CHAPTER I

The Knowledge-Based Information Economy*

by

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Contents

List of figures

List of tables

1 The economics of innovation and information

This study brings the intellectual dimension of economic activity onto focus. The universal use of abstractions as a foundation for economic analysis, understanding and decision making occurs both explicitly and measurably as information processing and less visibly as the use of "tacit", human-embodied knowledge.

The message is that abstract thinking or theory is becoming increasingly more important in down-to-earth practical matters. It draws significant resources, not in the least in the form of mistaken decisions.

Theory is needed to organize thoughts and facts into a coherent whole. You have to impose prior restrictions on your thinking to get intellectually organized. These are priors you normally avoid thinking too much about. Such *boundedly rational thinking* is necessary for any businessman, and the market is a powerful test for relevance. Boundedly rational thinking is typical for the scientist, arguing his theory, the only difference being that sciences, and notably social sciences do not have as powerful a test as the market. A scientist can live with erroneous priors much longer than the businessman.

Three phenomena in particular are making life difficult for the economist today. Inputs and outputs of the economic system are increasingly transacted in imperfect or regulated markets and/or are being dominated by quality components that we cannot easily measure. Production technology is increasingly moving economic activities across the statistical categories we have become accustomed to. The economist's representation of a nation – a statistical system interacting with the statistical systems of other nations, each being autonomously controlled by a political authority – is being gradually diffused through the international integration of markets and the increasing presence of the multinational corporation. Thus, we are measuring less and less well what is becoming economically more and more important. A particularly tricky measurement problem is the presence of "tacit" knowledge or "human embodied capital".

I am beginning this story with a dilemma facing current economic analysis in terms of a statistical measurement problem. I do this for several reasons. Neither theory nor measurement can develop without each other's support. And economics will have difficulties surviving as a science without a solid (read: better) foundation in good measurement. We lack the measurement system needed to capture an advanced market economy in operation, because we lack the adequate guiding theory.

Before World War II economics was very much social philosophy. It was concerned with, among other things, the nature of rational behavior in matters economics. Improved measurement helped to turn economics into an almost "hard" science. Economics still, however, has an intellectual dimension. It can be viewed from two different angles. With intellectual processes imposed on, or integrated with the physical flows of production, it becomes difficult, perhaps impossible or illogical to view matters economics through the glasses of a hardware-based, economic process. This is at least the case when you study the evolving organizational forms of an economy, which is what industrial economics is concerned with. The organizational form very much controls the information processing in the economy, the mix between markets and hierarchies, the balance between goods production and marketing and distribution, etc. And the intellectual economic process – we will find – draws significant resources. Hence, I want to approach my topic from both the intellectual ("information") and the physical side simultaneously.

Adam Smith (1776) coined the concept of productivity advance through division of labor. By breaking the work process down into finer and finer elements economies of scale in the small could be achieved. These scale effects became the drivers of the macroeconomy.

Work specialization, however, came at a cost. It required *innovative knowledge* to be created.

The more elaborate work specialization the more resources needed to *coordinate* production. Hence, there are explicit communications costs associated with organizing a specialized economy. Goods have to be moved (*transports*) and *information* has to be *processed* to guide and control all specialized activities. Such coordination can be achieved *through the market* by what Adam Smith called the invisible hand, and through management or *administrative method* in production units. The relative efficiency of the two methods determines the size structure of administrative units, or firms in the economy, as suggested by Coase (1937), and hence the market structure.

Determining the division of labor and thereby the information technology to coordinate economic action is also a prime function of markets. This *"choice" of organization technology* is rarely made explicit. It comes about through experimentation, mostly in markets and to the same extent through the political process. The outcome of that *experimental choice process,* the organizational memory of the economy is largely "tacit" and strongly influences the properties of the economic system. It has evolved through the entry and exit of firms, or the recombination of firms, the movement of people with competence between firms and within firms (internal labor markets). This determination of the organization of the economy of a nation is much more fundamental than the classical stereotypes of choosing between a planned and a market economy. The complexities of the sorting and selecting mechanisms of the markets, the *filter,* in a large measure characterize the economic system.

Finally, knowledge, once created (innovation) is diffused through the economy through imitation, or through various educational arrangements. *Learning* is an important fourth category of economic activities that has to be considered to capture the whole economy at work (see Table I.1).

The first conclusion coming right out of Adam Smith's original idea is that macroeconomic growth theory has to be based on a theory of organization of markets and of hierarchies to capture what goes on in a growing economy. And the prime ambition of this book is to measure the inputs and outputs of a growing economy such that its organization, the creation of knowledge and information use is accounted for to the extent possible.

This study will furthermore demonstrate empirically that the four information activities listed together make up the bulk of resource use in the advanced industrialized economy. One could say that economics really is about the *economics of coordination, innovation, selection and learning* (Eliasson 1989c). A significantly improved national accounts taxonomy to capture the relevant inputs and outputs of the *knowledge-based information economy* is in fact necessary to understand what is going on economically. This is also what this whole publication is devoted to.

This chapter attempts to design an information accounting system that is capable of capturing the relevant economic activities of a modern, industrial economy. This accounting system will be based on the end use classification of Table I.1. Some of the principal problems of economic measurement related to the choice of accounting system will be discussed in Section 6.

In Section 5 of this chapter, I will choose one classification scheme to measure the *information processes of the economy.* This classification scheme is a modified form of cost accounting that we have studied in business firms. In Chapters III and IV complementary information accounts for the manufacturing sector have been put together.

Information technology as a form of organization

The information technology of an economy is largely embodied in its organizational structure. The organizational structure has evolved historically, being influenced by the ongoing economic process. At each point in time the organizational structure sets the limits – very much like an operating language of a computer – of the innovative, coordinating, filtering and knowledge transfer processes of the economy. The economy so to speak has an organizational memory, and economic development becomes path dependent.

To understand technological advance in terms of the four activity types in Table I.1 we want a measurable characterization of the organizational structure of the economy. To model, or theorize about economic growth you have to explain (endogenize) institutional and organizational change. Currently this is beyond the art of economics.

On the other hand, looking at identifiable innovations like the "steam engine", one by one – which is the conventional conceptualization of technology advance in economics – biases our focus onto a much too simplistic model of economic advance. A clustering of innovations into "development blocks" or "infrastructures" or "technology networks" conveys a better understanding of technological development. The moving forces behind economic growth, however, occur at lower levels through a flow of changes in the organization of physical flows of production. Such *"reallocation of resources"* drives macro productivity growth and releases the productivity of physical factors. Hence, to explain macroeconomic growth one has to understand how changes in the organization of communication and information transfer in the economy generate measured productivity advances at the macro level.

Quality destroys the accounts

The theme of this book will be the knowledge-based information economy as it is reflected in a rapid shift of structure towards service production rather than goods manufacturing, and also a rapid, but statistically less visible change, pushed by technology towards different work organizations or institutional forms.

This development increases the heterogeneity of qualities of outputs and inputs, and hence also the difficulties of measuring *input and output.* Capacity "installed" to produce quality of output has two dimensions, namely the distributional one associated with the rate of return, and the welfare, output dimension. On the input side we cannot measure knowledge capital well. On the output side we lack statistical techniques to measure volume of quality produced. Technological competition through quality of output hence has a strongly disruptive effect on economic measurement. I suggest that these two intangibles are what really matters in an advanced economy. Thus, the modern industrial nations may be entering a phase in which the most important and the most rapidly growing inputs and outputs – knowledge and quality, respectively – are not measured at all (Eliasson 1989a). Our economic sensors will only be able to pick up a noisy reflection of the ongoing "hidden" production process, namely a positive return to these unmeasurable quantities, reflected in above-normal returns to measured capital in the capital market.

Knowledge or information?

The economic importance of dominant "tacit" competence capital embodied in the organization of firms and the economy, unmeasurable qualities associated with inputs and outputs of the economy, and difficulties of communicating essential economic information will be discussed, hence making this introductory chapter an essay on economic theory and measurement.

Modern computer technology has, however, been very helpful in this respect. It has forced a standardization on the terminology in the field. Being *informed* and *possessing knowledge* or even being *learned* are concepts long used synonymously in literature. As we go on information will mean coded and communicable knowledge, that can be articulated and understood if the requisite receiver competence exists. All other knowledge is "tacit" to use a term from psychology introduced to a reluctant economics profession by Polanyi (1967) and later by Nelson-Winter (1982) Murnane-Nelson (1984), Pelikan (1989). I will not make the conventional assumption that communicating knowledge is only a matter of transactions costs. Transactions costs are the dominant information processing costs of Table I.1. Information costs account for the bulk of resource use in the economy and the efficiency of information processing is reflected in the "tacit" organizational structure of the economy.

There are various ways of demonstrating the existence of tacit knowledge beyond the notion of prohibitive costs to communicate. If individuals in teams or organizations exhibit significant heterogeneity in competence or talent there will always be significant knowledge that cannot be communicated due to lacking receiver competence (Eliasson 1988d). It is "tacit" to those who don't understand. And this simple proof, assuming differences in sender and receiver competence will be a critical line of reasoning in the rest of my chapter.

2 From the printed word to modern information and communication technology – the necessity of path dependent economic growth modeling

Even though the fine detail of our measuring instruments limits our statistical precision, the fact is nevertheless that improvements in *information and communication* technology constitute the moving forces behind historic economic growth among industrial nations. Practically all technological advances referred to in the literature belong to this category, meaning more or less that new technology created under item 1 in Table I.1 has upgraded the physical and administrative capacity of the economic system to coordinate specialized work (item 2 in the table), including the technology to upgrade technology. The latter learning dimension is important since it lends new properties to the economic system.

The filtering and educational activities have not been quoted very much as technological advances, but I will show in this brief historical overview that they belong here, that they have contributed significantly to economic performance at the macro level, especially in recent decades and that they probably will to an increasing extent in the future. This is enough to establish empirically the notion of a *knowledge-based information processing economy*. A theory, furthermore, that entertains the ambition to explain the development of that economy has to be *organization- or micro-based.*

Major technological advances in the past have been heavily geared towards communication techniques, affecting both the *use of information and physical transports.* Information technologies related to communication and transports have a common property, namely to be very general (generic) in application, and contributing to the coordination and filtering processes of the economy. Hence, they exercise leverage effects on the entire economic system and form the basis for building so called development blocks (see Dahmén 1950). These advances in information and communication technologies have in turn completely reshaped the organizational forms (NB!) in those societies where they have been adopted and accommodated. The most general example of such social technologies is the organization of markets. Joseph Schumpeter (1942, p. 123) mentions double entry bookkeeping, an accounting control device invented in medieval Italy as a revolutionary improvement in the technique of rational cost and profit calculations, that makes large business entities manageable.

Among the more well known clusters of new technologies from the text books, we have;

- the printed word
- the steam engine
- electricity
- standardization
- automobile transport
- financial institutions
- electronics based information technology
- general education.

To this I want to add:
- the art of managing large business organizations.

I will link these "innovation blocks" together to show that they have been instrumental in moving economic development in industrial nations.

The printed word

Communication through the printed word is perhaps the most basic technology of a market economy. This innovation of 500 years ago[1] is not only a way of passing on a coded message. It is also a technique of documenting agreements (contracts), of standardization etc. Studies of historic, long-run growth processes have generally neglected the printed word as a form of (information) production technology and concentrated on the diffusion of technical innovations. The diffusion of information for hundreds of years through the printed word, however, tells a different story. The printing technique was a path-breaking production technology. It made it possible to pass on large volumes of knowledge in the abstract form of written information, which is a technology in itself. The use of that information required, however, a knowledge base in the receiver. He or she had to be able to decode the messages, be literate. Eisenstein (1979, Ch. I) calls printing "the unacknowledged revolution". She goes on to point out that the contribution of the printed word to the development of an industrial society has been a matter of many centuries and it may never be possible to realize the full extent of society's debt to this information technique.

Parker (1984), on the other hand, passes over "printing" in the

[1] The invention is in fact much older than that (Macioti 1988), even though Gutenberg's invention seems to have started the information revolution in Europe ascribed to the printing press.

traditional way: the importance of communications techniques before 1850 has to do with physical transport of people and goods. In the second half of his section on communication, the economic "effects of the telegraph and the telephone" are discussed in passing. Economic growth is typically propelled by physical innovations that move the goods producing machine called "industry". Parker fails to observe, however, that none of the innovations he mentions would have been discovered or applied with success were it not for the ability to pass on coded information through the printed word. In fact, a money-based market economy cannot be conceived of without a complementary, extensive use of information techniques based upon this fundamental discovery.

Braudel (1972, p. 764) emphasizes that "one of the great borrowings of Mediterranean civilization was undoubtedly the printing press which German master-printers introduced to Italy, Spain, Portugal and as far away as Goa".

Later Braudel (1981, pp. 397ff) refers its contribution to the development of more efficient techniques of warfare ("artillery") and ocean navigation and the printed word as a vehicle for transforming and transmitting the mathematical revolution of the 17th century into practical applications. These two techniques helped propel Europe to military and commercial dominance in the world for a long time.

But the capitalist market economies that began to develop in stages used information techniques – and since the 16th century the printed word – as an integral part of innovative, productive and distributive activities. Eisenstein (1979, p. 8) also notes how the abundance of written records "affected" ways of learning, thinking and perceiving among literate élites. It affected the ways tradition was passed on from generation to generation. Barriers to the spread of information and knowledge were efficiently broken down and the way was paved for the age of enlightenment. Eisenstein also underlines that "standardization was a consequence of printing". Standardization and improved taxonomies are "requisites of printing". Standardization and improved taxonomies are requisites for improved measurement techniques and, hence, an integrated part of scientific and industrial development. The coded message is the first stage in the development of theory, measurement and quantification techniques. The development of mathematics certainly depended on the technique of printing, as is still the case for the diffusion and transfer of sophisticated skills of industrial society.

On the other side of the coin, the potential importance (indeed danger) of this was officially recognized as long ago as the early 1600s when the Vatican attempted to suppress all printed references to the unwelcome conclusions of Copernicus and Galileo (de Santillana 1958). (It is instructive to note that representatives of the Swedish social democratic Government some years ago voiced cautious opinions about prohibiting the public use of satellite antennae.)

The steam engine

The steam engine is the classical innovation always referred to in explaining the upward "kick" in economic growth experienced during the industrial revolution. The steam engine, once perfected to the reliability needed for practical use, made railroads and large scale, fast sea transports possible. The production organization of the industrial world was entirely reshaped over a period of 50 years.

Since the industrial revolution has been so closely associated with the harnessing of energy and the substitution of steam energy for human muscle power in transports of various kinds, many researchers have preferred to relate industrialization to the increased efficiency of energy production.[2] The point, however, is that lowered transport costs due to increased transport efficiency made a different and more efficient organization of production possible. Railroads, steamships and steam powered equipment to move goods within factories and between factories, cities and nations are what made specialization of production possible. Only part of this increase in transport efficiency can be attributed to cheaper energy.

It is interesting to observe for later consideration that besides the East Indian companies of some nations and the organization of wars, the organization of railroad businesses constituted the first large scale business organization, and an intermediate organizational phase between medieval and modern organizational techniques. At least in Sweden, the early organizers (Glete 1987) of railroads came from the military. In addition only those nations that built railroads early belong to the wealthy industrial nations of today (see below).

Electricity

Electric power generation and transports also belong to the often quoted growth-generating technologies. It is universal in application. As with railroads also electric power distribution required heavy network installations. And it allowed the creation of many development blocks such as sources of power in industry, in transports and in household appliances, heating and illumination. Electricity is also a technology behind the new electronics-based information technology.

David-Bunn (1988) illustrate the emergence of electricity genera-

[2] Schurr (1984).

tion as a major source of energy as the result of a standardized system of distribution. Standardization of the electricity grid is indeed an information technology. This standardization, including the choice between alternating and direct power, took its time in emerging, offering along the way many different, extreme and hybrid solutions.

Standardization

A language is a standard for communication. Specialization of work processes to achieve economies of scale in the small was the new organizing and coordination technology of the early industrial revolution. The design of standardized, interchangeable parts defined the second phase in the industrial revolution, especially enhancing the process efficiency of American industry (Carlsson 1986). Both phases of development made it possible to design standard machine tools for repetitive, standardized, and precise machining sequences (cutting, drilling, etc.). Configurations of these standard machine tools since almost 150 years in fact still define the design of the bulk of engineering production. Standardization is a typical scale technology, and is currently becoming important for the universal applications of the new electronics-based information technology in the form of standardized operating languages, communication protocols and compatible networking designs.

