# THE GROWTH OF KNOWLEDGE AND THE INFORMATION SECTOR

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## 1. Introduction

The seventies launched a development which, no doubt, will affect the social relations of future generations. The slogans of "service economy" (FUCHS 1968, GERSHUNY 1978), "electronic era or millenium" (EVANS 1979, ROBINS, WEBSTER 1980), "third industrial revolution" (BALKHAUSEN 1978), "post-industrial society" (BELL 1973, 1977, 1978, CHANNON 1978), "information society" (PARKER 1976, PORAT 1977, 1978, BARRON, CURNOW 1979) and "leisure society" (JENKINS, SHERMAN 1979), emphasise at least two phemomena; the growing importance of knowledge and information in future societies and the creation of a new "information technology", without which the transition towards an information society would certainly be severely retarded.

Information (and hence knowledge)[1] is a necessary condition for the existence of societies. Some authors have treated it as a resource, like the classical resources of capital, labour and energy (WILKINSON 1980). The question then arises as to how present and future societies differ from those of the past. It will certainly not be in the existence of information or knowledge per se, but rather the different qualitative and quantitative dimensions of this resource. In the past, the first industrial revolution was characterized by physical human power being substituted by non human power, namely machines. The "third industrial revolution" is characterized by the progressive substitution of certain intellectual processes by information machines (LENK 1982). This is the new qualitative dimension which the economics of information must address. How then do we measure the contribution of information activities to the national economy, when the marginal productivity concept becomes still more difficult to apply? How do we value knowledge with its public good properties? It is to such questions that we turn in Part II.

The quantitative dimension relates to the increasingly pervasive role of information technology within society (MOSCO, HERMAN 1980). The "electronic millenium "represents the convergence or computer, or rather information processing, technologies and telecommunications technologies on the basis of

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1) ch. 3 considers the links between information and knowledge.

an enabling micro-electronics infrastructure" (ROBINS, WEBSTER 1980). One of the factors underlying the rapid diffusion of this technology is the potential of mass production in the information field[1)] and to a lesser extent in knowledge production. Microchips, are in this sense in the same position as the steam engine and the electric machine (KING 1982).

The new technology cannot be detached from its broad social context. Transition to an information based economy is in essence a social process, bringing dynamic forces to bear on the established social structure[2)]. Any analysis which concentrated only on the economic aspects of this process would be incomplete and by omitting important socio-economic interactions must yield biased results.

The following paper intends to throw light on some of the main elements in this process. Part I deals with the more theoretical aspects of this transition towards a knowledge based society. Part II deals with statistical approaches which have been used to measure this transition, and finally Part III looks at policy options.

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1) To quote only one example, in the United States the prime growth industry is the minicomputer business. Its revenues in 1978/79 grew at an annual rate of 35 p.c. For the quite new microprocessor industry, sales grow by 36 p.c. in 1979. These growth rates however, do not reflect solely the interaction of expanded demand and scale economies but also substitution processes for other major sectors of the economy (HAMRIN 1981, MOSCO, HERMAN 1980).

2) There is a large body of literature on this topic. See e.g. the contributions in HANSEN, SCHRÖDER, WEIHE (1979), FRIEDRICHS, SCHAFF (1982), SPIEGEL-RÖSSING, DE SOLLA, PRICE (1977), BOYLE, ELLIOT, ROY (1977), NORA, MINC (1979), KALBHEN, KRÜCKEBERG, REESE (1980), HETMAN (1973).

# PART I

## 2. Socio-Economic Views of the Information Process

One of the first, if not the first, to deal extensively with socio economic aspects of the transition process towards postindustrial society was BELL (1973, 1977). He emphasized the key role of knowledge in postindustrial societies, a fact that "gives rise to new social relationships and new structures which have to be organized politically" (BELL 1973).

BELL distinguishes five dimensions of postindustrial society;

(i) the creation of a service economy
(ii) the pre-eminence of the professional and technical class,
(iii) the centrality of theoretical knowledge as the source of innovation and policy formation in society,
(iv) the possibility of self sustaining technological growth, and finally
(v) the creation of a new "intellectual technology."

This chapter will concentrate on points (ii) and (iii). These points suggest that the importance of unskilled and semi skilled workers in this stage of industrialization will continually be reduced, with the result that a new class - the technocrats - will emerge[1)]. The latter will mainly consist of academics and technologists, bringing a completely new dimension, not only into the production process, but also into political and sociological processes (STONIER 1981, MULKAY 1977). The role of experience will gradually be downgraded with severe effects on the social structure. Age as an index of experience, of past accumulated knowledge, will lose its importance, partly on the ground that this accumulated knowledge may be irrelevant in an ever changing environment for solving todays problems. The old man as the reference person for the young man may become a historical anecdote. The young, or to be more precise, the young with the latest acquired knowledge from educational establishments, will take the reference positions. This leads on to point (v), the creation of a new intellectual technology. Under this heading, BELL includes varies techniques, such as linear programming, systems analysis, information

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1) This point is not generally accepted. Some authors emphasize the continuing degradation of skills brought forward by the new technology. This degradation even spreads to those occupations which have been considered "intellectual" in the past, it brings with us the "proletarianisation of clerical and service workers who make up the bulk of the white collar workforce, the backbone of the so - called - information society." (See BRAVERMAN 1974, also GERSHUNY 1978, MOSCO, HERMAN 1980).

theory, decision theory, theory of games, etc. These more sophisticated problem solving instruments would, however, largely lose their importance without the help of the computer, and the new emerging information infrastructure machines.

Point (iii) in BELL'S classification stresses the primacy of theoretical knowledge. In the last decades, the qualitative importance of knowledge for society has changed. It is "the primacy of theory over empiricism, and the codification of knowledge into abstract systems of symbols that can be utilized to illuminate many different and varied circumstances" (BELL 1973). It is the tendency towards specific codification of knowledge which is one of the most controversial elements of this process. It results in the emergence of isolated scientific branches, whereas the problems to be solved often demand an integrated overall view. This tendency, especially the creation of specific scientific terminology (MULKAY 1977, MENZEL 1967, HAGSTROM 1970), which makes it impossible for an uninitiated person to follow the discussion, or to read the relevant literature, may gradually result in incomplete problem formulations and consequently in inappropriate results. This can hardly be interpreted as a pessimistic outlook; the consequences of the process just described can already be seen.

HIRSCH'S (1977) position is quite different from BELL'S view of the progressive primacy of education and theoretical knowledge. He investigates the possibility of an infinite growth process and finally concludes that some growth factors eventually constitute growth barriers[1)]. One such is education, which is regarded as a filter as well as an investment in human capital, higher productivity and growth. Since one man's higher qualification devalues the information content of another's, it is not the total of accumulated knowledge in one individual which result in benefits and satisfaction, but the additional quantity of knowledge compared to his potential rival. Education therefore becomes more and more a signalling device for personal productivity (a "positional good"). It finds its counterbalance in personal earnings, but not commensurately in the social product[2)].

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1) see chapter 4 for a detailed discussion.

2) This topic is dealt with in the human capital approach, in which, however, HIRSCHS' argument of the positional character of education is largely neglected. For a survey see BLAUG (1977).

These two opposite contemporary views of the transition process towards post industrial society merit some further comments.

Firstly, BELL emphasizes the positive aspects, whereas HIRSCH points at the sisyphean character of the process. In his words, it is a case of everyone in the crowd standing on tiptoe and no one getting a better view.

Secondly, BELL regards knowledge as an essential social product; it is the driving force towards post-industrial society, emerging in the form of new social and economic structures. Knowledge and information in this context provides the energy for fuelling this dynamic structural process. HIRSCH on the other hand places knowledge among other traditional economic goods and services, an overproduction of which results in a misallocation of resources; though the system itself remains unaffected.

Thirdly, BELL points to the collective social role of knowledge and information, whereas HIRSCH attributes value solely to the individual level. Contrary to BELL, an increase in collective knowledge is only of minor importance, if important at all. To HIRSCH it is rather a question of how a given stock of knowledge is distributed which affects its value to society, rather than any qualitative or quantitative change in that stock.

HIRSCH'S position is interesting, though his global interpretation of the knowledge phenomena is certainly too restrictive. It neglects the dominant role of knowledge, in particular of intellectual inputs, into contemporary production processes. The changing structure of human capital, especially the increasing weight of skilled human capital, the growing importance of R&D activities, of innovation, and the increased complexity of human relations in production, can all be clearly observed. They are not merely, as HIRSCH would suggest, manifestations of a greater individual valuation of knowledge, rather they are components of a broad social revolution originating from the new and decisive role of knowledge. These interelated developments cannot be explained by a single hypothesis.

In reviewing four modern improvement theorists (SCHUHMACHER 1973, GALBRAITH 1974, DAHRENDORF 1975, and BELL 1973), GERSHUNY (1978) discusses six post - industrial themes, namely

- politics and change

- technocracy and planning
- increasing role and scope of education
- change in consumption patterns
- changing attitude to, and conditions of, employment
- changing nature and scale of organisations.

GERSHUNY acknowledges it "to be common for all our authors to see the planning system ... as the main block to the transition from the growth goals of industrial society to the improvement goals of post-industrial society". This can only be achieved when government planning plays an ever increasing part, if - in the words of SCHUHMACHER - only for negative early warning purposes.

Education, in traditional terms an entirely individual service, gradually assumes the societal function of changing the public consciousness from quantitative to qualitative growth targets.

Changes in consumption patterns reflect the increasing importance of services, in other words the high income elasticity of these products.

The last two themes will be dealt with more extensively later (chapter 7), they point to the fact that an increasing proportion of the working population is engaged in the service sector. This, together with the increasing need for controlling the planning system, changes the structure of organisations.

Although all the arguments brought forward support the social context of this process, it seems necessary to point to the most important aspects, some of which have been the subject of criticism.

The first, and certainly the most important aspect is - in BELL'S terminology - the axial principle of acquisition and codification of theoretical knowledge, and the power connected with it. To understand this we must go beyond economics, and take into account some anthropological principles. One of these principles can be traced back to one of the most unorthodox economist of our days, GEORGESCU-ROEGEN (1977), who emphasises the distinction between endosomatic and exosomatic organs. Endosomatic organs are those with which each individual is biologically endowed by birth, such as the human brain. They are not constant or fixed through all time, but continuously adapt to life through advantageous biological mutation. Exosomatic organs are on

the other hand those elements taken from nature. With endosomatic organs alone the human species could never have reached the existing standards and life style of today. It began to produce, and use, the fire, hammer, knife, automobile, etc., all of them exosomatic organs. The incorporation of these organs could in turn only occur as a result of improvements in the human brain, since exosomatic organs by themselves reduce to single material units of little value.

The trend towards numerically more, and more complex, exosomatic organs would gradually have reached a halt if a completely new technology had not arisen. Although information technology could have been substituted, at least to some extent, by the human brain, the time factor would have been a serious constraint. Calculations which a few decades ago would have engaged a person for some years, can today be performed by computers in a few seconds. This has opened a completely new dimension which, together with the developing needs of society, is the central feature of the process under investigation (ROBINS, WEBSTER 1980).

The second aspect can be derived from the intrinsic characteristic of knowledge and information. Knowledge is power, and a certain structure of accumulated knowledge yields a certain structure of power[1)]. The increased scope for knowledge centralisation created by information technology promotes tendencies which have already been recognized, of both greater power in the hands of a few, and yet at the same time vulnerability to disruption by the activities of a few[2)].

The third aspect is a social one, namely the extension of "redundancy"[3)]. This is a tendency which does not fit well into the picture of a rational economic world. Such "redundancy" is characteristic of the growing mass media industry.

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1) This point is analysed in HETMAN (1973). He concludes that "...technology is a new source of power, which has been largely directed to the ends of established power groups, adding power from knowledge to power from social predominance".

2) During a high level conference on, "Information, Computer and Communications Policies for the 80's a whole session was devoted to this topic; see especially the Swedish contribution "The Vulnerability of the Computerised Society", reprinted in OECD (1980a).

3) An indicator for this redundancy is given by ANDERLA (1973). He quotes a study by URQUHART (1958), in which the latter analysed the 53.000 loan (continuation page 9).

The average man or woman reads newspapers, in most cases several newspapers, he listens to the radio and watches television programmes. It goes without saying that this is possible only by passively consuming information. Nevertheless the question remains, what are the causal factors of this redundancy?

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3) applications recorded in 1956 at the Science Museum Library in London, which then had a collection of 9.120 periodicals. He showed that more than half were never consulted throughout 1956, and that 25 per cent were consulted only once. At the other end of the scale, 900 publications were sufficient to meet 80 per cent of requests.

## 3. Concepts of Knowledge and Information

Any reasonably complete analysis of information activities should be based on a manageable definition of the object of investigation. This raises severe problems since there are many different views as to the nature of knowledge or information. The variety of these views mirror the complexity of these phenomena, which encompass physical, psychological, sociological and economic dimensions. It goes beyond the scope of this paper to deal completely with all of these dimensions, and we shall concentrate on the economic, though a short digression on the others seems appropriate[1)].

Knowledge is essentially derived from isolated individual thinking. It is nevertheless a social concept since individual knowledge which is not transmitted to present or future generations loses its impact on society (BARNES 1977). This leads us to classify

- individual knowledge, and
- collective or social knowledge[2)].

Strictly speaking individual knowledge without any link to the social environment is hardly possible and, in any case, of little interest to our analysis[3)]. Therefore, when we speak of knowledge, we shall mean social knowledge unless otherwise stated. Nevertheless, we must clarify precisely what we mean by individual knowledge. It is the abstract counterpart in one's mind of reality. More pragmatically, it is what a person knows at a specific time, and can therefore be classified as a stock variable, attributable to a single individual.

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1) For a more detailed exposition of this topic see ANDERLA 1973, RESCHER 1978.

2) In our discussion we try to avoid the concept "value of information or knowledge" respectively, since "no statistical approach can completely measure the quality of a service or the value of information to the user" (WHITE 1977).

