic growth, point out that prior delivery of such data to commercial concerns in industrialized countries could seriously harm them.

Privacy and security. This familiar issue has given rise to much debate, since the possibility of computerization of personal data, health records, police records, and financial information and the like has become a reality. Obviously, any large enterprise, including the state, cannot function without efficient recording systems; on the other hand many individuals fear the extension of bureaucratic control possible if records of different kinds are aggregated together. Further, the possibility that such data may be stolen or used for some unauthorized purpose by third parties with no practical possibility of detection gives rise to objections to administrative computerization as a whole. Many countries have enacted legislation which is intended to safeguard individual rights in this respect, but their success is not entirely clear. It has moreover been suggested that privacy legislation on the sanctity of personal data has been used to hamper perfectly normal transactions which could not be objected to if handled by the post rather than a computer network.

Transborder data flow. At present many countries are concerned with the uncontrolled flow of data in and out of their territories via telecommunications networks, whether their main concern is for national security, trade advantages, protection of home data-processing industries, maintenance of tax revenue from national data transactions as distinct from untaxed exported data processing, or simply the rights of the individual enshrined in national privacy legislation. There is also

concern that data might be exported to "data havens" beyond the control of the originators or other interested parties.

Perhaps the transborder data flow issue should be looked at from the opposite point of view. Suppose, for example, that texts were regularly imported from a "data haven" which did not observe the international copyright convention, and moreover which allowed the recipient to avoid paying value-added tax on alternative nonelectronic national services. This could result in national telecommunication administrations refusing to accept any such data transaction regardless of origins, on the grounds that control at the individual transaction level was impractical. In the eyes of many, this would constitute an unacceptable interference in the free flow of information.

While transborder data flow has received considerable attention from international organizations, it has been difficult so far to establish the balance of desirable and undesirable impacts. Many developing countries feel that the facilities offered by global data communications make it possible for multi-national corporations to act in ways which are detrimental to their national economies; but on the other hand, the existence of international data communications gives them access to industrialized countries' information systems in science, technology, agriculture, and medicine, which otherwise would be unavailable to them. There is another point contributing to the complexity of the international debate, i.e., if it were necessary to develop internationally-agreed programs for regulation of such data flows, would it in fact be possible to control them either internationally or at the national level?

7. The Economic Value of Information

Many analysts argue that if the information society is "different", a fundamental part of this difference is concerned with the society's economic behavior. Masuda (1980) characterizes the economic structure of his idealized computopia as a synergistic economy, with increased self-production of information by users and shared utilization of information. Although he does not provide a detailed discussion of the concept, it seems clear that in his view such an economy will be

based on the production and exchange of information. This will be the dominating force, rather than the production and distribution of material goods either through a market or a planned economy. He does not discuss the relationship between production and exchange of information and that of material goods; presumably some sort of linkage will have to evolve as the information economy gets under way.

Other authors see a fundamental contradiction between a western-style industrial economy and the evolving information society, if that society is to serve human beings rather than develop into a more effective means of enslaving them. Engberg (1979), for example, suggests that the principle of competition for material goods embodied in economic behavior in the industrial society is inconsistent with the free exchange of information principles fundamental to the information society: he equates the idea of competitiveness with the development of the work ethic, and (in the information society context) an unnecessary distinction between work and free time. Other analysts have considered that the evolving information society has much in common with the non-money economy of the informal (and non-taxable) exchange of goods and services which is becoming an unofficial adjunct to the formal economic behavior of industrial societies.

Some characteristics of the information economy. Parker in his 1976 seminar paper discusses some of the contradictions and difficulties inherent in applying conventional economics to the information society in its present manifestation. In his view, information is not a commodity, a commodity being a product of "matter-energy"; however, information is always associated with some minimum amount of matter or energy as the information carrier. In practice it is difficult to separate the two forms from an economic point of view, since it is the combination of the two in the form of information goods and services which are bought and sold in the market place in the same way as physical goods.