One could argue that standardization represents an important information technology in itself. The main point is to decide on a standard to achieve the desired generic effects; a standard operating system to make data communication possible; a standard language to make people communicate.

But hastily conceived standards may produce a long-term inefficiency even though there are significant short-term productivity improvements. If the standardization task is complex enough a concerted effort under the auspices of an appointed standardization commission might produce the wrong standard; you get Esperanto instead of English. There are optimality properties associated with the choice of standard, and the best standard can perhaps only be obtained, if it is allowed to be freely filtered through the market through experimentation and competition, very much as it is currently happening with operating systems of Personal Computers.[3]

The development of the U.S. electricity generating and distribution system offers a challenging example. It developed in the market as a result of trial and error, and competition. Edison, that was originally locked into a direct current technology eventually realized that

[3] The ongoing (April 1989), so called UNIX war is very instructive. See Business Week, March 27, 1989 p. 54f.

the alternating current was the winner, and bailed out, in fact profitably. The alternating current network offered a host of efficiency improvements, especially cheap long distance, high voltage distribution. But, argues David (1989), direct current transmission required a battery system for efficient use, which was a handicap at the time. Imagine what could have happened to battery technology, and the automobile engine, if Edison had decided to stay on and compete Westinghouse's alternating current solution out of the market.

Financial institutions

Financial markets provide at least three different economic services:

- supply of finance
- goal setting, coordination of investment and production
- compensation for risk taking and for contributions of tacit organizational knowledge.

The first "notion" is the common one and most frequently referred to in the context of economic growth. Ashton (1948) argues that the creation of new financial institutions that pooled and distributed the real resources of the economy was what really "engineered" industrial take-off in the late 18th century England. The volume of resources needed in 18th century England was, however, small compared to the volume of resource reshuffling that can be achieved at short notice in international markets for finance, and in the U.S. domestic markets for ownership and control. The effects of such financial transactions are "reshaping industrial America" to use a popular term from business journals of the last few years. Ashton's argument carries directly over to modern raider and take-over activity. Many new financial investments contributing to this financial capacity, like option markets, would have been infeasible without modern electronics-based information technology.

We won't go deeper into this special dimension of economic activity, but only mention that the key production activity going on in financial markets is risktaking and reallocation of resources and competence according to signals in the markets. Improvements in market information processing, hence, make it more clear than before who performs below, and who performs above the market standard, and force the corresponding reallocation of resources. In that sense the strength of the signal in the capital market that somebody is exhibiting a better performance than you, and forces you, or somebody else, to do something about your own efficiency, defines the efficiency of the goal-setting function of markets. Even though abstract, the goal-setting function of the capital market is the true manifestation of the information technology of markets.

The existence and compensation of tacit knowledge is a particular instance of this information technology, in the sense that the capital (stock) market is the only market in which tacit competence can be properly rewarded, and the appropriate effort stimulated to come forward. The evidence on the efficiency of the "efficient" stock market in that respect is, however, not convincing (Eliasson 1988d).

It was observed already by McKenzie (1959) that the competence input by owners or entrepreneurs had to be recognized for all factors to be compensated, total value exhausted and equal to total costs and general competitive equilibrium possible (also see Eliasson 1985a, Ch. VI, and 1989a). However, if this entrepreneurial knowledge is typically tacit, an experimental process with unknown transactions costs is required to establish the equilibrium. We have just discussed the entrepreneurial process in the capital market and its compensation mechanisms. New financial institutions define new information technologies in capital markets, that lower transactions costs and/or affect these compensation mechanisms. The interesting question is whether entrepreneurial activity in both the real system and in the financial system at all makes a competitive equilibrium situation feasible. Whatever the answer, recognizing the importance of entrepreneurial and information activities in the capital market, as they occur in the intersection between the financial and the real system, fundamentally changes the dynamic properties of the economic system.

Automobile transport

During the last 50 years or so the automobile has provided an increasingly important and flexible "communication" service, including physical transports of goods as well as transports of human beings. This "communication" technology is universal in its application and has been increasingly expanded as the infrastructure needed to support it (roads, gas stations, repair facilities, motels, etc.) has been built. The "automobile" is a classical source of a "development block" in Dahmén's (1950) sense. It has dramatically reshaped both the production system and the ways of life in modern, industrial societies. Its main advantage over earlier forms of transports is flexibility in speed, direction and bulk size. This flexibility was achieved at a cost. As flexibility of transport became an increasingly important quality of the goods being delivered, however, the volumes being transported over roads rather than railroads increased.

The electronics revolution

The modern electronics-based information technology is a recent parallel to the printed word. Both technologies are extremely general as to their applications potential. The use of both technologies requires a correspondingly broad-based receiver competence. The economic implications were and are (respectively) formidable, and the gestation periods very long.

Generalized and efficient taxonomies, standardization and mathematical thinking are key notions in the new, digitally based information and communication technologies with which this study is concerned. For purposes of our further analysis of the commercial implications of information techniques, we will reformulate a distinction that Eisenstein (1979) carefully makes. The spread of printing first profoundly affected and altered the nature of communications within the already literate élite; i.e. where the required receiver competence existed. Second, however, the advent of printing also encouraged the spread of literacy, although the latter has been a very drawn-out process. Printing both lowered the costs of communication per se, the costs of teaching its use as well as the costs of further improving the same technology. If we generalize this observation to information technology in general, and modern computer technology in particular, we can say that the change in the nature of communication among those already "literate" corresponds to improvements in productivity experienced in already existing firms, while the spread of literacy corresponds to the widening of the base for such improvements. Even though this means stretching the argument a bit too far, modern electronics-based communication technology would have been impossible without the help of coded information exchange through the printed word.

The latter is what matters in the longer run. It explains why nations and individuals have experienced a tremendous variation in success, and why the economic effects can be profoundly negative if a "nation is unobservant" and negligent. Hence, each individual, each firm and each nation at each point in time face a large "education" problem.

The importance of universal education

Education and scientific research are the catch words for achieving success in the knowledge-based economy. Hence, the creation of a competent receiver system for complex information must be a "generic" growth-producing factor. Thus, the creation of a universal education system has often been referred to as a necessary infrastructure for a wealthy industrial economy. Evidence is overwhelmingly in favor of high levels of literacy being correlated with high levels of industrialization and economic wealth, and vice versa (see Boserup 1981, Eliasson 1988a, p. 19). In principle it is easy to accept the idea that universal education is one of the key "information technologies" upon which western industrial growth has been built. Sweden spends about 6 percent of total labor input on education and research, as measured in the national accounts and the U.S. more than 8 percent. The figure is lower for the OECD world on average. But such figures only give a partial picture of the enormous differences in human capital that distinguish the rich and the poor nation from one another, and the enormous resources needed to upgrade the human capital of the poor world to standards of the industrial world. The operational content of human capital and the production of useful educational output furthermore remain to be clarified. How to design an efficient educational system is still a matter of trial and error (see Eliasson 1988a).

From the economic perspective of this book I will define research as the creation of new knowledge and education as a method (a technology) of facilitating the transfer of new knowledge (see Table I.1). To transmit and to receive knowledge of something new, you need the know-how to package/present the message and receive it as intended. Education then is a method of removing the property of "tacitness" of knowledge, putting it on a coded form as information. One could say that the potential of science to uncover and transmit understanding – "the truth" – is the very foundation of western culture, beginning with the Greek culture, being boosted by the encyclopedists of the period of enlightenment, and manifesting itself on an enormous resource-using scale in the form of the cultural, educational and scientific establishment of western industrial nations.

Economics is, however, schizophrenic in its approach to education. On the one hand we have the economics of information, by which agents search or interpret (market) signals. On the other hand we have the completely contrary idea, implying that knowledge is all tacit, being embodied in capital and in labor as a "quality", the size of it possibly being measurable indirectly by the value it creates in the production process (Denison 1962, Jorgenson-Griliches 1967, etc.).

However, beyond regressing production value created on schooling input, or estimating "learning functions", very little research on the nature and efficiency of the total educational processes of an economy has been carried out. This was noted already by Froomkin-Jamison-Radner (1976), and the survey of the state of knowledge in Murnane-Nelson (1984) does not indicate any great leaps forward. This is an interesting absence of scientific attention to an activity that in the U.S. draws labor resources on the order of magnitude of a quarter of the labor (hour) input of manufacturing industry, and much more than that if we recognize that higher classroom education in private U.S. industry draws very large resources, in some large firms being almost as large as R&D expenditures (see e.g. Eurich 1985, Eliasson 1988a, etc.). In addition to that, work as such, and increasingly so the higher up the "quality" ladder you go, is a constant on the job-learning process. Few would argue the point that the natural science revolution of the 17th century laid the foundation of the industrial revolution. An increasing number of researchers would, however, not buy the idea that feeding more resources into basic natural science research would necessarily increase economic growth (Eliasson 1988a). The knowledge diffusion process requires both resources and "technology". It may even be argued that the stock of new technology existing globally is being poorly exploited by the firms of the industrial nations. A firm, an industry or a nation without the appropriate receiver competence of new scientific knowledge would not be capable of exploiting it industrially. Thus, it is perfectly possible that lacking the appropriate manufacturing receiver competence, the huge U.S. natural science research establishment may work against U.S. interests, by subsidizing increased Japanese competition, Japanese firms having passed U.S. manufacturing firms in technological receiver competence (Eliasson 1988c).

Similarly, arguments and studies purporting to show a causal effect from engineering education to industrial growth still are mainly reporting prior assumptions and have failed to come up with the evidence (Eliasson 1988a). In fact, the French began formal engineering education (in road and bridge building in particular) in the late 18th century to beat the British in warfare. No industrial revolution followed. The British had no formal engineering schools until very late. They did, however, have a long tradition in applied natural science, dating back to Sir Francis Bacon, being carried by Gresham College, the core of the Royal Society, and running very counter to scholastic, philosophical or theological thinking elsewhere (Frängsmyr 1977). The professors of Gresham College were very practically oriented and worked together with the industrialists. Hill (1965) argues that the importance of Gresham College has been disregarded by historians, who have overestimated the influence of Oxford and Cambridge. As Hill (1965) also observes, the areas of England first to become industrialized to an increasing extent built their advance on a population of – if I may use the word – "consultants", that specialized in diffusing, for a profit, the growing knowledge base of natural science, through small booklets and handbooks or through direct consulting, publications or activities that demanded a significant receiver competence in physical and mechanical science. The industrial revolution started in England.

I would personally argue (see Eliasson 1988b) that the organization of knowledge creation and diffusion – the scientific and educational process – and the scientific traditions upon which these processes are organized are decisive for the end result (in the firm) of industrial advance and of economic growth. Furthermore, the most general educational experience an individual can have is a varied job career; because new knowledge in tacit form in the intersection between coded scientific principles and practical applications is being generated in the experimentally organized business sector.

While research is rapidly (1) creating new tacit knowledge (2) the educational level of the receiver determines how fast the knowledge can be transferred onto communicable codable form and (3) the educational and technological level of the production system determines how fast and efficiently the new knowledge base can be turned into industrial applications. Hence at least three stocks of knowledge or competence have to be considered. They are differently sized at different places and they grow at very different rates. And we cannot even define these knowledge bases.

I would thus, finally, argue that *understanding economic growth is impossible until the nature of the educational processes of an economy has been properly understood;* both early formal schooling, higher formal education and (above all) on-the-job training in all its varied forms. But most of the empirical information to go on is lacking.

3 The art of managing large business organizations – the corporate language

The industrial knowledge base of a nation

A comparison of different countries shows enormous differences in human skill endowment. In the advanced industrial society this endowment is normally taken for granted. It is "tacit" and its inhabitants may not even realize its significance for their economic well being.

The costs in the past in the form of lost physical work input to educate, or train the population is what modern, industrial nations derive their wealth from. Since educating and training the people of advanced industrial nations require the presence of "teachers" that possess the competence needed – and much of this competence resides in human beings or teams of individuals working in the advanced industrial nations – it is easy to understand the difficulties associated with "trying to catch up" through educational crash programs. And the competence endowment of a nation appears to be "durable". Not even the devastation of the Second World War destroyed the industrial human capital endowment of Germany and Japan, only physical capital. But in a historic perspective the human capital of a country, by degrees and through political and institutional arrangements, can be made both to deteriorate and improve in quality and quantity. The problem is that science currently provides no guideline as to how.

The postwar period, and the last decade or so, in particular, has witnessed the growth of giant Swedish multinational firms that have replaced basic industries as the backbone of Swedish industry, and hence economic wealth. This development is in contrast to developments in other industrial nations, that have seen a shrinking in the size of the large firms, and in this see a cause for concern. Is the large manufacturing corporation really the efficient future organization of industrial production?[4]

The earlier section discussed financial markets as suppliers of finance, as goal setters, as coordinators of investment and production and as allocators of scarce human competence. This section discusses the same economic problem, not as it is solved in the markets but as it is solved in a hierarchy through administration or management technique rather than through the price system. Apparently administrative techniques in Swedish firms have beaten the market in that task over the last ten to twenty years, in contrast to developments abroad.

The large firm

A firm by definition derives its existence from a "team" or "hierarchical" competence to coordinate production that is superior to the market. This coordination competence is one of the information processing activities investigated in this essay.

Hierarchical superiority over the market depends either on badly functioning markets, or superior management competence. We therefore see an interesting paradox in the historic development of the giant firm. The specialization of work, so well presented by Adam Smith, was made possible through the development of a viable market economy. However, in some dimensions physical size turned out to be exactly what made a difference; namely large volume production of standardized goods for "universal use" ("steel"), assembly of standardized products ("automobiles"), finance and risk handling (banks, insurance, conglomerate organization), etc.

[4] This problem is investigated in more detail in a separate study (Eliasson, 1989d).

Sometimes a hierarchy substituted for the absence of a market, as was the case in the provisions of risk capital in the early industrialization process. In recent years the capital markets are becoming increasingly efficient compared to hierarchies in profitably managing scarce funds. Raiders are threatening to take over the very large U.S. corporations. And there are often good reasons for it.[5]

The larger the organizations the more complex the coordination problems. As a rule the large business organizations are all afflicted with various forms of scale diseconomies when it comes to coordinating the hierarchy (see Eliasson 1976, 1984b). In each case some specific scale economy or synergy makes all the difference. Many of these synergy effects have also been documented in literature. The wealthy industrial nations have succeeded over the last 100 or so years, to exploit large, in some cases global economies of specialized scale, through the ability of their firms to organize and coordinate large business hierarchies. The coordination technologies have been efficient enough to overcome the handicap vis-à-vis small competitors in terms of flexibility, bureaucratic overheads, etc. and to generate a large surplus (rent) from the particular scale factor (competence) upon which the firm is built (see Eliasson 1988d).

While a combination of finance and crude processing scale (''steel'') characterized the early industrialization, scale on the assembly side took over as engineering industry grew in importance, giving way in the postwar period to distribution and marketing and in more recent years, to the appropriation of technology rents through controlling the market outlets (''buying market shares'').

As time has marched on process technology and market technology have also changed, affecting the hierarchical efficiency and the nature of big business and its rents. Some industries of the rich nations have not performed well on either innovative or educational accounts. They have lagged behind industrially as they got stuck in obsolete "scale technologies". The Swedish "industrial cycle" over the last 100 years is especially illustrative. Natural resource industries (forests, iron ore and hydroelectric power) were first transformed into raw material (basic) industries. In the postwar period these industries were used to finance a rapid expansion of specialized engineering industries. During the last 20 years or so a combination of advanced product development and global marketing/distribution competence has become the key characteristic of technological (product) competition, manifested through a heavy concentration of Swedish manufacturing production to a few giant international firms. Each of these stages of development required the earlier stage as a knowledge base.

[5] See *Expansion, avveckling och företagsvärdering* (Expansion, exit and valuation of firms), IUI, Stockholm 1988.