3) One could even go further and constrain certified knowledge as existing only after it has been communicated to and endorsed by those (scientists) competent to assess them (MULKAY 1977). Similiar BARNES (1977): "... knowledge is not produced by passively perceiving individuals, but by interacting social groups engaged in particular activities. And it is evaluated commonly and not by isolated individual judgements".

Information on the other hand is a flow variable. It requires the simultaneous fulfilment of at least three conditions;

- the existence of both transmitter and receiver,
- either a common language or an interpreter, and finally
- a knowledge deficit on the side of the receiver.

The first states that with information there are always at least two parties involved. A transmitter sending signals to a receiver. The transmitter need not be a human being or any other discrete entity. It might even be the universe itself, the signals transformed to knowledge by some agent either passively perceiving or actively reflecting upon the environment (MOSCO, HERMAN 1980).

This leads to the second condition of a common language between both sides of the information flow. Whether this will be manifest directly, or indirectly via an interpreter, is solely a matter of efficiency.

The final condition implies that we exclude from information flow that data which is "redundant", in the sense that it does not increase the stock variable, knowledge. The content of messages already known and which are part of one's individual knowledge will be of little or no use to the receiver (ANDERLA 1973, URQUHART 1958). However this does not necessarily mean that the second reading of say, a scientific article, a book or a poem be considered completely redundant. Repetition may increase knowledge by promoting better understanding. This makes it difficult to draw a clear line of demarcation for redundancy.

The last condition is at the heart of the problem of establishing a theory of value for information flows[1]. We shall show that only a knowledge deficit elicits demand for information. Yet such a deficit precludes the apparatus of marginal utility theory since the characteristic of information flow is transmission of what is not known. When I do know, the knowledge deficit disappears, and with it the demand for information (ARROW 1962).

The distinction between information and knowledge has an analogy in that between physical investment and capital stock. Just as economic understanding of production processes is aided by separating the flow and stock concepts of investment and

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1) See the extensive discussion in RESCHER (1978) and ANDERLA (1973).

capital respectively, so it must be with information and knowledge if the burgeoning field of the economics of information is to be adequately analysed[1].

Before pursuing classifications within the economic dimension as our main area of concern, let us briefly review alternative views of information and knowledge. WEISS (1967) and LAMBERTON (1971) stress the conceptual differences underlying the terminology, for instance WEISS "...information is not tantamount to knowledge. Information is but the raw material, the precursor of knowledge". In contrast ANDERLA (1973) sees no difference between these two terms, "the socio-cultural view holds that information and transferable knowledge are one and the same thing". MACHLUP (1962) interprets any difference between knowledge and information chiefly in terms of linguistics; "to inform is an activity by which knowledge is conveyed: to know may be the result of having been informed". He then continues "information as that which is being communicated becomes indentical with knowledge in the sense of that which is known. Thus, the difference lies not in the nouns when they refer to what one knows or is informed about, it lies in the nouns only when they are to refer to the act of informing and the state of knowing, respectively" (MACHLUP 1962).

ANDERLA (1973) on the other hand regards information as being as fundamental as energy or matter, affecting all aspects of human activity and an indispensible link between intellectual and material activities. This "positive" definition hardly lends itself to further analysis. STEINBUCH (1978) is more useful in this respect. He distinguishes between three categories of knowledge,

- knowledge as an abstract terminus technicus in the sense "I have enough knowledge". This includes a subjective valuation of the stock of knowledge,
- knowledge as a semantic terminus technicus like the passport number, the date of birth, etc. He estimates most information transferred to be on this level, and finally
- knowledge as a physical terminus technicus like a mathematical formula.

This classification by STEINBUCH (1978) stresses the different delineations of reality. It can be accompanied by another, the relevant time horizon. Thus we distinguish between

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1) In purely theoretical terms this is analysed in the human capital theory (see footnote 2 on page 5) and in empirical terms in various analyses, e.g. WARSKETT (1979).

- knowledge or information relating to the past
- knowledge or information relating to the present, and finally
- knowledge or information relating to the future.

Here it seems necessary to clarify that the time dimension gives no insights as to whether information is reliable or not. Historical books on past events need not necessarily be more accurate than projections concerning a future state.

As to content we may distinguish between

- genetic knowledge which is the determinant of human beings,
- cultural knowledge such as languages, or tradition, and
- social experience.

A separate and more detailed classification is found in the seminal work, "The Production and Distribution of Knowledge in the United States", by MACHLUP (1962). His criterion of knowledge embodies the subjective importance of the known to the knower and he distinguishes five categories of knowledge:

i) Practical knowledge: useful in a persons work, his decisions, and actions; can be subdivided, according to his activities, into
   a) professional knowledge
   b) business knowledge
   c) workman's knowledge
   d) political knowledge
   e) household knowledge
   f) other practical knowledge

ii) Intellectual knowledge: satisfying his intellectual curiosity, regarded as part of liberal education, humanistic and scientific learning, general culture; acquired, as a rule, in active concentration with an appreciation of the existence of open problems and cultural values.

iii) Small-talk and pastime knowledge: satisfying the nonintellectual curiosity or his desire for light entertainment and emotional stimulation, including local gossip, news of crimes and accidents, light novels, stories, jokes, games, etc.; acquired, as a rule, in passive relaxation from "serious" pursuits; apt to dull his sensitivity.

iv) Spiritual knowledge: related to his religious knowledge of God and of the ways to the salvation of the soul.

v) Unwanted knowledge: outside his interests, usually accidentally acquired, aimlessly retained.

MACHLUP continues "The adaquacy of a classification cannot be judged before one knows what is done with it". Our investigation is directed towards the roles which information and knowledge play in static and dynamic performances of an economy. It is in this light that the foregoing classifications must be judged. A purely economic oriented classification might help us better understand the functioning and the importance of that segment of the economy, labelled the "information sector".

The categorisations mentioned are hardly applicable to a statistical measurement procedure. However MADEC'S (1976) proposes the following classification which does meet this requirement. He distinguishes between

- a legal classification, distinguishing information regarded as public from information protected as being confidential;
- a commercial classification, which may be the most useful one, distinguishing information which is sold from information which is not;
- a functional classification, to highlight the diversity of roles played by the information carrier; and finally
- an economic classification defining the place occupied by a given data flow within the information production process, from the "crudest" data to the most "sophisticated" information.

Referring to economic theory, MADEC continues to classify information flows in final consumption goods, intermediate goods and capital goods, according to their standing in the production cycle. Thus we have

- final consumption flows of knowledge and messages, whose purpose is straight forward information (books, television programmes, etc.), or decison - making (telephone, telex);
- flows of semi-finished materials (or intermediate goods) in the form of data for later elaboration by man-machine systems to extract their essential content, raw data acquired from the environment, or existing data retrieved from memories, and lastly,
- flows of capital goods; these comprise the organisational system containing all the elementary instructions applicable to each link in a production chain, including computer software technologies.

This classification is essentially limited to the micro level and therefore leaves out a great bulk of information flows which originate from the macro level. The similiarity to micro and macro economics is evident and it is exactly this link which seems to be one of the most important dynamic forces towards information society. The following table 1 shows the relationship betweeen these two levels. The micro level encompasses the production and consumption units respectively. It can be regarded as a system in itself, producing and disseminating information in various stages. This system is part of the economic and social environment. The connections are flows of goods and services in the real sphere and information flows. Information flows between the individual units at the micro level as well as between these and the macro level. The objective of the latter is to guarantee the functioning of the whole system.

Attemps to incorporate both micro and macro aspects of information flow, and their associated resource requirements, have in fact been made by MACHLUP (1962); MACHLUP, KRONWINKLER (1977), PARKER (1976), PORAT (1977, 1978) and now the OECD (1980a, 1981a) in which the whole economy is characterised by either the functional or institutional approaches. The first refers to the different occupations of the labour force, and the latter to the products of the different industries. The first approach aims at categorising occupations into "information" and "non-information" types. The second similarly categorising the wide range of produced goods and services. It should be noted that the two appproaches are likely to result in different magnitudes for the "information sector", not least because information labour may be involved in part in the production of non-information goods (R&D in steel), and conversely with non information labour involved in producing information goods (machine workers in computer production).

This attempt to establish the role of information activities in the whole economy stands in contrast to earlier work by the OECD (ANDERLA 1973). Previously a selection of fragmentary indices had been used for examining the hypothesis of a growing information sector (see figure 1). Again in the U.S., the Natural Science Board used a Science Indicator incorporating both input and output indices to reflect changes in growth and structure of that sector. In avoiding such selectivity the more recent OECD approach, to which we turn in ch. 6, constitutes a radical departure from that which has preceded it.

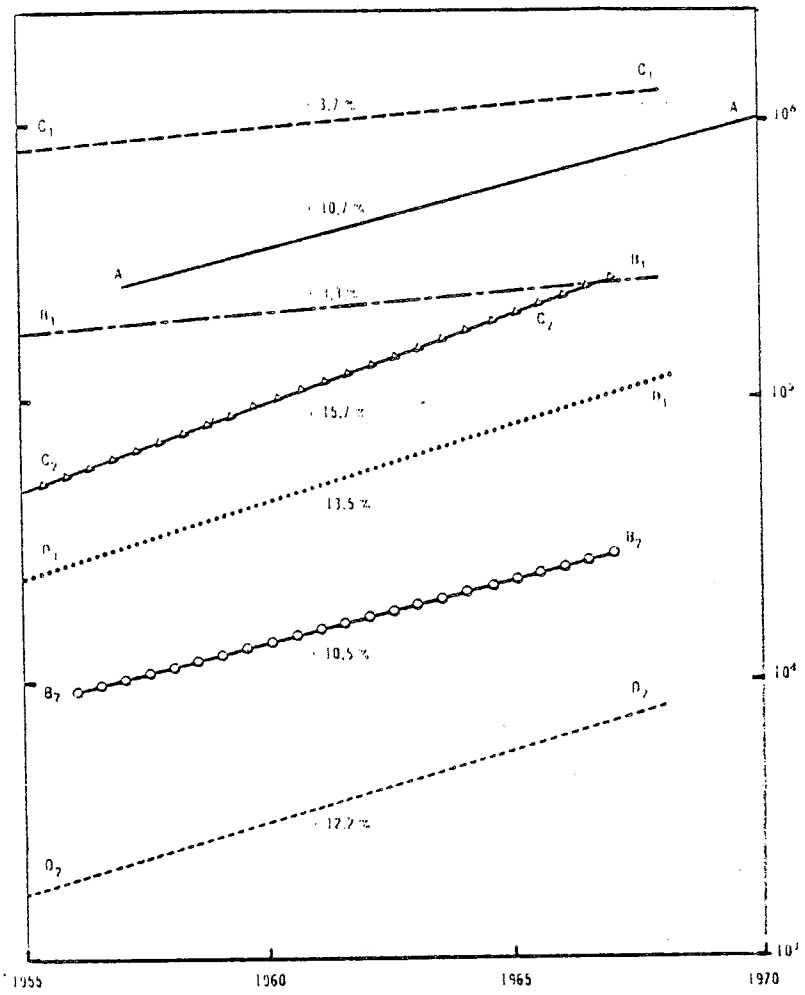


Figure 1: Recent trends in a number of selected indicators for the supply of and demand for scientific and technical works and documents 1955-1970. Source: ANDERLA (1973).

A: Number of scientific and technical abstracts listed throughout the world. Annual rate of increase: 10.7 per cent.

$B_1$: Number of scientific works held by academic and scientific libraries in Sweden. Annual rate of increase: 3.3 per cent.

$C_1$: Number of loan application recotded by academic and scientific libraries in Sweden. Annual rate of increase: 3.7 per cent.

$B_2$: Number of scientific and technical journals at the National Lending Library for Science and Technology in London. Annual rate of increase: 10.5 per cent.

$C_2$: Number of issues of scientific and technical journals loaned out by NLL. Annual rate of increase: 15.7 per cent.

$D_1$: Number of university students in Sweden. Annual rate of increase: 13.5 per cent.

$D_2$: Number of research scientists in Swedish government service. Annual rate of increase: 12.2 per cent.

## 4. Theories of the Growth of Knowledge

One of the first to investigate the phenomenon of the growth of knowledge was ADAMS (1918), an American historian, who formulated the law of exponential growth of knowledge. This hypothesis, which lacks any causal relationship, is that knowledge doubles in a given period in quantitative and qualitative terms, so that the following development can be expected.

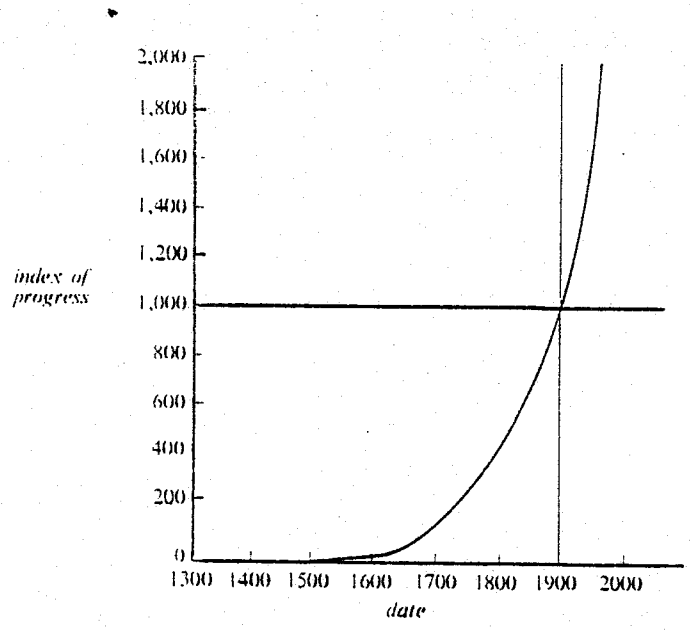


Figure 2: ADAM'S Law of Acceleration of Progress.
Source: RESCHER (1978).

