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# THE MACROECONOMIC EFFECTS OF NEW INFORMATION TECHNOLOGY, WITH SPECIAL EMPHASIS ON TELECOMMUNICATIONS

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# THE MACROECONOMIC EFFECTS OF NEW INFORMATION TECHNOLOGY, WITH SPECIAL EMPHASIS ON TELECOMMUNICATIONS.

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**Abstract**
The nature of information use and knowledge transfer is explored in an economy wide context. The purpose is to design a research project on the use and the macroeconomic effects of new information and communication technology in a growing economy, with particular emphasis on the use of telecommunications techniques.

The *demand* and micro-*supply effects* of communications technology will be studied separately. In a third part the influence of new telecommunications based financial instruments on investment allocation and growth will be investigated. Hypotheses later to be investigated through simulation on a micro based model of the Swedish economy will be presented. Some results should be ready by July.

It is recognized that information use, and the diffusion of knowledge are dominant economic activities, subjected to technical change. This will be seen to mean that significant parts of the knowledge base that influences economic behavior cannot be represented analytically. New information technology and increased *receiver competence,* however, have made it possible to convert previously tacit knowledge as information to communicable code. The classical assumption of costless availability of information, or predictable costs for information use, nevertheless, cannot be imposed. Learning about economic structures through search and experiments has to be explicitly modeled. This introduces *uncertainty* as distinct from *computable risks.* While information and communication technology has traditionally been studied as improvements in the analytical capacity of firms to make the economy transparent, in this project we also look at the use of such analytical information and communication methods in the Swedish micro-to-macro model to make the (financial) market arbitrage process more efficient. The increase in efficiency of arbitrage exercises a strong leverage on the macro economy through investment allocation and is shown to be capable of causing both positive and negative effects. To explain this some introductory text on the nature of knowledge and information in economic analysis is needed.

## 1. Introduction

Economics has always had a problem with information (see Stigler, 1961, Lamberton 1971). It is difficult to measure. Much of its use occurs within the heads of individuals. Because of lacking *receiver competence* important aspects of knowledge in society cannot even be communicated. It is tacit and cannot be translated on communicable form as information (Eliasson 1990a). This is particularly important for economic analysis when the importance for growth of new technology and business judgement is to be taken into account. What is the state of information in markets for investment?

The number of investment opportunities residing at any time in an advanced economy is immense. The theory of economic growth has to explain how these opportunities are discovered, explored and exploited. The sheer size and complexity of the space of business opportunities and the free access of innovative agents to enter and compete with incumbents mean that anything can occur. What does this everyday situation mean for the definition, the use and the communication of information?

## 2. The scope of opportunities

Attempting to understand the space around us is not only a practical problem for the firm or a scientific problem for the information specialist. Neither is it unique to economics. The notion of open versus a closed systems has long been the concern of philosophers, and it has always been considered intellectually uncomfortable to think in terms of open, non-transparent state spaces. Hume and Locke discussed the world in terms of *memory logic* and *imagination*. Logic and memory were acceptable concerns for the human mind and from the two a large number of combinations could be derived. Imagination was the rest. Leibnitz accepted no more imagination than all possible combinations of logic and memory (the reducibility assumption, Gustavsson 1991). This was also sufficient to introduce *complexity* and a limit to understanding.

Kant, however, was willing to go beyond the computable world of Leibnitz and accept the presence of imagination as a separate dimension of human awareness, i.e. the representation of something that is not derivable from existing facts, or the past. Imagination was created out of nowhere, from the unknown depths of a human mind. Schumpeter (1912) used a similar notion to introduce *innovation*, as a "deus ex machina" previously incomprehensible.

That a stable structure, a language, a theory is needed to organize facts and thoughts (Eliasson 1990a, b) such that information can be communicated took a long time to understand. Not until the 30s, and Wittgenstein did philosophers and linguists realize that language is the limiting factor of knowledge. Pelikan (1969) used the same idea to study the impossibilities of being fully informed, and in control of a large organization from a central point. The language limits the kind and volume of knowledge that can be communicated on code, as information.

It is very obvious that going beyond an economy that limits itself to a codable representation of facts – the computable world – into *the experimentally organized* economy that allows for non-predictable imagination or innovation, represents an entirely new experience to the analyst. We will find, in this paper, that it changes the nature of the concept of information, and that it all has to do with the size of state space and the difference of opinion between Kant, on the one hand and Leibnitz on the other.

## 3. The Experimental Nature of Economic Activity

Adam Smith (1776) laid down the principal design of a decentralized market economy in which division of labor made economies of scale "in the small" possible and the realization of large macro productivity effects feasible. He saw no limits to the possibilities of productivity advance or the potential wealth of nations. His world was essentially an open system (Loasby 1991). The benefit of productivity advance and economic wealth, however, came at a significant cost, a fact that "modern" mathematical representations of the "invisible hand" have had difficulties incorporating. The organization of the division of labor is an instance of innovative behavior. It evolved gradually in the market. Once realized, economic activity had to be *coordinated* physically (transports) and through the communication of information.

Once an innovative design, whether technical, organizational or commercial has been accomplished, competitors will be "on your doorstep" to learn (imitate). If your organization is large enough you will want to diffuse the new knowledge throughout your organization. You may also want to sell your knowledge at a profit (consulting). *Learning*, hence, becomes the general and resource using economic information activity.

Even very simple tasks (you soon learn) can normally be solved in a large number of ways. The higher up, the more complex the decision problem and the larger the number of possible solutions. Some of these solutions are better than others. The problem, however, is that *you will never know until you have tried them. This is the essence of the experimentally organized economy.* The number of possible solutions defines the size of the *business opportunity set* that each agent probes into through experimental search, a search being directed by a limited vision (theory) of all possibilities (*bounded rationality*, Simon 1955). With his or her particular vision as guidance, agents are limited in communicating with each other because of limited and differently composed *receiver competence* (Eliasson, 1990a, p. 17; 1990b). The result will be a heterogeneous structure of competence, defined by the organization of people in the economy.

