A list of Working Papers on the last pages

No. 220b, 1989

MODELING LONG–TERM MACROECONOMIC GROWTH as a micro–based, path dependent, experimentally organized economic process

by

Gunnar Eliasson

June, 1989

PRELIMINARY

MODELING LONG-TERM MACROECONOMIC GROWTH
– A Micro-Based, Path Dependent, Experimentally Organized Economic Process

by Gunnar Eliasson

CONTENT

Prepared for the

Second International **WORKSHOP ON DYNAMIC SCIENCES**

at the Industrial Institute for Economic and Social Research

(IUI), Stockholm, Sweden, June 5–16, 1989

1. Abstract

The lead theme of this essay asserts that a model of economic growth has to be explicit about the market dynamics of firm behavior. Firm dynamics originates in innovative behavior and in the price and quantity adjustments of agents when their mutually inconsistent plans are confronted in markets. Three characteristics determine what I call the experimentally organized model of an evolving economy; (1) the size of the opportunity set ("state space"), (2) the presence of "bounded rationality" and "tacit knowledge" ("behavior"), and (3) the degree of access to market opportunities.

The firm in the "markets" of the classical model has to be conceived of as an imperfection based on economies of scale. This paper will place the firm – so perceived – in the intersection of three markets; the (international) product market, the labor market and the capital market.

I will think of economies of scale as originating in the unique competence of the firm to create a temporary monopoly rent from coordinating activities in these markets, a rent that shows up as a return above the interest rate in the capital market. The innovative competence to create those results is the source of economic growth of the economy. For the capital market to be in equilibrium those rents have to be competed away to the extent that their expectation is zero, without removing the incentives of firms to innovate sufficiently to move growth of the economy. Hence, the dynamic behavior of the market imperfections called firms has to be modeled explicitly; how they make independent price and quantity decisions based on their ideas about each others' behavior. The experimental market process thereby introduced is the core machinery of the growth model of this paper.

The unique competence upon which firm market performance is based is acquired through participation in market competition ("in the market learning"). It is largely embodied in the competent team making up the core human capital of the firm, a competence that is sometimes almost impossible to communicate. It is refleced in the Salter (1966) productivity distributions that at each point in time characterize the state of the economy.

The bulk of resource use in the advanced industrial economy has to do with the creation and diffusion of knowledge supporting this productivity distribution and the coordinating and filtering functions of markets that force low performers to exit. The state of technology in the economy is embodied in its organizational structure. The economy carries an organizational memory and technical advance will originate in changes in the organization of these forms of information processing, together making the evolution of the economy dependent on its "tacit" technological or organizational memory.

So conceived the key to the growth explanation is to find a way to model the market forces that determine the balance between short-term process (flow) efficiency and the long-term innovative efficiency of the economy. Part of this has to do with the mechanisms that generate and control economies of scale, the size distributions of firm and concentration in markets. I will be able to do some of this, however, at the expense of clarity of presentation. The various principles involved are simple and classical, but the simultaneity of ongoing economic processes is what matters. Numerical techniques using general and relevant, but complex models allow you to simulate ongoing economic processes closely. Precision is raised but at the expense of didactic transparency. To understand you have to learn to work with this type of models. The last section will illustrate this.

So presented the theme of this paper also lies in the intersection of three IUI projects, or recent IUI books [1];

one on principles of economic measurement, documenting the empirical relevance of the knowledge-based, experimentally organized economy,

one on the internal information and control systems of business firms organized as competent teams of people; demonstrating the dominant nature of human capital in agent behavior and the nature of competence,

one on the Swedish micro-to-macro model, quantifying the dynamics of the competitive games among the few that make up a market economy.

This paper is about the design of a growth model. I will use the design of the Swedish micro-macro model as blueprint. It is a growth model. It exists. It is empirically implemented. It can be used to illustrate most features of the growth model of the experimentally organized economy that I am presenting. But I will not restrict my presentation to that model. It is already fully documented (see Eliasson 1976a, 1978, 1985, Bergholm 1989, Albrecht et al. 1989 etc.). I will go beyond this model in a number of respects, especially concerning the firm as a competent team (Eliasson 1988d).

The above mentioned three characteristics of the experimentally organized economy are modifications of the classical model that endogenizes growth. They are all (crudely) represented in the micro-macro model. The paper concludes with some simulation experiments demonstrating the importance for long-term economic growth of the macroeconomy of the intensity of market competition and competitive entry.

---

1 Eliasson–Fölster–Lindberg–Pousette (1989), Eliasson (1985; 1988d; 1989b).

2. Can economic growth be explained beyond assumption?

In the neoclassical model exogenous growth of capacity or technical change makes also long-term growth in output exogenous. Explaining macroeconomic growth requires a micro-based model that endogenizes capacity expansion through the intermediation of organizational change. This mean making the technical specifications of the economy dependent on the economic process itself. Such models are path dependent and are driven by endogenously determined, tacit technical or organizational memories. Each step forward taken, depends on the position (the state) of the economy. Hence, early steps taken back in history will keep influencing future economic development, possibly in a cumulative fashion. Since the state or the competence memory, is "tacit" at each point in time, there is no way to correct for historical mistakes by backtracking, to try a new experiment.

The dynamic, evolving economic system that I will model can be sketched easily. Think of the supply structure of each market as characterized by sets of actual and potential so called Salter (1966) productivity distributions (Figures VI A,B). Their shape – the spread between best and worst performers – defines potential competition in the market. The position of a firm on that curve, as reflected in an excess rate of return over the interest rate, measures the innovative competence of the firm.

The classical model restricts analysis to finding the price structure among these Salter distributions that clears the market, assuming that Salter curves are invariant to this price adjustment (exogenous) and known.

In our model economy this allocation function is explicitly performed by the market. Agents, however, do not know the Salter curve of their own market, or in other markets, but have to form images of the Salter curves through reading off whatever imperfect signals the market process emit and act competitively upon their perceptions. Hence, learning plays an important role in markets.

Agents furthermore strive to improve their positions in the Salter structures through Schumpeterian innovation. New, agents enter the market through innovative entry. We will try to demonstrate below that the micro outcome of such innovation is basically unpredictable. Salter curves are furthermore upgraded through investment that brings in known best practice technology and at the low end through competitive exit ("creative destruction") forced by price competition of superior producers.

Increased competition, furthermore, induces firms to be more competitive through increased innovation, or contract or exit. The consequence of these market activities is that not only the images of underlying fundamentals (the Salter curves) will be blurred due to lack of information, but the fundamentals themselves will move as as consequence of the competitive market process. The likelihood of a stable, full information equilibrium is low; its existence will depend on the ability of agents to decode the tacit organizational memory developing as a consequence of the market selection process (entry, relative investment growth, exit), a memory embodying the competence (productivity) specification of the economy.

I make the accumulation of administrative competence to coordinate the real and financial dimensions of the economy more efficiently than the capital market – in a Coasian (1937) sense – the rational foundation of the firm as a market imperfection, or a temporary monopoly. Competition among these temporary monopolies through innovative behavior is the essence of my growth explanation.

It is important to understand that dynamic markets are modeled explicitly as competition among a few agents. The slope of the Salter curves, i.e the most efficient agents determine potential competition, not the number of agents.

There are several reasons for introducing the firm as a specialist in integrating the product, labor and capital markets to earn a return above the market interest rate, as a temporary monopoly. First, both the creation and the sharing of these rents have to be explained. Extensions of the classical model like contestable market theory and the new theory of international trade assume economies of scale to exist. The analytical problem is seen as finding the equilibrium of a competitive game among the few given these scale factors, without indicating the economic process that leads to that position. I go beyond that ambition. I try to explain how scale advantages arise through innovative behavior, how they generate financial resources to reinvest and allow firms to grow faster than other firms – and eventually generate excessive market concentration (Eliasson 1983) – but also how scale-based temporary monopolies are competed away in the capital market, thus exercising a competitive check on the concentration process. Second, the explanation of this temporary monopoly has to be sought in the organization of competence accumulation and the forming of competent teams called firms (see Eliasson 1988d, 1989a,b). This makes human capital the dominant capital item and the core of the growth model. The next section will demonstrate how the creation and diffusion of unique firm competence through participation in market competition depends on the way the market process is organized and gives the firm model, the industry and the economy endogenously developing tacit memories that (in turn) make them path dependent. I will also demonstrate that the bulk of resources in a modern industrial economy is devoted to the creation, the transmission, the filtering and the use of industrial competence.

Third, the economic organization so envisioned to be created requires only three modest modifications of the classical, general equilibrium model, modifications relating to the (1) size of state space (I call it the opportunity set), (2) agent behavior and (3) the nature of competitive access to markets.

These modifications may appear minor, but they are not. In the product market agents no longer operate anonymously as "atomistic competitors" but appear in limited, but variable numbers in a game of general monopolistic competition. In the capital market equilibrium is ruled out together with it the notion of a "rational expectations equilibrium" or "efficient markets". In the labor market the traditional homogeneity assumption is abanconded giving way for diversity of quality of human labor input. The creation and allocation of heterogeneous labor quality, not "labor hours", is what matters.

Heterogeneous industrial knowledge becomes "bounded" and in a critical way incommunicable ("tacit"). The outcome of market exchange cannot be analytically understood ("forecasted") but has to be resolved through experimentation. The realization of generally inconsistent plans becomes the source of dynamics of the economy. As a consequence aggregation is endogenized and characterized at each point in time by the memory of the model.

The experimentally organized growth model with memory, so obtained embodies the allocation of tacit knowledge of the economy. Hence, the experimental model occupying the intersection of the imperfect ends of the three markets becomes the natural central, or core theory for industrial economics.

This also means that technical change largely becomes a matter (of change) of economic organization, within agents (firms) and between agents (across the markets of the economy). This is where growth policy, if needed, may have a role to play, namely in influencing the organizational regime (or technique), the memory of the economic system. A particularly important side of organizational technique is the organization of competitive entry and exit and the consequent organizational ("structural") change. The organizational regime determines the efficiency by which the economy and its agents are exploring the economic opportunities available, i.e. exploring state space.

The experimentally organized economy turns the economic optimization problem upside down. In the classical (static) model either factor inputs are costlessly adjusted to relative price change, or slack is being minimized through some optimization program, restricted by the production frontiers. If transactions or information costs are introduced, they are known to decision makers.

In the experimentally organized economy optimizing in this sense is not possible. Allocations have to be tried out in the markets through experiments to be evaluated. Successes push the production frontiers of the static model outwards. Failures are recorded as costs for achieving the same successes. To increase the outward shifting of the production frontiers (i.e. growth) you have either to speed up the experimental process, or redesign it (improve its efficiency) through reorganizing market structure. In both cases you increase the number of failures to be filtered out. If you formulate the growth problem of the economy as a long-run maximization problem, paradoxically, economic growth will be maximized through maximizing both the number of successful experiments and failures. Failure becomes a standard cost of output and growth.

This means for instance that the overinvestment argument becomes misconceived. Except by chance, no investor is doing the same thing. And only after having been tried in the market can the best solution be selected.

This also means that the quantitative growth explanation (model) becomes very complex, embodying a multitude of organizational characteristics of the economy. I think this is exactly as it should be. Economics is replete with single valued explanations of long-term economic growth, each one carrying a partial dimension of the full explanation. But each one is erroneous in isolation, since understanding economic growth, or economics in general, requires understanding how the large number of diverse factors at work merge (synergize) dynamically. This is where the theory of the dynamic market economy enters. It will be seen to incorporate some of the fashionable properties of non-linear dynamics exhibiting phases of unpredictable, seemingly "chaotic behavior".

3. The four fundamental principles of the knowledge-based information economy

The Swedish economist Johan Åkerman (1950) argued that economics really centers around four fundamentals; interdependence, value, process and institutions. So far, economic theory has only paid proper attention to welfare and interdependence, being the foundation and purpose of the classical model. To understand economic growth both dynamics ("process") and institutional change – in the classical meaning of institutions as organizations and rules – have to be explicitly accounted for. Once the static foundation of the model is removed the intellectual foundation of classical welfare analysis has also been removed. But that – I will argue – is a necessary sacrifice for understanding economic growth.

The institutions of the economy embody its competence specification, very much as the design of an electronic chip embodies its capacity. Hence, the most efficient way of introducing knowledge – or the competence-based information economy – is to begin with Adam Smith (1776) and the division of labor; however not only the allocation of labor hours, or labor hours on machines, but of human competence, something that was in fact well understood already in 1768 by the Swedish economist Westerman (1768).