ADAMS characterised this principle as "... a law of acceleration, definite and constant as any law of mechanics (which) cannot be supposed to relax its energy to suit the convenience of man...". Thus the growth of knowledge is a historical process, "... the ever quickening historical pace of the development of the methodological repertoire of human capacities", with time as the dominant structural parameter.

ADAMS' explanation is not very satisfactory. Firstly, the time parameter as the sole factor is inadequate to explain social phenomena, since any causal explanation is missing. Secondly, ADAMS law concentrates on the supply side of the development without considering the dynamic factors of the demand side. The process of accumulation and diffusion of knowledge is primarily a social process, the complexity and heterogeneity of which does not allow us to reduce it to one single dimension. The growth of the information sector, especially in the last two decades

may be largely attributed to the demand side. The question of the growth of knowledge, in the form of the limits to scientific progress, has been on the public agenda for more than a hundred years[1].

GLUCKMAN, one of the most famous anthropologists of his time wrote: "Science is that discipline by which the average citizen of our generation transpasses the point that the genius of the last generation has reached". GLUCKMAN thus reformulated a thesis, which SENECA established many hundred years before him. SENECA concluded that some of the unsolved problems of his day will be an easy task for future generations. It is still the generally accepted opinion of the scientific community of our day, that scientific progress will continue (e.g. MULKAY 1977). But what is the nature and limit (if any) to this growth process? This is a question well known to economist. In fact the question as to whether limits to economic growth exist on the real production side is linked to the question of whether there really are limits to the growth of knowledge itself[2].

Before dealing with this issue, it may be useful to consider some historical trends. RIDER (1944), a librarian of the Wesleyan-University investigated the stock of books of American Universities. Investigating ten representative colleges he could show that in the period 1831 - 1938, the stock of books doubled every 22 years, and those of the pure research universities in 16 years, resulting in growth rates of 3.2 and 4.4 per cent respectively.

PRICE (1961) followed this research line. In his "Science since Babylon" he estimated the annual growth rate of the stock of knowledge at 6.5 per cent. This growth process has severe repercussions on the information sector. Even in 1830 it was already impossible for one interested individual to study all the 3000 Journals published at that time. The use of "abstracts" was therefore established. By 1950 the number of abstract Journals amounted to 300, again a number impossible for a single person to study (see figure 3).

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1) For an extensive discussion, see RESCHER (1978) ch. I - IV.

2) See the extensive discussion - on this point - in GILL (1976), esp. chapter four.

Another illustrative example is given by BELL (1977). He stated that the first edition of the Encyclopaedia Britannica (1745-1785) was produced entirely by two persons. These two were able to review the total knowledge of that time. With the third edition, specialisation took place for the first time, and by the time of the 1967 edition ten thousands experts made contributions to it.

This trend raises the question of the paths this expansionary development might follow. RESCHER (1978) suggests that "... the prospect of scientific discovery is limited/unlimited. In the former case of a limitation, the limits of innovation will eventually be asymptotically approached -, and these limits are due to the finitude and limited complexity of - nature/man -".

Following this he lists five theories of scientific progress; nature exhaustion, nature saturation (asymptotic completion), capacity exhaustion, capacity saturation and finally, unlimited horizons.

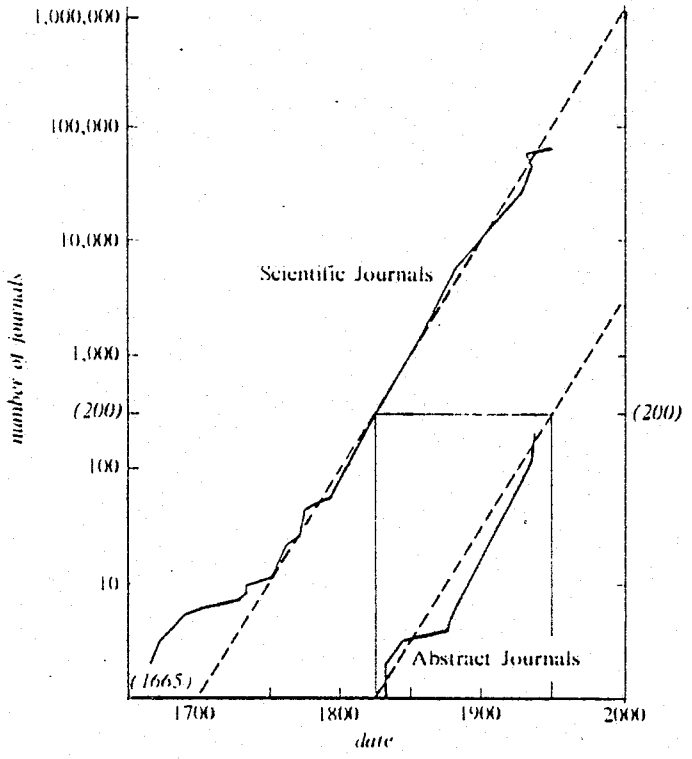


Figure 3: Total number of scientific Journals and abstract Journals founded, as a function of data.
Source: DE SOLLA PRICE (1961).

(i) **Nature Exhaustion**

This view establishes the finite horizon of science, caused by discovery exhaustion; in other words, a complete occupation of the "terra incognita". This expectation is similar to that of some of the most famous philosophers of the seventeenth and eighteenth century, such as BACON, GALILEO, DESCARTES, BOYLE, DIDEROT. The latter pronounced the idea of a total cessation of discovery, "I dare virtually to guarantee that before one hundred years have passed one will not find three great mathematicians in Europe. That science will come to a dead stop pretty much where a BERNOUILLI, a EULER, an AUPERTUIS, a CLAIRAUT, a FONTAINE, and a D'ALEMBERT and a LA GRANGE have left it. They have erected the pillars of Hercules beyond which there is no voyaging". This possibility is shown in figure 3, where w is that point where "completion of science" is reached and where the total of potential discoveries are exhausted.

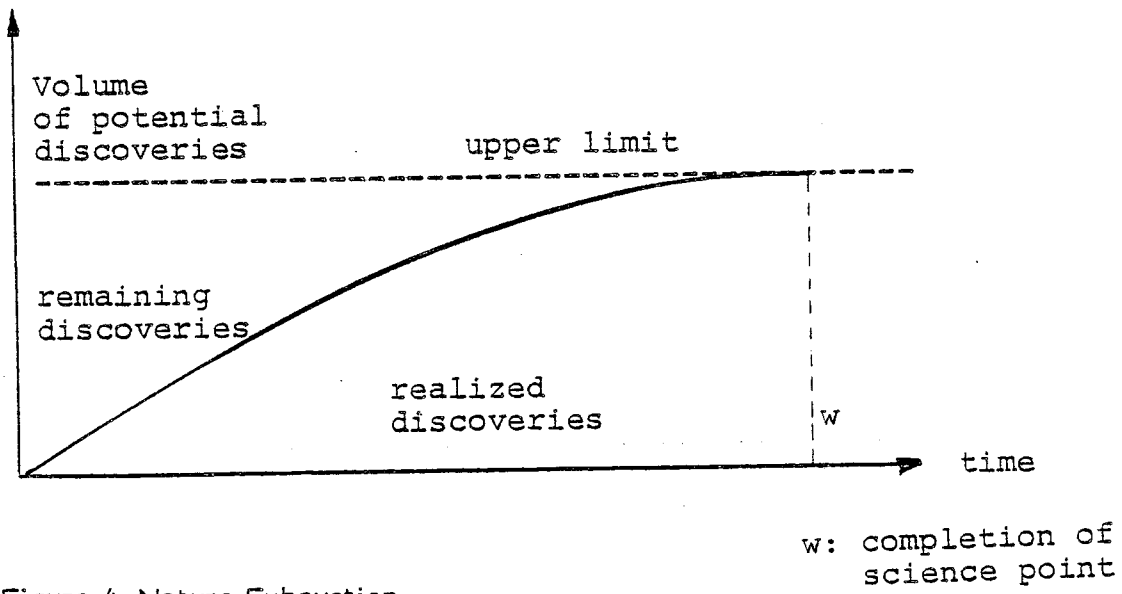


Figure 4: Nature Exhaustion.

(ii) **Nature Saturation (Asymptotic Completion)**

Like the previous case of exhaustion of potential discoveries this school defines an upper limit of knowledge which, unlike point (i) which mentioned nature exhaustion, postulates an asymptotic approach. Thus "there is no final Götterdämmerung, and natural science does not come to a stop in a final blare of definitive innovation, that extinguishes all prospects of further discovery for the rest of time. But, nevertheless, science as an innovative enterprise comes to an end for all practical purposes - it simply goes out with a whimper rather than a bang." (RESCHER 1978).

This position was defended by PRICE (1961), an American philosopher. He saw the growth process of knowledge passing through two phases; an initial phase establishing qualitative relations among the scientific parameters, and a second phase marked by the quantitative refinement of findings in the first phase.

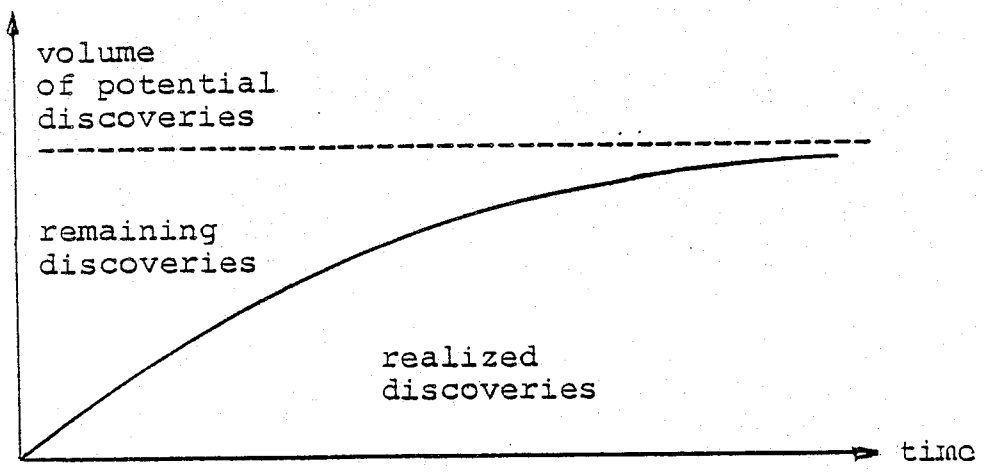


Figure 5: Nature Saturation.

In the first two hypotheses which impose a limit on the supply of potential discoveries, no reference to the production side, to the creation and transformation of knowledge, is made. RESCHER (1978) defines these two theories as optimistic ones, perhaps "naive theories" is more appropriate.

(iii) **The Theory of Capacity Exhaustion**

The theory of capacity exhaustion no longer concentrates solely on supply side constraints to scientific progress. It brings in some sense an individualistic element into the set of causal factors explaining this process. The individual constraint in knowledge acquisition is familiar to everyone, why shouldn't this also be relevant for a group of individuals or for society as a whole.

This theory extablishes a barrier to scientific growth; a barrier solely determined by limitations in the individuals potential for knowledge acquisition, as shown by figure 6.

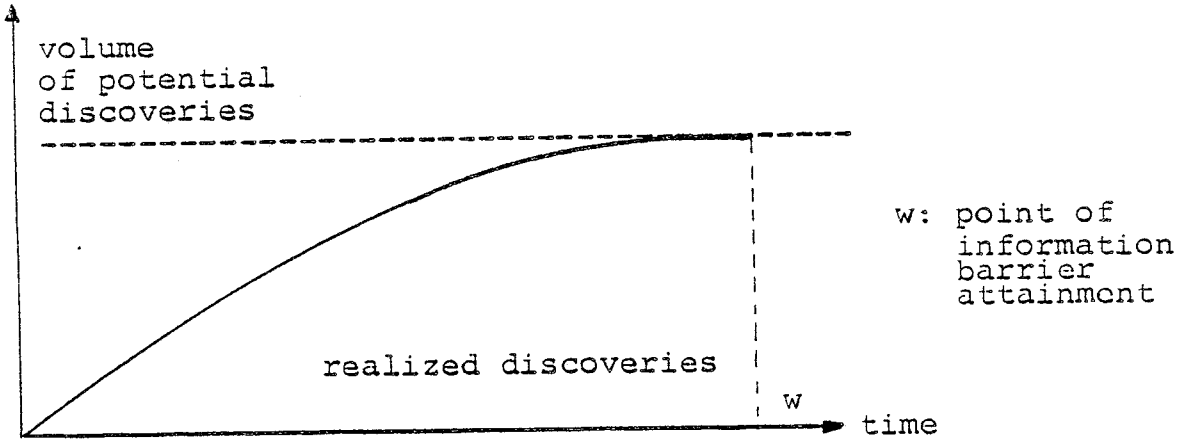


Figure 6: Capacity Exhaustion.

The barrier beyond which the field of unrealizable knowledge lies, is not a fixed one. It is certainly influenced by the technology used in knowledge creation, as well as in information transfer. In other words, this barrier is itself a function of the accumulated stock of knowledge.

(iv) **The Theory of Capacity Saturation**

This possiblity is shown in Figure 7. It postualtes not a fixed barrier, as depicted in point (iii), but a barrier which is approached in the passage of time.