Much of the knowledge put to use in a firm, especially high level competence is difficult or impossible to communicate on coded form as information. It is *tacit*. Tacit knowledge is acquired through on-the-job learning and filters through the economy (selection) through the acquisition of whole, or parts of firms in the mergers and acquisitions market or through the mobility of people or teams of people with competence in the labor market (Eliasson, 1991d).

I have now introduced four general, knowledge-based economic information activities; *coordination, innovation, learning,* and *selection* (see Table 1). How much of all resource use in an economy that falls under these categories depends on the economic measurement system choosen. Measurement taxonomies that make them cover all economic activity can be defined, making information processing an intellectual superstructure (the memory) that controls all other activities. If there were no limits to our possibilities of measurement all economic activity would consist of using and communicating information. For instance, automating production in a work shop can be described as a change of the information system that coordinates the underlying physical production. In this particular case it is also very obvious that this change in information system is a change in work organization. Available statistical measurement technology, however, does not allow the economist to work with the high resolution necessary to automate factory production. The standard national accounts statistical system is, nevertheless, sufficient to demonstrate the dominance in total resource use of knowledge-based information activities. In the economic model that we will use *coordination, innovation, selection* and *learning* will also dominate economic resource use, making the *use* and *the communication of information* the dominant production activity. We can also establish that most of what we call technical change, as observed through macro production function analysis, really is composed of changes in the technology of economic information processing, which in turn originates in *innovative organizational change,* including innovative change in the organization of learning to accumulate new competence (Eliasson, 1992a). This observation, however, demands a very broadly based definition of innovation, that is not restricted to hardware equipment in factories. Innovation occurs throughout business organizations and is particularly important at the level of the top competent team in the form of *innovative organizational change,* exercising strong leverage effects on the entire firm (Eliasson, 1990c). Innovative organizational change is also associated with the organization of the entire economic system and its capacity to efficiently coordinate economic activities. Particularly important is the balancing of the reliance on coordination through free markets on the one hand, and through the central control by government on the other. Another equally important problem is the tradeoff between the short- and the long-run.

## 4. Information processing the dominant production activity – some basic facts

Even though clearly observable in reality, and recognized by economists, the mathematication of economic theory, beginning in the late 1900th century, had problems with knowledge and information from the start.

The classical solution to this problem was rather typical. Knowledge and information was simply ignored. General equilibrium based models of Walrasian origin dominated pure economic analysis well into the 70s. With such models information gathering and communication required no resources. The auctioneer or God made sure the economy was safely in equilibrium. Industrial organization theory has increasingly recognized information use in the form of asymmetric information and incomplete markets, and the possibility of limited understanding (bounded rationality). Observing that value added was rarely exhausted by observed factor payments, Mc Kenzie (1959) suggested that residual profits should be seen as compensation for unmeasured competence inputs. Analysts carefully avoided selection mechanisms (like entry and exit) and information activities drawing large resources and/or being subjected to innovate technical change.

For economists attempting to understand the use and communication of knowledge in economic growth this simplifications is not acceptable. Significant selection mechanisms and/or large information costs that are (unavoidably) subjected to unpredictable technical change dramatically changes the properties of the economic model. Above all it will have to be recognized that technical change in information processing in an economy occurs through organizational change, that significantly affects the reliability of information in markets and the capacity of markets to coordinate the economy. To show that, let me just state one empirical fact to make the point, and then go on.

*The Fact: Information Costs dominate*

Figures A and B present Swedish manufacturing and the entire Swedish economy on a break down in physical, manual production and various forms of service and information activities like R&D, product development, global marketing and internal education. Even at the rough categorization used in the national accounts it is possible to show that the bulk of labor costs in Swedish manufacturing goods production consists of service production, and that most of this service production consists of information activities of some kind. The dominance of information activities would become even more pronounced if the presentation were in terms of value added, since profits is a form of compensation for financial services rendered, and/or the compensation for ownership services of various kinds, including risk taking and competence contributions. Figure 1B gives the same picture (in terms of GNP value added contributions) for the entire economy. Again service production dominates, and among services various forms of information processing and communication accounts dominate.

Against this statistical background the use and communication of knowledge in various form becomes the dominant resource use in production, unavoidably subjected to innovation and technical change. (I will later show that technical change in service production and information use is mainly occasioned through organizational change).

*<u>Consequence one:</u> innovative organizational change reduces information in markets and hierarchies*

Information processing occurs in markets and within firms (hierarchies), the goal of agents being to identify better business solutions and make economic decisions that are superior to other decisions. When information costs were zero or small and predictable and state space small and transparent the exact nature of existing options could be identified analytically. In the type of models used it was a matter of routine analysis to find the optimal solution that was related to external factors that remain unaffected by the allocation decisions in the economy.

With information the dominant resource use, information costs being affected by technical change in information use and communication and not known in advance, the optimal positions of the economy or the firms depend on the actual technology of using information. In a market prices signal information on quantities. In static equilibrium this relation is one-to-one. If the production organization that sends these signals is subjected to innovative change the information content of price signals also changes, and is reduced until the actors have learned to interpret them. With (fact one) the bulk of resource use in an economy engaged in information processing in various form, quantities become extremely difficult to identify. The problem is identical within hierarchies. The efficiency of internal communication top-down or bottom-up depends critically on the stability of the information content of internal statistical categories. Reorganization of firms changes the information content of such internal statistical measures and, hence reduces the state of information in the firm (Eliasson 1976, 1984a, 1990c). Hence, organizational change is always resisted by the middle management hierarchy responsible for communicating information and excersizing control within the firm (see below). This is also a very practical concern for designers of internal information systems in firms.

Consequence two: *economic growth is organizational change*
Organizational change, we have just shown, reduces the coordination capacity of markets through price signals and the coordination capacity of hierarchies through administrative (planning) techniques. Three important conclusions emerge from research carried out by Bo Carlsson. *First,* in an early IUI study, Carlsson (Carlsson et al, 1979, p. 34; Carlsson, 1980) demonstrated that when stripped down to the level of a division, or an establishment, more than 50 percent of total factor productivity change at the manufacturing industry level originated in structural adjustment between existing establishments, most of which was due to the exit of low performing units and the transfer of resources to high performing units. *Second,* Carlsson (1989) reports that technological change in manufacturing is generally making smaller scale production more economically viable than earlier, which is reflected in a general reduction in the average size of both plants and firms among the industrialized countries. This observation is strengthened by the relatively faster advance of private service production. Smaller scale, service-oriented, and competence-intensive production will increase the importance for macro performance of structural adjustment at the plant and establishment levels.