The division of labor required human ingenuity ("innovation" or the creation of new knowledge) to be achieved.

It introduced a separation of economic activities, which required communicative technique to coordinate; information processing and transports. Once new knowledge (an innovation) had been created, an economic potential existed in the educational process of diffusing it through the economy. Since communication requires a receiver competence that may not exist, some knowledge will always remain "tacit". It can only be communicated through "on the job learning", apprenticeship or through "filtering" of competent people. An important part of both the coordinating and the educational functions hence takes place through the filtering of people or teams of people with competence through markets and hierarchies.

As I will demonstrate below much of that competence is embodied ("tacit") and incommunicable. It has been acquired individually through "on the job learning" and within "teams" through participation in market competition.

Competence at all levels controls business choices and thereby also the new competence the individual, the team or the firm acquires through "in the market learning", and again the new choices and so on. The competence memory is continually updated. The growth process becomes path or history dependent.

This is enough to introduce the four, fundamental functions of the knowledge-based information economy of Table 1. The more "heterogeneous" the competence base of an economy the larger its "tacit" knowledge base, the more important the filtering function and the more important the competence embodied in the "institutions" that regulate the filtering (of competence) functions of the economy.

Considering this, it is no surprise that the bulk of resources of an advanced industrial economy is devoted to the four functions of Table 1.

I won't go through the principal problem of measuring the resource inputs and information outputs of the economy according to Table 1. For this the reader is referred to Eliasson (1989). Figure I.1 summarizes the results from such measurements on the Swedish economy. Figure I.1 shows a reorganized statistical composition of total GNP based on the National accounts and internal IUI databases (part of which are shown in Figures I.2 and I.3).

While the traditional manufacturing sector (3000 in the National accounts code) makes up almost 25 percent of GNP today, a properly measured manufacturing goods producing sector, including related services generates almost half (48.7 percent 1986) of GNP. While manufacturing as traditionally measured, and especially if you include Basic industries (1000+2000), has been steadily decreasing since 1950 (not shown here; see Eliasson 1989a), the extended manufacturing sector has in fact increased its GNP contribution slightly since 1950, and significantly if you add in foreign manufacturing production. The "engine of the economy" becomes significantly larger than the statistical accounts show. If you also recognize that a large part of resources spent on infrastructure are devoted to keeping the labor force educated and healthy, to the benefit of productivity, the bias of the traditional statistical information system becomes even more obvious. This eliminates the whole nonsense discussion of deindustrialization. The only thing of any significance observed in that context is the diminishing share of blue collar workers, notably unskilled workers in the labor force.

Figure I.3 furthermore shows that not only external, manufacturing related services increase. Internal service production within the manufacturing sector in fact accounts for more than half of total labor (cost) inputs and has been increasing. Most of it is very competence intensive service production.

This should be enough to remove the standard notion of the manufacturing firm as a "factory" with its productivity characteristics embodied in its machine capital. The performance characteristics of the firm is embodied in individuals or teams of people.

The next task is to demonstrate that the efficiency characteristics of the firm depends on how that human capital is allocated in the organization and how the firm is organized to continually develop and allocate new human competence through the filtering functions.

I have already shown (1988c,d 1989b) how that is done within the business organization. And I have no ambition to model the macro productivity effects of the internal firm allocation of individuals. However, the firm itself can be regarded as a hiearchy of competent teams, or a "bank of competence" characterized in that respect by a number of performance variables, that are continuously updated. The macroeconomic effects of different modes of reallocating that competence between firms can be studied within the design of the Swedish Micro-to-Macro model.

More concretely the knowledge-based information economy operates over an industrial structure of Salter (1966) type productivity distributions, each firm occupying a position on the curve corresponding to its "tacit economic competence". This competence exhibits itself in the classical model as a scale factor. If all firms could immediately, and costlessly "learn" the competence of the best competitor, or "best-practice" operations in each market there would only be one firm in each market.[2]

[2] The straight line MAX in Figure VIII:4A in Eliasson (1985) or on p. 317 in Eliasson (1983) illustrates macro output growth when all existing firms operate at best practice, full employment levels.

This is not possible for a variety of reasons.

- learning is costly, time consuming or impossible (being "tacit") except through experimentation (the filter)
- new competence is constantly being created that reduces the value of existing competence monopolies.

All models that do not incorporate the endogenous creation of new knowledge (innovation) will eventually exhibit unlimited concentration and/or collapse on the neoclassical model with exogenous, unexplained growth.

The traditional assumption of making innovative behavior a stochastic process partially avoids this problem. The nature of the stochastic process assumed, however, includes an assumed exogenous long-term growth path of the system.

The only way of getting around this problem of assuming the long-term growth path exogenously is to be explicit about the nature of the competence accumulation process.

Table 1 THE STATISTICAL ACCOUNTS OF THE KNOWLEDGE-BASED INFORMATION ECONOMY

1. Business opportunities exploring state space)	The creation of new knowledge (Schumpeter 1911) – innovation – entrepreneurship – technical development
2. Dynamic Coordination	The invisible and visible hands at work – of specialized production flows through competition in markets (Smith 1776) – of investment through disequilibrium capital markets (Wicksell 1898) – through demand feedback (Keynes 1936) – through management in hierarchies
3. Filtering	– entry – exit – mobility
4. Knowledge transfer	Education (Mill 1848) – imitation – diffusion of knowledge – information design

Source: Modified version of Eliasson (1987, p. 12).

4. The three critical modifications of the classical model needed to obtain an experimentally organized, path dependent (history bound) growth model

The growth model I am proposing is obtained through modifying three basic postulates of the classical model (Eliasson 1988a);

(1) State space (or the opportunity set) is assumed to be sufficiently large to preclude at each point in time the possibility of reaching a state of full information at limited information costs.

(2) Agent behavior is characterized by
- bounded rationality
- tacit knowledge

(3) Access to markets is impeded by
- natural obstacles
- regulation (policy).

The information system of an agent determines the degree of insight into the opportunity set, the agent can achieve, and how biased it is. This is also how I interpret the concept of "bounded rationality" (Simon 1955, 1979), namely the limitations and biases of vision (into the opportunity set) that characterizes its information system, or "competence".

One could say that if the opportunity set is made sufficiently large all agents will become boundedly rational and vice versa. If bounded rationality prevails (i.e. full information is impossible), the opportunity set will always be very large and non-transparent to human intelligence. This may be so in the static, classical model. But the two notions are not substitutes in the model I am proposing. Two dimensions of state space have to be kept apart:

Subset (1) – the short–term, economic environment determined by systems capacities and expected market strategies of all competing agents.

Subset (2) – the expected long–term environment with capacity frontiers widened through innovation.

Subset (1) of the total opportunity set is potentially learnable at a cost, provided certain forms of strategic agent action do not occur (moral hazard etc.). Transparency is achieved through traditional economic learning. Subset (1) corresponds to the notion of state space in the classical model. A deficient learning technology (a form of "bounded rationality") and/or strategic activity prevent the state of full information.

Economic learning for coordination refers to understanding what agents (competitors) are about to do just now; activities that will be reflected in next period prices and quantities in all markets, except the capital market.

Subset (2) (including subset (1)) is extremely large. Transparency from the point of view of each agent is "bounded" by its local competence. Since local competence is very diverse (heterogeneous) each agent will "understand" and "interpret" the content of subset (2) very differently, and accordingly access it very differently.

With sufficiently heterogeneous knowledge at work the existence of "tacit" incommunicable knowledge, due to limited receiver competence can be demonstrated (see below).

If tacit knowledge exists the content of subset (2) is beyond description. No inventory of its content can be made at any point in time. New knowledge creation (innovative activity") becomes experimental and its output truly "unpredictable" at the micro level.

Ample historic evidence, furthermore, shows that subset (2) is constantly pushed outward through research and through experimental action in markets. In this respect the opportunity set can be likened with the pig Särimer of the viking sagas (see Eliasson 1987). It was eaten for supper, but returned each morning, in full vigor, to be consumed again for supper. The difference between economics and the viking sagas is that the "opportunity set" even expands from being exploited. This is my way of introducing – through the notion of the opportunity set – the positive sum game implicit in my growth model.

For (our) practical purposes it is not very interesting to ask whether experimental improvements in human understanding through innovative activity are pushing towards a total opportunity set of limited size, or whether its full state will forever be beyond human comprehension. Economic man is satisfied to know that subset (2) is still so small, compared to the full state space, that he can confidently discount all such philosophical problems away, beyond his horizon of awareness. The main point of my growth theory is that venturing into a more or less unknown state space is the normal economic activity. There is a technology involved in doing it, and if innovative activity is efficiently organized from a base in local competence capital, it is profitable.

In this context the opportunity subset (2) is conceptually close to the notion of a technology system of a firm or a nation. In a limited sense the opportunity subset (2) is defined by the technology systems of all firms (agents) in the world, its outer limits being set by the best performers. Each local (firm) technology system is designed to improve (upgrade, innovate) the local system, and (also) to "take in" and implement locally the content of the global opportunity set (learning, imitation technology). Granstrand–Sjölander (1987) have shown, that the broader the local technology base the more successful firms.

Both the learning and development side of the local technology system, however, includes a considerable management element, to choose (select) and to organize all information activities. Many researchers argue that technology can be separated from management (technology). In my growth modeling context this separation is not possible (see below).

This little exercise into "understanding" may appear academic, but it is important for what follows. It establishes "bounded rationality" as the central economic concept, thereby making "economic learning" the dominant economic activity. Even more paradoxical is that economic learning becomes the dominant resource-using experimental activity, precluding the state of "full information". A theory of economic growth has to explicitly model the organization of this experimental process. The Swedish micro-to-macro model is a crude version of such an organization-based experimental process, thereby making also the fact that "economic learning" is a dominant, resource using activity compatible with economic theory.

The necessity of "tacit knowledge"

It may appear as if "bounded rationality" becomes redundant when you have introduced a sufficiently large opportunity set, and vice versa. This is only true, however, if you disregard the future and innovative behavior to create new knowledge to earn temporary monopoly rents..

Agents perceive and understand their environments in a time perspective and from the point of view of their local competence. Once this competence is allowed to be "bounded" in the above sense, it is also declared to be "heterogeneous". Heterogeneity will not only generate different exploratory access paths to the opportunity set. It will preclude the communication of unique knowledge to competitors except through the demonstration of successful experimental action in markets. The reason is the deficient receiver competence of competitors, due to the heterogeneous competence capital of each agent. This property of any language (or any communication system) was well recognized already by Wittgenstein. If expressed in different jargon it is a well known experience of any teacher (see further Eliasson 1988d).

While agent behavior in the short run may be strategic, and therefore unpredictable, innovative behavior takes much longer to materialize in markets, and has a larger "tacit" element, that cannot easily be communicated. Expectations on innovative behavior show up in capital markets, notably stock markets.

Access to the opportunity set

Access to markets regulates the speed, intensity and nature of competition.

There are two kinds of obstacles to competitive entry in markets; entitlements to natural resources and possession of tacit competence on the one hand, and deliberate regulation on the other.

Substitution, or the creation of new monopolies or new competence through innovations check the size of monopoly rents from natural monopolies. Hence, growth models have to include such creation of new competence as an endogenous property.

The exercise of regulation is the only policy control option allowed in my model. Policy and Government then become synonymous with exploiting a monopoly position in the market. If the Government cannot impose monopoly power like the tax monopoly, it cannot carry out policies. It might even disintegrate as a consequence of market competition.[3]

Agent behavior becomes experimental

With local competence being characterized by extreme diversity and access to state space relatively free, a situation of full information can never obtain. State space can never be fully explored at any costs. But in addition no agent can ever, even at immense information cost, eliminate the possibility that some other agent comes up with a better solution, because he can never understand the heterogeneous local knowledge bases of all (relevant) competitors, being partly "tacit", and the access routes to the opportunity set they may take. Therefore each agent will have to adopt an experimental strategy, acting prematurely, long before being fully informed to prevent competing agents from coming up with superior solutions earlier. This guarantees genuine unpredictability at the micro level.

Since the distribution of successes feeds back dynamically the performance characteristics of the firm is upgraded for the next experimental round. The process has a memory. Hence, the total experimental process is not likely to be a stationary process.