In fact, as Bo Carlsson has recently (1987) demonstrated, Swedish manufacturing industry appears to have developed along a course, contrary to the rest of the industrialized world, breeding increased scale both in production (plants) and firm (financial) size. More specifically the scale economies developed appear to be (Eliasson 1984a, 1985b, 1988c) a combination of product development in Sweden, and global marketing. This innovative organizational technology is indirectly reflected in the statistics of external service purchases in different countries and industries reported in Chapters III and IV. The Swedish orientation would bring critical service functions like marketing and product development inside the firms. Since these are particularly resource-using internal services, since they are particularly extensive in those firms that have developed that particular competitive edge, and since these firms have been very successful to the extent that they now dominate the entire manufacturing industry, one would expect that their dominance in the large firms significantly affects the "statistical characteristics" of the entire manufacturing sector. The data differences reported therefore may not be puzzling at all.

An interesting question is whether this selforganizing hierarchical structure is a viable organizational form for the future, when smaller scale and organizational fragmentation seem to take precedence in the rest of the world. Perhaps the economists are in for another puzzling experience if they don't improve their measurement systems fast.

Industrial and statistical fragmentation

On this score a number of new technologies directly related to the problems of this book have developed. There are two tendencies counteracting each other.

First, hardware technology in a number of traditional industries is making small scale, flexible production increasingly competitive compared to the traditional, large scale factory organization. New flexible manufacturing production techniques explain part of this development, but economic factors probably are decisive, namely tastes and demand for variability in product design, of industrial goods in particular, but also of course for consumer products among the rich industrial nations. The result has been the development of global markets for specialized products, and a diminishing scale in goods manufacturing, partly reflected in an increased decentralization of production through subcontracting.

A particular instance of this development has been the rapidly increasing institutional fragmentation of manufacturing-related service production making the statistical definition of manufacturing industry increasingly diffuse. If a large manufacturing firm like Volvo operates its marketing, or R&D, product design, or maintenance functions internally, all these typical service activities are classified as manufacturing. If the same services are subcontracted in the market, they are called private services, today making "business services" the most rapidly growing employer in both the U.S. and in Sweden (see Figure I.1. Also see Elfring 1988a,b, Eliasson 1988a, pp. 67 ff). We will return to this below when going through the numbers. But I should add that economic factors play an additional, forceful role in pushing this development. First of all a large factory line organization can never satisfactorily define individual efforts and productivities. Furthermore, the morale of large hierarchical organizations, reinforced by unions, is not to allow the enormous spread in individual productivities to be fully reflected in work compensation. Hence, any large, hierarchical organized production unit exhibits a strong internal wage and salary equalization, compared to the corresponding productivity spread. Thus, there exist strong incentives for highly productive and economically valuable individuals or teams, to break loose from such a rigid work organization, to establish their own team in the market and appropriate their own productivities. Obviously, taxes also stimulate this development, although this development has so far gone faster in the U.S. with lower taxes than in Sweden. With engineering industry, where this development is most visible, it is based on a new organization of production and possibly on new communication and information technology.

Decentralization of production through more efficient central controls

The opposite tendency towards monolithic, financial organizations composed of a decentralized production system has also been made possible by modern information technology.

A rigid line organization of production needs a minimum of coordination, since the speed of the line forces a consistent work input. With increasing heterogeneity of products and of markets a corresponding internal fragmentation of the organization of production has followed, requiring a rapidly increasing middle management bureaucracy to coordinate the large firms. Middle management essentially serves the purpose of communicating targets top down through the organization and communicating information or capacities etc. bottom up (Eliasson 1976). In very large firms this administrative coordination bureaucracy – the comprehensive budget process belongs here – eventually became counterproductive and costly enough to attract attention as a potential rationalization target.

The concern with improved information and communication technology in the organization of production has increased steadily over the last 50 years.[6] The first steps were purely organizational, including the spread of divisionalization in the early postwar years. However, with the advent of computer age it has become common to talk about making corporations (electronically) *transparent*. There is an obvious direct rationalization potential here, that has been slow in coming. The largest benefits of the new technology have come through fast growth of firms as financial organizations, breaking the size limits previously set by prohibitive internal coordination costs. The technique has been decentralization of operations through a more reliable central profit control system. Swedish firms in mature markets have been particularly creative in exploiting this technique, globalizing and reaping benefits from large scale in global markets and from distribution in particular, increasingly decentralizing goods production. Global marketing and distribution scale has become very profitable through this coordination technique, since it allows firms to capture the rents from new product inventions through R&D very rapidly and ahead of the rate of imitation of competitors.[7]

Thus it is completely wrong to talk about the lacking high technology or competence industries in Sweden. The global coordination technology we can observe in large Swedish corporations is indeed high-tech in management, and there is no evidence whatsoever, that high-tech industries of the traditional cut have been particularly successful in terms of profits. Above all, small, high-tech start ups take an incredible time to grow large, and most of them fail. The employment backbone of Swedish industry sits in the big manufacturing corporations, basing their success on sophisticated global management and information technology.

4 The information design sectors

The broad presentation of the information and communication processes of a national economy in the earlier sections means looking at production from a different point of view than the conventional one. Rather than studying the input-output structure of the economy we have been looking at its organizational design, acknowledging

[6] or perhaps over the last 500 years or so. As I mentioned, Joseph Schumpeter (1942, p. 123) called double entry book keeping – a typical information device – the major innovation of the industrial world that made rational profit and cost calculations possible.

[7] This is further elaborated in Eliasson (1987b, 1988c, 1989d).

thereby that the designs can differ and exhibit different performance characteristics. We have made the organizational design of the economy the blueprint of its information technology. Having said this we have also said that the above account of information processing is grossly inadequate, since it has been restricted to the production of typical consumption goods and services. Once innovations, tacit knowledge and learning have been accepted as important elements of the dynamic economic process, we also have to accept that decisions now and then go wrong. Mistakes, being a normal part of economic processes is the essential learning cost of the *experimentally organized economy* discussed at length elsewhere (Eliasson 1987a, 1988b, 1989d). Part of resources of the economy has to be devoted to coping with change and the unexpected. Furthermore, the whole mood controlling part of society and deliberate designs to bias information and understanding; culture, policy, teaching, religion, etc, has been left out.

Service production that has earlier been regarded as services for direct consumption now become part of the huge, resource using "software" or information structure that controls economic processes.

There is a goods-producing "engine" somewhere underneath this deep structure. But it is no longer only "manufacturing" that moves and supports all the rest of the economy. A large chunk of typical information activities has to be added; the church, the media and the political, the entertainment, and the cultural establishments, union activity and lobbying, and probably also the research and teaching communities. Together the typical information design activities (excluding research and teaching) accounted for at least 8 percent of total employment in an advanced industrial economy and contributed about as much to GNP in 1985, as we measure it (see Table I.6). With the exception of parts of manufacturing, these activities employ the most well educated members of the labor force.

Misinformation society

Information design filters, hence, play a fundamental role in shaping, modifying and biasing the flows of information in modern industrial society. Some of them interact directly with the physical production process of manufacturing firms (finance, retail and wholesale trade, etc.), others indirectly, while a large part of service production operates on the "mood" or "culture" of society. There is not yet a method available to capture this entire information process. Table I.6 is a crude attempt.

Economics traditionally assumes policy and culture and other "institutions" to be exogenous to the economic system. The volume of direct intermediating and trading inputs can, however, be measured. It follows from what I have just said that the softer services side is the one most fundamentally affected (so far) by the rapid advances in communication technology of recent years. Even though people at large are bad readers of books the less literate masses are influenced by an increasingly potent presentational technology, launched at them by lobbying organizations, interest groups or the political system, and other members of the information design sector through the most formidable of communication techniques. The influence of television (compared to before television age) on demand patterns, on the political system, on ways of thinking and on culture in general can hardly be underestimated. This is probably both where demand growth will occur and where the largest technology potential is to be found over the next few decades. The economic effects of an even more effective international voice, text and picture based communication system are mind-boggling, as are the educational demands on economies still shaped in a national mode of thinking.

Understanding what to do has become – in our presentation – more important and more resource demanding than doing it. Understanding includes three steps:

(1) Establishing the existence of a fundamental factor or relationship upon which to act.

(2) Choosing a "theory" through which to screen (filter) facts (bounded rationality; Simon 1955).

(3) Interpreting the facts.

Classical economic literature discusses only (3), assuming that (1) is no problem, and that all information that is needed is freely available, and both can be and are used. This is the full or perfect information syndrome of economics. It has made classical economic theory a very hazardous support for understanding things economical.[8] It focuses attention on analytical technicalities and leaves the intellectually much more demanding task of establishing context (1) and relevance (2) to the discretion of the decision maker. Hence, our interpretation filters make us all observe more or less distorted images of the underlying fundamentals.

[8] The asymmetric information literature of the last few years is an improvement, since it recognizes that agents may be constantly uninformed. But as long as the basic fact is not acknowledged that information use is the largest resource input in the economy, that it is steadily influenced by technological innovations and that agents may be constantly misinformed, also the economist will be giving bad advice, sometimes with devestating effects on national economies.

For me it comes very naturally to think in terms of misrepresentation, misinterpretation and misinformation economics. This is more than misinterpreting price and quantity signals in markets and making pure economic mistakes. The really important effects come through the screening devices of decision makers (''the choice of interpretation model'') by which we all choose what to see, what to neglect, what to be important etc. Such choices permeate all layers of society from the unskilled worker who chooses to compare his wage with that of a group of other unskilled workers only, to the mood and culture controlling educational bodies at the top of society. Let me conclude with the seemingly innocent observation (Nordberg 1984, p. 9) that 1400th and 1500th century Italian humanists – the learned men of Italian Renaissance – managed to make 500 years of western civilization believe that 1000 years of medieval times – from the 5th to the 15th hundreds – was a time of intellectual stagnation.

The size of information design activities

It is difficult to get a statistical hold on the importance of the information design activities. The reason is partly conceptual, but lack of concepts and theory and archaic statistical classification systems are the main reasons. Private entertainment production poses no more difficulties of measurement than automobile or computer production. With the right numbers modern information design and communication technology would do wonders here.

A few attempts to get to grasps with the numbers can be reported. Myerscough (1988) has studied the economic importance of the arts in Great Britain, primarily to investigate the economics of tourism. But a few extra insights are reported. The arts sector, including primarily theater, film, TV, musical performance, publishing and art and crafts employed some half million people in 1984/85 or 2 percent of the British labor force, its turnover accounting for 2.5 percent of all spending on goods and services in the U.K. The sector is highly knowledge intensive. Some 27 percent of British overseas earnings can be attributed to the arts. Similar numbers are not available for Sweden.

This illustrates a point that I have discussed elsewhere (Eliasson 1986b, 1988a). There may be an optimal economic policy design for a nation, given a set of policy objectives. But there may be prohibitive economic costs associated with convincing the members of a democratic society that this is the policy design they desire.

The reason may be – the positive interpretation – that voters do not understand. The issue at stake is too complex. Education is needed to make people at large understand.

Another reason may be – the negative interpretation – that people do not want this policy and need to be convinced, or a large minority does not like it. Hence, an undecisive majority has to be convinced to vote down the minority.

All political systems incorporate both "forces of values", and in addition carry on a heritage of values and traditions that has to be maintained by the political system to achieve orderly economic behavior. The enactment of the so called "Swedish policy model" was not a costless activity designed by Swedish intellectuals. It served the important economic function to bias people's views to accept the social costs associated with the rapid structural change needed to support rapid macroeconomic growth. The implementation and the use of the Swedish policy model carried an extensive cost account in the form of economic debate, lobbying etc. to convince reluctant political forces (see Eliasson-Ysander 1983 and Eliasson 1986b, 1988b). The information design sector, as I see it, is engaged in carrying on this task through education, through entertainment, through religious ritual, and through lobbying and politics, and other kinds of preaching. I have estimated it to "contribute" 8.5 percent to GNP – as we measure it – in Table I.6 This measure does not include education. It is my guess that if this information design activity is measured properly from the cost side, which cannot be done today, the relative resources used up would be considerably greater.

Earlier we took note of the fact that new information technology was capable of improving the technology of creating new information technology having significant implications for our ways of looking at the organization of a national economy. The information design sectors add a new dimension to that influence, in the sense that they also affect our ways of looking at, and accepting technological advance.

5 The knowledge-based information economy in figures

Statistical data are gradually becoming available that quantify the structure of the knowledge-based information economy. I will summarize the results in this section. I will try to identify both the inputs and the outputs of knowledge-based information processing. The overall conclusion is that information processing dominates as a form of production and that the extent of service production sometimes is a reasonable proxy for the extent of information activities.

Information processing costs dominate

Total employment in the Swedish economy can roughly be divided up into one third in each of the three sectors; public service production, private service production and goods production.

Public service production is almost all information processing; partly for *coordination purposes* (the tasks of the national night watch state; legal and monetary contract responsibilities) but mainly for infrastructure provisions like education, health care and insurance, including defense.

Private service production is more or less entirely engaged in coordination and in market-based culture and entertainment activities. We have, on the one hand, transports of people and goods, trade, and finance that support goods production, and, on the other hand, the whole leisure and entertainment sector.

Goods production itself, finally, includes a dominant information activity, probably using up significantly more than 50 percent of total costs. We have technical information processing, for instance product development, marketing and distribution and not the least, internal education.[9]

Marketing is the largest item, drawing some 30 percent of total labor costs in the largest Swedish corporations. It serves to identify, inform and convince the "right" customer, i.e. those who pay well. Central financial control takes a considerable human input, the size of which we cannot quantify. Internal coordination within a modern factory takes about half of total labor input.

We have production flow scheduling, work preparation, monitoring etc. and quality control.

The production flows are represented – as far as possible – one-to-one by gigantic databases and computational algorithms. In some cases this "representation" has come very close to what can be called "automated manufacturing" and applications of CAD/CAM technology are rapidly gaining ground.

Costs associated with coordination within firms, and most obviously within large firms, are so large, and growing, that *technological upgrading of the (information) technology of coordination* is becoming the important element of business success and long-term survival.

This has been dramatically illustrated during the past two or so decades by rapid automation or subcontracting abroad of simple manufacturing components processing, cutting the relative share of workers, notably unskilled workers in total manufacturing employment.

[9] See *Kunskap, information och tjänster. En studie av svenska industriföretag* (Knowledge, information and service production – a study of Swedish manufacturing firms), IUI, Stockholm 1986.

A similar automation drive is under way at the core information machinery of the modern corporation, threatening large groups of unskilled middle management into joblessness. This development is particularly interesting, since we are concerned with the improvement of a genuine information (coordination) technology through the application of new technology (see above).

The distinction between private and public service production is in a large measure arbitrary when it comes to functions performed. The distinction has to do with how and by whom work is organized. In that sense privatization, i.e. moving public service production into private markets, signifies a change in information technology.

The service content of GNP (inputs)

As I have argued before it is easier to measure the costs of paid factor inputs than their contributions to the economic value of final output. Provided factor inputs can be classified on categories that can be associated with the desired output categories, we obtain an indication of the inputs expected to generate information or knowledge. Let us begin with this.

The national accounts provide a source of information on direct service production that can be said to approximate information and communication activities. Table I.2 compares labor inputs in service production, classified by four end use categories, in the Swedish and U.S. economies, using the statistical resolution of the national accounts systems.

Total service production so measured is somewhat larger in percent of total employment in the U.S. than in Sweden.

The distribution sectors are of roughly the same proportions. Labor inputs in social services substitute for personal services in Sweden compared to the U.S. The reason may be partly classificational, but is mainly due to the fact that social services are predominantly produced by the public sector at heavily subsidized costs. It is to be noted that social services – for some reason education belongs here – that are regarded to be privately important are consumed in proportion to the real level of income, with a slight subsidization bias. Thus public formal education and research, including private colleges and universities in the U.S., in 1983 accounted for 8.1 percent of total employment in the U.S. and somewhat less, or 6 percent in Sweden. Health care, being almost 100 percent publicly produced (and heavily subsidized in Sweden) accounted in 1983 for 9.9 percent of labor input in Sweden, and somewhat less, or 7.6 percent in the U.S. There it is produced more than 80 percent privately, but with heavily subsidized costs, although not to the Swedish extent.

Agriculture and mining, public utilities and the construction sector are equally large measured by labor input. The interesting difference is to be found in a comparison of producer services and manufacturing in the two countries.

As I noted already when discussing the large manufacturing firm its internal activities are dominated by knowledge-intensive service production, mostly information processing, while the statistical taxonomies go by judicial criteria. Hence, manufacturing service production, like marketing is rather arbitrarily classified as manufacturing goods production or as private services, depending upon whether the service is produced internally within the manufacturing firm, or purchased in the market.