*Third,* Carlsson (1991) observes that in a 20-year perspective total factor productivity growth is almost all a matter of reallocation of resources within and between existing plants. This tallies nicely with my own results on entry and exit (Eliasson, 1991a, 1993c). Beyond the 20 year horizon, the introduction of new technology through entry and through new investment begins to exhibit sizable macroeconomic effects. Summing up, this means that organizational change determines long-term productivity change and economic growth but that organizational change lowers the state of information in markets and the capacity of markets to coordinate the economy in the short-term. *Organizational change* at all levels are instances of innovation. But contrary to the exchange of tacit knowledge, the efficient transmission of (coded) information requires *organizational stability,* or a stable grammar, something that linguists and business information systems designers have both understood (Eliasson, 1976, 1990c). Hence, in an economy where information processing is the dominant production activity, and where information processing is subjected to technical change, *the experimentally organized economy,* the nature of information becomes fundamentally different from that in the classic model of a transparent world. The question asked is how individuals and firms find, interpret and use information under such undefined circumstances. We will find that intuitive business decisions that turn out right and mistaken decisions that cause business failure constitute the critical, and positive dynamics of a growing economy.

*Learning Theory*

Modern learning theory illustrates these practical problems clearly. Learning theorists like Blume, Bray and others (see Lindh 1993) have been confronted with a kind of impossibility problem, or the impossibility (already in the classical model), of learning to be fully informed, through standard statistical methods. If you have no prior knowledge of the important structural characteristics (the specification) of your model you will be stuck with limited and biased insight. Thus the notion of "bounded rationality" or limited insight (Simon 1955, Eliasson 1990b) is forced upon the analyst already in the classical model. Financial economics has – on similar grounds – come up with the idea of rational "noise traders" that realize that other agents are not well informed and do not behave rationally. Therefore they cannot behave as if all are informed, but have to make guesses about the state of information in the market. Antonov-Trofimov (1993), find that agents (firms) in the truly experimentally organized economic environment of the Swedish micro-to-macro model (MOSES) equipped with sophisticated, econometric learning instruments, (rational statistical learning) still does not improve performance, if they do not know the structure of the economy beforehand. The structure of the economy depends, however, as we have just shown on the state of information in market. In an experimentally organized economy, "noise- trading-like behavior" – Antonov-Trofimov (1993) show – improve long-term macro economic performance compared to rational statistical learning or, above all, centrally imposed "information" based on structurally specified econometric models. Noise-traders by chance or (to others) incomprehensible intuition stumble on opportunities in the state space of the model that are excluded in the centrally restricted, "optimal" decision environment.

This paradoxical result can also be expressed in terms of *prohibitive complexity.* If you know the structure of the economy – expressed as the prior structural specification of an econometric model, the prior requirement of learning theory – then you can proceed to try to estimate the model. If you don't know the structure of the model you have to make prior assumptions, and run the risk of *misunderstanding through misspecification.*

If you know the structure of the economy and (hence) of your model, it may still not be estimable by standard econometric techniques. This is almost always the case with models like MOSES (see below) featuring selection mechanisms like entry and exit, and other forms of non-linearities. Even if you would know the code you would be unable to estimate its coefficients.

The next step would be to work with simplified representations of the underlying model structure. This is what Antonov-Trofimov (1993) did. Even though they knew the code of the underlying standard model (MOSES), it did not help, since the structure of the underlying linearizable and estimable model was not stable over the entire estimation period, due to agent behavior and multimarket interactions. This is sufficient to render the standard equilibrium model dangerous for any analysis that has to do with resource allocation. (And note carefully that we are still in the highly unrealistic world of *costless information processing.* The experimentally organized economy changes all that).

## 5. The experimentally organized economy

The model of the experimentally organized economy (Eliasson 1991c) confronts the analyst with the impossibility of defining all information needed for a fully informed economic decision and of communicating the complex information needed for a fully informed decision. This problem is similar to that of distinguishing (Knight 1921) between *uncertainty* and *computable risks,* a distinction that has no meaning in the classical economic model which uses risk and uncertainty as synonyms, but that carries utmost significance in the experimental model.

The main conclusion of this section is that when fully informed decisions are impossible and when decisions are normally significantly biased, business mistakes become a normal cost for economic development. The rational expectations or efficient market model treat such mistakes as random noise. In the experimentally organized model business mistakes cannot be treated as random insurable noise. They furthermore become the most important learning cost for economic development (Eliasson 1991c). This proposition is best illustrated with the help of the Swedish micro-to-macro model.

*A Generalized Salter Curve Analysis of Innovative Learning and Competition*

A market, or the entire economy, can at each point in time be represented by a distribution of potential performance characteristics, like the rates of return over the interest rate ($\overline{\varepsilon}$) in Figure 2A. These types of distributions – especially if presented as productivity rankings of establishments (Fig. 2B) – are often referred to as Salter (1960) curves. Each firm is represented on this curve by a ranking on the vertical axis (the columns in Fig. 1), the width of the column measuring the size of the firm in percent of all other firms. Figure 1A shows that even though the firm in the model has increased its rate of return between 1982 and 1991, it has lost in ranking. Figure 1B shows the same firm's labor productivity and wage cost positions. Finally, each firm is operating under its productivity frontier to position itself on the productivity and rate of return rankings (see Eliasson, 1991c, Fig. 1). This is still actual *ex post* performance 1982 and (simulated) 1991. The dynamics of markets, on the other hand, are controlled by the potential *ex ante* distributions that capture the planned action of all firms, including new entry.

A firm can improve its position through *reorganization* or *rationalization*. If it does not succeed it will eventually be acquired by some other firm or exit. This leaves us with four fundamental growth investment mechanisms

a) entry
b) reorganization
c) rationalization
d) exit

that together make reorganization and selection the fundamental mechanisms behind economic growth (Eliasson 1993, a, b).