---

[3] The distinction between these two types of "ownership" is both practical and traditional. Ownership in itself is a manmade regulation enacted to instill order in economic transactions. While ownership regulates the physical possession of a potential source of income, wealth regulation is traditionally seen as directed towards the appropriation of "rents" from property, including competence. The most viable control of rents from ownership of resources, however, is competitive entry in markets. Economic policy in its early manifestations was all concerned with regulating competitive access to markets, protecting incumbent producers, or vested interests.

5. The organization-based experimental growth model

The Swedish micro-to-macro model – called MOSES – is structured on the design of the knowledge-based information economy. All information activities, innovation, coordination, filtering and learning, in the model, although innovation is crudely modeled, and explicit education absent.

Learning about the opportunity set

The main experimental activities of the model are concerned with economic learning for coordination (internal, and external through markets) and filtering. This means that subset (1) of the opportunity set is explicitly modeled and updated as the economic process evolves. Subset (2), however, is exogenously updated. Firms "tap" it for innovative output through their endogenous investment decisions. In the MOSES model ready made "innovations" are brought into the firms with new investment. The innovative process per se is not explicit.

This means that access to the opportunity set can be explicitly captured in organizational terms, and its macroeconomic implications studied. I can thus use the design of this model to discuss growth modeling in more general terms. In particular I will illustrate quantitatively how productivity growth depends on organizational change, including the organization of market competition. The development of a "tacit" systems competence embodied in the organization of the entire economic system – a competence memory – will emerge from this presentation.

Even though the nature (read "organization") of micro-based innovation and knowledge transfer is not (yet) explicitly incorporated in this particular micro-macro-model, I have conducted enough preparatory research on how this process is organized in business firms (see Eliasson 1976a, 1984b, 1988d, 1989b) to be able to tell how the modeling should be done.

The MOSES model as it is currently implemented empirically presents the firm as a financially defined organization, represented by its financial accounts and its internal, financially based statistical information system. The whole model can be seen as a dynamically coordinated computable disequilibrium adjustment model of economic growth. Agents in markets (firms and labor) make quantity decisions on the basis of perceived profit or wage opportunities, but adjust prices, price expectations, and quantities as they learn about actual opportunities from participation in the ongoing market process.

Economic growth builds on dynamic coordination of micro (firm) behavior, which is in turn restricted and influenced by the ensuing macro feedback. Micro (firm) behavior is explicit in the form of an experimental learning process. Hence it is not optimizing behavior. Competition is technologically based (through process efficiency).

Firm behavior

The firm intelligence system exhibits bounded rationality and tacit knowledge. It is designed for competition in the extremely large, and for all practical purposes unknown state space, that we have introduced in the previous section. Profit opportunities are perceived, unexploited commercial and technological combinations in that opportunity set. Firms are characterized by rent (profit) seeking on a hill climbing (not optimization) mode. The landscape of immediate rent opportunities [subset (1)] is however, constantly changing as a consequence of all agent behavior.

Ex ante plans normally fail to match the constraints imposed by the plans of all other actors and the characteristics of the opportunity set. Individual mistakes are frequent and unpredictability at the micro level the normal situation.

Firms, as a consequence, conceive of themselves as experimentators in a positive sum game. Mistakes are common and firms are specialists in fast identification and effective correction of errors (Eliasson 1988d, 1989b).

Failure of agent plans shows up in unused capacity, undesired stocks and price adjustment. This explicit plan realization function is the source of dynamics in the MOSES economy. Constant failure of ex ante plans to match at the micro level, cause a constant ex ante – ex post dichotomy. (The realization process.)

If you only have an equilibrium model there is no way to tell how prices and quantities will behave out of equilibrium. For that you need a process representation of economic activity in which learning behavior, expectations forming, decision making and the realization processes are explicit in time. Such a model will have to be started from a state description (initialization) of the economy, (see Albrecht – Lindberg 1989).

The nature of the plan realization process determines the state of information in the economy, the potential for learning reliably about its fundamentals and the feasibility of a state of full information.

How do MOSES firms exhibit competence?

The competitive position of a firm in the model is represented by a relative technological (process) performance defined by its ranking on Salter labur and capital productivity distributions.

MOSES firms accumulate and exhibit competence to position themselves higher up on the Salter curves in three principally different ways.

(1) They learn dynamically through reading off market signals and orient themselves in their market environment. They also have the capacity to modify their learning algorithms incorporating signaling patterns of the past.

(2) They are subject to selection through competition, a circumstance that upgrades the average productive capacity of surviving firms.

(3) They make internal investment decisions through which new technology is brought into the firm.

Since MOSES economic development is characterized by endogenous market induced reorganization of micro structures, the evolving micro state is a "tacit" memory of competence, that determines the ability of the firm to exploit the opportunity set and at each time bounds the feasibility of future states (path dependence). Unexploited business opportunities are abundantly available to firms willing to engage in risk taking through trial and error (experimentation). Hence, price and profit expectations are enough to move the MOSES economy. By exogenously changing the market regime characteristics, very different growth paths can be generated from the same initial states. Furthermore, the model structure is very non-linear and simulations exhibit typical phases of unpredictable ("chaotic") behavior. This occurs, for instance, when I attempt to force the economic system close to a situation of capital market equilibrium (Eliasson 1985, p. 294 and 306 f.).

One should also note that Micro-Macro theory as represented by the MOSES model can be regarded as an extended positive sum game of infinite duration with a variable number of players, learning, and forming and enacting decisions on the basis of "intermediated information" from the markets. In retrospect the latter is particularly interesting but crudely represented in the model. Since each firm cannot be in touch with all other firms individually, it interprets various items of aggregate information ("indices") generated by the market process, provided with a delay by traders, intermediators, and institutions that with a few exceptions are not explicit in the model. The nature and efficiency of this learning process depends on how the economy is organized into markets and hierarchies, but learning also affects this organization and hence the future efficiency of economic learning, and so on, creating a path dependent evolutionary process, that cannot be predicted due to the complexity of the combinatorial organizational possibilities facing the agents of the economy. On this point, an interesting theoretical development should be possible considering the two facts that this intermediation is the dominant resource using activity in an economy and that practically nothing seems to have been done in this area of research.

Market dynamics – access

The productivity characteristics of the economy – the size of the positive sum achieved – are determined by the intensity of search into the opportunity set; learning and competition. This market technology of the economic model can to some extent be regulated exogenously. I call this policy. Hence, economic policy, besides traditional Keynesian demand policies, that we don't discuss here, is concerned with determining the intensity of market competition, the market regime.

The standard setting is that firms can compete freely in their markets, hire people in the entire labor market, including raiding competing firms for labor and borrow money freely. The intensity by which they pursue this competition affects the competitive situation, including market prices of other firms. Various forms of dynamic feedback, hence, characterize the MOSES economy. There is direct interaction – through firms – between different markets (multimarket interaction). Demand feedback occurs through the macro expenditure system. Without efficient demand feedback domestic economic growth is affected.

Demand feedback is, however, complicated by price feedbacks forcing firms to make decisions about their cost price margins, making them both price makers and quantity setters.

Even though the "domestic" MOSES model economy is in constant market disequilibrium, the model economy is placed in an assumed steady state global market environment, with competing firms embodying best-practice technology and taking world market prices so as to achieve capital market equilibrium, i.e. rates of return equalizing the exogenous world market interest rate. Hence, the capacity of domestic firms to compete technologically, the efficiency of markets in allocating labor and capital, and the capacity of the economic political system to control the level of wages and the domestic interest rate also controls the macro economic growth rate.

Long–term economic development is dominated by the capital market. Investment and growth of potential capacity at the micro level is driven by the difference between the perceived rate of return of the firm and the interest rate. The interest rate imposes a rate of return requirement on the firms in the market.

Firms enter markets on the same profit signals, and exit upon long–term failure to meet profit targets and/or when their net worth is exhausted.

The overall outcome is a micro(organization)-based economic process model driven by profit seeking firms, characterized by some institutional change (entry, exit), but with other major technology-influencing reorganizations within firms being exogenously determined.

While the capital market controls firm profit performance the labor market reallocates people. Depending on the market organization this reallocation can be potentially destabilizing through wage overshooting. The reason for this is (partly) asymmetric downward rigidity in nominal wages.

Relation to the standard general equilibrium model

Personally I would say that the micro-macro theory upon with the MOSES model has been designed puts life into the General Equilibrium Model and – with the complements suggested here – makes it an ideal theoretical base for studying industrial organization problems. Looked at from the perspective of economic doctrines it combines (exogenous) entrepreneurial activities à la the young Schumpeter (1911), and the Austrian tradition with Smithian (1776) dynamic coordination in markets, notably the capital market, characterized by a permanent state of Wicksellian (1898) capital market disequilibrium (see Table I.1). Innovations generate economies of scale. Concentration is checked by technological competition among all agents in the market. Salter curves are so to speak truncated at one end by Schumpeterian "creative destruction" (exit) and updated at the other end through innovative activity, including competitive entry. Thus a situation of a general (monopolistic) competitive game among a limited, but variable number of players is endogenously carried on. The intensity of competition is determined by the slope of Salter curves, the enforcement of profit targets in firms and the efficiency of their learning and coordination mechanisms. Hence, competition is not at all proportional to the number of players. Optimum market efficiency occurs with a limited number of agents, the number depending from time to time on the above factors.

The capital market disequilibrium is defined as the expected return of the firm over the market loan rate. Hence, rate of return criteria imposed through the capital market dominate long–term dynamics in the model. A Smithian invisible hand coordinates the whole economy dynamically through monopolistic competition in the product, labor, and capital markets. Foreign prices, the foreign interest rate, and the labor force are exogenous. Together these mechanisms determine the dynamics of resource allocation. Keynesian demand feedback is needed to keep the economy growing. It enters in three ways: through endogenous income formation and demand feedback (the system is closed), through exogenous government, fiscal and monetary policies, and through foreign trade.

The M-M economy is regulated by the interaction of domestic (endogenous) and foreign (exogenous) prices in the (four) markets for manufacturing goods. Hence, Marxian demand deficiency (or excess demand) situations of varying length occur all the time in the model through failure of local demand plans to meet local supply plans. Markets do not clear and stocks, and later prices adjust. Disequilibria then feed back into next period decisions. The source of dynamics of the macroeconomy originates in this failure of ex ante plans to match through the realization functions of markets. (Modigliani–Cohen 1958, 1961; Eliasson 1967, 1968.) This notion can be traced to Wicksell and Myrdal (1926, 1939), the Swedish School of Economics (also see Palander 1941) but for some reason was lost to economics in the postwar era, heavily influenced as it has been by the classical, static model.

Experience from model work tells that the realization function is the critical factor behind macroeconomic dynamics. Endogenous Growth Cycles of different length occur as a consequence, and occasionally they develop into severe depressions of long duration.

All theory has to be parsimonious in one way or another. Which way, however, depends on what analytical problem one has in mind. I look at theory as a way to organize your thoughts and your facts. There are always a large number of such ways. Hence, scientists, and especially social scientists, are all boundedly rational in Herbert Simon's (1955) sense. Once the notion has been accepted that the problem chosen determines the analytical method ("theory"), the ultimate scientific problem becomes the tacit art of choosing the relevant item from a menu of ad hoc theory.

6. The Micro–Macro Model[4] Mathematically Formulated

This section presents the mathematics of the Swedish micro-to-macro model on short form, (for details see Eliasson 1978, 1985, 1989c). Focus is on the evolutionary features of the model. I thus exclude (in this principal presentation) the intermediate goods, input/output structure of individual firms and all other production sectors than manufacturing. Hence, all labor work in manufacturing and manufacturing firms produce the investment goods. Gross production value and value added become identical.

I begin by presenting the firm model. The sum of all manufacturing/firm value added is total production of the economy. I then sketch how demand feedback is achieved through the households.

1. Deriving the control function of the firm – the information and targeting system

To outline the capital market dynamics of the M-M economy we derive the profit targeting and profit monitoring formulæ used for both production and investment decisions. These guide the firm in its gradient search for a rate of return in excess of the market loan rate.

---

[4] The M–M model in its applied version is designed for analyzing industrial growth. Therefore, the manufacturing sector (the growth engine) is the most detailed in the model. (Even though we have now understood that a much broader conceptualization of the "growth engine" is called for. See beginning of paper.) Manufacturing is divided into four industries (raw material processing, semi–manufactures, durable goods manufacturing, and the manufacture of consumer nondurables). Each industry consists of a number of firms, some of which are real (with data supplied mainly through an annual survey) and some of which are synthetic. Together, the synthetic firms in each industry make up the differences between the real firms and the industry totals in the national accounts. 225 firms inhabit the manufacturing sector, 154 of which are real firms, or divisions. The real firms cover 70–75 percent of industrial employment and production in the base year, currently 1982. The model is based on a quarterly time specification. For full technical detail see Eliasson (1985), Bergholm (1989) and the MOSES Code, IUI 1989.