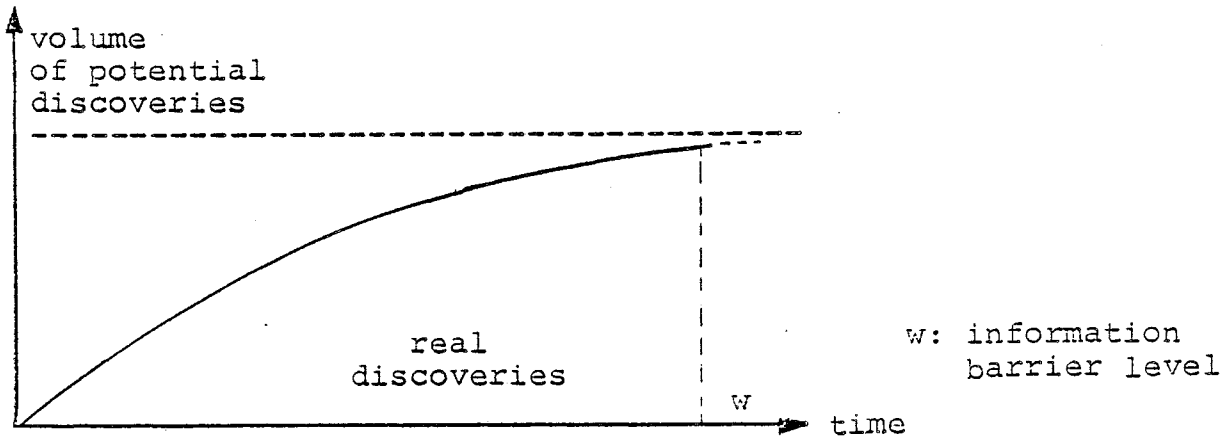


Figure 7: Capacity Saturation.

The theory of capacity saturation fits well into the theory of decreasing marginal productivity in the knowledge production sector. It can therefore be regarded as an applied branch of orthodox neoclassical production theory. The limits are therefore determined by the production factors "human capital" and "information capital", between which substitution may prevail to some degree.

(v) **The Theory of Unlimited Horizons**

This theory has already been mentioned under the heading of ADAMS' Law of progressively expanding scientific progress (s. figure 2).

Essentially these five theories can be reduced to two. The first emphasises the limits to potential discoveries, and the second locates the barriers to scientific progress in the productivity of factors inputs, especially human capital. Another explanation for growth barriers can be derived from autonomous forces governing the functioning and allocation of factor inputs. We have seen that in his "Social Limits to Growth" HIRSCH emphasizes structural aspects. PARKINSONS Law is more empirical; concentrating mainly on administrative activities, it to some extent verifies that only a small share of all information occupations are primarily concerned with pure knowledge producing activities (PARKINSONS 1957, 1967). It is based on two observations;

- every official tries to increase his subordinates, and
- every official tries to increase his activities.

According to PARKINSON (1957), the administrative activity increases according to the following formula:

$$x = \frac{2.k^m + l}{n}$$

where

k: number of officials
l: age difference between entering and retirement
m: number of hours, devoted to one special activity
n: number of cases
x: new demand for officials.

The above formula leads to growth rates between 5.2% and 6.6%, a figure which nearly perfectly fits into the long term growth of the information sector. Nevertheless, this theory emphasises only one aspect of the growth process we observe. It totally neglects the qualitative aspects, both on the demand as well as on the supply side. Therefore, PARKINSONS' law may help to explain some aspects of the transition process, but not its entirety.

# PART II

## 5. The Measurement of Knowledge or Information

The classification "information society" visualizes an advanced society in which information plays the dominant role (FUCHS 1968, BELL 1973, 1978, MACHLUP 1962, PARKER 1976, PORAT 1977, 1978). The question immediately arises as to what one regards as the relevant unit of information or knowledge. Do we try to quantify information flows or knowledge stocks, and, in the latter case, do we mean the sum of stored individual knowledge, an aggregate variable entailing severe measurement problems[1].

Another problem should be mentioned. "Information society" reflects the dominant importance of information or knowledge, but not necessarily in terms of measurable units of input or output[2]. Though all three elements mentioned in the first paragraph seem to move in the same direction, it need not be so. In one of the first chapters the similarities between energy and information have been emphasized. Without energy, no economic activity could prevail. But this does not mean that the share of energy inputs in real terms grow forever. Even the absolute share of energy in total input, i.e. its quantitative importance, does not reflect its true importance. Knowledge is another essential input, without which the existence of a living mechanism is impossible (WILKINSON 1980). Here too a discrepancy between the quantitative importance and its qualitative substance may arise.

Another, problem refers to the relation between the flow and the stock variable. This difference is worked out in the mathematical theories of communication, especially in the works of SHANNON and WEAVER (1969). Their units of information are "bits", and as a result, clearly specified and easily identified aspects of information or communication channels can be analysed, as well as the

---

1) From a biological view "information" is used in a much broader sense. The following characteristics require analysis:

   (i) the quantity of information,
   (ii) macroscopic and microscopic information,
   (iii) the redundancy of information,
   (iv) the indispensability of information, and
   (v) the value of information

   s. VOLKENSTEIN, CHERNAVSKII (1978).

2) In addition, qualitative aspects have been left out. For a discussion of this point, see RESCHER 1978, ch. vi. The relation of supply and utilisation is dealt with in ANDERLA (1973).

contribution of information to knowledge. An aspect of the latter is redundancy, the most typical experience of the modern information society.

The mathematical theory of communication is a good starting point for dealing with different concepts for measuring the phenomena under investigation. Let us start with information flows. The following possibilities exist:

(i) bits

(ii) words

all per unit of time. These quantities are abstract measures since no qualitative interpetations can be attributed to them.

In the context of national account statistics, we distinguish between

(iii) input measures and

(iv) output measures.

Here, the following input measures have been used:

- information labour
- information capital
- intermediary information goods.

The first to use labour statistics and to disaggregate them into information labour and non information labour was MACHLUP (1973). The following table shows his categorisation. MACHLUP'S work was followed by PARKER (1976), PORAT (1977) and the OECD (1980a, 1980b, 1981a) etc.

All of them, though different in detail, follow the functional approach, where the actual human activity is divided into its main functions, one of them being the information activity.

Information capital comprises all those capital goods which produce, transform and convey information services or goods. Typical information capital goods are the typewriter, the radio, the television set, the computer etc.

Intermediary information goods are those, which enter the production process for a transformation into other products. A typical intermediary information good is a blueprint, a pencil, a sheet of paper and so on.

The third group of indicators are output measures, the output being goods or services of the information sector. Whereas the measurement of goods is a

relatively easy task, those of services might again incur measurement problems. (How can one measure the teaching activity and its value. Is the relevant unit time, is it the number of words, or is it the content?)

The most common unit is the economic value, measured in prices, and if not available, in costs. We know that the valuation process does not mirror the quality or the true value of the information services (WHITE 1977, WILKINSON 1980), and therefore we have to separate as sharply as possible the quantitative element from the value measurement.

## 6. Knowledge and the Information Sector

MACHLUP (1962) was one of the first to use the concept of information industries within an information sector, and he produced empirical estimates of the absolute importance of this sector. MACHLUP's pioneering work was followed by the investigations of PARKER (1976) and PORAT (1977, 1978), and most recently that of the OECD (1981a). It is to the latter that we now turn for a detailed enquiry.

### 6.1 The Functional Approach

The OECD first sought to measure the changing constribution of information related activities in terms of occupational structure. An inventory of "information occupations" was established, comprising those whose primary purpose[1)] is an output of produced, processed or distributed information, or its infrastructure support. The following table shows a typology of information occupations with tables providing the occupational detail to be included within each category.

According to the OECD - nomenclature, information producers create new information or package existing information into a form appropriate to a particular recipient.

Information processors are primarily concerned with receiving and responding to information inputs. This response may be to decide, to administer, or to perform some manipulative operation upon the information inputs.

Information distributers are primarily concerned with conveying information from the initiator to the recipient.

Information infrastructure occupations install, operate and repair the machines and technologies used to support the previous information activities.

Using the detailed inventory of tables 2 - 5, figure 8 illustrates the progressive shift which has occurred in all the OECD-member countries examined towards those occupations primarily concerned with the creation and handling of information per se. Although both starting base and rate of change vary across the

1) We might note that the inclusion/exclusion of entire occupational units is enforced by the lack of detailed time-budget studies in the OECD Member countries. This was revealed in a preliminary investigation and thereby precludes the aggregation of proportions of time spent upon "informational activities" across all occupational units.

| I.S.C.O | |
|---|---|
| | 1. Information Producers |
| | Scientific and Technical |
| o-11 | Chemists |
| o-12 | Physicists N.D.C. |
| o-13 | Physical Scientists N.E.C. |
| o-22 | Civil Engineers |
| o-23 | Electrical and Electronic engineers |
| o-24 | Mechanical Engineers |
| o-26 | Metallurgists |
| o-27 | Mining Engineers |
| o-28 | Industrial Engineers (Except o-28.3o) |
| o-29 | Engineers N.E.C. |
| o-51 | Biologists, Zoologists and related |
| o-52 | Bacteriologists, pharmacologists |
| o-53 | Agronomists and related |
| o-81 | Statisticians |
| o-82 | Mathematicians and actuaries |
| o-9o | Economists |
| 1-92 | Sociologists, anthropologists and related |
| | Market Search and Co-ordination Specialists |
| 4-1o.2o | Commodity Broker |
| 4-22 | Purchasing agents and buyers |
| 4-31 | Technical Salesmen and advisors |
| 4-41 | Insurance and stock agents, brokers and jobbers |
| 4-42 | Business Services/Advertising Salesmen |
| 4-43.2o | Auctioneers |
| | Information Gatherers |
| o-28.3o | Work Study Officers |
| o-31 | Surveyors (land, mine, hydrographic, etc.) |
| 1-39.5o<br>3-59.3o<br>3-59.45<br>7-54,7o<br>8-59.2o<br>9-49.8o | Inspectors, viewers and testers (various) |
| 3-91.5o<br>5-89.2o | Information Gatherers N.E.C. |
| o-33.2o | Quantity Surveyors |
| 4-43.3o | Valuation Surveyors |
| | Consultative Services |
| o-21 | Architects and town planners |
| o-32 | Draughtsmen |
| o-61 | Medical practitioners |
| o-69 | Dietitians and Nutritionists |
| o-75.2o | Optometrist |
| o-83 | Systems Analyst |
| o-84.2o | Computer programmer |
| 1-1o<br>1-21<br>1-29 | Accountants (except 1-1.2o)<br>and<br>Barristers, Advocates Solicitors, etc. |
| 1-39,2o | Education methods advisor |
| 1-62 | Commercial artists and designers |
| | Information Producers N.E.C. |
| 1-51.2o | Authors |
| 1-71.2o | Composers |

Table 1: Information Producers

| | 2. Information Processors |
|---|---|
| | **Administrative and Managerial** |
| 1-22 | Judges |
| 1-39.4o | Head Teacher |
| 2-o1 | Legislative Officials |
| 2-o2 | Government administrators |
| 2-11 | General Managers |
| 2-12 | Production Managers |
| 2-19 | Mangers N.E.C. |
| 3-1o | Government Executive Officials |
| 4-oo | Managers (Wholesale/retail trade) |
| | **Process Control and Supervisory** |
| o-33.4o | Clerk of works |
| o-41.4o | Flight and ship navigating officers |
| o-42.3o | |
| 3-o | Supervisors: clerical, sales and other |
| 4-21 | |
| 5-2o | |
| 5-31.2o | |
| 6-oo.3o | |
| 6-32.2o | |
| 3-5 | Transport and Communication Supervisors (except 3-59.3o and 3-59.45) |
| 3-91.2o | Dispatching/Receiving Clerk |
| 7-o | Supervisors and General Foremen (production |
| | **Clerical and Related** |
| 1-1o.2o | Auditor |
| 3-21 | Stenographer, typists and teletypists (except 3-21.3o) |
| 3-31.1o | Bookkeeper (general) |
| 3-31.2o | Bookkeeper (clerk) |
| 3-39.2o | Cost computing clerk |
| 3-39.3o | Wages Clerk |
| 3-39.4o | Finance Clerk |
| 3-91.3o | Stock records clerk |
| 3-92.2o | Material and production planning clerks |
| 3-92.3o | |
| 3-93 | Correspondence and reporting clerks |
| 3-94 | Receptionist and Travel Agency clerks |
| 3-95 | Library and Filing Clerks |
| 3-99.2o | Statistical Clerk |
| 3-99.3o | Coding Clerk |
| 3-99.4o | Proof reader |

Table 2: Information Processors

| | 3. Information Distributors |
|---|---|
| | **Educators** |
| 1-31 | University and Higher Education |
| 1-32 | Secondary teachers |
| 1-33 | Primary teachers |
| 1-34 | Pre-primary teachers |
| 1-35 | Special education teachers |
| | **Communication Workers** |
| 1-51.3o | Journalists and related writers |
| 1-59 | (except 1.59.55) |
| 1-73.3o | Stage Director |
| 1-73.4o | Motion picture, radio, television director |
| 1-73.5o | Storyteller |
| 1-74 | Producers, performing arts |
| 1-79.2o | Radio, television announcers |

Table 3: Information Distributors

| | 4. Information Infrastructure Occupations |
|---|---|
| | **Information machine workers** |
| 1-63 | Photographers and Cameramen |
| 3-21.5o | Teleprinter operator |
| 3-22 | Card and tape,punching machine operators |
| 3-41 | Bookkeeping and calculating machine operators |
| 3-42 | Automatic Dataprocessing machine operators |
| 3-99.5o | Office machine operators |
| 8-49.65 | Office machine repairmen |
| 8-62 | Sound and vision equipment operators |
| 9-21 | Compositors and typesetters |
| 9-22 | Printing Pressmen (except 9-22.7o) |
| 9-23 | Stereotypers and Electrotypers |
| 9-24 | Printing engravers (except 9-24.15 and 9-24.3o) |
| 9-25 | Photo-engravers |
| 9-26 | Bookbinders and related |
| 9-27 | Photographic processors |
| | **Postal and Telecommunications** |
| 3-7o | Postmen, mailsorters, messengers |
| 3-8o | Telephone operators |
| 8-54 | Radio and television repairmen |
| 8-56 | Telephone and telegraph installers/repairmen |
| 8-57.4o | Telephone and telegraph linesmen |
| 8-61 | Broadcasting station operators |

Table 4: Information Infrastructure Occupations

| Function | occupations |
|---|---|
| Information producers | Scientific and technical workers<br>Market search and coordination specialists,<br>Information gatherers,<br>consultative services. |
| Information processors | Administrative and managerial<br>Process control and supervisory,<br>clerical and related components. |
| Information Distributors | Educators<br>Communications workers |
| Information infrastructure occupations | Information machine workers<br>Postal and telecommunication |

Table 5: Typology of Information Occupations.

member countries, a revealing summary statistic is that on "average"[1] in each five-year period, postwar, such "information occupations" gained an extra 2.8 per cent in share[2] of total economically active.