But, as Parker says, "information as such is not a commodity that can be readily bought and sold. We do not have satisfactory units for measuring quantities of information or for establishing a price per unit". Echoing this thought Thompson (1979) has commented on the concept of

information as an economic good, and how it might be handled and exchanged. He advances the hypothesis that "the new transformative wealth-creating class of innovative applications of this new technology appears inhibited by some constraining factors... stemming from two sources: (1) our perceptions of utility and wealth, or in a word, economics; and (2) our use of language". He views the optimization of the benefit from the use of information technology as involving the establishment of an information market place, requiring a new type of mass medium for the exchange process (perhaps a parallel concept with Masuda's information utility), linked by user-friendly networks which would be necessary in designing and organizing the market place. Its infrastructure must be such that it encourages the suppliers and users to interact synergistically. In a later paper (1982) the same author returns to the theme of the information market place, adding that it is necessary to find ways of operating it that have the appearance of creating wealth: but by wealth it seems clear that something different is meant than a value which can be expressed in monetary terms.

Both Parker and Thompson emphasize the point that, in terms of "value", information is radically different from physical commodities. In general, the original possessor of information does not lose value when he passes it on to someone else. In fact, it could be said that (aside from secret information) a piece of information gains (social) value each time it is used, unlike the tangible goods of the industrial society (which, if they are usable, usually have less monetary value at each reuse). Not only does information in general gain in value with each acquisition, but the marginal cost of distributing it to the (N+1)th user is minimal, once the original cost of production and distribution to N users has been met.

Parker points out that this property makes it difficult to create incentives for the original production of information. However, he also stresses the difficulties encountered when society attempts to legally enforce property rights in information, as though it were a material good. Thompson underlines an inherent economic contradiction: the more a piece of information is copied, for example, by taping a song broadcast on the radio, the more it can be said to gain in social value;

from the point of view of the money economy, however, value is lost since the manufacturer of the medium (the original record) and the owner of the copyright lose a sale each time a copy is made.

The central problem of Thompson's new information market place is therefore how value is to be determined, if not in terms of money. Obviously something more complex than an audience-rating system is required, but the question is still open: is it necessary to derive a new, non-monetary measure of value for the economics of the information society, and if so, how should this be done with the needs of the transition phase in mind?

The present price of information. If Masuda, Engberg, and Thompson are right in suggesting that monetary values must be superseded in the new information economics, there would seem to be no sign of a trend in this direction in respect of information in our present society. In the more traditional areas of information provision, such as local or national public libraries, the original concept that information is a basic resource like water, for which the user does not have to pay directly, still survives. However, the application of informatics and telematics to the problems of retrieving and selecting relevant items of scientific, technical, medical, economic, and other information for the professional user has, if anything, resulted in a much closer association of monetary value in the rigorous application of complex price scales per unit of information or per unit of time the information system is occupied.

Before the advent of computerized information retrieval systems, retrieval of relevant literature items was a function performed without specific charge by the reference librarian: on-line information retrieval using continental or worldwide computer networks has now become a major international business with significant user charges. It is noteworthy that the user pays not only the added value of the use of communications and the host computer facility enabling the relevant references to be sorted and delivered to his screen, but also for the information itself.

In some countries, the practice of photocopying for private study and research purposes is still allowed, but in others copyright legislation is becoming increasingly invoked to provide a legal means for charging royalties on photocopies. Now that the automatic ordering and electronic delivery of full texts is becoming a practical proposition, publishers propose to use this technology to regain control over copying by licensing and royalty arrangements, whether the copy is electronic or a photocopy.

In summary, therefore, the computerization process in the information field itself has so far led to the generation of an information market place based entirely on cash value, and whose characteristics are in no way dissimilar to any other manifestation of a market economy. If the authors previously cited are correct in their concept it seems clear that the transition between the monetary market place and non-monetary market place for information is by no means straightforward.