Defining the rate of return

To derive the control function we begin by decomposing total costs (TC) of a business firm, over a one year planning horizon, into:

$$TC = wL + (r + \rho - \frac{\Delta p^k}{p^k})\, p^k \cdot \bar{K} \qquad (1)$$

w = wage cost per unit of L
L = units of labor input
r = interest rate
ρ = depreciation factor on $K = p^k \cdot \bar{K}$
p^k = capital goods price, market or cost
$\bar{K}$ = units of capital installed

In principle the various factors (L, $\bar{K}$) within a firm can be combined differently, and still achieve the same total output. Depending upon the nature of this allocation the firm experiences higher or lower capital and labor productivity, as defined and measured below. In what follows we investigate the capital labor mix as it is achieved through the dynamic market allocation of resources among firms.

The firm is selling a volume of products ($\bar{S} = S/p^X$) such that there is a surplus revenue, ε, over total costs, or profit:

$$\varepsilon = p^* \cdot \bar{S} - TC \qquad (2)$$

The profit per unit of capital R^N is the rate of return on capital in excess of the loan rate:

$$\bar{\varepsilon} = \frac{\varepsilon}{K} = R^N - r \qquad (3)$$

$$R^N = \frac{\varepsilon + r\bar{K}}{K} \qquad (3B)$$

In this formal presentation K has been valued at current reproduction costs, meaning that ε/K expresses a real excess return over the loan rate, but that r is a nominal interest rate.

In the M-M model firm owners and top management control the firm by applying targets on R^{EN}, the return on equity-capital. This is the same as to say that they apply profit targets in terms of ε. Thus, we have established a direct connection between the goal (target) structure of the firm and its operating characteristics in terms of its various cost items.

The Control Function of the firm

Using (1), (2), and (3) the fundamental control function of a MOSES firm can be derived as:

$$R^{EN} = M \cdot \alpha - \rho + \frac{\Delta p^k}{p^k} + \varepsilon \cdot \phi = R^N + \varepsilon \cdot \phi \quad (4)$$

$$M = 1 - \frac{w}{p^*} \cdot \frac{1}{\beta} \quad (5)$$

where:

M = the gross profit margin, i.e., value added less wage costs in percent of S
R^{EN} = $(p^*\bar{S}-TC)/E$ the nominal return to net worth ($E = K-debt$).
ρ = rate of economic depreciation
α = $\bar{S}/\bar{K}$
β = $\bar{S}/L$
ϕ = $Debt/E = K-E/E$
ε = $(R^N-r)K$

Management of the firm delegates responsibility over the operating departments through (4) and appropriate short-term targets on M (production control through (5) and long-term targets on ε ,which controls the investment decision.)

$\bar{\varepsilon} \cdot \phi$ defines the contribution to overall firm profit performance from the financing department.

A target on M means a labor productivity target on $\bar{S}/L$, conditional on a set of expectations on (w, p^x) in (4) determined through individual firm adaptive error learning functions (see below). Thus, the profit margin can be viewed as a price-weighted, "inverted" labor productivity measure.

Long–term objective function (investment selection)

The objective function guiding long-term investment behavior is to select investment projects that satisfy (ex ante):
$\varepsilon/K = R^N - r_i > 0$
where r is the local loan rate of the firm. The local loan rate depends on the firm's financial risk exposure, measured by its debt-equity position.

$$r_i = F(r, \varphi) \quad \frac{\partial F}{\partial \varphi} > 0 \qquad (6)$$

The $\bar{\varepsilon}$ of an individual firm is generated through innovative technical improvements at the firm level (Schumpeterian innovative rents) that constitute Wicksellian type capital market disequilibria defined at the micro level. The $\bar{\varepsilon}$ drives the rate of investment spending of the individual firm. The standard notion of a Wicksellian capital market equilibrium is that of "average" $\varepsilon = 0$ across the market[5]. As a rule this state is not achieved. Unused capacity may prevent the firm from expanding capacity even though investment long term is expected to yield $\varepsilon > 0$. More important, however, is the fact that realized investment comes much later than the current quarter and that firms continue to make mistakes.

2. How do firms upgrade their performance – Four kinds of boundedly rational behavior

I. Creation of knowledge (innovation and reorganization)

Innovative and reorganizational activities based on tacit, experience-based knowledge are exogenous. They include basic restructuring of the financial organization of the firm as described above. Also, major investment programs, particularly those into new areas, belong here. Costs are normally insignificant in comparison with the profit consequences of successful reorganization.

[5] The notion of the "efficient market" translated into MOSES is $\Sigma\varepsilon=0$ (over all firms at each period). This never occurs in the experimentally organized economy. We are, however, interested in knowing whether the MOSES economic process is such that the expected value of all Σ is zero, or $E(\Sigma\varepsilon) \neq 0$.

The dominant, "measured" intelligence gathering and interpretation activities of a manufacturing firm concern technical information processing creating new knowledge, mostly associated with product development. [This activity is driven by investment in R&D and shifts the technical specifications of the firm's production system). If this activity is not somehow explicitly accounted for, the firm is grossly misrepresented and – I claim – aggregate dynamics misspecified. Lack of data on (and lack of academic insight into) the nature of information use in business organizations thus far means that we have had to be crude in modeling innovative behavior.

II. Learning behavior in markets (coordination through boundedly rational expectations forming)

Self-coordination in markets is achieved through intelligence gathering and learning behavior. Firms interpret price signals (prices, wages, interests and profits) and transform them into expectations. These transformations include correction learning from past mistakes and attitudes toward risk. The self-coordinating properties of the entire economy depend significantly on the specification of these intelligence gathering and expectations functions.

There is, however, also the theoretical problem of whether the representation of the underlying fundamentals of the economy – the quantity structure – through prices can be seen as a stationary process that will allow rational agents to learn with the exception of random mistakes and eventually place themselves (and the economy) in a stable expectations equilibrium. As I write this I don't know.

III. Competitive selection (the filter)

The Salter (1966) curves of each market are constantly upgraded endogenously through competitive exit ("creative destruction") and entry. Only firms which have acquired superior performance characteristics through innovative creation of new knowledge (item I above), through learning in markets (item II) and through interior process efficiency (item IV below) survive in the long run.

IV. Learning about interior firm capacities

No firm management is fully informed about its own capacity to produce (see Eliasson 1976a). A boundedly rational search procedure that I call MIP targeting (MIP = Maintain or Improve Profits) is applied by top management to force upward improvements of interior firm performance.

The MIP targeting principle rests on three facts of life in all business organizations (Eliasson 1976a):

(1) The difficulty for top CHQ managers to set accurate targets for the interior of the organization, close to what is the maximum feasible.

(2) The importance for target credibility and enforcement that targets be set above what is conceived to be feasible, but not unreasonably high. A 'reasonable' standard is performance above that achieved in the recent past. 'It was possible then!'

(3) The general experience that a substantially higher macro performance of the firm can normally be obtained if a good reason for the extra effort needed can be presented ('crisis situation') or if a different, organizational solution is chosen ('other firms do it better!), if time to adjust is allowed for. The MIP targeting establishes an acceptable profit plan to constrain production planning.

MIP-targeting assumes that top management knows that the firm always operates somewhere below the feasible level of capacity. Past experience determines the level from which top management knows that an upward improvement in its profit rate can be achieved. The psychology of targeting is that top management knows that some improvements can be achieved. However, knowing that excessive, impossible targets are never taken seriously even if slack is quite large, it is ineffective to impose grossly infeasible targets. Hence, targeting is organized only to push for gradual improvements. Targeting, then, becomes a form of learning, or transferring knowledge of potential capacities within the firm organization. Top corporate management is probing for the limits of capacity, information that lower level management wants to conceal. If new technology is not being created, targeting will eventually push activity onto the feasibility (production) frontier (see QFR(L) in Figure II).

3. State description of production structure

Experimental search for improved positions goes on within the capacity structures of individual firms. The mathematical formulation of this structure, of the updating and of this search is presented briefly below.

Production capacity structure of firm (state description)

Production planning is carried out individually by each firm. Each firm chooses a preliminary, planned output and labor combination (Q, L). The capacity specification is simple (Figure II).The algorithm by which a (Q, L) plan is chosen is intricate. Figure III illustrates the principles.

Each firm faces a set of feasible (Q, L) combinations (a short-run production possibilities set) each quarter that are delimited by

$$QFR = QTOP*[1-\exp(-\gamma \cdot L)] \qquad (9)$$

This feasible set shown by the curve in both Figures II and III is determined by the firm's past investments as they are embodied in QTOP and γ. Investment between quarters pushes this set outward. To the set of feasible (Q, L) combinations of the firm

$\leq$ QFR or

$\leq$ QFR/L

corresponds a set of satisfactory (Q, L) combinations

$$\frac{Q}{L} \geq \frac{EXP(W)}{EXP(P)} \cdot \frac{1}{1-TARGM} \qquad (10)$$

A quarterly profit margin target (TARGM), defines the satisfying criterion. This target is calculated as defined above. The shaded area in Figure III defines the feasible and satisfactory production set.

Targeting is done on a yearly basis with quarterly adjustments, and profit margin targets adapting gradually as information on what is possible to achieve is accumulated.

As shown above (see (5)) a profit margin target (TARGM) can be derived from the rate of return target. Bad profit experience can make the firm lower its target in the short term. This will normally affect long-term development negatively; immediately through smaller cash flows and in the longer term through less investment and perhaps also less profitable investment, that keeps future cash flows low.

Difficulties in meeting short-term profit targets are met by exploiting various forms of slack within the company, in a way that can be called <u>learning or search for better solutions</u> (see below and Eliasson 1978a, pp. 68-73).

Expectations are of an adaptive error correction – learning type based on a standard smoothing formula. Risk considerations ('aversion') in expectations forming enter through a standardized variance measure in the expectations variable. If variance increases in product prices, firm management tends to underestimate future prices, and vice versa for wages. This makes profit target satisfaction tougher and forces (Q, L) closer to the frontier and possibly down left along it (contraction). The expectations side of the model is discussed in great detail in Eliasson (1978a, section 4.2, 1985, p. 154).

<u>Inventories</u>

Inventories exist as buffers on the input and the output sides of each firm. There are no strategic inventories built on price speculation. Each firm aims for a desired level of inventories, but always comes out ex post with too much or too little depending on how production plans come true.

Each production planning round – as mentioned – aims for restoring desired inventory levels.

Since firms dimension their production plans from sales plans, which are themselves trend projections out of the past, it may be worth observing how a turn-around in production from decline to growth occurs through inventory adjustments. A sequence of declining sales years would be followed by a sales projection continuing that trend. However, a market turn-around of course means that finished goods inventories will soon be depleted. The firm then adds – to each projected sales plan – what is needed to restore inventories. If the market improvement continues, the situation repeats itself until the opposite situation occurs.

Selecting the production plan

The firm now chooses a point within the shaded area of Figure III that is both feasible and satisfactory. This is done by specifying an initial set of (Q, L) points and the rules to adjust these points if they do not fall within the feasible and satisfactory lens area. Note that it is labor productivity that is adjusted.

This search for improved productivity is a learning process that is activated and intensified by difficulties of meeting profit targets. This is a well recognized phenomenon in the business world. Firms do not know their feasibility sets well even in the short term. Learning goes on all the time in a piecemeal fashion. This learning is speeded up when the profitability situation deteriorates. Under such circumstances internal resistance to change yields, and improvements often do not have to be associated with more than minor, additional expenditures (Eliasson 1976a).

Search is guided by a comparison of the productivity ratio to an equally scaled expected price ratio. The initial positioning of L and a corresponding expected sales volume establish an initial activity level of production. The search path into the shaded lens in Figure III may, however, lead onto B, and down along it, to a premature collapse of operations. This may be incompatible with rational behavior in the sense that the firm deliberately chooses to lower its expected profits to find a quarterly (Q/L) combination within the shaded area. This is prevented by a supplementary rule that stops further search whenever expected profits begin to decrease.

For each L, there is an interval of output plans that are (1) either both feasible and satisfactory in the lens in Figure III and/or (2) feasible but not satisfactory (Region B), or (3) neither feasible nor satisfactory (Region C).