Table 6 und 7 seeks to identify the occupational types responsible for the changes described. We see[3] that "information processing" occupations contributed almost 59 per cent of the quinqennial growth rate we observed. Of this, one-third came from enhanced use of both "administrative" and "managerial" personnel, with two-thirds from specified "clerical and related" personnel. "Information producers"

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1) For the countries and years presented in figure 8, see table 14.

2) Absolute rates of change of such occupations will, of course be even higher. This is because the figure quoted relates to increase in share of "information occupations" in the "total economically active", when that total has itself rise in the Member countries.

3) Form figures in the final column of table 7, expressed here as per centages of the average quinquennial change for "total information" occupations.

| Components \ Country and time | Austria | | Canada | | Finland | | France | | Japan | | Sweden | | United Kingdom | | United States | | Germany | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1951 | 1971 | 1951 | 1971 | 1970 | 1975 | 1954 | 1975 | 1960 | 1975 | 1960 | 1975 | 1951 | 1971 | 1950 | 1970 | 1950 | 1978 |
| INFORMATION PRODUCERS | 3.3 | 5.1 | 4.4 | 7.6 | 3.3 | 4.3 | 3.6 | 6.4 | 2.1 | 4.5 | 2.5 | 4.8 | 3.9 | 5.0 | 5.0 | 7.2 | 3.1 | 6.3 |
| Scientific and technical | 0.4 | 0.4 | 2.6 | 5.3 | | | 0.6 | 1.3 | 0.6 | 1.0 | 0.4 | 0.8 | 0.5 | 1.4 | 1.3 | 2.1 | | |
| Consultative services | 0.9 | 1.6 | | | | | 1.8 | 3.0 | 0.5 | 1.1 | 0.5 | 1.2 | 1.1 | 1.5 | 1.9 | 2.7 | | |
| Information gatherers | 0.6 | 1.2 | 0.8 | 1.1 | | | 0.3 | 0.5 | nsc | nsc | 0.1 | 0.2 | 1.0 | 0.9 | 0.3 | 0.3 | | |
| Market search and co-ordination specialists | 1.4 | 1.9 | 1.0 | 1.2 | | | 0.9 | 1.6 | 1.0 | 2.4 | 1.5 | 2.6 | 1.3 | 1.2 | 1.5 | 2.1 | | |
| INFORMATION PROCESSORS | 10.7 | 17.8 | 20.1 | 25.2 | 12.7 | 16.3 | 13.4 | 19.7 | 12.3 | 20.6 | 17.0 | 21.8 | 18.3 | 23.5 | 21.2 | 26.5 | 11.2 | 19.5 |
| Administrative and managerial | 4.8 | 7.7 | 10.4 | 12.3 | | | 6.3 | 6.7 | 2.3 | 4.4 | 3.1 | 3.5 | 4.5 | 6.6 | 8.6 | 8.1 | | |
| Process control and supervisory | | | | | | | 1.5 | 3.2 | nsc | nsc | 6.0 | 7.9 | 3.2 | 3.7 | 1.4 | 2.0 | | |
| Clerical and related | 5.9 | 10.1 | 9.7 | 12.9 | | | 5.6 | 9.8 | 10.0 | 16.2 | 7.9 | 10.4 | 10.6 | 13.2 | 11.2 | 16.4 | | |
| INFORMATION DISTRIBUTORS | 1.8 | 2.1 | 2.5 | 4.7 | 3.1 | 3.5 | 1.9 | 3.9 | 1.9 | 2.4 | 2.5 | 4.2 | 2.0 | 3.2 | 2.3 | 4.0 | 1.1 | 2.8 |
| Educators | 1.6 | 1.9 | 2.1 | 3.9 | | | 1.6 | 3.7 | 1.8 | 2.2 | 2.3 | 3.9 | 1.7 | 2.9 | 2.1 | 3.8 | | |
| Communication workers | 0.2 | 0.2 | 0.4 | 0.8 | | | 0.3 | 0.2 | 0.1 | 0.2 | 0.2 | 0.3 | 0.3 | 0.3 | 0.2 | 0.2 | | |
| INFORMATION Infrastructure | 2.2 | 3.0 | 2.3 | 2.4 | 3.0 | 3.4 | 1.4 | 2.1 | 1.6 | 2.1 | 3.9 | 4.1 | 2.5 | 3.9 | 2.2 | 3.4 | 2.9 | 4.6 |
| Communication machine workers | 0.7 | 1.2 | 0.9 | 1.3 | | | 0.6 | 0.7 | 1.0 | 1.4 | 1.3 | 1.4 | 1.4 | 2.3 | 1.0 | 2.3 | | |
| Postal and tele-communications | 1.5 | 1.8 | 1.4 | 1.1 | | | 0.8 | 1.4 | 0.6 | 0.7 | 2.6 | 2.7 | 1.1 | 1.6 | 1.2 | 1.1 | | |
| TOTAL INFORMATION | 18.0 | 26.0 | 29.3 | 39.9 | 22.1 | 27.5 | 20.3 | 32.1 | 17.9 | 29.6 | 25.9 | 34.9 | 26.7 | 35.6 | 30.7 | 41.1 | 16.3 | 32.2 |

Table 6: Components of "Information Labour Force", as % of "Economically Active".

SOURCE: OECD (1 981 a)

| Components | average change |
|---|---|
| INFORMATION PRODUCERS | + 0.60 |
| Scientific and technical | + 0.14 |
| Consultative services | + 0.20 |
| Information gatherers | + 0.05 |
| Market search and co-ordination specialists | + 0.18 |
| INFORMATION PROCESSORS | + 1.65 |
| Administrative and managerial<br><br>Process control and supervisory | + 0.54 |
| Clerical and related | 1.08 |
| INFORMATION DISTRIBUTORS | + 0.36 |
| Educators | + 0.35 |
| Communication machine workers | + 0.02 |
| INFORMATION INFRASTRUCTURE | + 0.24 |
| Communication machine workers | + 0.14 |
| Postal and tele-communications | + 0.05 |
| TOTAL INFORMATION | + 2.83 |

Table 7: Contributions to the quinqennial growth rate of the components of "Information Labour Force".
SOURCE: OECD (1981a)

accounted for 21 per cent of the overall growth rate, with major contributions from "consultative services", "market search and co-ordination specialists" and "research and development" personnel. "Information distributors" contributed a further 13 per cent, largely due to the growth of education. Finally, occupations deemed to provide "Infrastructure" support to the creation and handling of information accounted for the remaining 7 per cent of the observed growth. The major role in this latter category being played by those who install, repair and operate the various "information" machines and technologies.

A further perspective upon the growth of information occupations can be obtained by extracting such occupations from the conventional sectors[1] of agriculture, industry and service. We then obtain the four "sector" aggregation presented in figure 8. The trend towards the "information sector"can clearly be observed in all reporting countries, with residual agriculture contracting in all cases, residual industry contracting in all but Japan, and residual services expanding in all but the United Kingdom. In fact, with the single exception of Japan, over the time periods indicated there has occurred a crossover to the "information sector" as the predominant sector for employment. When we describe the "sectors" in terms of "employee compensation" rather than number of employees, then there are no exceptions and the crossover to the "information sector" as predominant occurs even earlier in time[2].

We might supplement the cross-sectional approach so far adopted with time-series data, so as to examine the changing contribution of conventional "sectors" to the growth of "information" personnel. Table 8 provides such a time-series by broad "sector"[3] of origin, with sectors defined here by the "industrial location" of the occupation.

---

1) Defined here in terms of "Function" of occupation using ISCO 1968.

2) This is due to the fact that "information occupations" are relatively well-paid, so that their share in "employee compensatin" exceeds their share in mumber of employees. For instance, this excess has been measured in the following countries:
Canada (1979) + 7.4 per cent; United Kingdom (1976) + 2.1 per cent.
Japan (1975) + 7.5 per cent; United States (1967) + 8.4 per cent.

3) Defined by industrial location, using ISIC Series M, No. 4, Rev. 2 United Nations, New York, 1971.

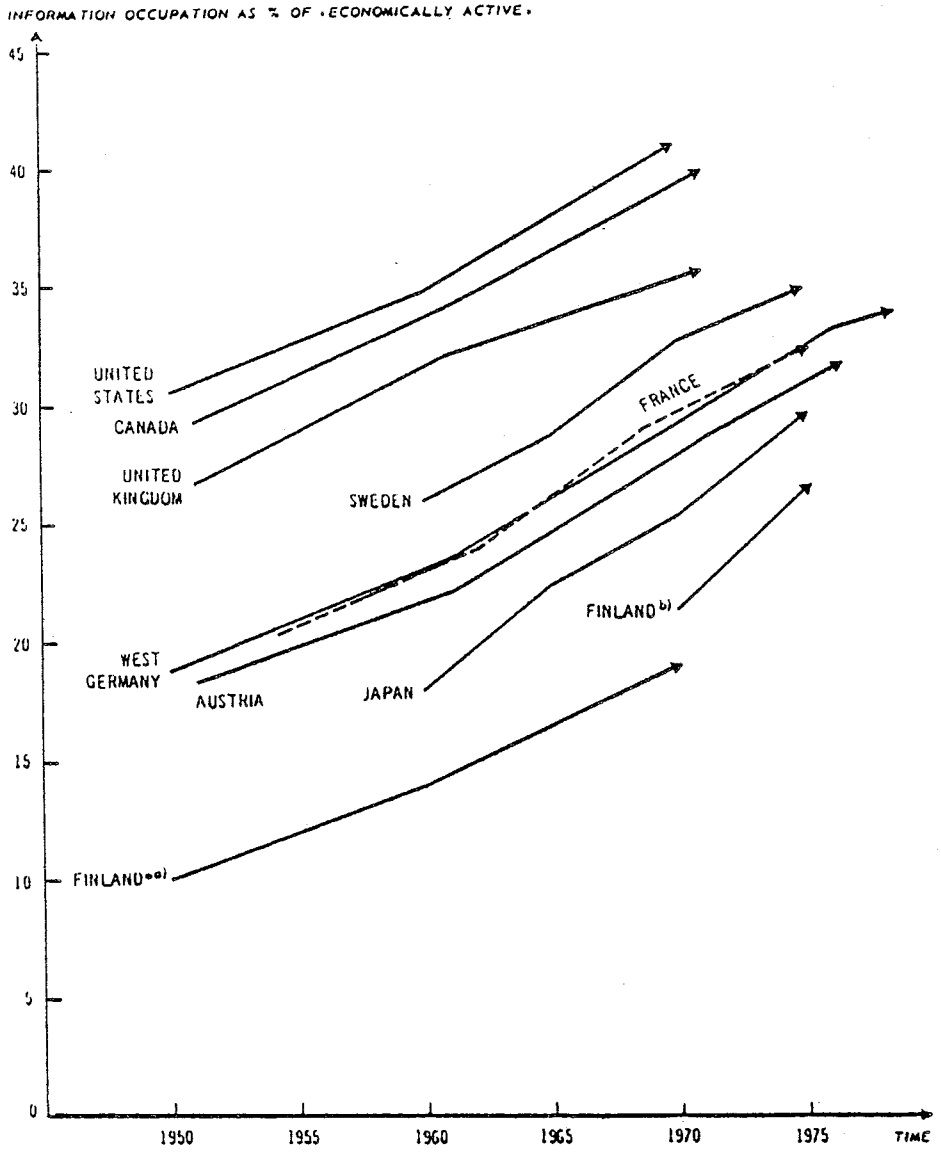


Figure 8: Four sector aggregation of "Economically Active".

Table 8 suggests that, important though the "service sector" is to the total of "information occupations", the growth of such occupations has not merely been a phenomenon of that sector. This can be seen by the substantial levels, and increases, observed for information occupations within the industrial sector" of countries presented in the table.

As regards the functional approach to classification, the picture is clearly one in which activities of generating, processing and distributing information have become progressively more important in the occupational structure of all OECD countries examined.