For the present, the investments made by information producers and suppliers have to be recovered with a sufficient return to meet the cost of supplying technologically-advanced information products. The issues therefore reduce to the following: assuming that a new non-monetary information economy is broadly attainable at some future point in time, what are the characteristics of the transitional system as distinct from the information market place as we know it today? Can policies be identified, both at the level of the information industry itself and at the governmental level, which should be followed to ease this transition?

Investment. If the new information society with its new economic concepts is regarded as both desirable and attainable, policy makers must also satisfactorily deal with the problem of how investment is to be directed into providing new information technology facilities which will form the infrastructure for that society itself. Under present circumstances it is quite clear that investment for computers, communication networks and new information systems, data banks, etc. must be made on the basis of an expected monetary return, at least in the private sector, or as a direct result of government subsidies or central

planning. In any case, the funds required must come from earnings, whether from the information sector or from other parts of the economy. It would therefore seem that an important issue for the transition period is how the necessary investment capital can be provided, the degree to which (in market economies) private capital needs to be supplemented, and whether or not machinery is required to steer investments into priority channels. How are priorities to be determined?

A value added approach. Strassmann (1982) has shown that, in decisions relating to the introduction of information technology at the enterprise level, standard economic doctrine as represented by accounting systems results in policies dominated by cost saving, the main ingredient in productivity gains in industrial economics. He points out that the net gain to the enterprise is much greater if a value added approach is taken, and that this leads to quite different policies centered around maximizing productivity by reorganizing the work (and the organizations carrying out the work), and by redeploying and retraining surplus labor. He gives examples of how a value added analysis provides a means for optimizing enterprise investment in information technology since it can indicate the overall importance of different components, rather than merely the degree to which they save costs.

Does this type of approach offer the possibility of bridging the gap between matter-energy economics and the view of information per se as an economic good? Does the value added concept provide a system of measurement which potentially makes for better policy analysis in implementing information technology at the national or supranational level than the existing economic tools? Strassmann's answer seems to be a qualified "Yes": the qualification lies in the need to develop new organization and management structures in the public sector, in addition to economic tools, to direct the large amounts of capital investment in information technology required to maximize productivity in the service sector of the economy as a whole. To quote: "the greatest challenge ahead lies in transforming the information-intensive and extremely inefficient service sectors of our economy into organizations that are much more responsive to unique customer needs at a low management cost".

Parker in his 1976 paper made the same point from a different angle: at a time when the information sector is the largest in our society, and when the application of information technology is the means to obtain productivity gains, it could also be counterproductive to pour more money into labor-intensive information activities: instead, governments should devote resources to improving productivity in the information sector itself. It may be observed that Parker, too, stresses the need for structural and institutional changes to make optimum use of information technology.

Returning to the question of new economic tools as the other major component of policy decisions for applications of information technology, both Strassmann and Parker stress the need for new insights. The former points out that new information network planning is almost entirely concerned with the cost of equipment, microelectronics and associated services. Under a complete accounting system, the major cost is found to be not hardware (probably reducing to negligible proportion of the total), and operation, but non-technological costs, such as training, start-up inefficiency, and consultancy. These organizational costs apparently only decrease slowly as experience is doubled: "the gap between the very rapid decline in cost of technology and the slow decrease in social learning costs is not adequately understood nowadays ... The technology application choices may have to be dictated much more by the training and usability expenses than by any other consideration. The cultural acceptability of information technology then emerges as one of the primary influences if we want to elevate our analysis to the national level" (Strassman 1982).

It seems therefore that those who have written on this subject regard the development of new economic insights as essential if we are to understand how to manage the information society that exists now, and if we are to be able to exercise some control over its future development. Whether or not Masuda's new information society with its different economic values is regarded as a realizable objective or not, most would agree that there are urgent economic issues in the present stage which are imperfectly understood. Moreover, investment decisions on

information technology and its applications at the enterprise and national level have to be made now and in the future, and it seems that the analytic procedures and measurement systems developed in industrial-age economics do not seem to work very well in this respect. The arguments advanced by Parker, Thompson and Strassmann would suggest that a different approach is required--one which embodies a much more flexible and interdisciplinary view; the economic issues are seen to be intimately connected with social issues such as employment, education and retraining and, of course, with organizational and structural change.