Slack in the form of labor hoarding and unused machine capacity exists by way of the measurement technique we use to estimate QFR(L). It is a normal cyclical phenomenon. It occurs because ex ante plans can only rarely be made to match ex post realizations. Furthermore, even though technically the model firm competes with process efficiency, the firm we have in mind is a temporary monopoly based on product knowhow. Through the investment decision the long run QFR(L) tends to be located where long-run profitability targets are satisfied. Hence, long-run targets are satisfied when the firm operates on its QFR(L). In markets for technological product competition where we see MOSES firms operate one furthermore does not lower the price to achieve a short-term increase in volume. Customers do not change suppliers and product technology at short notice and producers do not compete with price, but rather by adding more quality, information or marketing to the product. So, prices are sticky in the short term, and price wars do not normally occur.

In addition, on the assumption of bounded rationality, firm management is aware only of the existence of slack, not the exact location of the boundary. It operates on the assumption that it is closely above the actual operating domain. As a consequence QFR(L) will function as a stopping rule in the production planning process. Work on improving productivity goes on all the time. It is, however, time consuming and rarely completed within a period. Target non-satisfaction may force it to speed up a bit, but improvements normally stop when production plans hit QFR(L). Where exactly to stop is, however, endogenized within each period depending upon which way search goes and over time when QFR(L) shifts because of investment. (The model even allows this maximum frontier capacity to be exceeded under exceptional (crisis) circumstances.)

The state of slack across firms – the vertical distance to QFR in Figure II – can be measured every year in the Planning Survey of the Federation of Swedish Industries which was designed on the format of the model. Each year some firms are operating at full capacity, but most are not. We also know roughly from empirical studies (see for instance Eliasson 1976a) how firms adjust their output plans in a stepwise fashion. Production search has been tailored to mimic such procedures within firms. When a model run is set up, the state of slack is assessed for the initial year in the initialization process (see Albrecht – Lindberg 1989). The state of slack is then monitored through the MIP-targeting and production planning procedure every quarter by every firm as the simulation goes on.

When a feasible and satisfactory (Q, L) point in Figure III is reached, the firm's preliminary plan is set at the minimum Q such that SAT(Q, L) holds. If SAT(Q, L) does not hold, and if the point is in region A, the firm adjusts by planning to lay off labor. If this does not help, the firm's preliminary plan is to set the minimum feasible Q and L.

Each firm now has a planned employment and output level. At the aggregate level, however, these plans may not be feasible. Firms must confront one another in the labor and product markets to sort out remaining inconsistencies.

4. The creation of new technology

A new investment vintage can be regarded as a "new firm" with exogenous capital productivity ($\alpha=\overline{S}/\overline{K}$) and labor productivity ($\beta=\overline{S}/L$) characteristics. A new investment can be seen as a new vintage of capital with these particular technology (α, β, ρ) characteristics in the profit control function (4) that mix with capital installations in existing firms. Technology is exogenous and embodied in new investment vintages. Hence, the international opportunity set (subset (1) introduced earlier) is represented by current (α, β, ρ) specifications of new investment vintages, while local competence is defined by the local investment process (and – of course – the short-term production decision) that upgrades the technical specifications (the "frontier") of the firm, under which quarterly production decisions are taken.

The productivity upgrading process can now be seen to take place in four steps (See Eliasson 1985a, pp. 329 f). Call current operating productivity of one unit of measurement, one firm (α, β), when operating on the QFR(L) frontier (α^*, β^*) and productivity associated with new investment (α^{**}, β^{**}).

We have $(\alpha^{**}, \beta^{**}) > (\alpha^*, \beta^*) > (\alpha, \beta)$.

(1) Actual, operating labor and capital productivities (α, β) are pushed by competition towards potential productivity (α^*, β^*) on the frontiers. Static operating efficiency of the economy improves.

(2) Potential productivity (α^*, β^*) of existing units is increased through more investment of higher productivity (INV of quality (α^{**}, β^{**}) > (α^*, β^*) raises → ($\Delta\alpha^*$, $\Delta\beta^*$) of existing units). Neoclassical efficiency improves.

(3) Reorganizations between existing firms raise (α^*, β^*) at higher levels of aggregation. Labor is reallocated towards the more efficient plants. Allocational efficiency improves.

(3B) Allow all three above changes to occur simultaneously. Dynamic allocational efficiency improves.

(4) Innovations create new type ($\Delta\alpha^{**}$, $\Delta\beta^{**}$) of productivity characteristics. Schumpeterian efficiency is achieved as these new investments enter the economy through the intermediation of entrepreneurs, and competes old technology out of business (creative destruction) thus upgrading the Salter structures of the economy.

It is difficult to distinguish between efficiency categories (2), (3) and (4) in principle, since the categorization depends on the definition of the unit of measurement. In practice, and in modeling they sort themselves out nicely once we have defined the unit of measurement.

Fix investment, close down new entry, stop innovative improvements of best practice techniques, and increase competition in the MOSES model. Firms tend to operate closer to the QFR(L) frontier and type (1) efficiency improves. Productivity improvements are rather small and if competition is too fast macro intstabilities develop (Eliasson 1984a).

Stop exogenous ($\Delta\alpha^{**}$, $\Delta\beta^{**}$) = (0,0) upgrading of new investment, hold the market competitive regime constant, and allow investment to vary endogenously. Type (2) efficiency will improve.

Change both competitive regime and (α^{**}, β^{**}) characteristics of new investment and reorganizations between existing units (relative size, exit) and type (3) allocational efficiency will improve. Carlsson (1987) has demonstated through individually varying market regime and technology characteristics that the economic allocation mechanisms are far more important for macro productivity advance than improvement in best practice technology. This confirms earlier results on the model that the introduction and diffusion of new technology take a long time to affect macroeconomic performance, and especially so if allocation mechanisms of the market (the market regime) are inefficiently organized (Eliasson 1979, 1980, 1982, 1983). [Internal reorganizational improvements within a unit of measurement by definition come under type (4)]. If no investment is allowed (all capital installations being given) and if no initial slack of type (1) is allowed, type (3) allocational efficiency will be identical to comparing two statically efficient allocations within a general equilibrium model, each corresponding to a different given set of relative prices.

All four types of efficiency improvements occur simultaneously in the MOSES model. The classical model can only account for type (1) and (possibly) type (2) productivity improvements. Sector models with investment endogenized [e.g. the Cambridge Growth model, and the IUI ISAC model (Ysander 1986)] allow for aggregate improvements in neoclassical productivity. To sort out the relative importance of different productivity improvements requires a careful design of model experiments. One design problem relates to the endogeneity of prices in the MOSES model, which the classical model has no problem with. One cannot (in MOSES) and should not be able to compare quantity trajectories generated from different ("fixed") relative price developments.[6]

However, type (1) productivity improvements could be measured by simply taking the aggregate difference at one point in time between Q on QFL, vertically above existing L, and actual aggregate Q (see Figure II). Hold total labor input in each firm and technical change constant and study the consequences of a proportional increase in investment. Type (2) improvements in productivity occur. Stop investment and technical change and set the model going. Type (3) allocational efficiency improves.

With all factors at work simultaneously type (3B) or <u>dynamic</u> allocational efficiency occurs.

The interesting things, however, occur when competitive regime is changed, when exit and entry are allowed, and when improved technology enters through the investment decision. Then type (4) Schumpeterian efficiency improves.

---

[6] There is one exception. The model has been designed to allow the interest rate to be varied, ceteris paribus, being imposed exogenously. Then, of course, the expected neoclassical model properties emerge (Eliasson 1984, Figure 5b). Personally I expect the real world to exhibit a much more diverse pattern than this figure shows, for instance long periods with, and perhaps a long-term "perverse" relationship between the interest rate and economic growth, as long as the interest rate stays below the capacity of frontier industries to generate profits. A particular example is the postwar low interest rate period, which to my mind, and to the mind of the MOSES model, reduced long-term economic growth (Eliasson – Lindberg 1981).

The difficulties arise when one tries to explain the creation of new (α^{**}, β^{**}) at the level of the unit of measurement. This requires that we model the creation of new technology through entrepreneurial search in the opportunity set.

The simplest way of doing this is to model R&D investment and define stochastic pay-offs, possibly from a differentiated risk approach (imitative or innovative technological regimes. See Winter (1984), who does this.)

Alternatively, and much more ambitiously, one can introduce priors about the content of the opportunity set and model search (information) technology in approaching the set, very much as some industrial policy authorities and R&D managers in large firms believe it can be done.

The problem is that the MOSES model does not recognize firm technology characteristics, except by broad product and market identification. So at this level we are back in practice to the Nelson–Winter (1982) Winter (1986) R&D modeling specification.

The investment decision

We have presented the short-term quarterly production planning sequence of the micro-to-macro economy as it occurs within a given production feasibility frontier. The investment decision deals with the choice of future production frontiers. Technology enters in the long-term capacity augmentation phase (shifting of the production frontier).

New techniques are embodied in new investments and affect the MOSES economy in five ways:

(1) – through the exogenous technical performance characteristics of a unit of new investment (called MTEC). MTEC measures labor productivity (β),

(2) – through the amount invested (endogenous),

(3) – through the allocation of new investment over firms,

(4) – through the rate of utilization of installed investment (UTREF endogenous); and finally

(5) – through price competition from abroad (DPFOR), which is exogenous.

The investment function is driven by the ex ante $\bar{\varepsilon}$ factor of the individual firm, i.e. the rate of return expected to be earned over the going interest rate;

$$INV = F(EXP(\bar{\varepsilon}), UTREF) \tag{11}$$

This specification simplifies the investment decision considerably. The firm aims for a certain INV, conditioned by expected $\bar{\varepsilon}$ and the rate of capacity utilization. It gears up the capital budget accordingly. Actual investment, however, is also determined by the actual ex post cash flow, and the actual $\bar{\varepsilon}$.

5. Institutional change

Strategic behavior

There are two principally different types of micro-macro models. In the first kind agents form expectations about all other agents as a group, or attempt to see through all intricate interactions of the micro-macro machinery to aim for a perceived equilibrium. The MOSES system is mostly of this kind.

The second kind of model involves strategic behavior, each agent attempting to foresee and counter the strategies of competing firms. Strategic behavior involves withholding information, becoming a free rider, or showing moral hazard behavior. If agents learn that strategic behavior is occurring and that it cannot be dealt with as random noise, they take defensive strategic action against the strategic action of others. Behavior of this kind may be self-defeating, non-optimal.

Strategic behavior of firms generally increases the probability of mistakes, and new inconsistencies arise in individual plans.

Strategic behavior enters through profits targeting and expectations forming, and the model allows deviations from the standard procedure of reading market price and wage signals, and projecting aggregate local market growth to set targets on ones own performance. (See Eliasson 1985). The firm can in fact tag its targets or expectations on any set of signals coming out of the MOSES economy. Thus, for instance, profit targets can be set as profit performance of the best competitor, and wage and price expectations can be derived from information from the highest paying firm, and the lowest price recorded in the market. Firms can also be tailored to read off certain aggregated signals provided e.g. by "consultants" in the market. If these aggregate signals are designed to be "biased" in various ways the macroeconomic effects of inconsistent information processing can be studied.

It is an empirical question how (and how much of) such strategic behavior, or how much of misinformation that should be allowed into the economy.

The entry and exit filter

Firms close down when they are persistently unable to meet rate of return targets and/or when net worth is exhausted.

New firms enter the market in response to the best opportunities in the market represented by some measure of $F(\bar{\varepsilon})$. $F(\bar{\varepsilon})$ determines the number of new entrants per quarter. The size and performance characteristics of each new entrant is a drawing from a distribution of these characteristics. In general (Granstrand 1986), the average new entrant is not better, only smaller, than the average incumbent firm.

Initiating a firm with known performance characteristics

Technically the entry of a new firm requires the specification of some performance characteristics and its mode of entry (initialization). I will explain it briefly below.

We begin with equations (4) and (5) that characterize the "state" of performance characteristics of the firm at one point in time completely, once a scale (size) factor has been added.

The entering firm is assumed to be 100 percent equity financed, i.e. $\phi = 0$ in (4). All prices (P^k, P^x, w, r) are given in the market from the moment of entry. We assume that the firm obtains all the people it needs from the pool of unemployed in the first quarter at the average wage in the market. The owners of the entering firm may have misconceived the price situation, but they will learn immediately.