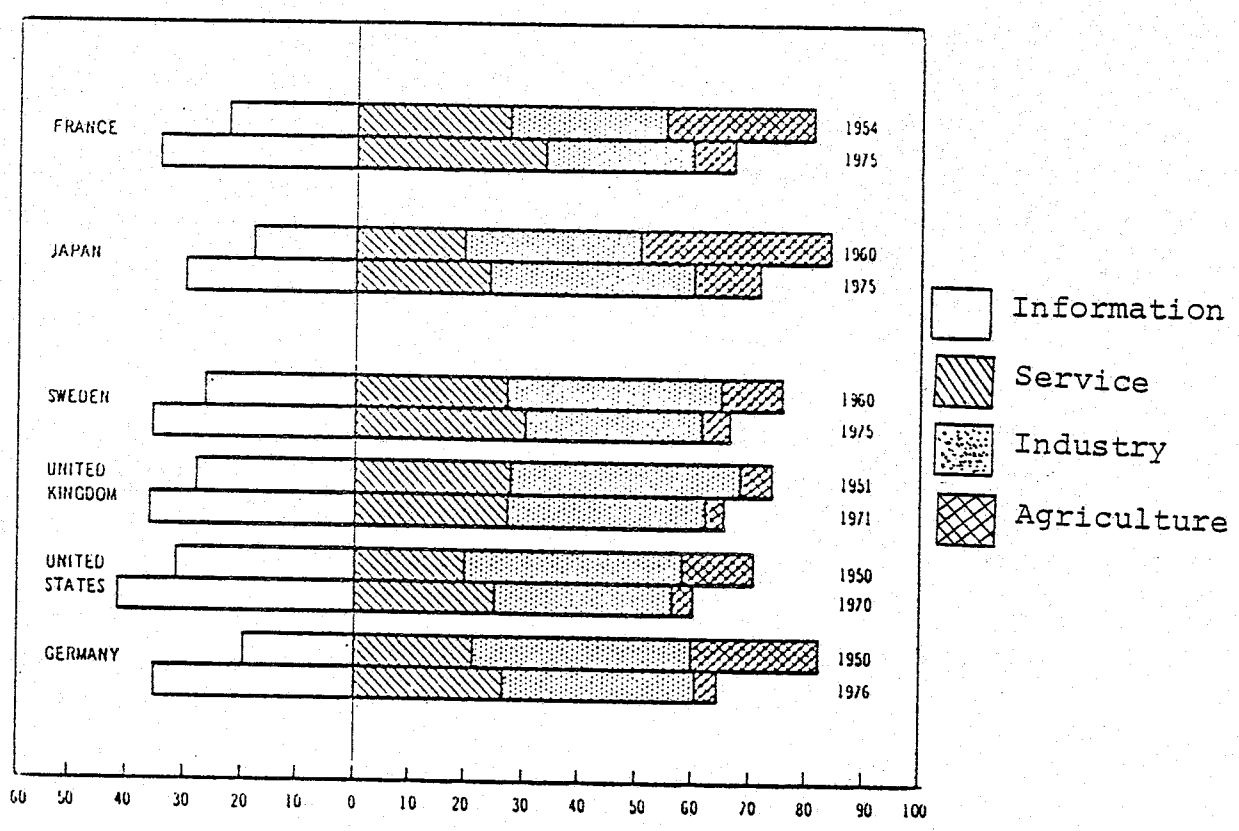


Figure 9: Four sector aggregation of "Economically Active".
SOURCE: OECD (1981a).

| Country / Sector | France | | Japan | | Sweden | | United Kingdom | | Germany | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1954 | 1975 | 1960 | 1970 | 1960 | 1975 | 1951 | 1971 | 1950 | 1976 |
| Agriculture | 0.3 | 0.2 | 0.1 | 0.1 | 0.6 | 0.5 | 0.4 | 0.2 | 0.2 | 0.1 |
| Industry | 5.1 | 9.1 | 6.5 | 9.5 | 10.8 | 11.3 | 5.9 | 8.6 | 5.1 | 10.0 |
| Services | 14.9 | 22.8 | 11.2 | 15.8 | 14.6 | 23.1 | 20.4 | 16.8 | 13.0 | 22.7 |
| Total Information Occupations | 20.3 | 32.1 | 17.8 | 25.4 | 26.0 | 34.9 | 26.7 | 35.6 | 18.3 | 32.8 |

Table 8: Information occupations by "sector" of origin in percentages of "Economic Active".

## 6.2 The Institutional Approach

This approach seeks to measure the changing contribution of information related activities within the wide range of produced goods and services within the national accounts of member contries. Such "information sector" accounts were presented in two parts, "Primary" and "Secondary"[1] which we proceed to examine consecutively.

### 6.2.1. The Primary Information Sector (PIS)

This sector includes all "information" goods and services which are sold on (established) markets[2]. To be included within this sector the product or service must intrinsically convey information (such as books), or be directly useful in its production, processing or distribution (such as computers). The typology outlined in table 9 makes a broad distinction between 'industries' which handle information itself (such as legal and accounting services, education, broadcasting, data processing, etc.) and those which manufacture, distribute and otherwise provide tangible information products. Code numbers correspond to the ISIC of all economic activities, with table 10 providing a more detailed breakdown of the components to be included.

We first assess the contribution of these products and services to GDP at factor cost, using a 'value added' method of measurement. Such a method was chosen for two main reasons; firstly, value added was considered a more appropriate vehicle than final expenditure for measuring the economic impact of information activities, in that it encompasses income creating activity at the intermediate, as well as final stage of demand. Secondly, a preliminary investigation into different country data sources revealed that "value added" breakdowns were available at a far more disaggregated level than those for final expenditure.

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1) We should note that in using the terminology of both 'Primary Information Sector' and 'Secondary Information Sector' we follow closely the seminal work of PORAT (1977).

2) Some part of government funded activities are included, such as Education, Research and Development, and Communications. Of course, not all these may be 'sold' on established markets at non-zero 'prices'. Nonetheless, we consider them indistinguishable from their market equivalents and so we incorporate their value added contributions into the Primary Information Sector.

| | |
|---|---|
| Information handling services | 1. Knowledge production industries<br>2. Search and co-ordination industries Risk management industries<br>3. Information distribution and communication industries<br>4. Information processing and transmission industries |
| Goods for information activities | 1. Non-electronic consumption or intermediate goods<br>2. Non-electronic investment goods<br>3. Electronic consumption intermediate and investment goods. |

Table 9: Typology of PIS by broad aggregates.

A "factor cost" concept was used for comparative purposes in that it avoids distortions induced by differing tax/subsidy structures as between OECD-member countries.

| AUSTRALIA (2) | FRANCE | JAPAN | SWEDEN | U.K. | USA |
|---|---|---|---|---|---|
| (1968) 14.6 | (1962) 21.6<br>(1968) 22.8<br>(1973) 24.8 | (196o) 8.4<br>(1965) 14.4<br>(197o) 18.8 | (197o) 16.9<br>(1975) 17.8 | (1963) 16.o<br>(1972) 22.o | (1958) 19.6<br>(1967) 23.8<br>(1972) 24.8 |

Table 11: Percentage share of Primary Information Sector in GDP at factor cost: selected countries and dates.
SOURCE: OECD (1981a).

Table 11 demonstrates that there has been a considerable increase, within different countries, in the proportions of value added accounted for by information goods and services sold on established markets. Table 12 below provides details of these changes at a more disaggregated level.

I. INFORMATION HANDLING SERVICES

1. Knowledge Production Industries

a) Research, Development and Investigative Industries

Commodity Inspection Services. 1120, 1302, 2100, 3211, 7191(a).
Exploration Services. 2200.
Research and Scientific Institutes. 9320.

b) Private Information Services

Legal services. 8321.
Accountancy, auditing, bookkeeping services. 8322.
Engineering, architectural and technical services. 8324.
Business services N.E.C. 8329.
Medical consultytive services. 9311.

2. Search and Co-ordination Industries, and Risk Management Industries

Clearing house services. 7111, 8103.
Control centre services. 7132.
Agencies. 7191(b).
Brokerage services. 8102, 8200.
Advertising services. 8325.
Credit institutions. 8101, 8102, 8103.

3. Information Distribution and Communication Industries

Education. 9310.
Libraries, museums and related. 9420.
Radio/TV broadcasting. 9413.
Motion picture production/distribution. 9411, 9412.
Theatrical production services. 9414.
Authors, composers and related. 9415.
Photographic studios. 9592.

4. Information Processing and Transmission Industries

Printing, publishing and allied industries. 3420.
Communication services. 7200.
Data processing services. 8323.

II. GOODS FOR INFORMATION ACTIVITIES

1. Non-electronic consumptions or intermediate goods

Pocket books. 3233.
Rulers. 3319.
Stationary, etc. 3411.
Office supplies. 3412, 3419.
Inks, etc. 3529.
Photographic and optical goods. 3839, 3852.
Watches/clocks. 3853.
Pens, pencils, etc. 3909.

2. Non-electronic investment goods

Mechanical precision tools. 3811.
Printing trades machinery and equipment. 3819, 3824.
Mechanical measuring and control instruments. 3822, 3851 (parts).
Office machinery (parts). 3825.
Optical instruments and lenses. 3620.

3. Electronic consumption, intermediate and investment goods

Office machinery (electronic parts). 3825.
Electronic measuring and control equipment. 3831, 3851(parts).
Radio, TV and communications equipment, etc. 3832.

Table 10: Typology of PIS by nature of Product or Service.

From table 12 we see that on average over each five-year period, this primary information sector contributed an additional 3.2 per cent of total value added. Of the countries examined absolute growth rates for this sector are very much higher, since our data merely reflects rises in share of totals of GDP which have, themselves, increased. The size of the primary information sector can be gauged from the fact that it contributed, in the most recent time period, an average of 20.3 per cent of total value added in the reporting countries.

| | JAPAN | | SWEDEN | | U.K. | | U.S.A. | | FRANCE | | AVERAGE QUINQUENNIAL CHANGE OVER YEARS AND COUNTRIES INDICATED [1] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I. INFORMATION HANDLING SERVICES | 1960 | 1970 | 1970 | 1975 | 1963 | 1972 | 1958 | 1967 | 1962 | 1973 | | |
| 1. Knowledge Production Industries | | | | | | | | | | | 1. | + 0,31 |
| a) Research, Development & Investigative | 0,55 | 0,72 | | | 1,06 | 1,15 | 1,01 | 1,02 | | | a) | + 0,05 |
| b) Private Information Services | 0,30 | 1,19 | | | 2,21 | 3,34 | 3,38 | 4,06 | | | b) | + 0,48 |
| Legal | | | 2,76 | 2,98 | | | | | 4,6 | 5,0 | | |
| Accounting, auditing, bookkeeping etc. | | | | | | | | | | | | |
| Architectural, engineering, technical | | | | | | | | | | | | |
| Business Services N.E.C. | | | | | | | | | | | | |
| Miscellaneous personal/repair | | | | | | | | | | | | |
| 2. Search, Coordination and Risk Management Industries | 2,39 | 5,61 | 3,19 | 3,30 | 3,59 | 6,23 | 5,19 | 5,41 | 5,1 | 5,2 | 2. | + 0,90 |
| Finance, insurance & real estate | 2,24 | 5,34 | 2,92 | 3,02 | | | | | | | | |
| Miscellaneous | 0,15 | 0,27 | 0,27 | 0,28 | | | | | | | | |
| 3. Information Distribution and Communication Industries | 3,48 | 7,00 | 9,15 | 9,18 | 7,12 | 7,83 | 7,86 | 10,30 | 6,1 | 6,2 | 3. | + 0,97 |
| a) Education | 1,68 | 2,66 | 4,91 | 5,15 | 2,57 | 3,41 | 2,82 | 4,58 | | | a) | + 0,78 |
| Libraries, museums and other community services | 0,14 | 1,42 | 0,19 | 0,23 | 0,14 | 0,17 | 0,77 | 0,89 | 2,9 | 3,1 | | |
| b) Media of Communication | | | | | | | | | | | b) | + 0,20 |
| Radio/TV Broadcasting | 0,13 | 0,21 | 0,10 | 0,10 | | | 0,33 | 0,29 | | | | |
| Newspapers & other printing/ publishing | 0,56 | 1,13 | 2,11 | 1,77 | 2,46 | 1,76 | 1,57 | 1,57 | 3,2 | 3,1 | | |
| Telegraph & Telephone services | 0,65 | 1,22 | 1,48 | 1,57 | 1,95 | 2,49 | 1,72 | 2,45 | | | | |
| Postal Services | 0,16 | 0,22 | | | | | 0,65 | 0,52 | | | | |
| Miscellaneous | 0,16 | 0,14 | 0,36 | 0,36 | | | n.s.c. | n.s.c. | | | | |
| I. TOTAL | 6,72 | 14,52 | 15,10 | 15,46 | 13,98 | 18,55 | 17,44 | 20,79 | 15,8 | 16,4 | I.TOTAL | + 2,38 |
| II. GOODS FOR INFORMATION ACTIVITIES | | | | | | | | | | | | |
| 1. Consumption and Intermediate goods | 0,57 | 1,41 | 0,40 | 0,38 | 0,64 | 0,98 | 0,44 | 0,51 | | | 1. | + 0,19 |
| Office supplies, stationary & related | 0,04 | 0,08 | 0,37 | 0,36 | 0,39 | 0,50 | 0,24 | 0,26 | | | | |
| Photographic & optical goods, etc. | 0,13 | 0,26 | 0,03 | 0,03 | 0,04 | 0,14 | 0,02 | 0,04 | | | | |
| Miscellaneous (radio, TV sets, watches, calculators, etc.) | 0,40 | 1,07 | n.s.c. | n.s.c. | 0,21 | 0,35 | 0,18 | 0,21 | 2,7 | 2,7 | | |
| 2. Investment goods | 1,12 | 2,89 | 1,43 | 1,95 | 1,42 | 2,47 | 1,75 | 2,54 | | | 2. | + 0,63 |
| Measuring & control instruments | 0,57 | 1,35 | 0,14 | 0,18 | 0,36 | 0,39 | 0,85 | 0,73 | | | | - |
| Office machinery | 0,02 | 0,13 | 0,36 | 0,32 | 0,23 | 0,45 | 0,39 | 0,42 | | | | |
| Ratio, TV & communications equipment | 0,38 | 0,96 | 0,84 | 1,35 | 0,54 | 0,52 | 0,32 | 0,79 | | | | |
| Printing Trades machinery & equipment | n.s.c. | n.s.c. | 0,09 | 0,10 | 0,09 | 0,09 | 0,08 | 0,07 | | | | |
| Miscellaneous electronic components and accesories | 0,15 | 0,47 | n.s.c. | n.s.c. | 0,20 | 0,62 | 0,11 | 0,53 | | | | |
| II. TOTAL | 1,69 | 4,30 | 1,83 | 2,34 | 2,06 | 3,46 | 2,19 | 3,05 | 2,7 | 2,7 | II.TOTAL | + 0,82 |
| TOTAL PRIMARY INFORMATION SECTOR (I+II) | 8,41 | 18,82 | 16,93 | 17,80 | 16,04 | 22,01 | 19,63 | 23,04 | 18,5 | 19,1 | TOTAL P.I.S. | + 3,20 |

1) We should note that the "components" in this column do not always sum to their main group totals, as the data set for such 'components'' is sometimes less complete.
n.s.c. = not separately classified
= included in part in 'Radio, TV and Communications Equipment'.