IV. SUMMARY OF ISSUES: DIRECTIONS FOR FUTURE RESEARCH

The research questions which emerge from the discussion of the effects of information technologies (IT) on work and employment, business and management, developing countries, education and learning, culture and values, international regulation for social benefit, and the economic value of information may be summarized as follows:

Work and Employment:

- How does IT affect job content?
- Will new jobs be created to replace those lost through IT?
- How can labor utilization be planned to adapt to structural changes in industry and service sectors due to IT? For instance, How can IT be applied to increase productivity without decreasing the labor force? or How can labor be redeployed or retrained to improve quality of output?
- How effective are policies to shorten the work week or to encourage job-sharing in averting unemployment associated with IT?

Business and Management:

- What would constitute an optimum industrial structure in terms of type and size of enterprises in the IT field? What differences are created by the type of industry under discussion (i.e., computer industries vs auto industries)?
- At what level of aggregation should policies be formulated (global, international, national)? How can high-level policy measures be implemented while mantaining public control and fair corporate behavior (taking into consideration inter-industry variation)?
- What are the implications of IT for improving administrative productivity in the service sector? What are its implications for managerial priorities, employee behavior, and organizational effectiveness?

Developing Countries:

- How can IT resources be applied to the development process itself? (That is, to improve Third World possibilities for getting a foothold in wealth-producing technology; or for building up their infrastructure to permit entry into world markets).
- What are implications of IT for technical assistance and development aid programs?
- What kind of effect will IT have on employment opportunities in the Third World? Will IT widen or narrow the gap in wealth between developed and developing regions?
- What kind of effect could IT have on the Third World as a market for developed countries' products?

Education and Learning:

- How will information technology affect the quality of education?

- How can the democratic access of all sectors of the population to training in IT be assured?
- How can the needed volume and types of future education and vocational training facilities be forecast? How can such planning be related to the employment market?
- How can the content of educational curricula be made more quickly responsive to the requirements of the labor market? Is it possible to make the school system as sensitive to market needs as the computer industry is to its market?

Culture and Values:

- To what extent will IT result in a trend to accelerate decentralization of the working and social environment?
- Should such a trend be maintained?
- What would be its secondary effects, for exmple in urban planning, transportation, and telecommunications?
- Is it probable that information technology will contribute significantly to the development of new forms of social inequality by creating a new have-not, computer-illiterate class?

International Regulation for Social Benefit:

- To what extent is it necessary and desirable to regulate the transborder flow of data and electronic information products to minimize social disbenefits, especially in the fields of privacy and security of data relating to third parties?
- What are the modalities for any desirable level of control of transborder data flow?

The Economic Value of Information:

The social issues summarized above are closely bound up with economic aspects: new insights into the economics of information, particularly in value measurement, appear to be an inseparable part of their analysis. Attention should therefore be paid to the following:

- Monitoring studies quantifying the development of the information sector of the economy.
- If information does not behave as a material commodity, identification of other possibilities for value measurement.
- Examination of hypotheses such as that many kinds of information gain in value with each acquisition, while the marginal cost of distributing it to the (n+1)th user is minimal.
- The use of a value-added approach rather than simple cost-saving criteria to make decisions on introducing new information technology at the enterprise level; and the implications of criteria based on value-added on organization and management structures.
- If such economic criteria proved to be of value in decision making at the enterprise level, could they be adapted as criteria for information-intensive activities in the public sector?