The U.S. economy is a more decentralized economy than the Swedish economy – more markets, less hierarchies – and hence, contrary to conventional wisdom less dominated by large firms. Private producer services for manufacturing therefore draw more labor resources in the U.S. than in Sweden. The producer services sector is not only the fastest growing employer in both countries. It has grown relatively faster in the U.S. than in Sweden (see Figure I.1). This probably reflects the increasing fragmentation of hierarchies in the U.S. – more market decentralization – compared to the opposite development in Sweden. I would add here that the market for professional services is, perhaps, the most important aspect of the evolving new industrial technology. Very much as we never understood the nature of engineering education in Great Britain during the industrial revolution (see Section 2), we do not have any statistical information on a highly important form of institutional change going on. The reason is not only lack of statistical data. We rather lack the conceptual framework to make economic sense of this institutional phenomenon, i.e. we lack the theory needed to interpret the data and understand what is happening.

Including producer services, the U.S. manufacturing sector does not even decrease in terms of employment over the 70s and the 80s. Counter to current wisdom – it accounts for a larger relative contribution to GNP than Swedish manufacturing (see below).[10]

The conclusion so far is that national accounts not only tell a biased story about industrial structures. They are not designed to capture the nature of knowledge-based information processing in the modern economy.

[10] Again, if one includes employment in foreign subsidiaries U.S. and Swedish manufacturing may be of roughly equal size compared to GNP.

The information economy

Even though we have concluded that "the information economy" may be the wrong idea – emphasis should be on knowledge and competence – let us give it a try anyway. Many researchers have attempted to measure economic information processing, and the OECD has designed a corresponding input accounting system.

The OECD divides the economy into four categories; (1) *information producers,* (2) *processors,* (3) *distributors and* (4) *infrastructures providers.* What this means is explained below and in the next chapter. The problem is that this classification is factor input oriented. It does not tell much about the function or end use of information. Hence, it suffers from the same problem as industrial statistical systems around the world, being based on materials use or the techniques of production, rather than the purpose (end use) of production, or the markets for knowledge-intensive products. By these "biased" standards, however, the information sector (see Table I.3 and next chapter by Fölster) has been rapidly growing in all industrial countries, being the largest in the most advanced nations, reflecting their increased service production and increased use of skilled or educated labor. By these accounts Sweden together with Japan and West Germany, being the most hardware-intensive producers domestically, but with sophisticated manufacturing industries come in in the middle [see Fölster's chapter, and below], while the Anglo-Saxon, decentralized economies, Australia, U.K. and the U.S. come in with the largest information sectors. The large part of Swedish manufacturing industry being internationally based, may give a hardware bias to the Swedish figures covering mainly production in Sweden, since foreign activities have a heavy marketing, distribution and final assembly orientation.

A more appropriate statistical account of the information economy, should be based on Tables I.4 and I.6, that classify labor input by function and quality, respectively. I will present the numbers in two steps. The first step is recorded in Table I.4 and covers manufacturing firms in Sweden and abroad. This table is restricted to firms that are formally classified as manufacturing firms, and puts together data from a variety of sources, mostly IUI data. Table I.4 covers the large manufacturing firms only; all firms or divisions in Swedish manufacturing with more than 200 employees, or some 70 percent of domestic Swedish manufacturing employment. These data on large firms have a service or information processing bias, since we expect small firms to be more goods processing oriented, many of them being component producing subcontractors to the large firms.

Coverage is global and also includes purchase of services.

External purchases of services accounted for 22 percent of global labor costs. About half of labor costs within the factories should be labeled costs for information processing. At the firm level between 60 and 70 percent of total labor costs are most appropriately viewed as information costs.

The picture of the advanced manufacturing firm as a knowledge-based information processor emerges (see Eliasson 1988d).

At this stage we should pause and compare with the data reported in Chapters III and IV (in this volume) which tell that Swedish manufacturing firms differ from manufacturing firms in other nations in having an unusually low share (of value added or sales) of external service purchases. Neither degree of technological sophistication, size of firms, unionization or form of industrial relations nor other plausible factors explain (in Chapter IV) the differences between nations and sectors in external service purchases. There are, however, rather clear indications for Swedish manufacturing of substitutability between internal and external service production. The share of external purchases of services is negatively correlated with the share of internal service production. My personal interpretation – already told in Section 3 – is that this reflects the different organizational technology of large, dominant, Swedish multinationals, differing clearly from firms in other industrial nations in their extensive use of scale economies both in terms of financial and establishment size. The particular scale (or scope) economies exploited in Swedish firms, engineering firms in particular, is a combination of global marketing through controlled subsidiaries and product technology competition in mature markets, through innovative R&D activity, mostly allocated to product development. All these factors would together suggest a higher and growing share of inhouse service production (mostly marketing and R&D) and a relatively (to similar firms in other countries) lower external purchase ratio.

For the statistical people one could add that this is very disturbing. It emphasizes that the allocation of certain critical production activities on what is statistically called manufacturing or private service production depends on how the organizational technology of the firm develops.

The quality of labor input

The end result of factor inputs depends both of the volume and of the quality of factor inputs. The knowledge input in production can to some extent be captured by looking at the quality of labor input. In this perspective Tables I.5 are interesting. They show a high and growing share (measured by effective labor time) of knowledge-intensive human labor in the U.S., 25 percent in 1986, predicted to increase to 27 percent in the year 2000. Reweighted by relative salaries and wages this group – *creating and using new tacit knowledge* – would account for close to half of human labor (capital) input in the U.S. economy; and be increasing as long as relative wages are preserved. This would be expected, since members of this group encounter excess demand for their services while their low skill counterparts represent an excess supply, shrinking group, as far as employment goes,[11] indicating that relative wages will reinforce the development indicated by the tables. If relative wages do not fully reflect the differences in productivity between high quality and low quality labor input, a not unreasonable proposition, the U.S. labor market situation may look even more problematic, more than half of economic value, perhaps even 75 percent of production value being generated by one quarter of the people in the labor market.

Having said this I have opened up a classical problem in economics, namely the value of capital and its marginal contribution to output. I have suggested that human capital is the dominant factor input that really contributes value to output. How about the machines and other capital items? Well, how about doing the standard production function analysis, forgetting entirely about the quality of human labor input and getting all output growth attributed to capital or to a residual trend factor. If human competence is what makes machines and labor hours productive it should have the corresponding dominant value creating specification in production function analysis (see Romer 1986, Eliasson 1989a).

Corresponding Swedish data reflect the relatively smaller service sector and the relatively larger manufacturing activity. The Swedish labor force has a significantly higher share of skilled workers, a somewhat lower share of unskilled labor and a much lower share of "high quality" labor. I, unexpectedly, found (Table I.5C) that the composition of the Greater Stockholm labor force did not differ much from that of Sweden, and exhibited no resemblance with that of the U.S. My personal interpretation of these labor force data is that the U.S. composition mirrors the greater, and growing importance in the economy of advanced service production that may have deprived the manufacturing sector of human talent. The higher salary paying power from talented and educated people of the advanced service firms would be the reason. I expect a successful future economic development of the Swedish economy, to mean that Sweden would exhibit the same development of its labor composition. I would also expect this to be a problem for Swedish manufacturing industry as it is currently structured. I would also predict that this development will

[11] The drive of this analysis in fact is, that if this group is not shrinking as part of the labor force, it should be a source of worry in an advanced industrial nation.

be accompanied by a significant dispersion of the wage and salary distribution in the economy.

It is appropriate at this point to observe that high quality labor is not synonymous with highly educated labor. Classification is according to type of work performed, not type of educational background, even though a high level of education is typical of the high quality labor categories and vice versa (see also Osberg-Wolf-Baumol 1989, pp. 79–86). Lundberg (1990), in going through the "comparative advantages" of the Swedish economy in an international trade context, observed an internationally very high educational content of the Swedish labor force. This difference compared, e.g., to the U.S. is, however, explained by the high share of academically educated people in the public sector, and the large public sector of Sweden.

The final output of information processing as measured in the national accounts statistics

Table I.6 gives the same presentation of the entire economy. The manufacturing sector has now been more completely specified including also related, external service production. Certain distribution, transport etc services have been classified as manufacturing goods related inputs or complementary services. Other services have been allocated as household direct consumption services. Finally, there remains a basic industry sector, serving as inputs to goods production or goods consumption and a "residual" information design sector. This is a rough and ready approximation to a complete input/output representation of all the vertical, value-added contributions to the manufacturing product finally delivered to the end consumer, including all related distribution etc services, a computation the Swedish national accounts statistics currently does not allow. Let us see what we get.

Rather than accounting only for less than 25 percent of GNP this sector now accounts for almost 50 percent of GNP and its contribution to GNP has not been shrinking. If value added in foreign subsidiaries of manufacturing firms is added "manufacturing goods production" has been increasing as a share of GNP.[12] There is no reason whatsoever to talk about deindustrialization, only about a diminish-

[12] It may appear surprising that the manufacturing sector, so redefined has not shrunk between 1950 and 1985 while the public sector share has increased very much. Some of the contraction has occurred in private direct consumption services, as one would expect in a high tax economy like the Swedish one. Most of the adjustment, however, is to be found in primary goods production. It should also be observed that a not negligible part of what was publicly produced in 1985 and classified as "infrastructure" and "information design" services, was defined as privately produced services in 1950.

ing share of blue collar workers, notably low skill workers in the labor force. The latter is a positive sign, indicating an advancing industrial economy.

At least 75 percent of GNP is now made up of direct or goods-related service production, 40 percentage points being goods related, 12.7 direct private consumption or consumption support services, 15.3 infrastructure and at least 8.5 information design services carried out by lobbying groups, media, cultural associations etc.

6 The nature and measurability of information

Information processing, as we have used the term so far takes on two forms: one is information processing as conventionally defined on coded form, number crunching in the computer or diffusion through telecommunications networks, the other includes the whole range of complex processing of tacit, human-embodied knowledge through markets and hierarchies. The rapidly growing market for professional services is only one aspect of this (Eliasson 1986a, Elfring 1988 a, b).

I concluded already in Section 2 that technological advance in industrial nations largely had taken the form of creating new (tacit) knowledge and transforming it onto a codable, measurable and communicable format. The latter technique had an organizational origin; decentralization through markets or through divisionalization of companies, in effect improving the measurement system of the economy.

The purpose of this whole book is to assess organizational change in its entirety from the point of view of the economic potential of new information and telecommunications techniques.

This task has two parts; the potential for turning human or team-embodied (tacit) knowledge into information, and the technology of communicating (coded) information.

The first task means sorting out the tacit knowledge components of the information accounts of the previous section, to estimate the potential market for telecommunications techniques. We really do not have a scientific method to do this, but I will carry on, illustrating the principles through numerical calculation. And these principles very much stumble on the quality measurement problem introduced from the start.

Are we becoming relatively more or less ignorant?

A first philosophical question has to do with the size, or the value of the total human knowledge base and the rate at which it is being coded. We concluded already from the beginning that technological advance consisted in creating new knowledge, thus increasing the knowledge base and improving the knowledge to transfer tacit knowledge onto coded form. This technology more or less should be considered to be an international pool of knowledge available to any firm in proportion to its competence to tap it. The rate at which it is being tapped to be put into production constitutes technical change.

Part, or a large part of the knowledge base is allocated to the production of new knowledge. The size or value of it cannot be properly assessed since it cannot be communicated. As it happens the rate at which new knowledge is transformed into coded form – the rate of growth of the potential "telecommunications market" – depends on the rate of growth of known knowledge. Currently we haven't got the slightest idea which component is growing fastest, the tacit or the communicable part. Are we so to speak becoming relatively more or less ignorant? Will we ever know?

The second problem is the rate of advance of productivity in telecommunications. It may grow faster – and costs/prices may fall accordingly – than the growth of the market, and national accounts will show a diminishing share of information processing in total resource use. If market pricing is badly organized, as it is in the public sector, we may even use a cost plus accounting method for establishing the GNP contribution of information processing, showing as well – and erroneously – declining GNP contributions. It is my guess that both these errors seriously afflict the statistics reported in this book, and in all other studies. Nevertheless, let us look at available statistics.

First, I try to reclassify the Swedish national accounts into GNP contributions from the four more or less knowledge-intensive sectors in Table I.2. Second, I look at the crude (NB!) classification of human capital inputs in the U.S. and Swedish economies (see Tables I.5); one (Group I) being (possibly) associated with the creation and use of tacit knowledge, the other (Group II) applying tacit skills to relatively well structured tasks and the third (Group III) including low skill workers occupied with menial tasks. A third and more sophisticated attempt to relate human knowledge inputs to different GNP components, or end uses, through measuring the cumulative inputs of educated and skilled labor unfortunately cannot be carried out on Swedish data, and I have seen no study where it has been done.

The first figure tells a relatively simple story. The contribution of simple basic industry production to GNP has been decreasing throughout the postwar period while the contribution of knowledge-intensive private services has been increasing slowly.

Manufacturing production, that we classify as knowledge-intensive production, on the other hand shows a slowly declining contribution to GNP while public service production has significantly increased its share.

We know that both knowledge-intensive private services and public services have a high proportion of educated labor input. The rapidly growing public sector could perhaps be labeled knowledge-intensive production, since it employs a large share of the labor force with academic training. In Sweden we find almost all statistically measured health care, education, research etc. in the public sector! The two categories (2) and (3) in Figure I.3, however, may not represent economically comparable value added contributions. Private services are valued in the market. Public services have been entered on a cost basis, and the size of the sector has been determined through the public budgeting process, not in the market. One line of argument could be that protection from market competition has made knowledge-intensive public production less productive than it would be in a market environment, hence biasing its GNP contribution upwards. The alternative argument (Ysander 1979) would be that public subsidization has increased the production of socially valuable knowledge-intensive services like health care, that should be entered into the GNP accounts with a social profit above costs.

The question is what competitive advantage the high educational content of Sweden's large public sector employment – observed by Lundberg (1990) – gives to the Swedish economy. Is the contribution positive or negative compared to a situation with this highly educated labor input – with or without the education – allocated to the private sector?

Whatever we do the corrected numbers become arbitrary. The only comfort for statisticians is that typically income-elastic services like health care, education or insurance show roughly equal GNP contributions in equally wealthy nations; in the U.S., where they are predominantly privately produced and in Sweden, where public production dominates.

An international comparison of information processing categories

The OECD classification of the information sector is production oriented, not functional or end use oriented. Our crude end use classification in Table I.4 is needed to estimate the money side of the information sector and the potential telecommunications market. If we want to look at the factor use side the OECD classification is useful. We would of course like to have the different factor inputs on an end use (input/output) classification, since we can then relate end use development to data on the quality of inputs. This, however, is only possible for the U.S. and we have so far not had access to U.S. data.

This is the desired calculation method.
- Look at end-use development in terms of Table I.6.
- Assess productivity in information sector.
- Assume input coefficients to change, as productivity changes.

Using the OECD input classification, we can see that *information producers* correspond to the creation of new knowledge in Table I.1. They operate from a base in tacit knowledge. They use modern information technology intensively, but they cannot easily be replaced by artificial systems.

Information processing is a semi-knowledge intensive group that primarily operates in the *coordination* category of Table I.1. Hence, modern information and telecommunications technology should be making fast inroads. The coordination category of Table I.1 also includes what the OECD calls *information infrastructure* work, which includes the low knowledge-intensive operators of information processing equipment.

Information distribution, finally, falls into the category of *knowledge transfer* of Table I.1. First, Table I.3 divides the total labor force into an information sector and one residual, unclassified goods and service producing sector. The OECD has not had access to the internal firm data that we have. Looking at the Swedish data we can say, that using a finer categorization, also this residual sector includes significant information processing.

Second, the information sector has been divided up into different categories as described above. With this in mind the OECD data allow an international comparison.

While the data as such may be of reasonable national statistics quality, the classification includes a significant degree of arbitrariness, making the international comparison particularly dubious, but also the interpretation of data in terms of the knowledge-based information economy.

For instance, information processing would probably include a number of goods related information processing activities in the residual sector (item 5 in Table I.3) that the national accounts statistics cannot distinguish between.

Summing up, I conclude that an advanced industrial economy like the Swedish one has to allocate at least 8.5 percent of total production (GNP) to the creation, diffusion and application of new knowledge in the economy.[13] This is probably very much on the low side. The U.S. number would rather be much higher.[14] To this comes an information design sector of some 8.5 percent of GNP (at least), part of which is devoted to supporting or disrupting the value systems of society.