Table 12: Components of the Primary Information Sector, % GDP at factor Cost.
SOURCE: OECD (1981a).

"Information handling services" were found to have made the largest contribution to the observed growth of the primary information sector. In fact we can see from table 10 that almost three-quarters of our quinquennial growth rate of 3.20 per cent could be attributed to such services. In particular, "Finance, Insurance and Real Estate" (0.90 per cent), "Education and Related" (0.78 per cent), and "private information services" (0.48 per cent), have made major contributions to quinquennial growth. This latter category mainly consisted of legal, accountancy, design and a variety of other consultative services. 'Media of Communication' in the form of "Broadcasting, Printing and Publishing, and Posts and Telecommunications" (0.20 per cent), contributed most of the remaining quinquennial growth still to be accounted. Both in constituting nearly three-quarters of the observed growth of the primary information sector, and in comprising over 17 per cent of total value added in the most recent time period for those countries examined, "Information Handling Services" are an extremely important focus for policy concern.

We now turn to the other main source of growth in the primary information sector, namely "Goods for Information Activities". These comprised over one-quarter of the observed quinquennial growth rate and over 3.2 per cent of total value added in the most recent time period. "Information investment goods" (0.63 per cent) were the major item of growth, incorporating communications equipment, office machinery, measuring and control instruments, and miscellaneous electronic components and accessories. A variety of consumption and "intermediate information goods" (0.19 per cent), mainly office supplies, photographic and optical goods and a range of durable consumer goods, both electronic and non-electronic, made a rather smaller contribution to quinquennial growth of the primary information sector.

### 6.2.2. The Secondary Information Sector (SIS)

The primary information sector accounts by omitting non-market transactions understate the true contribution of information goods and services to GDP. For instance, non-information principal products use information inputs in their production and these would only have been included in the PIS accounts if they had been purchased on established markets. Suppose the pharmaceutical industry hired chartered accountants in preparing financial statements, such consultative activity would have appeared in the PIS under ISIC 8322 as a professional service. However, if the pharmaceuticals industry had used its own accountancy section (should such exist) then this non-market "information" activity would not have been measured within the primary information sector. The secondary information sector helps in this respect by recording the value added by all information "services" produced for internal consumption within those parts of the public sector and private industry which do not belong to the primary information sector. It includes the costs of organising departments and firms, maintaining and regulating markets, developing and transmitting prices, the monitoring of performance and the making and enforcing of policy.

| Japan | UK | USA |
|---|---|---|
| 1965 : 21.8 | 1963 : 13.8 | 1958 : 23.1 |
| 1970 : 16.2 | 1972 : 10.9 | 1967 : 24.7 |
| | | 1974 : 24.4 |

Table 13: "Secondary Informations Sector" as a percentage of GDP at factor cost. SOURCE: OECD (1980a).

The rather limited time series data of table 11 indicated that the share of the secondary information sector in GDP had actually declined[2)] for the countries presented. A tentative suggestion might then be that structural change is underway

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1) Employee compensation of information workers and capital consumption allowances on information equipment.

2) Absolute totals of GDP via the secondary information sector had in fact risen for the three countries examined, i.e. Japan, the United Kingdom and the United States.

in that information goods and services are increasingly purchased on established markets, thereby contributing to the growing primary information sector we had previously observed, rather than being produced and consumed 'in-house' by the non-information industries[1].

## 6.3 Conclusions

Conventional statistics already reveal a number of important structural changes taking place within the OECD countries. The progressive shift of employment away from agriculture, the primary extractive industries and industrial production, and towards service industry groupings, is well documented (OECD 1980a). That such changes are structural rather than cyclical is suggested by the fact that these trends were well established before the recessionary period 1973-77.

These and other structural changes, are well attested. However it has been the contention of the OECD report (1980b, 1981a) that conventional statistics actually obscure a profound structural change, namely the enhanced role of activities of generating, processing and distributing information, and the goods and services which these activities absorb. It was shown that occupations involved primarily in these activities have become progressively more important in the labour force of all member countries. At the same time the resources which these activities absorb have acquired a growing weight in the National Accounts[2].

In the functional approach of the OECD report (OECD 1980b, 1981a) mentioned above it was noted that information related occupations had secured an additional 3% share in the total of all economically active in each quinquennium. The report identified three main factors underlying this expansion;

(i) Slow growth in total factor productivity (TFP) in information-related activities resulting in high total factor input.

(ii) Low labour/capital price ratios in such tasks, so that labour secured the larger part of the enhanced total factor input.

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1) i.e. firms and governments which produce information services strictly for internal consumption rather than for 'sale' on established markets.

2) Only, in part accounted for by a switch from in-house provision of information, to 'out-house' purchase an established market.

(iii) Low technical elasticities of substitution between labour and capital in the information related tasks.

Whereas (ii) meant little price incentive for the substitution of capital for labour information activities, (iii) meant that there were in any case few technical opportunities for such substitution. In fact a study of Canadian manufacturing found information capital to be a complement to information labour, rather then even a weak substitute (WARSKETT 1979).

Whether such growth in the information occupations will continue is a most disputed point. It seems reasonable to suppose that continued advance in information technology will reduce the price of information capital relative to information labour. At the same time, the increased availability of highly flexible information-processing technologies can be expected to extend the range of technical substitution possibilities between capital and labour in the information-related activities[1]. These tendencies, might be expected to lead to substantial increases in capital/-labour ratios in the information activities.

So then, the enhanced total factor productivity of the new technologies will mean that for any given growth of demand for information outputs there will be a smaller growth of total factor inputs. Further, for any given growth of total factor input in the information tasks, there may be a smaller growth in demand for information labour. Trends such as those indicated in figure 7 above may not lend themself to extrapolation under the latest vintages of information technology.

Of course higher total factor productivity need not necessarily mean employment diminution. During the postwar period, industries with above average rates of growth of productivity faced below average rates of increases in costs. Cost savings were passed on to consumers through reduction in relative prices, leading to increases in demand for both output and factor input[3]. This implies that

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1) See for instance PETCHINIS (1978) for a discussion of variations in worker/machine ratios under the new technologies. For example, a word-processor no longer locks in a single typist to a single typewriter.

2) Three main employment effect can be distinguish the interactions of these make it difficult, to quantify effect, the employment effect and finally the supply effect. (HAMRIN 1981).

3) See for example, I.W. KENDRICK (1973), and also WRAGG, ROBERTSON (1978).

whether or not the rate of growth of demand adjusts to accelerated productivity growth in the information-related activities, will depend in part on whether the increases in productivity are translated into reductions in prices or into increases in factor incomes for these inputs, which might inhibit cost and price reduction. There is however, no way of resolving this question a priori.

If productivity increases do lead to reductions in relative prices, then the critical question is that of reaction of outputs to changes in prices. If price elasticities are sufficiently high, then higher total factor productivity in the information activities might have effects on output rather than on the level of labour input. Although we cannot assume figure 8 to be capable of extrapolation, neither can we yet assume that information occupations have reached their zenith.

In the institutional approach adopted by the OECD, the value added by information goods and services sold on established markets (the Primary Information Sector) increased in share of member countries GDP by 3.2 per cent in each five year period (see table 12). Again we might surmise whether such growth is likely to continue.

Information Handling Services were seen to form the major constituent of the observed growth; in fact almost three quarters of the quinquennial growth rate could be so attributed. The OECD report noted the tendency for enterprises to resort to "bought in" information services, rather than use "in house" activity[1]. If this tendency were to diminish, then the growth in value added by "private information service" might be curtailed[2]. For instance, the declining cost of data processing equipment may lead firms to develop in-house computer facilities rather than use the services of time-sharing bureaus.

Similarly the impressive growth rates for value added in the "Search Co-ordination and Risk Management Industries "may no longer continue at previous levels. Financial intermediation is at the heart of such industries, yet information technology is significantly reducing value added per unit output in this activity, particularly by capital/labour substitution for routine information processing.

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1) Evidenced by the decline in the Secondary Information Sector recorded in table 7. See also data for the French economy in TROGAN (1979),

2) For a detailed list of production units see table 10.

Again increased public expenditure has been instrumental in the growth of a number of the "information distribution and communication industries" recorded in table 6. Present restrictions on public expenditure through OECD countries will inevitably have their effect here as elsewhere.

If the "information handling services" can no longer be assumed to grow in value added at rates previously recorded, what of "goods for information activities," which accounted for the remaining quarter of quinquenial growth in the primary information sector? Certainly one constituent part may be expected to maintain its progress namely "information investment goods". First, information related products will be integrated into an increasing number of non-electronic capital goods, semiconductors will add "intelligence" to existing electrical control systems, micro and minicomputer systems will co-ordinate the workings of flexible machine tools, etc. Second, electronic capital goods will become an increasingly important part of the capital stock. The information capital available to each information worker will expand under the impetus of office automation, while information capital such as robots will replace non-information capital in production.

The other main constituent of "goods for information activities", namely final consumer demand is far less certain as to its future course. The OECD report, drawing on recent time series data notes that despite well known examples such as calculators, the post-war evolution of consumer final expenditure does not allow one to say that consumer tastes have shifted towards more information - intensive products.

As with the functional approach, sector measurement gives us little ground for assuming inexorable growth. In contradiction to theories, such as those of ADAMS, the OECD finds no immutable principles for continued growth, either in the information occupations, or in the output of information goods and services, both of, which are central to the extension and diffusion of the stock of knowledge.

## 7. Knowledge and Demand Patterns

In the foregoing chapter we emphasized the role of knowledge in economic performance thus creating an incentive by using more knowledge to increase efficiency and hence profits. It goes beyond saying that this is one driving force, perhaps the most important one, in the transition towards an information society.

The other one should not, nevertheless, be neglected. It lies in the domestic sphere of the individual and can again be decomposed into several factors;

(i) the first factor is the intrinsic demand of any individual in acquiring knowledge (STONIER 1978)[1), 2)]. This is true both for the scientist, where this constitutes the most important component of his profession, as well as the average housewife with her demand ranging from every day knowledge to trivial knowledge and popular scientific knowledge.

These demand patterns have induced the creation of mass communications and mass media, and are accompanied by another factor (BELL 1973, MOSCO, HERMAN 1980, ROBINS, WEBSTER 1980), namely

(ii) that information activities are generally characterized by a specific cost structure; relatively high fixed and small variable costs. This has implications for supply price, which can usually be realized in the price range of typical information goods, like books, newspapers etc.[3)].

(iii) The third factor is the growing importance of leisure, the heading "leisure society" having already been named as one classification of existing society. Increased leasure time creates increased demand for

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1) The primary role of knowledge has to be taken into account with a new established educational system which has to be more flexible to meet future demand as well as to manage the newly produced knowledge (see STONIER 1978).

2) HIRSCH emphasizes the social good character of education. "The value to me of any education depends not only on how much I have, but also on how much the man ahead of me in the job line has." (HIRSCH 1977.)

3) See the extensive elaboration in MACHLUP (1962).

leisure products. Knowledge is certainly one of the most important, if not the dominant, product within this category.

These factors led LEMOINE (1981) to anticipate the informatisation of households. Empirical studies on household consumption habits seem to support this hypothesis. The income elasticity of demand for information goods and services is comparatively high, i.e. greater than one, resulting in an increasing share of household budgets. This aggregate outcome however is the result of diverse effects, which should be recognized.

Knowledge, as we understand it, is not a homogeneous product. It can be attributed to at least three broad groups (SCHMORANZ et al. 1980);

(i) essential knowledge. Essential in the sense, that a deficit in it endangers human well being or even existence itself,

(ii) useful knowledge. Useful in the sense that it increases productivity in every day activities, and finally,

(iii) knowledge as an entertainment product.

It is the latter component which leads us to expect a high income elasticity, though the second component might be of more importance in the process of informatisation. This second component can be disaggregated into two quite separate effects, namely into

- accessing of information, and
- the carrying out of everyday transactions.

The (orthodox) neoclassical school emphasis as the role of prices as the most efficent transmitter of information[1]. But what happens if the prices themselves are not known, or the prospective buyer does not even know that the good in question is to be sold. How would the housing market, the second hand car market or the job market fare in the absence of the advertisement pages in the newspaper.

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1) see e.g. HAYEK (1945).

This would certainly lead to disaggregated local markets, with an absolute loss in aggregate social welfare. In other words, the absence of the well established information market would severly effect economic activity.

The second factor emphasises the new modes of transaction, especially the possibility of selling and buying without direct personal contact. The acquiring of necessary goods and services from a distance not only saves time, increasing leisure, but it also saves money. These are the productivity gains referred to above.

The most important factor, however, is knowledge as an entertainment product. It is the outcome of productivity gains in the economy which finds an outlet in new demand patterns.

Knowledge as an entertainment product is also subject to a structural process[1]. Esterhazy could afford to hire his own orchestra, and thus be entertained by live music. The average consumer of today can certainly not afford his own orchestra, but he can buy records and listen to the music he wants to hear. The radio and television is another form of entertainment, with the difference that the listener is bound to times offered to the public. Thus we have two significant changes; the first where performances, instead of being consumed by a few wealthy persons, are gradually changed to a public service, and the second where this public service is progressively substituted by privately consumable units in the form of records, tapes, video recordings and so on. The latter structural change has brought a greater variety, as well flexiblity, into leisure activities.

Household information activities of today thus differ greatly in terms of variety and flexibility. The direct and indirect effects of these new demand patterns can be but barely perceived.

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1) In analysing the characteristics of a self-service economy, GERSHUNY distinguishes three factors

   (i) high income elasticity of leisure
   (ii) a substitution of goods for services, and finally
   (iii) the trends towards the do-it-yourself economy.