Beyond identification of impacts and issues from a survey of current thinking, the authors also felt a need to survey the state of policy making itself. However, with the resources and time available in 1983, it was not possible to make an in-depth evaluation of policies now being pursued by governments and industry to deal with the many issues associated with the emerging information society. We did find, however, that in several countries (both market-economy and socialist), policies have been announced to expand information technology and microelectronics industries. Driving forces appear to be a perceived need to improve

national self-sufficiency, to increase automation and robotization, and to compete for export markets. In our preliminary survey it was more difficult to find coherent national policies directly related to the social issues, though piecemeal approaches have been suggested and some small-scale pilot programs have been set up. There does not seem to be an awareness, however, that more comprehensive policies, in general, are or will be needed.

In his paper on the "Economic and Social Impacts of Modern Electronic Technology" provided in Appendix II by permission of the author, Vasko has noted policy initiatives in several countries, including the USA, Japan, the Netherlands, Sweden, the United Kingdom, France, Austria, the Federal Republic of Germany, and the socialist countries of Eastern Europe. On a regional level, activities have been undertaken in such programs as FAST (Commission of the European Communities 1982), and other initiatives have been designed to improve the position of the EEC countries in micro-electronics and information technology generally. Priorities for future research would be to further identify policy options developed at the national and international levels, and to initiate the process of policy evaluation.

The list of research questions identified in this report constitutes a first step in an attempt to delineate the content of a possible IIASA-coordinated, cooperative, multi-cultural, and multi-disciplinary research program focusing on the socio-economic impacts of new information technologies. A next step would be to narrow the research options by carrying out a broad-ranging survey of decision makers or by holding a workshop to determine levels of interest in particular topics and their national and international relevance. A workshop could also serve as a forum to discuss whether IIASA's most productive role would be to serve: (1) as a clearinghouse, keeping national researchers informed about the projects of colleagues in other countries, (2) as a coordinator of a research project of which components are undertaken in national institutes, or (3) as a focus for in-house research on a topic of manageable size.

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APPENDIX I

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APPENDIX II

ECONOMIC AND SOCIAL IMPACTS OF MODERN ELECTRONIC TECHNOLOGY
(Draft Proposal for a Study)
Tibor Vasko 1984

This is a very timely topic and because of this may seem to be generally over-exposed. Two years ago a prestigious study by the Club of Rome (Friedrichs and Schaff, 1982) was published. In almost any national or international organization studies related to microelectronics are underway in one form or another.

The very nature of microelectronics and its impacts makes similar studies also useful in the future and the problem cannot be exhaustively analyzed once and for all. Past experience shows that many developments have not been correctly predicted (computer needs in the fifties, CB-transmission, personal computers, market for videogames, even the microprocessor development itself was launched almost accidentally).

Microelectronics is a typical "aggressive" branch of technology which generates progress, growth, and changes in many different branches of industry and services by constantly delivering the same functions, or even increasing the number of functions, for a lower price in a way which is, for physical reasons, inimitable in other branches of industry. The "aggressivity" of microelectronics, detected in the early sixties (Arthur D. Little, Inc., 1963), makes the technological path very different from all other technologies. Traditional industries such as steel, electric power, chemicals and others needed economies of scale to increase productivity which led, in turn, to the loss of flexibility and adaptability, to large start-up costs, to specialization and to the 'big-is-efficient' syndrome. Microelectronic-based systems solved the problem of the economy of scale by becoming more distributed, shrinking in size while growing in performance, and being available (for good or bad) to every citizen forcing them to turn into convivial instruments. These facts make the future development of microelectronics very important for decision makers on all levels of the economy and society.

IS THERE A REASON FOR IIASA INVOLVEMENT?

IIASA has the disadvantage of not being big enough and not having abundant resources. Therefore we cannot duplicate national efforts in this area, but

most of their results are available in any case. However, IIASA has the advantage of:

— being international (East-West) and having viable contacts with the scientific communities of sixteen countries;

— being interdisciplinary;

— having studied some aspects of this issue;

— having an interested constituency in supporting countries and organizations.

Some preliminary thoughts on this topic were distributed to cooperating organizations and individuals in member and non-member countries as well as to international organizations. This initial proposal evoked interest and brought several promises of cooperation and even support (see Annex II: Correspondence).