*Competition*

There is a third set of Salter curves that tell how *each firm sees itself positioned relative to other firms.* The real world of the experimentally organized economy, as well as its model approximation, the Swedish micro-to-macro model, shows large divergences between actual and perceived positions.

The *ex ante* distributions tell the potential for the firm to outbid all other firms in wages, or in paying a higher interest rate.

Learning about one's competitive situation – in reality or in theory – occurs in different dimensions. Prices offered in the market tell something about how other firms – notably the best firms – view their competitive situation. Competition, production, hiring, etc. can also be directly observed. The firm, finally, learns directly itself, when it enters the market. (The critical learning experience occurs when firms observe that competitors can do better. Firm management then knows that this *can be done* and that it had better improve in order not to be pushed down, right along the Salter distribution, and, perhaps, out). Similarly, when the firm finds itself at the top, or close to the top, it knows that a whole lot of "closely inferior" firms feel threatened and are taking action to better their positions through innovation or imitative learning.

The conclusion is that if potential Salter distributions are sufficiently steep and if all firms know it, firms – and especially the top left-hand group – will feel sufficiently threatened to actively aim for improving their positions on the Salter curve through innovation. If such innovative activity, notably through innovative entry in markets, is free, necessary conditions for maintaining sufficiently steep Salter distributions to move the entire economy through a self-perpetuated competitive process have been established (Eliasson 1985a, 1991a, c). These conditions become both necessary and sufficient if the opportunity set (Eliasson, 1987, 1991c) is sufficiently large. This also establishes the link between dynamic competition through the Schumpeterian (1912) entrepreneur and innovative entry, argued by Smith (1776) to be the critical mover of macroeconomic growth that perpetuates the disequilibrium economic process type Wicksell (1898). A sufficiently large and heterogeneous state space, boundedly rational behavior on the part of agents, and sufficiently free innovative entry are the small modifications of the classical model that create the experimentally organized economy.

The Swedish micro-to-macro (M-M) model exhibits these features. Dynamic competition determines entry and exit, and hence the selection process that creates a path-dependent evolution, and the non-stationary behavior that prevents classical learning[1]

*Simulating Approximate Static Equilibrium through Faster Market Arbitrage ($\bar{\varepsilon}$ Competition)*

The competitive process described above culminates in stock market competition for funds. The more intense competition the flatter $\hat{\varepsilon}$ distributions (see Figure 1) will be through forced exit, if new entry does not add even better performers from the left. The purpose of new entry, besides keeping competition going is to preserve diversity of the performance distributions. Registered $\hat{\varepsilon}$ in a market signal profit opportunities, and entrants enter on the basis of their expected $\hat{\varepsilon}$. Most new entrants, however, fail (Eliasson 1991a). The classical notion of a capital market equilibrium is that all agents' rents ($\hat{\varepsilon}$) are forced into line and made equal to zero (no profits over costs). Efficient financial markets perform that function in the classical general equilibrium model. This process can be simulated in the MOSES model. We then find, however, that the more efficient financial market arbitrage (through forcing agents' $\hat{\varepsilon}$ closer to a zero profit situation) the more volatile $\hat{\varepsilon}$ development and the more prone to major collapses the real economy. (Eliasson 1983, 1984b, 1991c). The closer to "optimal" agents are guided by market signals and forced by intense competition the more unreliable price signals become, and the more disorderly economic behavior; a true Heisenberg situation. This will be an important observation for the final analysis of new instruments in financial markets.

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[1] This is the case even though the M-M model, for all practical purposes, is deterministic. If you have the code of the M-M model, you can of course predict through a deterministic simulation. The question was, however, whether you would be able to learn the structure of the model (to perform that prediction), without access to the code, from observing the output from a large number of simulations, and with such precision that it would predict over a chosen future period, barring a predetermined and limited stochastic error. This question reduces to the problems of (1) finding an acceptable, estimable approximation of the M-M model and (2) obtaining unbiased estimates of the parameters of that approximate model. If (3) the error terms between the M-M simulation ("reality") and the corresponding computed model values do not pass a test for randomness over any chosen simulation period, classical learning is not feasible and the particular behavioral characteristics of the firm of the EOE should exhibit themselves. The seemingly erratic behavior exhibited by the model economy, like major macro collapses that occur out of the blue (Eliasson, 1983, 1984, 1991c) all originate in the endogenous changes of the Salter distributions, characteristics that are impossible to reproduce in a predictable way by known estimable modeling techniques. This is sufficient to rule out classical learning in the experimental setting of the M-M model.

*Three different forms of learning*

Three different forms of information processing or learning can take place in a dynamic or experimentally organized economy.

Agents

(1) use *analytic* or classical (costless) learning methods, like statistical learning

(2) *invest* in methods or equipment to assist in the gathering of knowledge or information

(3) learn through *experiments and mistakes*

(1) is the preferred method in economic theory, but it has also been practiced widely and wildly by firms (forecasting) and by policy makers and macro econometric model builders. The 60s was the analytical forecasting and planning decade (Eliasson 1976).

The *investment* method is more useful. Its typical application is in systems control like automated production etc. Such applications are surrounded by very costly investments in measurement equipment, process monitoring devices and control instrumentation. A necessary requirement for such applications is a stable underlying structure, meaning that signals emitted by the system (the measurement system) always contain exactly the same information, barring a small random error (tolerance).

Economic learning in more broad applications takes you into the third category. Business information systems is a good example. This time you lack full information both of the interior of your system, the firm and the environment (Eliasson 1976). The relevant decisions are *choices*. The very interesting first fact is that the typical business information system has long been, and still to a large extent is, designed on the format of category (2) on factory automation. The very interesting second fact is that it should be organized (Eliasson 1990c) for learning through experiments and mistakes, reflecting awareness that the entire economy can now and then be completely disorderly and unpredictable.