The telecommunications market

Continued productivity advance among the already wealthy, industrial nations at a rate comparable to growing skill inputs in competitive production in low wage, industrializing countries requires that an increasing share of total labor resources be devoted to the new knowledge creating, knowledge transfer sectors of the labor market. This is needed to maintain competitiveness of manufacturing industry through innovation. On this score Table I.5 shows that a surprisingly – I would say – high proportion of the total U.S. labor force belongs to the high quality end of the labor force. Most probably – and so is commonly assumed (Romer 1986) – strongly diminishing returns are associated with the accumulation of new knowledge. The richer and the closer to the industrial competence frontier the more vital to future economic well being the efficiency of the continued accumulation of new competence, i.e. the competence to increase competence.

High quality service production has both a high labor competence input and a high income elasticity. Such "products", if intended for final consumption, are not (easily) tradable and relatively well protected from competition from low skill production abroad. Much of the industrial knowledge created, however, is intended as inputs in tradable goods and service production and rather easily imitated, which leaves the knowledge-intensive production sector of the advanced industrial economy exposed to imitative competition. We know that manufacturing firms, notably Japanese and Swedish firms, are organized exactly like that devoting the bulk of their R&D spending to learning about competitors' innovative output (Eliasson 1987b, 1988c). For two reasons, the already wealthy industrial nations, thus, have a built-in demand growth mechanism for these already large, knowledge-intensive service sectors. Their inhabitants are to an increasing extent consuming or investing in knowledge-intensive services. Their industries have to spend an increasing share of their

[13] 9.8 + 3.0 (Ia – Ic in Table I.4) percent of total labor costs in manufacturing + the education and research contribution from the National accounts (5b in Table I.6). This corresponds to roughly 8,5 percent of GNP, most likely a significant underestimation.

[14] Considering the data on internal education in the U.S. private industry published by Eurich (1985).

total resources on keeping ahead of imitating competitors. The technology of becoming more efficient in creating, transmitting and applying new knowledge within firms and within the nation becomes imperative. It should be observed in passing that with a possibly diminishing competence among U.S. manufacturing firms to process goods compared to Japanese manufacturing firms, the large U.S. scientific establishment may operate as a negative competitive factor, since it is predominantly helping – almost free-of-charge – the Japanese firms to compete with the U.S. firms (Eliasson 1988c).

This knowledge-intensive investment and production process to a large extent builds on "tacit" competence inputs, and even though modern information technology is slowly gaining ground also here, such service production is not easily replaced by artificial information systems. A large part of knowledge-intensive professional service production – apparently occupying a large share of the U.S. labor force – is, however, occupied with automating production in the other sectors.

This development is putting continued pressure on medium quality labor, and (especially) on low quality information and process workers, at the low end of the production scale. There rationalization through new information technology is relatively easy and has been going on for years. (The knowledge creation and knowledge transfer part of the labor market, on the other hand, will not be subjected to the same rationalization pressure, for reasons already mentioned.)

The rationalization potential through new information technology is restricted by the rate of increase in technology per se (in the global opportunity set), the receiver competence in the nation – defining together the rate of productivity in applications – and by total demand.

A full assessment of the consequences for the telecommunications market of these technology developments is impossible. But a few simple, and still meaningful computations can be carried out. Since this section is methodological, outlining what can be done, rather than being an attempt to compute the size of the telecommunications market, the rest of the section becomes rather cumbersome reading. Let me therefore summarize my conclusions so that readers, not interested in methodological detail can go directly to Section 7.

Despite the difficulties of measurement one can at least identify some rough categories in the GNP accounts that may eventually be exposed to automation. The value added contribution of these activities amounted to some 23 percent of GNP in 1985 and this production drew about 30 percent of labor hour input, a figure that is much higher than the 2 to 4 percent (depending on your definition) GNP contribution of the postal and telecommunications sector. The market potential, hence, should be great. Econometric projections from the past (see Chapter II), however, suggest a rather slow exploitation of this potential based as they are on past experience. It will not be higher than 4.9 percent by the year 2000 (up from ca 4 percent). If production advance in the telecommunications industry is more rapid than before the GNP contribution may even decrease, as we measure it (see Fölster's chapter II), because of the lowering of relative input prices of telecommunications services and their use as inputs in production. Let me take an example. Suppose the entire resource use for marketing in the Swedish manufacturing sector (more than 20 percent of total labor costs) serves the purpose of increasing the quality of the product in the sense of making it available to the right persons. The costs for this marketing service are carried forward into final product prices. Suppose marketing is replaced by a new, formidable information device, that costs almost nothing and is as good. Either manufacturing prices increase, profits increase or wages increase as a consequence. The effect on the GNP contribution of the telecommunications sector depends significantly on the demand price elasticity of this service. Fölster (in Chapter II) has studied this across several countries, and over a 20-year period for each country. His conclusion is that – given current price elasticities, and provided technical change in the sector proceeds at the same rate as in the past – the telecommunications share will increase. If the rate of technical change increases significantly or very much, the share will decrease. Fölster concludes that the likely outcome is a lowering of the value contribution to GNP. If final prices for manufacturing products are lowered (relative to other products) a proper deflator should, however, show the same volume contribution. After having explained how I have arrived at the above conclusions I will, hence, indicate how a micro-based macro model can be used to understand the use of information in the economy. Some preliminary simulation experiments are reported in the last Chapter V by Erol Taymaz. They are, however, so far only methodological studies, and no results are reported in this summary. Let me begin with what has been done by others, and then sketch what we should be able to accomplish.

Static national accounts reclassification

There are four sides to the quantification of the potential telecommunications market using a static reclassification of factor inputs and outputs in the national accounts statistics;

(1) the volume of knowledge-intensive production
(2) the part (thereof) that can potentially be automated (information processing)
(3) the part already automated

(4) the part of (2) that consists of pure information and telecommunications activity to be applied to (3).[15]

This is the way we go about estimating the size of the telecommunications market. The first part of the analysis involves defining the end use of (the demand for) information services (Section 1, Table I.1) to project the future demand for the same information services. Telecommunication is a particular production technique to provide information services. Predicting this market, hence, means going back from a projection of end use categories (Table I.6) to the inputs of this particular production technique, assessing also the productivity of the production of information services. I begin with total GNP (end use) and total labor input (technique). I identify service production including transports and distribution in GNP as representing a gross measure of the knowledge creating, transmitting and coordinating functions in the economy. These functions contribute 38.5 percent to GNP and use up some 45 percent of total labor input[16] uncorrected for quality (Tables I.5B and I.6). I then identify the pure information process function of service production in the same categories. This is more difficult. I can identify categories that contribute roughly 23 percent.[17]

Some of this information processing is still of the tacit type, the rest is codable and a potential telecommunications market. We also recognize that information processing in "tacit domain" is expanding more rapidly than GNP, while earlier tacit knowledge creation and diffusion are increasingly being "rationalized" into the codable categories. Finally, I find that only 2 percentage points of the current potential of some 23 percent of GNP is really occupied by the postal and telecommunications sector.

The telecommunications market, including postal services, should be defined as the value added created by these services. The problem is the generic nature of these services entering everywhere in the production system, and the complementary context requirements. If competence to use the service is not present, little economic value will be created, only costs.

The second problem is most acute in machine-using goods production. The potential for factory automation may be the whole goods production value added contribution, or some 40 percent of GNP, if transports are added. But even in a fully automated factory, the bulk of costs will relate to machine capital inputs.

As for the rest, or 60 percent, the potential of substituting information and communication services (including hardware costs) for human paper shuffling should be large in the long run, and especially for the typical, non-tacit information processing items in Table I.6, adding up to a GNP contribution of some 23 percent in 1985.

How large a part of this is measurable telecommunications production? We

[15] This assessment requires a number of assumptions on the price equilibrating properties of the entire economy, that we have to make implicitly. A reasonable assumption is that welfare states like Sweden have exhausted their capacity to pursue income egalitarian policies and to soak up technological unemployment caused by overpaid low quality labor through public sector growth. A reasonable assumption, hence, is that relative wages will adjust to the productivity of rationalization investments such that profit rates are kept constant. Thus, if reasonable assumptions on labor-information substitution and rationalization can be made, a calculation of the potential market for telecommunications services is possible.

[16] Group I + Group II.b + Group III.b in Table I.5B.

[17] 60 percent of internal labor use (Table I.4) in manufacturing (i.e. of items 2a+b in Table I.6). Perhaps 40 percent of external information service (item 2d in Table I.6; see Carlsson 1986, p. 242), about 30 percent of 5b, 5c and 6 in Table I.6).

currently don't have the necessary internal data from firms. But adding up the postal and telecommunications sectors in the national accounts, gives us just about 2 percent in 1985 (see Table I.6).

Econometric projections

Adding in also the production of information and telecommunications equipment, as the OECD does (see Fölster's chapter II), we get about 4 percent of labor (hours) input in 1984 and 3.9 percent of GNP. This is not entirely correct, since the GNP contribution of postal and telecommunications services also includes the contribution of capital to value added in these particular activities. On the other hand, if all production of information equipment is used in Swedish domestic production one could say that 3.9 percent of GNP is too low a figure, since labor input and profits should also be added.

Fölster (Chapter II) runs a regression of these GNP and labor force components on different explanatory factors in different countries. He computes the GNP component of postal and telecommunications services to increase to 4.9 percent in Sweden by the year 2000 (from 4 percent in 1984), if productivity change follows the trend of the past 20 years. If the rate of productivity increase doubles the GNP contribution will decrease, but not as fast as labor use in the sector, which decreases from 4 to 3.4 percent by the year 2000, rather than increasing to 4.2 percent. The reason for this paradoxical result of course is that relative prices of telecommunications services will fall, while the demand price elasticity of the services is fairly low. Again we are locked into the problem of measuring quality. Does the GNP contribution decline because GNP is growing so much faster because of rapid advances of telecommunications technology, or is the end use production of communications output, despite rapid productivity advance, not large enough to motivate a rapid allocation of resources there, freeing resources to be transferred elsewhere?

I would tend to believe that the market potential for communications services as estimated in the studies reported is significantly on the low side because of failure of capturing the dynamic allocation effects made possible through the new information technology and/or through making the time perspective too short. For instance, even though the share of telecommunications services in GNP decreases, a development Fölster does not exclude, this service may still generate large economies of scale among the users. The economic value contribution is then incorrectly recorded in the user sector, and the economic size of the sector underestimated. The only way of learning more is to use an econometric model that explicitly incorporates both information processing and the dynamics of the resource allocation process.

Dynamic micro-macro analysis

Telecommunications technology enters into a multitude of economic activities, the outputs of which in turn serve as inputs in other activities and so on. Most of these input/output relationships furthermore extend in time and involve the accumulation of capital of different kinds (dynamics). Even though a full account of all these interactions is impossible, the Swedish Micro-to-Macro Model (called MOSES; see Eliasson 1977, 1978, 1985a, 1989b) allows significant improvements over the above static calculations. Since this section is methodological, let me indicate what can be done in four steps.

First, let me assume that the firms in the manufacturing sector constitute the "growth engine" of the economy, the activities of all other sectors being derived linearly from the manufacturing engine. Manufacturing firms plan production, labor demand and investment in new technology. They also use telecommunications services in measurable and projectable amounts. Firms can tell how much (such questions were asked in the spring of 1989 in the standard planning survey of the IUI and the Federation of Swedish Industries, on which the micro-macro model is empirically based). A standard simulation "forecast" of the economy on the model will then generate the derived demand for these services by manufacturing firms. This is, so to speak, a Keynesian derived demand computation using the elaborate micro input/output structure of the model. This is more or less what Imai (1987) has done, using informed guesses about the telecommunications input/output coefficients of sectors and assuming an exogenous growth trend in output. In Chapter V by Taymaz, such a demand simulation is reported. This is a methodological study rather than a properly conducted empirical inquiry. The reasons for the negative correlation between the telecommunications cost shares and firm performance, measured by growth in output, productivity or the rate of return, have not yet been fully explained. It is interesting to note, however, that despite these negative correlations between telecommunications coefficients and the performance characteristics of the firm, growth in telecommunications demand is somewhat faster than growth in output. The relative distributions of performance characteristics, growth rates and telecommunications shares generate this, seemingly paradoxical, result. The conclusion is that the estimation of macro demand functions easily gets seriously flawed, since the assumptions for static aggregation are not satisfied.

Second, one would expect increased telecommunications capacity to affect productivity of the manufacturing firms. Assumptions in this respect based on the raw data from the planning survey, as mentioned, would be contraintuitive. A parallel study at the IUI on business information systems technology (Eliasson 1989d) complemented with interviews to firms in the planning survey should make such an analysis possible. This would endogenize some of the productivity effects, that lowers the output value of telecommunications services per se. But the model simulations would also project the additional contributions of more productive and cheaper telecommunications services to the value created in manufacturing goods production.

Third, and more difficult, would be to extend the same analysis to the entire economy. The micro-macro model is not really ready for this analysis. In particular, all other sectors operate as regular ("linear") input/output sectors, in contrast to the dynamic (non-linear) behavior of individual firms in the manufacturing goods market of the model. Two modest additional computations can, however, easily be done. Assumptions on the inputs of telecommunications service in non-manufacturing activities can be added and an extended Keynesian derived demand analysis of the first kind (above) carried out. All this can more or less be done within the current model program.

More interesting, however, and *fourth,* would be to respecify the micro model somewhat, making information processing in markets outside the manufacturing firms explicit, introducing traders in information drawing resources of the magnitude indicated in the earlier analysis and being more or less efficient in gathering, analyzing and transmitting information to firms and to policy makers. With such coded information processing made explicit, affecting the behavior of manufacturing firms, the potential full impact of information technology on the entire economy can at least be illustrated. And the earlier analysis suggests that it is large. This side of economic information processing is further illustrated in the next, final section.

7 The endogenous fragmentation of industrial structures, and the collapse of national measurement systems – Sundry remarks on accounting in the knowledge-intensive information economy

This sector takes us back to the beginning of the chapter and the notion of a knowledge-based information economy. The statistical accounts of both business organizations and nations are structured on the concept of the goods producing firm. The representation of assets is limited to tangible items, that can be traded in external markets. Costs are itemized to the extent needed to exercise cost control and for pricing calculations.

All economic transactions are, however, guided by some ultimate competence inputs that are never properly costed and not compensated the ordinary way (Eliasson 1984b, 1988d). This competence input is compensated through capital gains in so far as the contributor is a part owner in the activity. There is a measurable capital value to this superior competence input. Its value depends on competing competence inputs and how informed its ultimate evaluation in the "efficient" equity market is. This puts us squarely into the morass of capital theory in its ultimate form, the measurement of knowledge capital. All the nice assumptions of classical theory are now gone. Complete arbitrariness rules. My point of argument nevertheless is that if you understand this you can improve your understanding through more elaborate measurement designs.

Cost accounting

Elaborate versions of cost account classification designs based on Swedish industrial studies some 50 years or more ago are still in use in Swedish engineering industry. Thus, for instance, machine depreciation computations by the Swedish Central Bureau of Statistics are still based on studies carried out at IUI in the late 50s (Wallander 1962). This means that the physical process side is heavily overrepresented by detail. The "soft" cost items that we try to measure and discuss in this book, like marketing, R&D and (in particular) education are extremely difficult to get a hold on. Large Swedish firms definitely do not know how much they spend on internal education (see Chapter II). The same almost goes for marketing. There are no clear guidelines about how such items should most appropriately be defined and measured. Most methods are biased to suit tax considerations, ethics and other concerns, that are irrelevant for the proper conduct of a business.

The absence of a good measurement tradition probably also means that cost controls and rate of return requirements on such invisible items are lax, leading to a less efficient utilization of resources. Attention is focused on what you can measure and see, which may not be what is relevant. The most obvious example of this is that you simply cannot pay attention to cost and capital items that are not made visible by measurement. The industrial world furthermore is replete with examples of external cost overruns on investments in soft or invisible items. Overruns by a factor of 1 to 10 or more are common.

Most of the problems associated with measuring inputs and outputs properly originate in the capital (stock) valuation accounts, and especially in the use of knowledge or information. Let me mention three examples; (1) temporary inflationary gains in inventories appearing in value added and in profits, as value contributions from production, (2) front loading of capital costs, because of excessive risk aversion, and (3) forgetting altogether about important capital items. All three represent distortions of the measurement systems of firms that can lead to large decision or policy mistakes (see Eliasson 1984b, 1989d). Capital as measured in large parts of Swedish manufacturing industry is more or less irrelevant for rate of return calculations. The pharmaceutical and electronics companies have far more invisible assets in market and product knowledge than they have in physical capital. Besides, installed software often has a larger replacement value than the machines. We will illustrate with an example below.