Hence, the vector of performance characteristics:
(size, α^*, β^*, γ, ρ)
is sufficient to define the firm and its control function can be written:

$$G = M \cdot \alpha^* - \rho + \frac{\Delta p^k}{p^k} + \bar{\varepsilon} \cdot \phi \qquad (12)$$

$$M = 1 - \frac{w}{P} \cdot \frac{1}{\beta^*}$$

Thus, the rate of entry in the market depends on the market

$$\bar{\varepsilon} = R^N - r$$

and its control function is (cf. (4) and (5)):

$$G = M \cdot \alpha^* - \rho$$

$$M = 1 - \frac{w}{P} \cdot \frac{1}{\beta^*}$$

The entering firm has no debt and expects no inflation

$$R^{EN} = M \cdot \alpha - \rho = R^N \qquad (13)$$

Since G now becomes
$G = R^N$
the assumption for entry is that

Expected $(R^N - r) \geq 0$
or sufficiently positive to warrant entry.

Technically again, entry can be seen as an investment vintage of each firm (defining its size) that is allowed to operate freely in the market, rather than mix with existing capital installations of another firm. To get the firm initialized and production started, this entering investment vintage has only to employ people. We assume that the firm hires people <u>the initial quarter</u> from the pool of unemployed such that all are effectively employed in production (no labor hoarding. A21 = 0). From there on the firm operates as any other firm.

α^* defines potential capital productivity in value terms[7] of entering firm, operating with employed labor on the frontier [S/K, see (4)].

β^* defines potential labor productivity of entering firm [$\bar{S}$/L ; see (5)]

γ measures the slope of QFR(L) for a firm of size QTOP (see Figure II).

$$\partial QFR(L)/\partial L = QTOP \cdot \gamma \cdot \exp(-\gamma \cdot L) \rightarrow QTOP \cdot \gamma;$$

when $L \rightarrow 0$

ρ measures the rate of depreciation of K.

For entry to function, and for all other state variables of the firm to be consistently initialized we have to make the size specification consistent with the performance vector.

$\frac{\partial QFR(L)}{\partial L}$ measures the labor productivity of a new, marginal addition of capital, or the labor productivity of a new vintage of capital = β^*.

Hence $\beta^* = QTOP \cdot \gamma$

$$\gamma = \frac{\beta^*}{QTOP}$$

β^* is exogenously specified for each vintage of new investment. QTOP is one of the needed size variables (see Figure II). The other size variable is the size of the labor force (= L) that the firm wants to employ.

---

[7] Note the terminological inconsistency. α in (4) is really = $P \cdot \bar{S}/P^x \cdot \bar{K}$ while β in (5) is $\bar{S}/L$.

Within (β^*, QTOP) of the entering firm, given QFR(L), can be estimated.
With L given, entry Q can be estimated.
With (β^*, ρ) the parameters of the control function are given.

Hence, the (minimum) specification (QTOP, L, α^*, β^*, ρ) is sufficient to identify a new, entering firm and set it in motion in the MOSES economy.

Sampling the performance characteristics of the entering firm

While the investing firm decides on the size of investment and buys the best practice equipment in the market the performance characteristics of the entering firm have to conform with the average of what we (think we) know about entering firms. These averages are the constraining facts of the situation and are entered as prior (assumed) distributions of performance characteristics:

(QTOP, L, α^*, β^*, ρ).

We know the first moments (averages) of these distributions, except for size which is completely specified.

In choosing the other parameters, the owners/entrepreneurs of the entering firm exercise business judgment and selective competence. The choice may be more or less risky, a circumstance entered a priori through selecting the second moment of the distribution. On this score we correctly assume (as does Winter 1986) new entrants to be highly risk-willing, selecting from distributions of (α, β) with a low likelihood of an extreme outcome. This is in contrast to the investment decisions in firms which exhibit a high likelihood of picking the average outcome (currently they always pick the average (α, β) characteristics).[8]

---

[8] The reader should note that the entry specification of the MOSES model is not yet tested. The entry experiments carried out so far (Eliasson 1978, p. 52 ff. and Hanson 1986) have been designed in a much more rough and ready fashion, by simply adding prepared firms by hand. Allowing firms to enter according to a general entry function similar to the one specified above in fact very soon overloaded the existing computer workspace. For the time being mainframe computers do not seem to allow the large number of firms needed for full scale entry experiments on a normal research budget.

Each new entrant so determined immediately establishes himself or herself as a competitor employing people from the pool of unemployed at the going wage rate up to A21 = 0 (i.e. at point B, on the frontier in Figure II).

From that point on, each new entrant behaves as a normal firm.

Exit (Schumpeterian creative destruction)

Firms exit when they constantly fail to meet profit targets, declaring their assets to be of nil value and laying off all labor. Laid-off labor is then available for work through the pool of unemployed. Firms also close down when net worth is exhausted.

7. Productivity change through organizational change – endogenous aggregation to macro through markets

Productivity change appears as changes in the organizational (structural) code of the model, embodying in turn the information technology of the economy. Even though there are technical (natural law-based) capacities in the economic system that allows a productivity performance way above current standards, the economy is always operating well below that potential, and also way below what is potentially possible today if best-practice equipment and competence were diffused throughout the economy. Information and social adjustment costs prevent the economy from operating on "its" best-practice trajectory (Eliasson 1979, 1980, 1982), and innovations keeps the potential ahead of applications.

7.1 Profits and productivity

Very simply expressed, the micro-macro model economy consists first (1) of a set of potential and actual Salter (1966) curves making up the state description of its capacity and competence structure. Second (2) each agent is characterized by its (local competence) learning, targeting and realization behavior. Behavior and the state description of all agents together define the economy's short-term state space (opportunity set (I)). Third (3) each agent is characterized by its ability to accumulate capacity and competence in the right market to earn a return on its capital, through investment and selection, all being controlled by the short-term market realization process. The Salter curves keep changing through the ongoing process of technological competition, through exit and entry, through investment, bringing in new best-practice methods, through innovation, improving best-practice methods and through efficient, short-term market performance, reducing slack, and the difference between actual and potential Salter distributions. The efficiency of competition, furthermore, is dependent on the state of new best-practice technology, the slope of the Salter curves and other factors characterizing the speed of market processes. It is thus obvious that economic factors, and the "technical" factors embodied in the Salter curves, cannot be meaningfully kept separate.

The aggregate outcome of this capacity and competence updating is the more widely defined opportunity set (II).

Since MOSES firm behavior is experimental, but would include optimizing behavior, if the critical assumptions of the experimental model were modified back to the classical model (narrowed down state space, no behavior, no access) the experimental market process may, or may not make the model converge back onto some balanced steady state, that could be called an equilibrium growth path.

This section includes a brief mathematical presentation in which macro productivity growth is related to the structural and behavioral characteristics of the agents of the economy. We will carry on the mathematics as if the model economy is on a steady state equilibrium growth path. To do it dynamically we have to simulate the model (next section).

7.2. Interior productivity performance

Corporate Headquarter and division heads interact through principal-agent contracts formulated in terms of ε. Division heads are pressed to deliver as large a surplus (after "agency costs"; Jensen–Meckling 1976, 1979) ε as possible.

Operations are controlled from division head level through targets on measures on M.

CHQ can influence division contributions of ε through the capital allocation process (see item 4 in table I) and through selecting the right division competence. Division management can influence its ε contribution through α and $\bar{S}/L$ via the investment decision and through operations control. α as well as M can be defined pairwise down to product group levels.

Using the taxonomy of the cost accounts we can now aggregate upwards to a goal formulation of the entire corporation, a description of the organization (functions) and an allocation of responsibilities.

Observe, however, that this aggregation – as in the classical general equilibrium model – assumes prices to be given (exogenous).

I will now relate the two profit variables M and R on the one hand to productivity measures (labor productivity and total factor productivity respectively) on the other. ε will be interpreted as a quasi rent, or a compensation for risktaking and entrepreneurial competence contributions. This means that a capital market equilibrium with all $\varepsilon = 0$ is a not feasible steady state, except when all other markets are in equilibrium, i.e. all factor inputs (except risk) have been properly accounted for at their marginal contributions and (obviously) no tacit knowledge exists.

7.3. Profit margins and labor productivity

We already demonstrated in (5) that M is a price weighted labor productivity measure. Since the willingness of the division head and the management to pay higher wages depends on how labor productivity measures up to rate of return targets we would expect the pairs (w/P^*, $\bar{S}/L$) to increase reasonably parallel over time so as to stabilize the contributions of ε to CHQ.

Combining (1) and (3) we obtain:

$$\frac{\varepsilon}{K} = M \cdot \alpha - \left(r + \rho - \frac{\Delta p^K}{p^K}\right) \qquad (14)$$

where

$$M = 1 - \frac{w}{p^*} \cdot \frac{1}{\bar{S}/L} - \frac{p^I}{p^*} \cdot \frac{1}{\bar{S}/I} \qquad (15)$$

$\bar{S}/L$ is a proxy for firm labor productivity
$\bar{S}/I$ is a factor (I) use coefficient.
This formula can be generalized to many other and input categories:

$$M = 1 - \sum_j \frac{w_i}{p^*} \cdot \frac{1}{\bar{S}/L_j} - \sum_j \frac{p_i}{p^*} \cdot \frac{1}{\bar{S}/I_j} \qquad (16)$$

Apparently we now have the beginning of the formula for growth accounting used by Denison (1967) and many others. The whole problem is to what extent included factors are properly priced (Jorgenson–Griliches 1967) or whether additional factors (like tacit knowledge) have been accounted for.

For example, the profit margin can be high because of higher labor productivity (high $\bar{S}/L$) or low wages (w) or missing cost items. Costs for capital inputs obviously is one such missing item.

The production processing of a division, given capacity utilization and prices, can now be described as a bundle of factor use coefficients (productivity coefficients). When these coefficients are weighted together with the relative price of this factor we obtain the profit margin M, which in a sense is a real profit variable.

If you dig sufficiently deep into the accounts of a firm each factor use coefficient can be given a well defined operational content. The cost accounts of the firm also describe what is going on at a level of very fine detail. It is nevertheless important to understand, that however fine the detail, the taxonomy corresponds to a given technology. The finer the detail, the larger the number of combinations (process solutions) within that technology that can be captured with the measurement system. If sufficiently fine there should always be – at given relative prices – a different combination that yields a higher aggregate productivity and, hence, a higher margin. The opportunity set (see section 4) is large. Furthermore, each shift in relative prices means that a new combination will give higher aggregate margins. The MOSES model generates such allocations between firms and exhibits the outcome at the macro level.

Choices of new allocations of factors, change the coefficients of the productivity measures. These coefficients define the "technological" memory of the economy.

Normally such recombinations within a given technology are associated with investment and new risks. But we can report on a number of reorganizations that have yielded higher productivity at no or minor investment spending (the so called Horndal effect, or embodied technological change, see Lundberg 1961, Arrow 1962a, Solow 1957, 1962, Eliasson 1980).

Finally, the above recombinatorial activities take place within a given technology. If technology changes, the taxonomy has to change, new items have to be included etc.

As mentioned productivity improvements can be achieved all the time at low investment and low direct costs. New solutions arise spontaneously. At the company level we can see three different sources of such improvements:

- spontaneous technical improvements (knowledge)
- investment
- reorganization within a division (i.e. within Σ).

As long as we can define an output volume S uniquely, we can also – through the cost accounts – identify and quantify productivity changes in firms on the three categories.[9]

To model these possibilities <u>within a division/firm</u> is beyond reach because of sheer complexity, even when technology is fixed. There is a nice example from one of the plants of a large Swedish corporation (Eliasson 1976a). A young operations analyst had been assigned the task of identifying bottle necks in the plant – a simple task compared to the above. The plant people were positive and curious and supplied all the data he wanted. After a year or so he was ready to run the program and came up with X bottle necks to remove (organizational improvements). The plant people responded graciously, and said they had been working on them, and Y more bottlenecks for a year or so. Figure IV shows how productivity adjustments within a Swedish multinational corporation has adjusted profit margins, given international prices and national wages such that rates of return become virtually the same across subsidiaries each year. This is exactly what MIP-targeting achieves between firms in the MOSES model.

The Swedish micro-macro model allows the macro consequences of such reorganizations between the minimum units of measurement (divisions) to be studied. The conclusion has been (Eliasson 1980) that even without entry and new techniques, such reorganizations explain a large part of labor productivity change. If capital inputs are accounted for (Carlsson 1981) and entry is allowed in the analysis the recombinatorial productivity effects between firms can be generated to the total factor productivity level, and the importance of organizational technology becomes even greater.