## 6. The nature of the firm in the experimentally organized economy

The way you look at the economy affects the way you look at and theorize about the firm (Eliasson 1994a). If you look at the economy in terms of the transparent static general equilibrium model you tend to see the firm[2] as a forecasting-planning machine that never makes mistakes, except random forecasting errors. Firms can plan (in principle) to achieve the state of full information, and this theoretical possibility of the classical economic model exerted significant influence on the business administration literature of the 1960s and early 1970s, which abounded with treatises on "business planning" (see Loasby 1967, Jautsch 1968, Eliasson 1976), until reality struck back in the form of the series of macroeconomic crises of the 1970s. This literature, and its promotion of formal, long-range business planning, is now gone. The problem, pointed out already by Knight (1921) is that such computable errors make business mistakes insurable. It leaves no room for business competence and, hence, is utterly at variance with facts (Eliasson 1990b). The EOE and reality, however, requires a very different animal, with different non-analytic competence specifications. Each firm has to reckon with the presence of many competitors aiming for its market niche through technological product competition (Eliasson 1987). The set of business opportunities is huge and mostly non-transparent to the individual firm. A firm that wants to survive cannot wait to compute its fully informed plan of what to do. If it does not act prematurely on a very incomplete information base, it can be sure that one of its many competitors will score a success. Thus top firm management had better be equipped with a good *sense of direction,* the first, dominant competence requisite for success (item 1 in Table 2). If it does not, it will fail anyway. Hence, a firm will have to demonstrate itself to outsiders as a gambler, taking on seemingly large risks. With a good sense of direction, however, the true risk exposure to the insider management is much smaller. Thus the competence of the firm can be defined in terms of its ability to transfer uncertainty, [Knight's (1921), Eliasson 1990b] into (for its own management) computable subjective risks.

There are also learnable, administrative techniques to minimize the costs of mistakes. Techniques can be developed that make it possible to take on (reduce the risk of taking on) large risks, that is, a technique to manage in situations when the first competitive requisite (intuition) has failed. This management technique consists of two elements: *identifying* mistakes early and *correcting* mistakes immediately (Eliasson 1990b,c). Once these tests (elements 3 and 4) have been passed, another and quite

[2] If you can see it at all, because it is atomistic.

different element of competence has to be clicked on: the ability to *operate* the firm *efficiently* on a day-to-day basis and to feed experience back to the top (*learning*). Here the next problem shows up, namely the limited internal transparency of a large firm. The large firm (at least) appears (Eliasson 1976) as an organization with a very limited top down insight into its internal life and a very partial understanding of its external market environment. The orientation of administrative techniques is clearly away from trying to understand the external market environment towards improved internal monitoring and control. (Eliasson 1984a, 1990c). This organizational technique dominates when firms have found themselves in the same market for a long time and in high volume production. (The large Swedish multinationals have been very successful in doing this in the 1980s). New information and communication techniques support the firm in exercising these competences. We have found that a business firm is far from a controllable economic system, and that intuition and arbitrary choice rules at the top. New communications technology has found successful applications at that level in making access to people and data faster and more easy. Data communication has found more applications in manufacturing process control, global inventory systems etc. and in production design and CAD applications. At the same time new electronics technology has contributed to improved product quality ("robots" etc). It is also observable from data collection in the so called planning surveys carried out annually by the IUI and the Swedish Federation of industries[3] that data communication intensity increases with firm and division size. Nevertheless, Taymaz (1990) found a negative correlation between both productivity and profitability and telecommunications intensity in production, a result that seems to repeat itself on the new data set collected for 1991. One possible interpretation might be that intensive uses of datacommunications services are the hardware oriented, large engineering firms that service global markets for not so sophisticated products. Here efficient routinized production and inventors control matter. But the same orientation might also have prevented the firms for moving into new high value added products and markets. Too much success in routine volume management may negatively affect the more important "innovative" tasks critical for long term survival, and even very large firms are at peril in the EOE.

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[3] and also used to load the MOSES model.

People in charge of the first orientation tasks (intuition) are always organizationally separated from the selection and operations people. While earlier information systems developers attempted to introduce analytical tools (forecasting) at this orientation level, these techniques have now been pushed down to the operations level.

**7. Policy making in the experimentally organized economy**

A business firm is not a well controlled economic system. Complexity and high resolution measurement make even simple production processes difficult to automate. The external environment is largely unpredictable. Much of the interior of a large business is unknown terrain for its top decision makers.

One would expect the control situation to be even more difficult for the central planner or policy maker of an entire economy. It of course is, and the policy maker has an extra problem to cope with. He normally acts against the market. His autonomy to do that has diminished in pace with the globalization of markets increasingly making each national economy an integrated part of the international economic system. New communications technology (see below) has played a decisive role in this development towards diminished policy autonomy of nations. The policy makers have resorted to three *tricks* to remain in control. They

(1) act on a simplified notion (model) of the economy and disregard possible mistakes.
(2) lower ambitions, or objectives (less detail)
(3) restrict innovative activities that cause structural change, which reduces the state of information in the economy but increases central control.

The *third* method has been practiced by the centrally planned economies within the former Soviet empire. By regulating unpredictable innovative activities "to a halt", economic growth was more or less eliminated. The *first* method has been increasingly typical of western industrialized countries since the Keynesian revolution. We have learnt from studying the Swedish micro-macro model (Eliasson 1993b, Eliasson-Taymaz 1992) that an advanced industrial economy is very robust and takes very long mistreatment before it responds with deteriorating growth performance.

The *second* method is the one choosen by business firms, after the bad experience with the forecasting planning mode (1) in the 70s.

In the experimentally organized economy firms and Government alike are unable – as illustrated by Antonov-Trofimov (1993) – to reach a state of full information and systems control. The same is true of stochastic control in the efficient market model. While the little firm that mismanages soon fails in the efficient market, large firms with large financial capacity can live longer. Government has the capacity to sustain mismanagement for generations, eventually moving the economy beyond restoration. I will conclude on this note with the amusing experience we have had over the many years of modeling work. If you sit down at the computer and attempt to correct unexpected, disruptive, and "socially undesirable macro behavior" by using its almost full assortment of traditional policy parameters you tend to create more and stronger disruptive macro behavior of the same kind at some later period (Eliasson, 1985a, pp. 78 ff; Eliasson and Taymaz, 1992).