Economics is information processing

Three aspects of economic measurement in the modern industrial economy are of particular concern to us. *First,* the earlier sections have demonstrated that knowledge-based information processing is the dominant economic activity. If you miss that in designing your statistical accounts, you misspecify the content of economic activities.

The problem is to draw the line between information processing and other economic activities. Traditionally, the line is drawn between service production and goods production, including physical transports. Wherever you place the dividing line it is – as we have seen – arbitrary. If you look inside the manufacturing firm it becomes a dominant service producer and information processor.

If the information grid is made sufficiently fine information activities could in fact (arbitrarily, but still meaningfully) be defined to cover all resource use. All physical, manual activities require a prior information input to be economically directed. *Why, what* and *how* have to be resolved before physical labor makes economic sense. The economic classification base, hence, should begin from the information side, which dominates all other activities. If you want to capture the substitution of physical labor for automation technique, this is necessary, since this substitution means replacing one information system for another (Eliasson 1989b,c). For instance, any hardware factory process can be broken down into a sequence of coordination processes (item 2 in Table I.1), being controlled by an information system. If you change the information system you change the productivity properties of the whole production sequence. Automating a workshop means substituting a decentralized production organization built on the local competence of skilled workers for a centralized control of physical flows of production. The problem is that it is almost impossible to construct statistical systems with enough fine detail for this kind of *complete information accounting*. You have done it when you have a fully automated plant.

Even if this problem appears to be on the philosophical side, it has a critical down-to-earth side. Wherever you draw the line you arbitrarily bias your statistical vision.

Changes in information technology distort statistical measurements

Second, I have also demonstrated that changes in information technology is the main vehicle for improvements in macroeconomic performance. The information technology of a firm or the entire economy is embodied in its organization. Changes in economic organization are sometimes called structural changes. We have found in earlier studies that such changes explain most of measured macro productivity growth (Carlsson 1987).

Our capacity to observe and measure organizational change is limited by the taxonomy of our measurement system, its resolution of fine details. The Swedish company Stora Kopparberg has existed under roughly the same name for 700 years. Suppose we have a complete set of annual accounts for that company on the format required for its entire history. It would tell us nothing about changes in the internal organization of the company. A much finer statistical grid is necessary. It is, however, impossible to ask corporate headquarter of Stora to provide more detail than it can access itself. As a rule (Eliasson 1984b, 1989d) Corporate Headquarter can access division accounts fairly easily, and often product group accounts. This would be sufficient to get a picture of organizational change, since organizational change within a company normally occurs between divisions and product groups. The problem is, however, that a systematic measurement of the exit, entry and recombination of product groups and divisions within a firm requires that the accounts are revised (standardized) backwards to account for the same change. Corporate decision makers don't need this information. They only want to access the productivity gain from a reorganization before and after the change. They may be wrong about this, since some of the effects only show in the very long run. However, when the organizational reform has been implemented, it cannot be reversed, so why should they bother? As a consequence of this "static" view of the need to measure and assess organizational change, the internal accounts of firms are not organized for historic analysis. While proper information accounting takes us down to the most elaborate levels of structural change within a firm, the accounts available for outsiders as a rule stop at the firm level, and sometimes at the division level.[18] Hence, structural adjustments at finer levels go unnoticed, and are misunderstood.

The institutional fragmentation of various forms of production over the demarcation lines of statistical systems may be more of an economic hazard, than the identification of information accounts, since these deficiencies of the measurement system bias the assessments of economists, observers, reporters and political decision makers alike, with possible, serious effects on the national economy. With 8.5 percent of total GNP generated in what I have called the information design sector, the leverage of misinformation, e.g. biases perpetuated through the economy by this "information" sector must be very large. And with such large resource inputs this sector should be able to do better.

To invest yourself out of, or into a crisis

The gross policy blunders in Sweden of the 70's is another illustration of what may happen if you don't have your economic measurement system in order. In 1974 Swedish firms grossly misread their profit accounts. Temporary inflationary gains were interpreted as a permanent – and long looked for – increase in operating profitability. A tremendous wage explosion followed and hardware investment boomed in the wrong industries.

The slow return to normal prompted the minister of industry to "ask for" increased investments in machines and buildings under the slogan "investing ourselves out of the crisis". Neither he, nor anybody else had then observed that manufacturing investments, including R&D and marketing investments had increased very much, and that foreign investment was soaring (see Figure II.6 in Chapter

[18] As in the MOSES database for the Swedish micro-to-macro model, from which much of the information in this book comes.

II). Adding it all up the investment ratio had grown, not decreased. A strong surge in hardware investments in Swedish manufacturing at that time should rather have been interpreted as a bad signal.

Information inputs or outputs

Third a proper account of the nature of production should distinguish between inputs and outputs in information terms. This is the most difficult task, with knowledge-based information processing being the dominant economic activity. I have tried to do this systematically for manufacturing firms above. I have excluded the final consumption of information services for pure enjoyment. At "lower" levels information enters as inputs in different kinds of activities as classified in Table I.1. Looking at the traditional input/output table I have, so to speak, to superimpose a third dimension of dominant inputs that control all physical activities of the traditional input/output table. Finally, also information processing has an input/output structure, the inputs being related to the end uses of Table I.6. In this chapter I have attempted to identify one such input, telecommunications services.

On the surface this exercise in terminology and measurement may appear irrelevant to the hardworking statistical officers of firms and national bureaus of statistics. It is not! The extent of resources devoted to economic information processing is much too big to be statistically ignored. Besides knowledge-based information processing dominates (controls) the entire physical production grid of the national economy. It defines the competitive capacity of the national industrial system.

Any production process can be represented by costs incurred in keeping it active. Costs are charged at market prices. If markets are not perfect there is a competence involved in buying good quality for a low price. On top of this *delivery* system *production* is imposed in which capital and human labor is put to work on materials. Labor can be substituted for capital and vice versa and competence is applied to choose the optimal combination of factors, the right product etc. Labor is paid at the going rate and capital is charged at the interest rate plus depreciation. On top of this there is a charge for management and financial risks. Again human competence makes selective choices to minimize these charges. And if this competence is sufficient there is a return to it over all recorded costs. This competence capital represents a residual capital value and a capital input in the production process that influences the *productivity of all other factor inputs*. This is the ultimate knowledge capital at work in each production unit that operates through selective choices – as a filter (item 3 in Table I.1). This most important capital input is not measured in the cost accounts from the input side. Since it has not been acquired in the market at a price it is usually "tacit" and compensated in proportion to the excess profits it generates. It is sometimes associated with the entrepreneurs and the owners (see below; also see Eliasson 1988a,b).

The size of knowledge capital

The stock of information in society, or tacit (human embodied) knowledge has some economic value. Some of this information is traded in markets (newspapers, telefax messages, instruction books etc.). The knowledge endowed (competent) human beings, as we have seen, fetch premium prices in the labor market. Human capital theory rests on the idea that compensation for human competence is reflected in wages and salaries paid for knowledge services delivered. So why cannot information and team competence in firms be valued similarly?

Much of the soft intangible capital of a business firm can be measured and capitalized along the same principles as a machine or a building. In both cases the efficiency of the market (the labor market, the stock market or the investment goods market) in evaluating the value of what is traded defines the quality of these measures. Similarly, as long as the production costs of creating information, software or a machine tool can be measured, replacement values can be established. Any critique on how to measure the capital value of an investment in an educational program, or in new software to keep track of accounts receivable can be leveled at the evaluation of a piece of machinery. There is also a good reason for making these assets explicit, namely to force firm management to pay proper attention to the associated capital costs, and demand a return also on these assets.

All capital (asset) measurements are, however, as principally dubious as are rates of return. Any asset value somehow depends on the profit the use of that asset can generate and is expected to generate. Capital stock measurements hence always fall back on some arbitrary calculation principle. The information value of the stock measure depends on the ability of the user to understand the measurement principle.

Even silly stock measures, however, like the assets in the official books of a Swedish company, can become meaningful if interpreted by someone who knows how they were compiled and who also understands what goes on in the firm.

This argument goes for any asset category that has been accumulated by known technology and at known costs, or when the item can be purchased in the market. This is the case for any general purpose machine tool as well as for a general purpose cost accounting system, or a software display system for the controller's office. In both cases reproduction costs as well as an alternative market value can be estimated. When it comes to special purpose machine tools, or special purpose software, for instance to run the same machine configurations, the possibilities to assess the alternative market value become difficult. Replacement costs of the software as well as the hardware can, however, be computed. So if you activate the hardware in the accounts there is no reason not to activate also the software.

A capital measurement design

A first requirement of an efficient market valuation of a firm is that known, and measurable intangible assets have been accounted for. The ultimate innovative, organizational competence of "the top competent team", however, has no defined reproduction value. It is tacit and cannot be traded. It does, however, earn a rent and to the extent the top competent team of the firm can be associated with the equity contract that defines the firm, the value of that contract should be the present value of expected future rents.[19] Shares in that contract can be traded in the stock market.

Table I.9 lists measured assets. The information needed to construct these measures is not proprietary and is available if analysts devote some effort to obtain it. An efficient or at least semi-efficient market should be aware of the nontangible assets (3) through (6) even though they are rarely specified in the accounts. All measurable capital inputs have now become visible. What remains is the "tacit" organizational knowledge of the top competent team of the firm. This knowledge does not depreciate from wear and tear. Its "size" depends entirely on what we believe of the rate of economic erosion of the economic values of the other intangible items. The active "depreciation factor" is the success in *creating superior knowledge* in competing firms (Item 1 in Table I.1). But the best firms each time earn a rent from their superior competence.

The residual (12) is the market estimate of the present value of extra future profits expected to be generated by this superior knowledge base of the top competent team of the firm. That residual may very well be negative if incompetence is known to rule at the top. The firm should then be a potential take-over target. A negative value

[19] Within the classical model with no risk and all markets, except the capital market, in equilibrium, the excess, or disequilibrium profit of an individual firm observed can now be seen as the imputed factor cost for inputs of not measured knowledge, that exhausts total value added, an observation made already by McKenzie (1959). This is the same as to say that if there are increasing returns to tacit knowledge inputs and if other inputs are paid their marginal products, the capital market can never be in equilibrium.

could also be the result of an uninformed or incompetent valuation, or of a systematic risk aversion of all agents in the market, or of other price distortions, like taxes.

In a *taxfree* world a q-value of 1 would mean that the negative risk factor exactly offsets the contribution of competence. The fact that the q-ratio between market and replacement valued assets in Swedish industry (Figure I.4) stayed consistently well below 1 from 1970 to 1984 can be attributed to three facts only: (1) incompetence of executives in running manufacturing firms, (2) incompetence of traders in the equity market in evaluating the firms or (3) excessive macro (political) risks associated with Government and Labor Union ambitions to expropriate private wealth. As far as can be seen, development since the early 80's eliminates the first explanation. The fact that the U.S. and U.K. stock exchanges exhibited a similar strong undervaluation during the same period apparently removes the political explanation, at least as the only one. The undervaluation in Sweden was much deeper. Could it be that traders in all three markets exhibit the same inability to assess fundamentals, and if so, why?

Using information from a variety of IUI data bases (including those used in Figure I:2) I have compiled Tables I:7–I.9 for the 10 largest Swedish multinationals. These ten firms[20] dominate Swedish industry employing directly and indirectly some 30 percent of the domestic manufacturing labor force and as many abroad. They are generally regarded as the flagships of Swedish industry. When all the computations are done using reproduction values of measurable assets, I find a very large negative market valuation (before correcting for risks) of the contribution of the top competent team, an obviously absurd result for these 10 firms. Even with the highest estimate of assets in the denominator, the real rate of return (1986) of the group of ten of 6.9 percent is significantly above the real interest rate on industrial loans of 6.0 percent the same year. What is wrong with the capital market?

It is no argument that the stock market evaluation may have increased relative to net worth since 1985 (year in the table). The valuation was wrong then and for years before, and the continued increase in the market valuation of equity, putting perhaps a positive value on the top competent team, is currently, generally interpreted as a warning, that the market may be too high.

One possible explanation would be in terms of a systematic *aversion to risk* on the part of all agents in the market. One would, however, expect an efficient market to filter out enough daring bidders to get the price right on the margin. The *second* explanation

[20] They are Electrolux, SKF, Ericsson, ASEA, Volvo, Swedish Match, Sandvik, Atlas Copco, Alfa Laval, and AGA. For details of the data see Eliasson (1989a).

is more intriguing. With easily available data on book values of assets [column (4), Table I.9] a positive residual valuation of about SEK 20 billions shows up. Not very much, but positive. Posit that this is what all market analysts look at. As you dig more information out of the databases of firms, hidden values appear, and all of a sudden a large negative residual value emerges, suggesting excessive incompetence in running these flagships of Swedish industry. But could this rather be a reflection of incompetence on the part of stock market analysts, commentators and traders to understand the proper value of the firms?

Access to the value growth and the selection of competent teams

The discounted value of future profits generated by the competent team is available today:

- in cash through dividends
- in the market through growth in the price of the firm (capital gains).

The value to the owners of the contribution of the top competent team, hence, depends on what market traders think of the earnings capacity of the firm, i.e. on the competence of the market to evaluate future net profit flows. One would expect a competent management to add value to the firm above the sum of the reproduction value of its assets. One would also expect top management to be influenced in its real business decisions by the values they expect market traders to place on its firm. The transfer of ownership entitlements (without selling assets), hence, depends on the competence of the capital market to assess the value of the firm and on the decisions top management takes in view of what it thinks of the competence of the capital market. This valuation is critical for an innovating firm that is selling its know-how to a larger firm which intends to develop the innovation for industrial scale production. Without an efficient market for innovations, with many competent competitors (insiders), the innovators will not be adequately compensated (Eliasson 1986a).

Old competence rents are competed away through organizational innovation, creating new rents, and inducing both growth of the economy and the exit of low performers because of increased competition. The first key to macroeconomic growth therefore is the incentive system that drives innovative behavior. Second, path dependence (caused by tacit knowledge, as discussed above) makes it impossible to estimate (from current observations) the future path of the economy. But this is needed to estimate future rents. It follows that economic growth cannot be represented by an estimable distribution function that is invariant of time. Similarly, individual firm rents are unpredictable because tacit knowledge grows partly through failure. Past failures may be as good an indicator of future success, as past successes. Markets are not even weakly efficient, because the evolution of the economy depends on how markets for corporate control are organized to stimulate experimentation and enforce targets. Market efficiency itself becomes dependent on the way the economy develops.

Because they lack the requisite tacit knowledge outside (market) analysts can never fairly assess the value of firms or industries. The efficiency of the market for corporate control will depend on how effectively insider knowledge is transmitted to the market. With this knowledge being largely tacit *it can only be diffused indirectly through direct participation in the market of the competent teams.* Thus compensation both for competence, and for the incentives to inform the market relates directly to how informed the valuation of shares is.[21] The efficiency of the stock market will critically affect the competence level of industry. But market analysts will be unable to value the tacit competence capital through analytical methods. Instead the efficiency of the capital market will depend on their ability to identify insider trades effectively.

Defining the information item

Asset evaluations are in principle limited by two considerations:

(1) specialization in and mobility of use
(2) generic properties, making it difficult to relate acquisition costs to the benefits.

The answers to these questions tell

(a) how well defined the product or the information item is, and
(b) how exactly production costs can be related to the product.

For physically defined products this identification problem is fairly easy to handle. Hence, physical products are well measured.

For a large number of intangible assets, however, the measurement problem is no more difficult. The problem is that the reproduction of a software system often is less costly than the reproduction of a machine tool. And, as the insider discussion illustrates, sometimes an almost costlessly transferred piece of information can have an

[21] Note the difference between having *access to valuable information* about the corporation and *contributing valuable competence* to the corporation, and making it known to the market.

extremely large economic value, as long as nobody else knows.

Knowledge creating capital in each firm represents a dominant asset that determines productivity of all other assets. It is usually very specialized and sensitive to change in demand conditions, but it can often easily be moved – as a competent team – out of one organization and reconfigured in another. The productivity of the organization depends on whether the competent team works there or not. In such organizations the efficient contract for the competent team is the ownership contract.