---

[9] E.g. the capacity of a printer to print so and so many lines per minute (Eliasson 1980, pp. 258 ff) or the capacity of a nuclear power plant to generate kWh in Jagrén (1983).

3. The rate of return and total factor productivity change

Formula (5) demonstrated that the operating profit margin really was a price adjusted productivity measure, accounting for all factor inputs except capital. The margin M is then expressed in terms of gross sales value S. If all factors except labor are removed and M is related to value added, labor productivity is the corresponding productivity measure.

The corresponding relationship between the rate of return, incorporating all factors of production and total factor productivity growth is more complicated. Total factor productivity (TFP) is defined as:

$$\text{TFP} = \text{Q/deflated TC} \tag{17}$$

Q is value added deflated by some suitable price index P^Q. Similarly TC is deflated by some suitable factor price index. TFP is often interpreted as a 'technical' factor contributing to productivity growth.

$$\text{DTFP} = \frac{\Delta\text{TFP}}{\text{TFP}} \tag{17B}$$

is by definition the shift factor in the production function. This technical interpretation is, however, much too narrow. Indeed, as shown by Carlsson (1981) <u>at least</u> half of DTFP can be explained as organizational change between the level of aggregate production and the division level, meaning that if this organizational change had not 'been allowed' to occur, there would have been no corresponding productivity growth, regardless of the rate of technological progression.

At some change in relative prices Q and deflated TC develop parallel over time, everything else the same. DTFP hence = 0. We can show that the definition of price indexes (P^*, ξ) matter for the rate of DTFP. We have to consider not only a practical but also a conceptual problem, that will be seen to take us all the way down to the axiomatic roots of welfare analysis. What are the value and volume of output?

At the more well defined production level a relation between DTFP and R^{EN} of the firm can, however, be derived. This done, we have established through the information system of the firm a <u>link between the profitability objective</u>

of the firm, its cost control system (via cost accounts and budgets), technical progress in the form of DTFP and growth in output (= DQ). This goal, control and measurement system described in Eliasson (1976, 1984, 1989) is categorized according to the ways business people think and measure. This formula makes it possible also to derive a direct link between on the one hand business objectives (profits) and on the other traditional macro policy objectives (growth in output). Obviously the nature of this link will tell the efficiency of the "invisible self-coordination" order of dynamic markets (the invisible hand). Under what circumstances do the maximization of long-term rates of return also maximize growth in output.

Let us define the exact relation between the distribution of value added and productivity change.

4. Efficiency and distribution

Call deflated TC = X. Then

$$DTFP = DQ - DX \tag{18}$$

According to (1), however,

$$TC = \xi X = wL + (r + \rho - \frac{\Delta p^K}{p^K})\, p^K \cdot \bar{K} \tag{19}$$

ξ is the implicit factor price deflator, i.e.

$$DTFP = \frac{\Delta Q}{Q} - (v_1 \frac{\Delta L}{L} + v_2 \frac{\Delta \bar{K}}{\bar{K}}) \tag{20}$$

where:

$$\sum^{2} v_i = 1 \text{ and}$$

$$v_1 = \frac{wL}{\xi X}$$

$$v_2 = \frac{(r + \rho - \Delta p^K/p^K) p^K \bar{K}}{\xi \cdot X}$$

Only two factors (L, $\bar{K}$) have been assumed for simplicity.

Growth in output can now be expressed as:

$$DQ = s_1 \cdot DL + s_2 D\bar{K} + s_3 D\varepsilon \qquad (21)$$

where:

$$\sum^{3} s_i = 1$$
$$s_1 = wL/p^Q Q$$
$$s_2 = \frac{(r + \rho - \Delta p^K/p^K)p^K \cdot \bar{K}}{p^Q \cdot Q}$$
$$s_3 = \varepsilon/p^Q Q$$

(v_i) and (s_i) are weights in the price index (ξ, p^Q) by which total costs in (X) and value added are deflated. ϵ is now expressed in constant prices, or in prices of a certain base year. Hence, DQ really means $D(p^Q_{base} \cdot Q)$. This year does not necessarily have to be the base year of the deflators (ξ, p^Q).

Also note that (s_i) defines the distributive shares of the factors or production:

s_1 = wages share determined in the labor market

s_2 = the share attributed to "risk free" contributions of capital

s_3 = the share attributed to unmeasured contributions of risk and organizational competence.

We can now say that the efficiency of the production system rests on the ability to raise the contributions of risktaking and organizational competence and the relationship between this contribution and their compensation in terms of distributive shares (s_3) – the incentive system.
Define the effective rate of return as:

$$R^{EFF} = \frac{\Delta SH}{SH} - \frac{\Delta P}{P} + \frac{DIV}{SH} \qquad (22)$$

SH; market value of the stock
P; is an appropriate deflator of SH.

Define the difference between R^{EFF} and R^{EN} deflated in (VI.5) as either the risk premium (classical model) or as the compensation for both risk and competence contributions not accounted for:

$$R^{EFF} - R^{EN} + \frac{\Delta P}{P} = \frac{\Delta SH}{SH} - \frac{\Delta E}{E} + \theta\left(\frac{SH-E}{SH}\right) \quad (23)$$

The efficient market does not guarantee that the expected value of the difference is zero. The difference includes perceptions of the future and contributions of competence, that could exhibit systematic, non-random behavior. However, the classical model does not recognize tacit knowledge, and hence competence, not accounted for. Furthermore, the difference as such, according to the efficient market hypothesis, should exercise an influence on real behavior. Hence, the question is whether – in the absence of tacit knowledge – the difference should not have an interpretable positive value, signifying the state of risk in the market.

5. Distributive shares and factor productivity growth

Note that

$$s_1 = v_1 \cdot \frac{\xi \cdot X}{p^Q Q}$$

$$s_2 = v_2 \cdot \frac{\xi \cdot X}{p^Q Q}$$

It follows that:

$$DTFP = \frac{\Delta Q}{Q} - \frac{\Delta X}{X} = \left[(1 - \frac{p^Q Q}{\xi X})\right] \frac{\Delta Q}{Q} + s_3 \cdot \frac{p^Q Q}{\xi X} \cdot \frac{\Delta \varepsilon}{\varepsilon}$$

This can also be written:

$$DTFP = \frac{\Delta Q}{Q} - TFP \cdot \frac{p^Q}{\xi} (s_3 \cdot \frac{\Delta \varepsilon}{\varepsilon} - \frac{\Delta Q}{Q})$$

With no change in ϵ, $\varepsilon \neq 0$, we obtain:

$$DTFP = (1 - \frac{p^Q Q}{\xi X}) \cdot DQ$$

or proportionality between DTFP and growth in output as long as relative prices (p^Q/ξ) are changed and the factor input/output ratio (Q/X) does not change. It follows

$$DTFP = \frac{\Delta Q}{Q} - TFP \cdot \frac{p^Q}{\zeta} (s_3 \cdot \frac{\Delta \varepsilon}{\varepsilon} - \frac{\Delta Q}{Q})$$

What does this mean? What happens when $\varepsilon = 0$ or $\rightarrow 0$? How does this formula demonstrate Carlsson's (1987) results that the allocation is more important for DTFP than the development of best-practice technology? See further Eliasson (1985, p. 157).

8. Economic systems properties

The dynamics of learning and competing that leads to the updating of the upper left hand section of the Salter curves and the creative destruction of its lower right hand tail is the essence of the growth machinery of the MOSES model. The intensity of the competitive process (access to the opportunity set and behavior) determines the macro productivity properties of the entire economy.

We first study long-term growth and productivity performance of the model under stable market conditions, when quantity change does not disrupt the price system unduly and vice versa. We then investigate technical change under more or less rapid market regimes to see under what circumstances long-term, very rapid and stable macroeconomic growth can be achieved. This will all be a verbal summary of a large number of published studies. We conclude with several quantitative illustrations of the micro dynamics of variously designed macro growth processes.

8.1 Close to steady state growth experiments – the business cycle

To understand the relationship between technical change, productivity growth and growth in output three distinctions have to be made.

First, technical change occurs and is introduced gradually. There is a delay before it affects productivity growth. A classical way of illustrating this is through measuring production at best-practice technology and compare with the productivity distributions of installed capacity (Salter curves).

Second, aggregate productivity is not helped if you have best-practice technology installed in the wrong markets or production lines. The allocation of investment affects macro variables..

Third, productivity per se is not the right goal variable to be concerned with. Firms are not and economic advisors should not. As we have demonstrated long-term economic growth is more adequately related to profitability, and the ability to maintain a high rate of return and a high growth rate for long periods. The rate of return is in turn – as we have shown – a price weighted productivity measure.

First of all the diffusion of best-practice technology ("learning") depends on economic factors and is asymmetric and usually slow (Eliasson 1980).

Increases in best-practice technology (DMTEC, DINVEFF) take a long time to show up as productivity advance. Intensive market competition speeds up the process somewhat. In Eliasson (1987) a domestic market protected from foreign price competition and a regime with price elastic foreign trade is compared, holding best-practice technology constant. The specialization effect on the macro economy from price elastic output competition is slow to come but very strong in the long run. If exogenous best-practice technology is decreasing in productivity (we impose that unusual situation) the negative effects in productivity are much faster to come, everything else the same (Eliasson 1981, p. 86).

If firms overinvest in high productivity production techniques in the wrong markets a negative correlation between advance in best practice techniques and aggregate productivity growth may occur. As Carlsson (1987) shows the allocation of investment normally means much more for macro productivity advance than the increase in best-practice technology (the shifts of production frontiers).

Third and most important; output growth is the interesting objective variable, not productivity growth. You want to allocate your resources to areas where they produce maximum value to end uses, as they show up in relative product prices. This means that from a welfare point of view it may be optimal to see growth occur in typical low productivity service production rather than in high productivity manufacturing.

Under normal circumstances (orderly pricing in markets) the macro economy shows standard neoclassical behavior. Increases in interest rates (Eliasson 1984, p. 27) reduce long-term growth rates monotonically. When market speeds have been calibrated such that the economy behaves well (the reference case) a typical busines cycle is exhibited around the growth trend (see Figures V).[10]

[10] The coefficients have been calibrated such that the model tracks historic macroeconomic variables. See Eliasson (1985, chapter VIII).

8.2 Structural diversity and stability of economic growth – the growth cycle

The MOSES model is strongly non-linear and market prices are easily perturbed by sudden quantity adjustments sending off trails of more or less dramatic price quantity interactions in the economy. The size of quantity shocks and the speed of markets are decisive. This means that the model exhibits as a typical property phases of seemingly unpredictable behavior ("chaos"). Individual business mistakes is a normal micro property and can be seen – in a macro context – as a normal cost of economic growth. Under disorderly market conditions, however, such mistakes can result in dramatic macro behavior.

If you attempt to remove mistakes by forcing markets to perform more efficiently in a static sense, through speeding up market transactions, you can – for long periods – increase productivity growth through eliminating slack and mistakes (Eliasson 1983, 1984). However, the closer to a steady state characterization of the economy you get the more potentially unstable the system. Wages become the same across the market; productivity rates are the same (the Salter curves become flat), and rates of return are becoming equal across the markets. When all (ε) $\rightarrow$ 0 diversity of structure disappears and small adjustments at the micro level tend to roam over broad flat surfaces with no natural stopping places. In a dynamic model diversity of structure corresponds to the convexity assumption in the static model. Once the extremely rapid macroeconomic growth rate achieved through fast market processes get slightly upset a growing instability of the adjustment process, and possibly collapse can be observed (Eliasson 1978, 1983, 1985, p. 292). [11]

This macroeconomic behavior has been numerically simulated (Eliasson 1978, p. 105 ff, 1983, 1984) and a half baked theoretical analysis is found in Eliasson (1985). The collapse means a temporary – a couple of decades – close down of parts of the economy, diversity of structure is restored and when the price system has eventually been stabilized to reflect the new quantity structures of the system, macroeconomic growth is gradually resumed. In a historic perspective the long-term growth of this bumpy market regime appears to be inferior to a more constrained ("slower") market regime. Economic growth may in fact never really come back for very, very long. On the other hand if

[11] Such instabilities correspond to corner solutions in the classical model.

market competition is very much reduced, eventually the allocation machinery will be so inefficient that long-term economic growth virtually vanishes. There is an optimal intermediate growth path corresponding to an orderly experimental market process (Eliasson 1983).