## 8. The macroeconomic effects of improvements in communication technology – a research project design

The use and communication of information is the dominant resource use in a decentralized market economy. Information processes are governed by a dominant competence capital. The economic value of that competence capital depends on the ability of agents of the economy, including Government to achieve certain targets. The value functions, however, will have to include not only target achievement measures but also the costs of failed decisions. The latter has normally been disregarded in analysis.

Information processing, broadly defined, includes critical tacit knowledge transfers within teams and firms. The efficient communication of tacit knowledge is a matter of organization, notably the organization of people. I have already gone through this and concluded that information in the experimentally organized economy, even though coded and technically communicable, will be based on subjective appreciations of the underlying fundamentals. Furthermore, only a fraction of the total stock of knowledge can technically be coded and communicated through artificial means. Even though the most important use and communication of knowledge occurs through the interaction of people in teams, modern communication technology has enhanced the efficiency of that knowledge exchange process through improved *access* to people with knowledge and information (Eliasson 1990c). Improved education and presentational techniques (theory) has also made previously tacit knowledge codable and communicable. However, the stock of knowledge (economic and technical) has also increased rapidly. The information processing capacity of the advanced decentralized and internationally integrated industrial economies has increased rapidly, but the share of total knowledge that can be communicated may have decreased.

The final section of this paper will present a method to evaluate the macro systems effects of this change in information technology, explaining how it is being used in an ongoing project at the IUI and finally illustrate with some simulations.

Within the ongoing project telecommunications or rather communication in general is being studied empirically under three headings:

*Demand*

(1) - from households

(2) - from firms

*Productivity change*

(3) - in firms

- in information and telecommunications sectors

*Investment allocation and growth*

(4) how telecommunications-based product technology in financial markets affects the allocation of investment resources in, and the growth of the economy

Hence, we study three principally different macro economic effects of information and telecommunications use;

- *demand*, and the importance of *economies of scale*, notably in the production of telecommunications services.
- the *supply* (productivity) effects of new technology at micro level
- improved investment *allocation* techniques and economic systems stability.

The macro economic effects of each category can be studied separately on the Swedish micro-to-macro model. *The strongest leverage* on the economy is expected to occur through the dynamic investment allocation mechanisms in financial markets, and multimarket interaction between firms. In this last and most difficult part of the study we expect to find the most interesting cases of learning through mistaken business decisions.

The particular empirical applications, partly carried out already, but mostly to be done involve analyzing the explicit economic systems effects of the use of coded information and technical change in the production and use of particular and well defined information services.

Basic to this analysis is the production of information services under §4 above. We currently have the two information and communication sectors integrated in the MOSES model. We can make macro assumptions of technical change in these sectors, and, hence, the long-run cost determined price of these services. In the future both macro analyses and micro firm-based analyses will be carried out. These, constantly less costly services enter firms through §2 and affect firm production through §3. They will all be empirically investigated. The empirical illustration, that I hope to present at the seminar, will be based on a combination of empirical results from that study and guesswork, notably about the effects of new data communications services on the relative development of capital and labor saving technical change in firms (see Eliasson 1987). This is one sequence of well defined systems effects of the new communication technology.

The third type of effects, however, may be potentially more important. They occur through the capital market and improved allocation mechanisms (under §5). These effects have in principle been explicit in the model for a long time. By improving what we call Schumpeterian innovative competition in the capital market (so-called $\hat{\varepsilon}$ competition, see Eliasson 1983, 1984b, 1988 1991c and above), resources are more efficiently allocated over firms. Up to a limit faster arbitrage (through competition and more unformed agents) will speed up long-term economic growth. After that limit, however, information and signalling gets disorderly, reducing the productivity effects through mistaken business decisions. The second type of allocation effects, occur through the introduction of improved financial instruments, making it possible to distribute risks more efficiently. More exactly, new electronics based financial instruments make it possible to establish separable markets for risks of the Markowitz (1952), Modigliani-Miller (1958)-Sharpe (1964) type. Even though only parts of the modelling work has been done, it is so important that we devote a separate section to this topic.

## 9. Improved allocation of resources through new telecommunications-based products in financial markets

Property rights is the fundamental institution in a market economy (North-Thomas 1973). Tradability requires ownership. The most difficult ownership to establish is the contract that entitles you to future profits from intangible wealth, like stocks (Eliasson 1993a). New information and communication technology has played a remarkably efficient role in making the design of and trading in new financial instruments feasible.

*The Emergence of the Market for Financial Derivates*

The services traded in financial markets are explicit (and sometimes implicit) contracts or entitlements to future profits from investments today. Such profits are generated from a pyramid of financial contracts in the form of interest and divided payments and capital gains. At the bottom of this pyramid there should be contracts defining entitlements to the future profits from tangible and physically defined investments like a factory or a firm (the stock certificate). But investment companies can own stocks in firms that own stock in other investment companies that at the bottom hold stock in a physical operation, Government bonds or other forms of financial contracts. The market for financial derivates is a pyramid of such contractual entitlements to future profits. (Rybschynski 1993), and modern information and communication technology has played the critical role in making the market for financial derivates feasible. The emergence of these markets has been made technically possible by new, electronically based information and communication technologies, but has also been stimulated by other incentives to capture rents in incomplete markets, *through:*

- avoiding regulation and taxes
- increasing risk sharing opportunities
- reducing transactions costs
- etc.

Globalization through the growing Euromarket occurred as a way to avoid Government regulation during the 60s. The options and financial futures markets developed in the 70s as a means to improve the sharing of risks, making the markets more or less complete

(Allen-Gale 1994). The markets for securitized loans and swaps, has grown enormously during the 80s.

*Has the decrease in total risks increased uncertainty in the financial system*

The more efficient distribution of risks, argues Allen-Gale (1994) has significantly increased the value of US stocks, as much as two-thirds between 1973-1986. The advantage for the individual of this market, as it has developed is that it allows you to take on the risks you want, and to hedge the risks you don't want to carry. This is indeed a very useful service. There are, however, three things to consider in this context. *First* you have the computable risks that are being traded in the market. *Second,* in addition to the computable risks there may be true uncertainty associated with the underlying fundamentals. If this is the case, *third,* how does the pyramid of risk trading in the market for derivates affect the total degree of uncertainty in the system; is it reduced or increased, or is the market destabilized?