FOCUS AND ENTRY POINTS

IIASA is policy oriented and not a technological institute. Policy orientation is inherent in all of the Institute's activities and also in liaisons with collaborating and supporting organizations.

Policy orientation, in a wider sense, can rely on the comparative advantage of IIASA being international and also on the Institute's previous work (see Annex I).

In spite of very different and specific situations in each country, there are many common features in social impacts which could be identified by cross-cultural comparisons. What strategy should be followed, for example, by a small country in order to gain maximum benefit from microelectronics is not only an open question but it is not even clear what factors are the most decisive in this respect. A random list of important factors could contain: the amount of R&D activities, access to technology, size of the home market, organizational structure of the industry, governmental support, etc. The presence and role of all these, and other factors, should be clear before a proper policy is designed. Our future activity could deliver usable "encapsulated" knowledge and experience.

WHAT METHODOLOGY TO APPLY?

Principally all the arsenal of systems science can be applied to study the impact of microelectronics, but initially reasonably reliable data would

have to be obtained. Perhaps starting with a fact finding mission, or a state-of-the-art report. The results of innovation research done elsewhere could be used to analyze the available data.

Later more complicated models could be built to encompass the dynamic properties of this industrial branch. At this point, however, classical economic instruments and theorems could not be fully relied upon. The macro-economic impact of microelectronics is difficult to identify as is also true for the impact of technology in general. Input-output methods have been applied (Dell'Mour, Fleissner, and Sint, 1980), but the static character of this method is a drawback in this fast changing domain. Equilibrium models could be applied to some issues, but again, the oligopolic character of the microelectronic scene worldwide may limit the usefulness of this method.

International interchange in this field cannot reasonably be studied on the basis of the Heckscher-Ohlin model (of factor-price equalization). This is because, in its original form, it is insensitive to the technology impact and, due to the roles of multinational corporations in microelectronics, much international trade goes into internal trade with transfer prices between divisions of the same company. But what is more, not only finished products are traded, but also capital (sometimes whole production processes) are transferred abroad—for example, encapsulation, testing and packaging.

The appropriate methodology should be found which fits in with the objectives of the study in an interactive way.

ANNEX I: SELECTED ISSUES FROM NATIONAL POLICIES

The following is an attempt to scan, if only sporadically, the activities in NMO* countries devoted to policy design or as an aid to decision makers as reflected in previous IIASA contacts with the respective scientific or policy making community. It does not reflect the vast scientific literature devoted to other than policy making aspects of modern electronic technology which is available to us. For clarity, remarks are in country order.

UNITED STATES OF AMERICA—USA

The transistor effect and planar technology, forming the principal basis of recent microelectronic technology, were discovered in the USA. This put America in a leading position and has thus been a generator of innovation for decades. The development of microelectronics in the USA has been the subject of numerous studies, for example, Tilton (1981) now at IIASA, Harman (1980) who worked at IIASA two years ago, and Braun and Macdonald (1978). Braun is still an IIASA collaborator. Some selected problems, evoked by microelectronics, have also been studied: regional, organizational, and industrial dynamics (Freeman and Hannan, 1981). Due to the fact that no single administrative authority in the USA is responsible for industrial policy problems related to modern electronic technology, these issues have been handled elsewhere (US House of Representatives, Department of Commerce, FCC, Department of Labor, etc.) even by trade unions (Chamot and Baggett, 1979). Competitive and national security aspects have been studied by different commissions, for example, the National Academy of Sciences (1980) led by Bruce Hannay, who was a former IIASA Council Member for the US National Academy of Sciences, and also former Vice-President for the prestigious Bell Laboratories.