Competent labor with more universally applicable skills is more mobile, but can also be hired in markets. The competence input is a matter of direct labor compensation.

This observation finally puts the finger on the eternal capital problem. Technical change lowers the economic value of installed machine capital without changing its physical production capacities. It becomes obsolete.

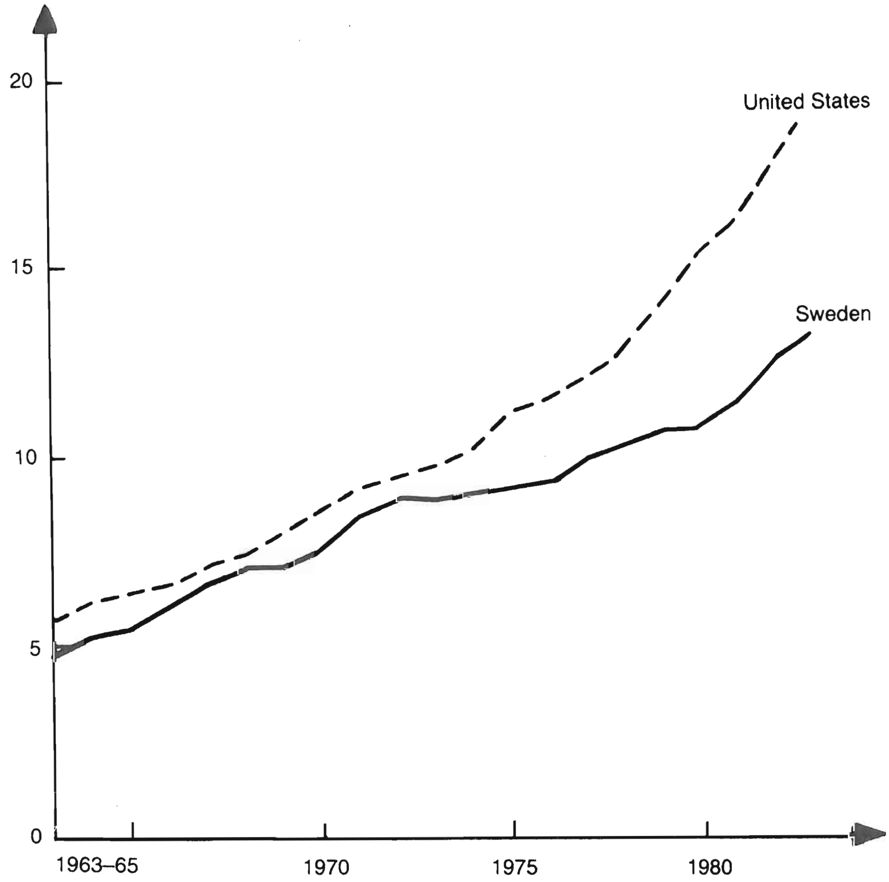
The creation of new, superior industrial knowledge makes existing industrial knowledge, vested in teams of people, economically less valuable, without lowering their physical capacity to put what they know into production. The only difference to a machine is that human knowledge does not depreciate, except through death (the sudden death depreciation method should be applied). And it can to some extent be passed on to the next generation, through education, if it has enough value to warrant a costly transfer.

On the whole, however, the excess return on visible (tangible) capital due to industrial competence supplied through ownership contracts will constantly be competed away through the creation of new superior knowledge capital. Hence, any firm has to devote resources to upgrading its competence to keep that from happening. If all firms do that technological or Schumpeterian competition is created (Eliasson 1988b). Such competition may be tremendously productive in generating growth through innovation, but seemingly inefficient through destroying the economic value of existing knowledge capital (creative destruction).

Economic competence will ultimately be demonstrated through the relative competence of individuals, competent teams or firms in generating new competence.

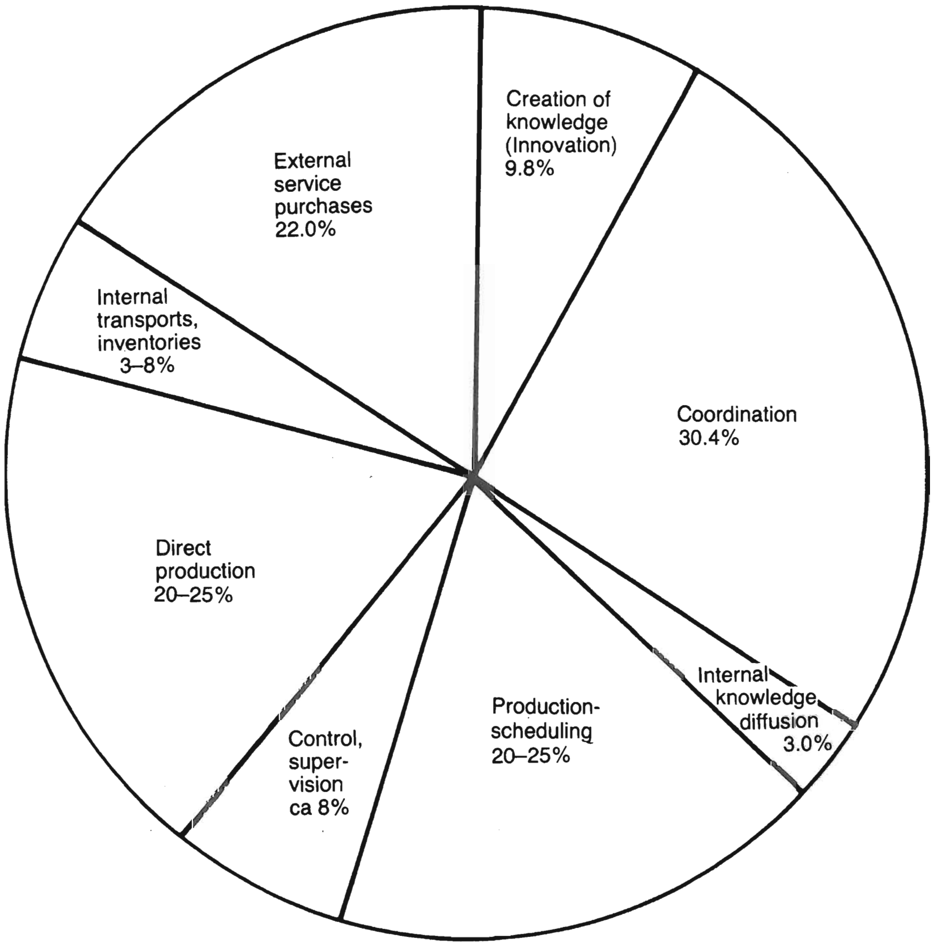
This seemingly futile, destructive competition, however, does not come about out of nothing. Incentives are needed. How does this incentive system look when tacit entrepreneurial competence may even be negatively valued by the experts in the stock market. The lemons will dominate prices. How do you find good used car in the used car market (Akerlof 1970)? This question (Eliasson 1988d) still awaits an answer. It is fundamental to the knowledge-based information economy. With tacit knowledge that cannot be properly evaluated economically an economically efficient organization of the economy requires that an appropriate valuation system be used to make people and firms both feel fairly assessed, and induced to act both innovatively and competitively, to generate economic wealth through rivalrous competition, very much as already Adam Smith (1776) understood it. What we can add here is that no wonder then that you need a large "information design" sector to support the culture inducive to such behavior. Since the organization of that activity is as tacit as innovative behavior its continued efficient performance requires it to become an economic, cultural and political tradition that keeps reinforcing itself. Once that tradition starts breaking down it will become almost impossible for the nation to find its way back to an informationally efficient economic organization (Eliasson 1986b).

Figure I.1 Employment in business services in the United States and Sweden
Percent of manufacturing employment.



Note: Business service is defined as SNI codes 832100-833000.

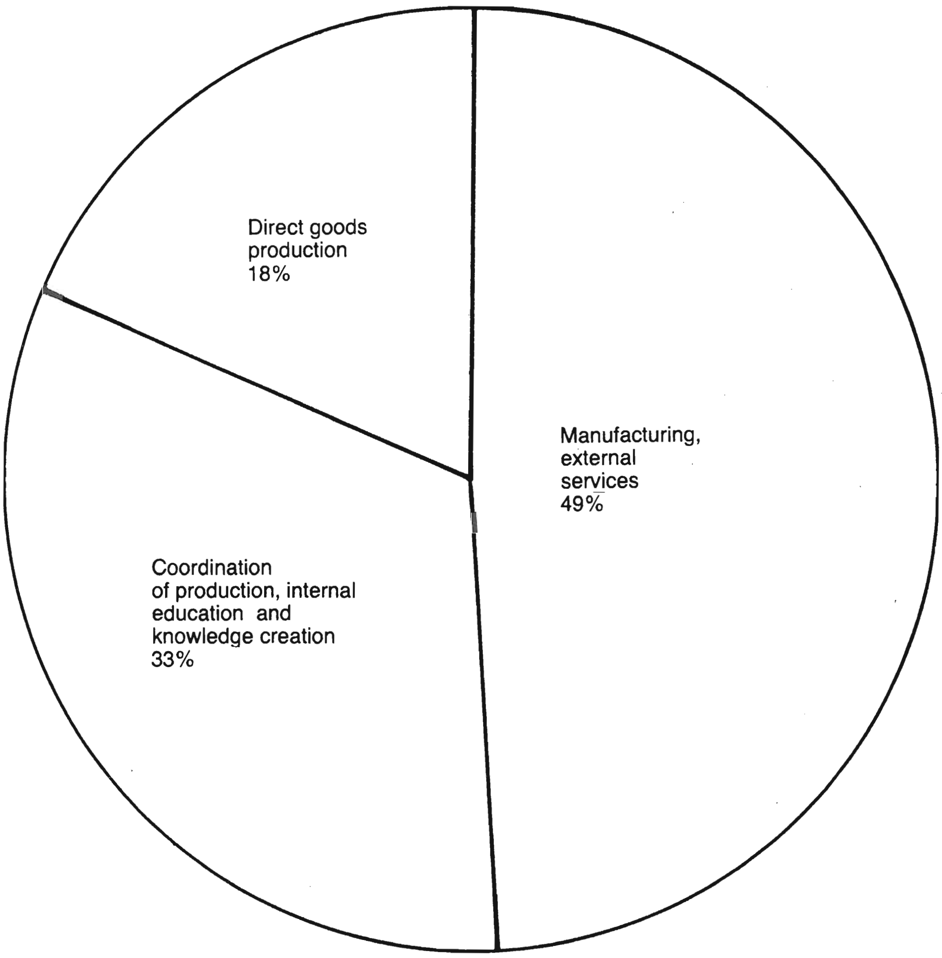
Figure I.2A Distribution of labor costs on functions
Large Swedish manufacturing firms
Global operations, percent



Total: 122%

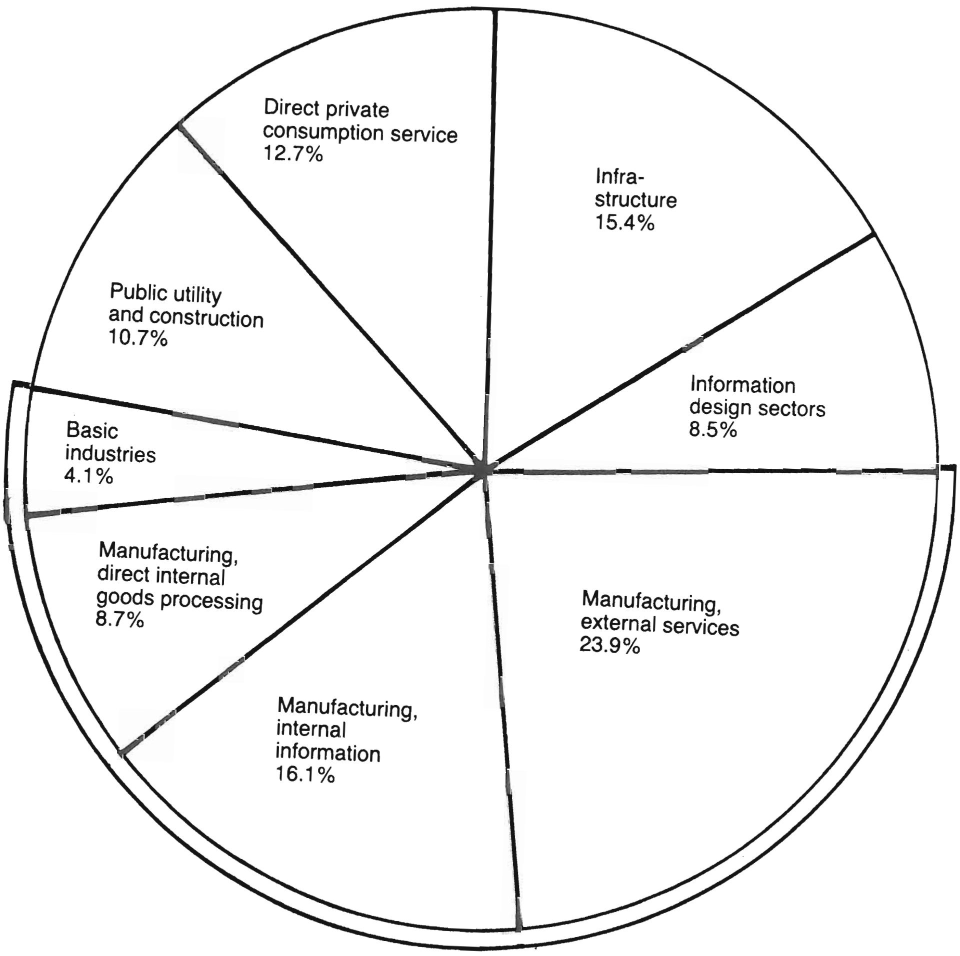
Source: See Table I.4
Design: See Table I.1

Figure I.2B The industrial engine
Manufacturing and related service production
GNP components, percent



Source: Eliasson (1989b)

Figure I.2C The information economy
GNP components, percent



Total: is GNP.
Source: Eliasson (1989b)

Figure I.3 The knowledge-based service economy in Sweden, 1950-86
GNP contributions, percent