The possibilities of taking on (buying) the risks you think you understand and passing other risks on to others for a fee, mean that you can give your portfolio of investments any risk profile you desire, making it possible for risk averse individuals to enter typically risky markets, where competitive investors offer you risk coverage at a reasonable price. This essentially amounts to making financial markets more informed, lowering the total risk level by allocating total risks over the market, such that those competent to evaluate risks earn money by taking them on. Allen-Gale (1994) estimate that the increased efficiency of financial markets achieved through these improvements in markets for risks have reduced aggregate risks and thus increased the value of stock on the US stock market by as much as two thirds between 1973 and 1986.

Uncertainty, on the other hand produces events that cannot be calculated from past observations. More particularly, if profits is your concern, and the value of your entitlements to future profits depends on the expected value of future $\hat{\varepsilon}$ in the previous section, then if the $\hat{\varepsilon}$ could be forecasted by a stochastic equation with known parameters, no uncertainty would prevail. This is, however, not the case in the experimentally organized micro-macro model, as we have shown, and it should not be the case under the assumptions of Knight (1921). Were it the case, there would also be a case for insurers to enter the market for business risks.

The new situation that has emerged with the market for derivates is (1) that the arbitrage process has been speeded up and (2) a new uncertainty may have been layered on top of the fundamental uncertainty associated with business investment decisions.

How do these two effects balance over time?

*Separate Markets for Risks*

Financial market arbitrage in itself (without a market for derivates) integrates (through multimarket interaction in price and quantity setting) all the markets affecting business decisions with the market for savings. For a separable market for risks (the market for derivates) to be established intermediaries trading in those risks have to be introduced. To do that risks have to be well defined, *for them,* to be tradable. They would not be if the traders in risks were able to assess the entire business market situation, as I have demonstrated above. Hence, these traders have to set up their particular perceptions (models, theories) of their market niche, in the particular risks they are trading in.

This necessarily means a partial model, excluding consideration of a number of relevant market interactions. Such partial markets for risks are often based on observed stabilities in the past, like the small corner of the financial market for bonds backed by home mortgages where risks were assumed to be "hedgeable" by the empirically established "theory of market – neutral mortgage investing". This market collapsed in the first week of April 1994, when movements in the thick hierarchy of derivates suddenly broke the empirical relationships upon which the heavily leveraged Granite Funds were based. Their equity value suddenly disappeared.

For a complex market economy the empirical fact is that for long periods there will be thousands of seemingly stable partial relationships that will be observed and used to trade on. Each trader will think of his observed relationship as a business secret, and invite customers to share his rents for a fee.

In the real world such empirical relationships build on physical and technical facts combined with less stable demand and supply conditions in markets.

The thicker financial market structures may, however, be internally quite unstable, resting as they do on a large number of observed relations between financial variables that in turn are based on the underlying value creating structures of the production system.

*Stabilizing or Shifty Expectations?*

To the extent that the market for derivates parcels out risks on institutions capable of evaluating them more efficiently than before the market for derivates will reduce the total risk level and financial transaction costs in the economy, and also be stabilizing.

To the extent that uncertainty prevails on top of computable risks, more traders in those risks might reduce the total level of exposure by creating a more diverse set of assessments. This, however, is only true as long as assessments are independent and not moved by a common underlying factor, or being affected by sudden expectational shifts in one direction.

About that we know very little empirically, but the potential exposure of the system to such shifts can be studied through simulation techniques.

*The Long- and the Short-Term*

The paradoxical result thus emerges that a growing pyramid structure of derivates effectuate the first task of diversifying risks, and placing them in competent hands, thus lowering the total risk level of the economy, driving up stock prices and decreasing capital costs. There should be two types of positive effects on the macro economy;

(1) decreased capital costs increases investment

(2) more efficient arbitrage in financial markets allocates funds better on projects and risks.

The same effects will to some extent occur temporarily even in the case when these assessments are based on observed partial relationships in financial markets, rather than venture capital type evaluations of investment projects, through increasing diversity in the economy.

This takes us back to the concluding stability analysis in section 4. On the informational assumptions of the static or the efficient market model, risk reduction in more efficient separate markets for risk lower capital costs and increase investment. But this time both the underlying fundamentals of the real economy and the complex pyramid of financial derivates may respond – if markets come too close to clearing – with destabilizing feed-back through multimarket interaction or one sided expectational shifts, causing significant real systems collapses and even further reduction in the information content of market prices.

This analysis leaves us with an impressive structure of economic activities; a relatively thin real production system and an enormous super structure of financial contracts based indirectly on the real economy, that speeds up allocation mechanisms in the real world through making the sum of all expectations of future profits immediately manifest in cashflows to and from real investors. The robustness of such a financially leveraged economy can only be studied through sophisticated simulation techniques.

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Table 1. **The four basic economic activities in the knowledge-based information economy**

| | |
|---|---|
| 1. **Coordination** | The invisible and visible hands at work |
| **(organizational structure)** | • competition (in markets, Smith, 1776) |
| | • management (of hierarchies, Chandler, 1977) 2. |
| **Innovation** | Creation and exploitation of new business opportunities |
| **(exploring state space)** | (Schumpeter, 1912) |
| | • innovation |
| | • entrepreneurship |
| | • technical development |
| 3. **Selection** | Incentives for change |
| **(organizational change)** | • entry |
| | • exit |
| | • mobility |
| 4. **Learning** | Knowledge transfer (Mill, 1848) |
| | • education |
| | • imitation |
| | • diffusion |

*Source:* *The Knowledge Based-Information Economy,* IUI, Stockholm, 1990, p. 73.