JAPAN

Japan is the only country which has managed to equal the USA in some technologies and products, having the volume of production of electronic components comparable to the whole of Western Europe. This is also the only country which recognized early on the importance of modern electronic technologies and made it a part of national strategy (Masuda, 1972). IIASA is fortunate to have published a paper in this field, thanks to Dr. Kozo Sugiyama

*NMO—National Member Organization supporting IIASA

who left the Institute at the beginning of 1983 (Sugiyama, 1982); he has also expressed interest in future cooperation (see Annex II). Japan has a unique program of fifth generation computers ("knowledge" processing) to which other countries seem to be joining in (the UK, and the USA). It is also a widely admired way of building concensus, not only among corporations, but also between government (represented by MITI) and business. IIASA was able to gain insight into this topic from visits of distinguished Japanese scientists and executives (Kobayashi, 1980).

THE NETHERLANDS

A widely based report on the economic and social impact of microelectronics was published on November 5, 1979. The report was prepared by a committee led by G.W. Rathenau (1980) at the request of the Minister for Science Policy. The Government issued its views on the report on September 16, 1980 and Parliament discussed the report early in 1981. However, many analyses have been, and are being, prepared; some have also been reported at IIASA (Boswijk, 1981).

SWEDEN

Microelectronics is the part of Swedish industrial policy designed for "technical capability and industrial competence" (IVA, 1979). This policy has now been specified into individual branches as indicated in the publication devoted to development possibilities of the electronics industry in Sweden up to 1990 (an eight volume report was completed in 1981—SIND, 1981) working out three alternatives—all with higher growth rates of development in the electronic industry than in the past.

This development has been complemented by more detailed studies in selected fields, such as process control (SOU, 1981), robots, etc.

UNITED KINGDOM—UK

The scene in the UK is not so well known but the announcement of cooperation with Japan on the fifth generation of computers indicates that government attaches high priority to microelectronics (in a wider sense).

This is also confirmed by several schemes of government support comprising of four components:

— A CAD/CAM scheme aimed at the mechanical engineering sector providing consultancy assistance and on hand experience at approved centers

(from January 1982 grants for approved cases of up to £2,000 for financing consultancy);

— The MISP scheme to help producers of components;

— The CADMAT scheme (computer-aided design, manufacture, and testing) for introducing microelectronics into other components;

— An FMS (Flexible Manufacturing System) scheme established by the government on June 8, 1982.

Professor Alec Lee (University of Hull) is willing to cooperate in the study (see Annex II).

FRANCE

Activities aimed at assessing the impact of microelectronics received a lot of attention when, in January 1978, the report entitled "L'informatisation de la Société" by Nora and Minc (1978) was published (including four volumes of appendices). Several activities have taken place since then and initiated either by government agencies or academic institutions. Specifically devoted to this topic is a study by Bonelli and Fillion (1981) "Impact of Microelectronics" which is part of the eighth five-year plan (1981-85). The applications are devoted to new products with special attention to energy saving devices.

AUSTRIA

In Austria business, banks, academia, and government continuously study the impact of microelectronics. A coherent study of the impact, diffusion and applications of microelectronics has been published by the Federal Ministry for Science and Research in 1981 with the Foreword written by Federal Minister Dr. H. Firnberg (1981). This report contains the results of work done elsewhere including IIASA (Dell'Mour, Fleissner, and Sint, 1980). Professor Paschke from the University of Vienna is willing to cooperate (see Annex II).

FEDERAL REPUBLIC OF GERMANY—FRG

Several private and academic research institutes are engaged in studies of microelectronics. One prestigious activity worth mentioning as an illustration is the periodic symposia prepared by the Institut für Weltwirtschaft at Kiel University. The last symposium was devoted to emerging technologies and contained interesting position papers on microelectronics in the FRG (Lorenz, 1981).

DEVELOPING COUNTRIES

The picture of the economic and social impact of modern electronic technology would not be complete without at least a rough estimate of the role that developing countries have. These technologies are not only of interest in international organizations (see for example, UNIDO/IS.285, 1981; UNIDO/IS.297, 1982) but also in individual countries, for example, India (see Annex II) and Egypt (ElHadidy, 1983) as well as others are ready to co-operate through IIASA on these issues.

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