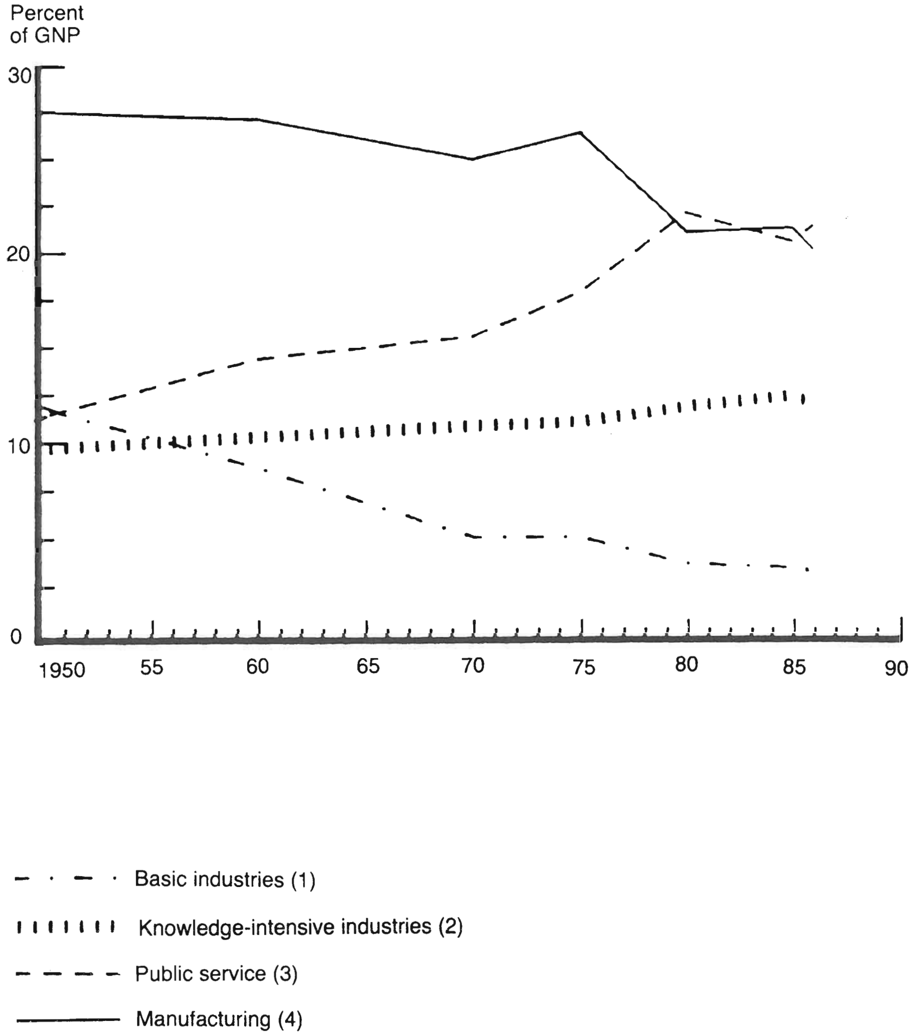
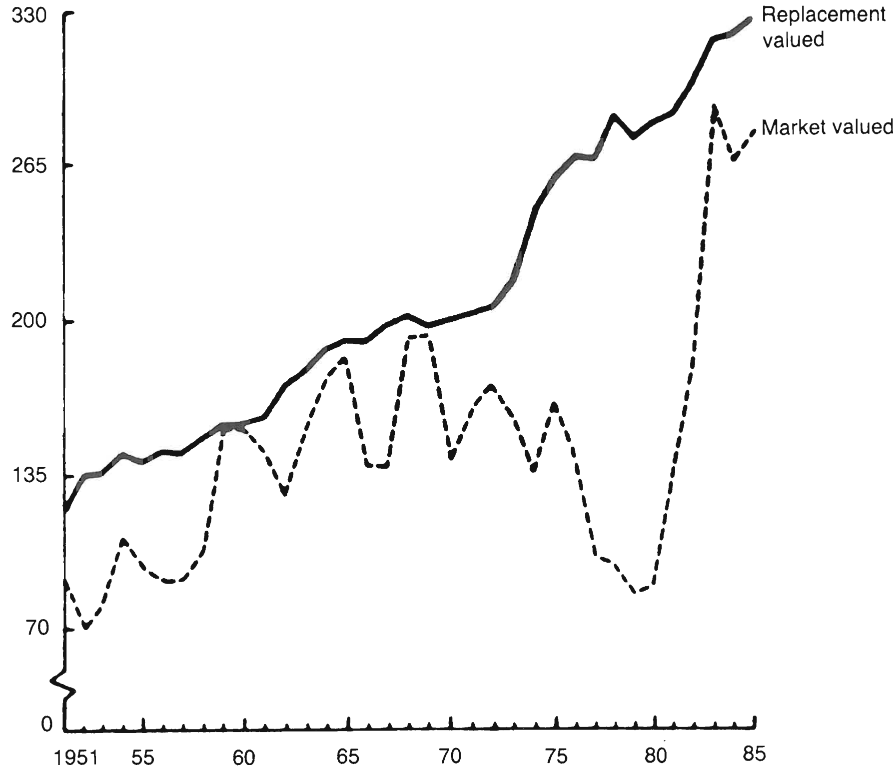


Figure I.4 Market valued and replacement valued net worth in Swedish manufacturing, 1951–85
Billion SEK in 1980 prices



Source: Eliasson, G. – Lindberg, T., Ägarrollen, innovatörerna och förnyelsen av svensk industri; chapter I in Örtengren, J. et al., *Expansion, avveckling och företagsvärdering i svensk industri,* IUI, Stockholm 1988.

Table I.1 The statistical accounts of the knowledge-based information economy

1.	**Coordination** (organizational structure)	*The invisible and visible hands at work* – competition (in markets, Smith 1776) – management (of hierarchies, Chandler 1977)
2.	**Innovation**	*Creation and exploitation of new business opportunities* (Schumpeter 1911) – innovation – entrepreneurship – technical development
3.	**Selection**	*Incentives for change* – entry – exit – mobility
4.	**Learning**	*Knowledge transfer* (Mill 1848) – education – imitation – diffusion

Source: Modified version of Eliasson (1987a), pp. 12ff.

Table I.2 Employment in service production in Sweden and the U.S., 1983
Percent

	Sweden		U.S.	
	Private	Share of labor force	Private	Share of labor force
Distribution	96	20	99	21
Producer services	91	6	100	12
Social services	8	32	40	26
Personal services	84	6	100	10
Total service production	*51*	*64*	*76*	*68*
Agriculture, etc and mining	–	5.5	–	4.5
Manufacturing	–	22.5	–	20.5
Utilities and constructions	–	7.5	–	7
Total goods production	–	*36*	–	*32*
Employed labor force	–	100	100	100

Source: Carlsson, B., Produktion och konsumtion av tjänster i privat och offentlig regi; p. 237 in Eliasson, G. et al., *Kunskap, information och tjänster,* IUI and Liber, Stockholm 1986.

Table I.3 Labor use in different countries
Labor hours in percent of labor force

	U.S.			U.K.			Japan	
Category	1950	1958	1980	1951	1971	1981	1960	1975
1. New knowledge creation	5.0	7.2	9.7	3.9	5.0	8.8	2.1	4.5
2. Economic co-ordination	23.4	29.9	31.7	20.8	27.4	27.7	13.9	22.7
3. Knowledge and information transfer	2.3	4.0	4.4	2.0	3.2	4.3	1.9	2.4
4. *Total information sector*	*30.7*	*41.1*	*45.8*	*26.7*	*35.6*	*40.8*	*17.9*	*29.6*
5. Other	69.3	58.9	54.2	73.3	64.4	59.2	82.1	70.4
6. Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

	Germany			Sweden		Norway		Finland	
Category	1950	1980	1982	1960	1980	1975	1981	1970	1980
1. New knowledge creation	3.1	6.5	6.9	2.5	5.6	5.1	5.4	3.3	4.7
2. Economic co-ordination	14.1	24.2	24.9	20.9	25.2	11.2	12.4	15.7	21.6
3. Knowledge and information transfer	1.1	2.8	3.0	2.5	5.3	4.5	5.1	3.1	3.8
4. Total information sector	*18.3*	*33.5*	*34.8*	*25.9*	*36.1*	*20.8*	*22.9*	*22.1*	*30.1*
5. Other	81.7	66.5	65.2	74.1	63.9	79.2	77.1	77.9	69.9
6. Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Note: New knowledge creation corresponds to "Information producers", *Economic coordination* corresponds to "Information processors and Information infrastructure", and *Knowledge and information transfer* corresponds to "Information distributors" in the OECD Classification.

Source: Table 2 in *Trends in the Information Economy,* publication 11, OECD, Paris 1986, and complementary data.

Table I.4 Wage and salary costs distributed on different functions, 1986
Manufacturing firms or divisions with more than 200 employees; global operations.
Percent of total internal *labor costs*

		Globally	
I.	**Information production and use**		
	a) Creation of new knowledge		
	R&D	5.2	
	Design etc	4.6	
		9.8	
	b) Coordination		
	Marketing and distribution	21.3	
	Administration	7.9	
	Other	1.2	
		30.4	
	c) Internal knowledge transfer (training costs)	3.0	
	d) External purchase of services	22.0*	
II	**Goods manufacturing**		
	Work preparation	?	(20–25)
	Direct work scheduling	3.5	
	Technical work preparation, supervision, service and control	ca 8	
	Direct production	20–25	
	Internal transports, inventories	3–8	
		56.7	
Total labor costs for products including external service purchases		**122.0**	

* or 18 percent of total internal labor costs + purchased services. See Chapter IV.

Note: This table has been put together from a variety of sources, primarily on data reported in the following three chapters, but also data in *Kunskap, information och tjänster,* IUI, Stockholm 1986, and in Eliasson, G. *Elektronik, teknisk förändring och ekonomisk utveckling,* IUI Booklet No.110, Stockholm 1980, and from the 1978 and 1986 Surveys of Swedish Foreign Subsidiaries, as reported in *De svenska storföretagen – en studie av internationaliseringens konsekvenser för den svenska ekonomin,* IUI, Stockholm 1985 (especially Chapter III by F. Bergholm and L. Jagrén), and Swedenborg, B., Johansson-Grahn, G. and Kinnwall, M., *Den svenska industrins utlandsinvesteringar,* IUI, Stockholm 1988.

Table 1.5 Labor quality distribution by occupational clusters and educational attainment

1.5A U.S., 1986 and projected to 2000
Percent

Occupation	1986	2000
Group I, total	*25.1*	*27.3*
Management and management-related occupations	9.5	10.2
Engineers, architects, and surveyors	1.4	1.5
Natural and computer scientists	0.7	0.8
Teachers, librarians, and counselors	4.4	4.3
Health diagnosing and treating	2.3	2.8
Other professional specialists	3.5	3.7
Technicians	3.3	4.0
Group II, total	*40.8*	*40.0*
Salesworkers	11.3	12.3
Administrative support, including clerical	17.8	16.7
Blue-collar worker supervisors	1.6	1.5
Construction trades and extractive workers	3.4	3.3
Mechanics and repairers	4.2	4.0
Precision production and plant systems workers	2.5	2.2
Group III, total	*34.0*	*32.7*
Service workers	15.7	17.2
Agriculture, forestry, and fishing workers	3.3	2.6
Machine setters and operators	4.5	3.6
Hand workers	2.4	1.9
Transportation and material moving workers	4.3	4.0
Helpers and laborers	3.8	3.4
TOTAL	**100.0**	**100.0**

Source: Kutscher (1988).

I.5B Sweden, 1985
Male and female

	Percent	Average wage and salary level (SEK thousand /year)
Group I, total	*15.0*	*121.1*
a) White collar, executive level	8.8	57.2
b) Self employed, academic training	0.1	129.6
c) Entrepreneurs ("företagare") excl. farmers	3.9	80.5
d) Farmers	2.2	48.1
Group II, total	*47.3*	*94.3*
a) Skilled workers	15.5	94.1
b) Middle management	24.5	107.5
c) Not classified	7.4	49.8
Group III, total	*37.6*	*75.3*
a) Unskilled workers	29.4	77.1
b) Unskilled white collar workers	6.4	78.8
c) Missing information	1.8	34.1
TOTAL	**100.0** (4 285 109)	**91.4**

Source: SCB, *Folk- och bostadsräkningen 1985,* Part 8, Table g, p. 3.

I.5C Greater Stockholm, Sweden, 1985
Male and female

	Percent	Average wage and salary level (SEK thousand /year)
Group I, total	*17.4*	*151.8*
a) White collar, executive level	13.8	165.7
Self employed, academic training	0.3	130.9
c) Entrepreneurs ("företagare") excl. farmers	3.3	94.0
d) Farmers	0.1	3.7
Group II, total	*52.6*	*101.9*
a) Skilled workers	7.3	107.2
b) Middle management	36.6	110.1
c) Not classified	8.8	62.0
Group III, total	*30.0*	*85.1*
a) Unskilled workers	3.7	4.3
b) Unskilled white collar workers	25.3	84.8
c) Missing information	1.0	59.6
TOTAL	**100.0** (788 942)	**104.2**

Source: See Table I.5B.
Special computations.

Table I.6 Information processing, end use classification, whole economy, value added components
Percent of GNP at producer prices

	1950	1970	1980	1985
1. Primary production (agriculture, forestry, fishing and mining)	13.0	5.6	4.1	4.1
2. Manufacturing goods production and related services production	45.3	49.6	47.0	48.7
a) domestic, internal goods processing	–	–	–	(8.7)
b) domestic internal information sector (for foreign part see previous table)	–	–	–	(16.1)
Manufacturing (a+b)	30.3	28.0	23.7	24.8
c) external transport and distributing services	13.2	14.9	14.9	15.2
d) external information services, incl. financial and related external services	(0.3)	5.4	6.3	6.9
e) Other services	1.5	1.3	2.1	1.8
3. Public utilities and construction	10.5	11.3	11.0	10.7
4. Direct, private consumption services	(14.9)	13.9	12.3	12.7
5. Infrastructure	–	13.5	17.2	15.3
a) health	–	4.9	7.4	7.2
b) education and research (non-firm)	–	5.0	5.9	5.1
c) insurance	–	3.6	3.9	2.9
6. Information design production, including social, distributional services	–	6.1	8.4	8.5
7. Total GNP at producer prices				
a) percent	**100.0**	**100.0**	**100.0**	**100.0**
b) billion SEK	**30.4**	**154.0**	**469.3**	**748.9**
8. Service production (Total-1–2a-3)	(61.0)	–	–	76.6
9. Knowledge creation, transmission and application, and economic coordination	–	–		38.5
10. Potential market for telecommunications services (codable knowledge)	–	–	–	2.3
11. Current size telecommunications service	–	2.0	2.1	2.0
12. Ditto at fixed 1980 factor prices	–	2.0	2.1	2.4

Note 1: The classification in this table is very rough and includes arbitrary assignments of items. The needed elaboration will have to await the new national accounts figures. The total is GNP at producer prices.

Sector 1; 1000 + 2000 SNR code
2a+b; 3000 SNR code
2c; 6100 + 2/3(6300+7100–7180) + 7100 (centr. Government)
2d; 8400 + 8500 + 2/3(7180+7200+9200+9510) + 8100 + 8500 (centr. Gov.)
2e; 1/2(9110) + 1/2(9200)
3; 4000 + 5000
4; 8300 + 9511 + 9513 + 9520 + 9530 + 1/3 (6300+7100+7200+9200+8100)
5a; 9340
5b; 9330
5c; 8210 + 8220 + 9120 + 9130
6; 9350 + 9360 + 9400 + undistributed

Note 2: All insurance has been classified under infrastructure.
Note 3: 8 500 is the Business Services sector ("uppdragsverksamhet") which is 0.35 percent of GNP in 1950 and 3.4 percent in 1985.
Note 4: For 1950 I have not had access to data on items 5 and 6 for local and central Government.

Table I.7 The composition of investments (INV) and capital
The 10 largest Swedish multinationals
Percent

	INV	Capital Alt I	II	III
(1) Machinery and buildings	39	39	60	100
(2) R&D	22	22	19	0
(3) Marketing	26	26	15	0
(4) Education	13	13	6	0
Total	100	100	100	100

ALT I: Depreciation: 5.6 percent for all categories
ALT II: Depreciation: 5.6, 15, 25, 35 percent, respectively
ALT III: Depreciation: 5.6, 100, 100, 100 percent

Note: Investments have been assumed to grow at a rate of 5.5 percent in volume, i.e. at the rate recorded 1976/86.

Table I.8 Real rate of return, 1986

The 10 largest Swedish multinationals	
ALT I	6.9
ALT II	9.7
ALT III (normal case)	11.0
The 40 largest multinationals,	
Global operations, (ALT III)	10.4
All Sweden	
Manufacturing, domestic operations (ALT III)	8.9

Table 1.9 Capital stock measurements of 10 Swedish corporations, 1985
SEK billion

	(1) Alt I Replacement valuation	(2) Alt II	(3) Alt II According to plan	(4) According to the books
Tangible Assets				
(1) Machines, buildings and inventories	149.5	149.5	120.0	105.3
(2) Financial assets	146.5*	146.5*	146.5*	140.6
Non tangible assets				
(3) Software investments	na	na	na	0
(4) Technical know-how (Accumulated R&D)	46.2	25.5	16.3	0
(5) Market knowledge	54.6	20.1	12.9	0
(6) Educational, human embodied capital	27.3	8.1	5.2	0
(7) Total replacement valued (measured) capital [sum of (1) through (6)]	424.1	349.7	300.9	245.9
(8) – debt	152.2	152.2	152.2	152.2
(9) – concealed tax debt	44.8	44.8	36.4	29.0
(10) = Net worth [(7) –(8) –(9)]	227.1	152.7	112.3	64.7
(11) Corresponding asset values according to the market	84.0	84.0	84.0	84.0
(12) Residual value [(11) –(10)]	–143.1	–68.7	–28.3	+19.3
(13) Deduct for risks, including political risks	na	na	na	na
(14) Deduct for lack of information or incompetence of equity market specialists	na	na	na	na
(15) Residual value measuring executive and entrepreneurial competence	na	na	na	na
(16) Real rate of return on total assets [= (1)+(2)+(4)+ (5)+(6)], percent, (N.B.!) 1986	6.9	9.7	11.0	**

* Adjusted upwards with SEK 5.9 billion for undervalued shares and hydroelectrical property.
** An analogous computation using book values would no longer give a comparable real rate of return.

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