**Table 2 Competence specification of the experimentally organized firm**

Orientation
1. Sense of direction (intuition)
2. Willingness to take risks

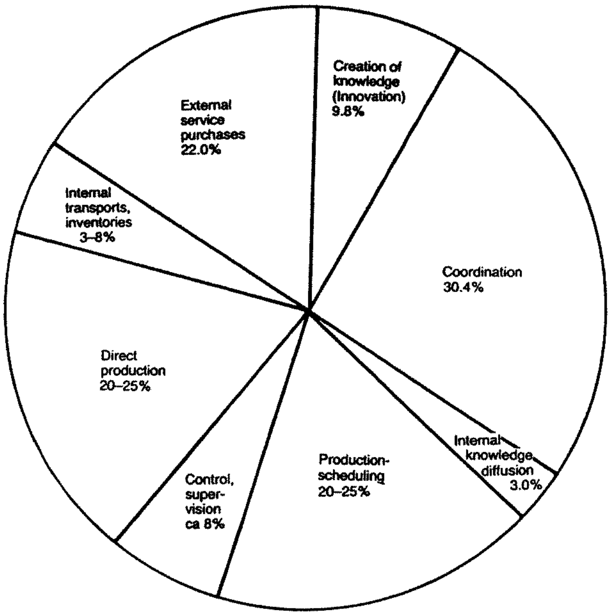
Control
3. Efficient identification of mistakes

Operations
4. Efficient coordination
6. Efficient learning feedback to (1)

*Source:* Eliasson (1990a).

**Figure 1A Distribution of labor costs were production activities**

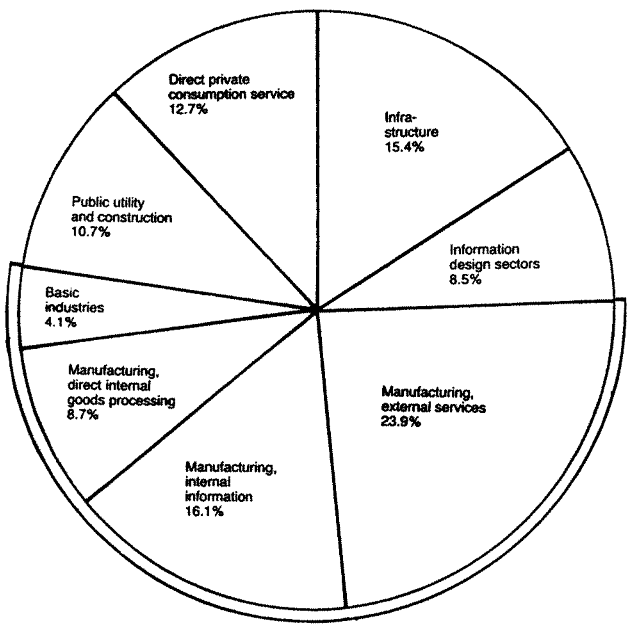
– large Swedish manufacturing firm
– global operation




Total: 122 percent

*Source:* Eliasson (1990a, p. 68)

Figure 1B The **information Economy**




*Source:* Eliasson (1990a, p. 70)

Figure 2A **Distributions of rates of return over interest rate (=$\hat{\varepsilon}$) Swedish manufaction, 1983 and 1990**

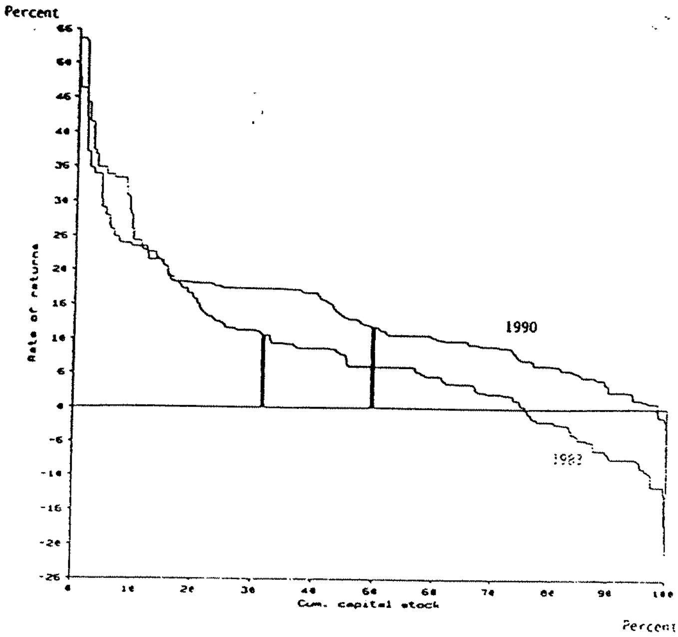
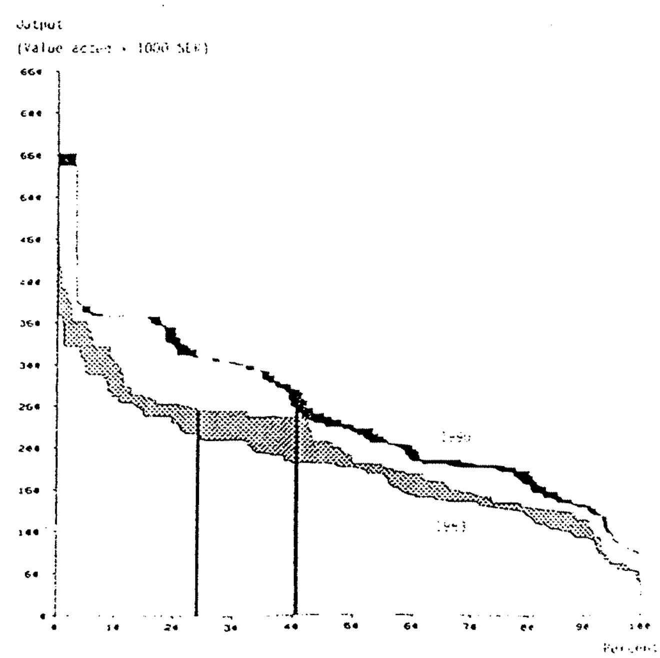



Figure 2B **Actual and potential labor productivity labor distribution Swedish Manufacturing, 1983 and 1990**




*Note:* Standard also demote caused labor capacity.