# PART III

## 8. Policy Options

A number of important issues directly related to the trends and analyses presented in sections I and II are discussed below and policy implications are presented for consideration by governments. Some of these issues may appear more closely related to the preceding analysis than others. Nevertheless all the issues are inextricably linked in that they are all related to the potential impacts of the further development and diffusion of information technology.

### 8.1 Economic Growth and Productivity

Section II catalogued the disproportionate increase in information inputs observed in member countries. In section I these were seen to be related in part to an increased demand for the outputs of information activities, and in part to the lower total factor productivity of information inputs. Such an analysis helps explain the decline in the rate of labour productivity gains, experienced in most member countries over the last decade. Continuous strong demand for information activities has combined with marked productivity differentials between information and non-information inputs. The increased participation of women in the labour force has swelled the supply of labour to information-related occupations and weakened factor-price pressures towards the substitution of capital for labour in such activities. In any case, technologies which would actually permit substitution between information labour and capital were unavailable during much of the post-war period. These trends have resulted in a gradual shift of labour to low productivity information activities. As information labour becomes the dominant form of labour its increasing weight tends to pull down the overall rate of productivity growth for the economy.

The new information technology appears to offer great scope for productivity improvements in the production of both goods and services. For instance, the Canadian case study referred to above (WARSKETT 1979) provides tentative evidence[1)] that the new generation of information capital may be a substitute for both information labour and non-information labour, raising labour productivity in the information related tasks. Such a result is supported by the technical fact that the new generation of information capital has a broad scope of application, ranging from capital goods, to consumer products, to automation and control of industrial

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1) In that the degree of complementarity between information labour and capital has started to decline.

processes, transportation systems and office functions. Factor price changes are providing the financial incentives for utilising the new technical opportunities for capital/labour substitution in the information related tasks. The relative price of information capital to information labour is declining, if at a diminishing rate. The net result of this analysis is to suggest that in the coming years there could be a significant deepening of information capital in the economy, with associated increases in productivity for information labour.

In fact an accelerated diffusion of information technology may be expected to raise not only labour productivity, but total factor productivity in the information related activites. Information technology is expected to save on the use of all inputs. Materials can be saved through inventory control, capital and energy through such things as reductions in floor space via miniaturization and the substitution of communications for travel. Increases in total factor productivity imply that a given increase in demand for the outputs of these activities will lead to a lower rate of growth of inputs than before.

Economic theory suggests that productivity gains will lead to reduced unit costs which in turn are distributed in the form of higher profits, increased wages or reductions in relative prices, or some combination of these. Such gains raise consumers real incomes which, together with higher investment demand associated with higher profits, stimulates overall demand. In addition, the new technology makes possible the provision of new services and products, directly raising investment, output and employment.

This rather optimistic expansionist scenario is similar to those appearing in long term economic growth models where there is no limit to growth. Current trends suggest that energy scarce resources and pollution controls will continue to curb economic growth. Although this remains an unresolved empirical issue, it is plausible that by saving on all inputs, information technology may help alleviate existing constraints to growth.

Certainly the impacts of the development and diffusion of information technology on economic growth will depend on the relative speed at which negative displacement effects, and compensating output and employment effects, work through the economy. Too slow an application rate of technology can depress demand as a result of slow growth in real incomes. Too fast technological change may cause displacement effects to outpace the compensatory factors, at least in the short and

medium terms, so that the economy cannot absorb the potential supply of goods and services.

Economic growth rates associated with the new technologies will vary among countries. Depending upon comparative advantages, some will take disproportionately large shares of the international market for products and services affected by the new technology. Problems of uneven economic growth and payment imbalances may require concerted attention. Nevertheless, international competition will be a driving force toward adoption of the new technology.

The possibilities of higher productivity and faster economic growth, together with the desire to avoid cumulative competitive disadvantage, make it appear probable that countries will seek to further the new technologies. Such a strategy will encounter a number of constraints to application of which three broad types can be distinguished; economic, structural and social.

Economic constraints include the lack of, or unwillingness to risk, investment capital. Modes of regulation and the shortage of key skills are among the structural barriers. The fear of unfamiliar technology by the public at large is an important social constraint.

We return to specific policy options as regards these constraints at various points in the remainder of Part III. Nonetheless a number of policy options immediately present themselves for further consideration.

A number of case studies indicate that the demands for information inputs in production are highly price elastic when compared to the demands for non-information inputs. A capital subsidy, such as a tax credit on investment, would appear an effective policy instrument for promoting more rapid diffusion of information capital goods.

In order to achieve competitive efficiency in production processes in an information-based economy, economic efficiency in its infrastructure - the underlying telecommunication system - is an essential requirement. Measures to stimulate the development of the telecommunication infrastructure and to promote low-cost innovative data communication services to business, merit careful consideration. Policy instruments which suggest themselves in this respect include changes in the modes of regulation for provision of telecommunication services. Regulated competition instead of monopoly, and relaxation of requirements for carriage/con

tent separation where such have previously been enforced, are particular proposals which have already been considered.

Curriculum development and retraining provision are other areas where policy measures may reduce structural barriers to adjustment, promoting a closer match between skill supply and demand.

To decrease social barriers, public awareness programs to explain the benefits of the new information technology and to dispel unwarranted fears may be necessary. Some countries have indeed already launched such campaigns. Specific social problems caused by rapid technological change must be tackled separately, as where specific groups within the labour force bear the brunt of any adverse effects. A number of such instances are considered below.

## 8.2 Labour Related Issues

The new information technology will initiate both quantitative and qualitative changes in the labour force. It is simulataneously the driving force behing the increasingly dominant role of scientists and technicians, which led BELL (1973) to announce the primacy of theoretical knowledge, and which spilled over to the skill structure demanded in individual production processes (SCHMORANZ 1981). On the other hand empirical evidence can be quoted, we experience an "intensification" in labour process[1)], where the prime movers of the information society, technicians and engineers, feel the effects of "Taylorization" (MOSCO, HERMAN 1980, GERSHUNY 1978).

One policy issue related to information technology which has received a great deal of attention recently is the problem of technological unemployment[2)]. This can be further divided into two main sub-issues; impacts on employment levels and impacts on employment structures.

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1) Some authors see in this process the beginning of the proletarianization of clerical and service workers, who make up the bulk of the "white collar" worke force, the back bone of the so called information society (BRAVERMAN 1974).

2) See the survey of studies in LANGE et al. (1977), STONEMAN, BLATTNER, PASTRE (1982).

Our review of the characteristics of information technologies led us to conclude that the new technologies need not necessarily result in net labour displacement[1]. Productivity increases leading to a lower output price would be expected to raise the aggregate value added of information activities if the price elasticity of demand is greater than one. However it appears that in the seventies, there has been a tendency for increases in productivity to be taken in the form of higher factor incomes rather than reductions in output prices. The rate of growth of demand in response to productivity increases will vary with the distribution of the economic rents accruing from productivity growth. The future distribution of such rents is an empirical question which cannot be resolved a priori.

Other factors which could stimulate the growth of outputs of information-related activities are increases in real income consequent upon price reductions, given positive income elasticities of demand, or increased profits which could create opportunities for investment or expansion. The falling cost of energy may also mean that more income will be available for other expenditure categories.

New products and services may also be initiated, opening new markets. In this regard, available evidence on the post-war evolution of consumer final expenditure does not allow one to say that consumer tastes have as yet shifted towards more information intensive products. For instance the growth in demand for electronic consumer durables appears to have been largely a substitute for purchased information services. Therefore, a rapid increase in expenditure on these products would represent a marked change in trend.

Since a significant proportion of information related activities are not sold on markets but are publicly provided, the future demand for them may depend more on political decisions than economic considerations. In this regard, shifting public perception of government may mean a reduction in the size of the public service. In addition, changing demographic trends may result in less emphasis on educational services. On the other hand, the future may see increased expenditure on health and welfare, associated with an ageing population, and on R & D activities.

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1) see Footnote 3 on page 35.

Although our contention is that technological unemployment is by no means inevitable, the serious consequences which would follow from such an eventuality do make this whole issue one of central policy concern. Many highly publicized studies that have predicted massive unemployment effects have been based on partial equilibrium frameworks and have thus failed to take into account the dynamic effects of the productivity increases generated by the new technologies (BARRON, CURNOW 1979, DOSTAL, KÖSTNER 1977, DOSTAL 1978). A common approach has been to extrapolate specific cases and experiences within individual industries. The ultimate impact of technology is then viewed as the displacement of workers, who in this partial framework constitute a growing stream of new entrants to the pool of the unemployed. A macroeconomic approach is required to provide a more realistic appraisal of the impact of new technologies.

Turning to the question of employment structures, the possibility that the accelerating change in information technology will lead to frictional/structural unemployment of some duration cannot be discounted. For one thing, there will be changes in the pattern of skill requirements, which, being unevenly distributed, will have a differential impact upon various segments of the labour force (BARRON, CURNOW 1979, STONEMAN, BLATTNER, PASTRE 1982).

Female employment appears to be particularly at risk for two separate, though related, reasons. Firstly, female employment is restricted to a comparatively small range of occupations. Secondly, these occupations are heavily weighted in favour of routine information processing activities, which are amongt those thought to be most vulnerable to contemporary technologies (see table 6). It may therefore be advisable to encourage a wider distribution of female employment by occupational type.

Policy instruments which might accomplish this objective are varied, and must of course be assessed in cognisance of any trade offs with other specified objectives.

School curricula for girls is often narrow, restricting the range of subsequent training opportunities. Greater encouragement and opportunity might be given to girls to participote in a wider range of non traditional 'female' subjects, as well as to more carefully consider non-traditonal routes for female training on entry into the labour market.

A further problem for female employment is that large numbers of women withdraw from the work force during the childbearing years. This lack of continuity

in employment is particularly important when previous skills are becoming more rapidly obsolete. A wide range of policies can be considered for overcoming this problem, ranging from the provision of adequate child-care-facilities to the encouragement of part-time permanent work. In fact the latter may be particularly appropriate in that a high and growing proportion of female employment is part-time in nature. However, indirect costs to employers of part time labour are often high; for instance in some countries social security payments are levied irrespective of hours worked. More favourable treatment of part-time employment would appear particularly helpful to female employment prospects.

With affected activities unevenly distributed by geographical location, regional unemployment may be another manifestation of technological change. There is also some agreement that job destruction will be more severe for lower skilled workers and for older workers who have less flexibility in retraining, re-education and relocation. Developments will have to be monitored closely so that governments will be in a position to alleviate hardship for those who are displaced or for those who fail to gain entrance to labour markets.

That governmental intervention of some form will be required in labour markets becomes more probable under the new technologies. Take for instance the unskilled labour market. The upward shift in skill compositon of labour demand imposes an inevitable adjustment requirement here. Yet the high turnover rates characteristic of such markets are notorious in dissuading employers from investing in the retraining of employees. At the same time, low levels of income and education, combined with uncertainties as to future patterns of labour demand, reduce both the ability and desire of low skilled workers themselves to invest in the upgrading of their skills. Market signals are unlikely, unaided, to bring about smooth equilibrating adjustments.

Adult education and retraining will be increasingly required to ensure that workers can upgrade their skills and adapt to the new needs of the workplace under the information technologies. Of course there are aptitude limits to retraining which cannot be overlooked. Even if the demand for technologist/technician skills is sufficiently high, and training opportunities are available, not all the unskilled are intrinsically capable of retraining. Further, insofar as any occupational mismatch is a function of locality, then policies to promote geographical mobility may be required to supplement those encouraging occupational mobility.

A mechanism which has helped labour markets adjust to productivity increases in the past, has been the tendency for workers to take part of increased real income in the form of extra leisure. Again it appears that the free market palliative of voluntary reductions in working hours is less likely to follow the application of the new technologies. The corollary then follows of a higher premium being placed upon central agreement or intervention as instruments for adjusting working hours.

Worksharing schemes are of this variety and aim at spreading employment among more workers by limiting total hours worked, restricting overtime or increasing vacations. In fact work-sharing is but one of a whole range of measures directed at the avoidance of unemployment, such as marginal job subsidy and early retirement. Its full evaluation must take account of the relative merits of each type of measure, an analysis beyond our present brief. However we are able to indicate the circumstances favourable to work-sharing schemes:

- where such schemes concentrate on longer vacations or longer weekends. Two factors are particularly important here; first, that the recreational side of leisure has become progressivelly more important than the avoidance of excessive fatigue. Second, that the alternatives of shorter working days or shorter shifts have the disadvantage that they may lower hourly productivity. Were this to occur, then either hourly wages would fall, increasing employee resistance to the scheme, or hourly wages would be maintained by union pressure, in which case employers are given the incentive to adopt more capital intensive techniques, offsetting at least in part any rise in employment.

- where such schemes can be applied discriminately to occupations and sectors that are most affected by a reduction in demand for labour. It is in such sectors that workers are more willing to accept income/leisure trade - offs and employers are more willing to substitute men for hours and thereby avoid redundancy payments.

- where such schemes are applied after the employment effects or the new technologies have become apparent. Except in sectors of excess labour supply, too early an application might create labour shortages, raise real hourly wages and encourage capital/labour substitution.

In contrast to the problem of job displacement, there is also concern about the lack of skilled labour to develop, operate and use the new technologies. If necessary

skills are in short supply, the price paid for these skills may rise until much of the cost advantage of the new technology is lost.

Governments will require plans of action to ensure that there is a good supply of workers with the necessary skills. Appropriate educational systems for the young will be vital to this task. Since the evolution of information technology will place a high premium on adaptability, an educational foundation which provides a base for subsequent flexibility, rather than highly specific skills, may be the most important feature for curriculum development.

In addition, consideration should be given to the identification of frameworks for management-labour consultation which minimize frictions resulting from changes in the nature of jobs, status hierarchies, and promotional opportunities. Operational success or failure of the new technology may well depend upon the extent to which these less tangible effects have been anticipated and mutually resolved. Governments should therefore ensure that appropriate mechanisms exist, whereby problems can be considered prior to implementation of the new technologies.

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