With macro productivity and output growth mainly generated by economic forces, under the constraint of an upper technological best-practice limit, it becomes interesting to understand the dynamics of resource allocation that positions the economy somewhere underneath this maximum growth path. As I have presented it in the introduction I view this as efficiency characteristics of the innovating, coordinating and educational (new knowledge diffusion) processes of the economy, or in short improving the technology of economic information processing.

In a first round of experiments (reported extensively elsewhere; Eliasson 1983, 1984), the state of technology – available best-practice productivity technology – was held constant. A series of simulation experiments varying the "market regime" characteristics only were run. I found that the speed of adjustment to price signals was far more important for productivity performance than the parallel development of best-practice technology, since the economy was always operating far below best-practice capacity, as long as price signals were reliable predictors of long-term future prices.

This (latter) was the case as long as a sufficient adjustment slack was maintained, to smooth the adjustment process. If speed of allocation was increased the economy operated as a car on a narrow road; as long as it stayed on the road arrival time got closer and closer, but the margin for errors decreased. So also with the economy, flow performance increased until all of a sudden a small disturbance tipped the entire economy. Once this had happened the price system was in complete disorder, price signals misguiding output and investment decisions causing further disorder. A period of some 10 to 20 years was needed to stabilize the price system, and in the meantime productivity and growth performance were down.

The robustness of the model economy has increased as the database has been improved, meaning a more detailed specification of the structure of the economy (cf. Eliasson 1978b, 1983, 1984). Still, however, the absence of an entry feature has meant that concentration tendencies have eventually taken over, reducing diversity of structures.

8.3 Competitive entry and exit

The above mentioned simulation studies illustrated the macroeconomic productivity consequences of more or less intense market competition, with to a few, big firms. Eventually diversity disappeared and the system collapsed.

Earlier (Eliasson 1978, p. 52ff) simulation experiments have confirmed that competitive entry controls the concentration process, changing the exercising of monopoly pricing power. We find that competitive entry reduces inflation and increase growth in output expanded.

In new, more systematic experiments carried out by Ken Hanson (1986) the results of which are partially published, the above results from enhanced competition through market entry are confirmed. The main reason for these experiments, however, were to test for the importance of competitive entry in maintaining structural diversity to stabilize rapid economic growth.

New competitive entry was specified according to the empirical information available. Entering firms are not more productive on the average than incumbent firms, However, entering firms show a significant spread of performance characteristics, possibly a larger spread than of incumbent firms, as illustrated by the Salter curves in Figure VI.B (see Granstrand 1986). The rate of new entry was assumed to depend on ε.

Even so, with enough competition in the market, firms entering on misconceived perceptions of the competitive situation were rapidly competed out of the market (exit).

The hypothesized results were confirmed, new competitive entry tended to stabilize the macroeconomic growth path, smoothing "bumps" in the matching growth path with no entry. Growth in both production and output was increased (Figures VII.A,B).

Most important, however, the key explanation to increased macroeconomic performance was the maintenance of structural diversity. Figure VIII shows how the flattening of the Salter distributions at the end of a 30 year run in the no-entry case, has been halted by entry. Furthermore, if a separate Salter distribution for the remaining firms from the initial state 30 year earlier is computed it is extremely flat, showing that the initial Salter tail firms have exited, and the remaining firms have been forced to increase their productivity. The new entrants more or less account for the innovative, upper left part of the productivity distribution.

8.4 Price instability, price reliability and efficiency

Efficiency of market coordination largely rests on the reliability of market price and quantity signals as predictors of future prices and quantities.

Destabilized (relative) prices, prices that are systematically pegged differently from what a free market would set (regulation), or price wedges due to taxes and subsidies distort allocation mechanisms and cause a deterioration in productivity performance.

A particularly interesting case is to study the systems responses to the price shock that occurs when a regulated price structure is removed and replaced by a free price adjustment. A case in point is the adjustment disorder that the once planned Chinese and Russian economies are currently experiencing when being opened up to free market competition. Similar, but more gradual experiences occur when barriers to trade are removed and a common price system is imposed on a wider area through competition. (Also cf. Eliasson 1978b).

Removing the constraint of regulated prices would be expected to generate a long-term improvement in allocative and process performance of the economy. However, during the intense period of adjustment when price and cost structures are trying to find an equilibrium alignment, macro productivity might very well deteriorate. We have found (through simulation experiments) that this adjustment period is very long, that performance comes down on average, but not very much, but that quantity development is very unstable during the adjustment period. This instability is a parallel to the deficiencies in structural diversity discussed in the previous section.

The macroeconomic effects of three different kinds of price distortions have been analyzed on the model; (1) tax wedges in the investment allocation process (Eliasson–Lindberg 1981), (2) industrial subsidies (Carlsson 1983a,b, Carlsson– Bergholm–Lindberg 1981) and (3) price overshooting, notably wage overshooting (Eliasson 1977a, 1978b,c, 1983a, Eliasson–Lindberg 1987).

These experiments fall into two categories, one where price distortions are permanent, and one where they are temporary and endogenously self-correcting.

Price overshooting is a temporary price distortion. A seemingly paradoxical result from model experiments is that the faster price adjustments in markets, the more prone to price overshooting the economy and the longer it takes for prices – often a disturbance – to return to normal, cost aligned (equilibrium) rates. The reason is that once the quantities of the model has been affected by "erroneous" price signals, then the entire price and quantity adjustment structure of the economy gets disorderly, and there are no "rational expectations" algorithms that allow the economic machinery to become dynamically transparent fast. In fact, once significantly disturbed by the cost crisis in the 70s the model economy took more than a decade to get the price system back in order. At the time we "learned that" this was not part of current economic wisdom. Since economists at large expressed disbelief, we were very cautious in expressing the results (Eliasson 1978b,c). The long adjustment period has been confirmed by empirical analyses on similarly structured price data (Genberg 1983).

The price adjustment of the Swedish economy was significantly aggravated by the industrial subsidies of the mid-70s, inserting temporary price wedges, especially on the wage setting mechanisms, but also in the mechanisms controlling the allocation of investment. Several different policy scenarios, the actual subsidization scheme being one, were reenacted on the model. The worst outcome in terms of long-term production growth and employment was – as expected – the actual subsidization scheme. The next best scheme would have been to lower wage taxes across the firm population, the total tax reduction being equal to total subsidies. There would have been a local, intermediate and traumatic unemployment experience when crisis firms were shut down, but most unemployed were reemployed in other firms after three to four years. The precision of the model is illustrated by the fact that crisis firms survived until "today" (the time of the experiment) on more or less exactly the "subsidy handout". With 10 percent less all subsidized firms were closed before "today". The best macro outcome came when subsidies where reallocated in favor of high profitability firms, signifying that high profits today increase the probability of a high rate of return tomorrow. Allocating subsidies in favor of firms with fast export growth did not increase macroeconomic growth as much, indicating that rapid export growth is not necessarily a good predictor of future high rates of return and productivity growth.

We thought of an additional scenario, implementing the phasing out of crisis firms more slowly, to smooth the local unemployment situation, but still very much faster than what actually occurred. We thought that some intermediate rate of phase out would be optimal, with a minimum of price disturbances, but were unable, at the time to design the appropriate experiment.

Finally, the allocative effects of the plow back features of the Swedish corporate income tax system were tested on the model. The intention was to evaluate the negative effects on internal rate of return targets and investment allocation of the corporate income "tax wedge". Results were as expected. The tax stimulated retained earnings (as against dividends) in firms where profits had been generated. As long as relative (product) prices did not change, this policy was clearly growth stimulating, since a high rate of return today was a signal of future high rates of return. The slow pivoting of relative prices against basic industries compared to an alternative scenario with unchanged relative prices, turned out a slow deterioration in growth from relative price change, and the more so the higher the tax wedge.

This effect became dramatic when we reenacted the cost crisis years of the 70s. As a result of high corporate income taxes basic industries entered the second half of the 70s with new, modern production capacity to face a catastrophic market slump. In retrospect, the best scenario would of course have been to have the resources invested elsewhere. A strong revaluation of the currency or even a floating rate, would probably have helped eliminate some of the temporary inflation profits in basic industries 1973/74. However, as we learned from the experiments, from an economic point of view it was alright to invest in the wrong markets – the actual investment was a minor cost to the economy. The large macroeconomic effects came from carrying out production in the new factories, taking labor away from the labor market and significantly increasing the general wage level (Eliasson–Lindberg 1981). This detrimental effect on economic growth from price wedges that raises the general wage level has been reconfirmed in the experiments. In fact we have found (Eliasson–Lindberg 1987) that the high real interest rate, partly propped up by the Swedish exchange controls (Oxelheim 1988) lowers investment and raises profit margin targets in firms. The latter means that wage inflation and wage overshooting tendencies are checked. The negative investment effect is minor, since the allocation of investments is improved by the high interest rate.

8.5 Is big bad or good?

Economies of scale is a classical problem in economics. The classical static model is phrased in terms of atomistic competition. In "applications" like computable equilibrium models the size of firms are normally concealed through aggregation, or controlled through convenient assumptions, as in contestable market theory, to overcome the problem, that the static general equilibrium model cannot cope with economies of scale or scope.

Scale introduces the firm as a market imperfection or as a (temporary) monopoly. In MOSES scale effects originate in superior organizing competence (Eliasson 1988d). Competition (among the few) through learning and upgrading of competence, checks excessive monopoly profits and concentration endogenously.

Size and concentration is the classical problem in industrial organization theory. Facing severe problems of lagging industrial competitiveness a discussion of whether big is good or bad has been carried on in the U.S. One argument is that "oversized" firms have become sloppying because of past successes, and the protection of accumulated financial wealth.

This issue cannot be resolved within the framework of the micro-macro model. The model, however, features a competitive market process, that checks concentration tendencies, that are not matched by superior competitive performance.

Model firms exist as market imperfections on the basis of their ability to maintain scale advantages and superior profit performance. Scale advantages in turn arise out of their ability to create new competence (innovation) or through rapidly imitating new technology created elsewhere. This is the essence of technological competition and economic growth. Such a model specification requires an explicit market process that checks (bounds) concentration endogenously.

With no new entry and exit I naturally found a steady concentration of output to a smaller and smaller number of firms, even though this process turned out to be very slow. (See Figures IX and X.) Concentration was checked by competition which in turn depends on the spread of productivities of the Salter curves, the high end producers exerting price pressure to the detriment of the tail of the Salter curves. However, in the end the initially superior producers tended to take over. New entry prevented the flattening of Salter distributions, though increasing entry in markets where monopoly profits were earned.

Empirical evidence and analytical results, however, still pose questions.

Economies of scale can be demonstrated to exhibit superior process performance in existing lines of business, but large firms tend to be less efficient innovators, even though the definition of innovative performance remains to be operationally defined (see Eliasson 1989).

Conventional wisdom would suggest, that allowing scale ("bigness") to take over through forcing low end producers to exit would enhance medium–term process efficiency , but reduce the long-term creation of innovative, new best practice production techniques.

The static antitrust position would be to prevent large scale operators from becoming monopolists. Increased competition by a larger number of firms would increase efficiency and lower prices, through reducing short-term slack in the economy. This might, however, reduce profits to the extent that innovative activity ceases. (If innovative activity is restricted to mean the entry of new firms, responding to the favorable rate of return conditions in some markets, the importance for innovative activity of rents from innovations can be studied within the model (see below).)

The balancing of short-term efficiency and incentives for innovation has been a theoretic and empirical concern in economics for decades. The problem is that the classical model is completely silent on this issue, since it can only pronounce extreme results.

The third position would be to build a theory in which markets can be organized such that this balancing occurs endogenously. I have just illustrated that my micro–macro model does just that, even though some of the efficiency characteristics of firms are exogenous. The most important one is innovative efficiency within existing firms. The classical, theoretical position is to follow the old Schumpeter (1942) and formulate innovation as a routine process in production function terms. Then organizational technology does not matter. You may even find (assume) economies of scale in innovative activity. Such assumptions are clearly wrong (Eliasson 1988d). The Arrow (1962) welfare results depend entirely on this kind of assumption, implying that R&D activity in Government sponsored laboratories outside their business environment are as efficient as innovative activity in the firms.

The empirical evidence is rather pointing in the direction of small scale. New technology is making small scale profitable where huge scale once dominated (e.g. in steel production). The general tendency (Carlsson 1988) among industrial countries – except Sweden – is a lowering of average firm and establishment size. We find that some large and very successful firms, engaged in volume production, shop around in the market for small innovative firms, that have come up with something new in the product range of the large firm. The reason is that the large firm is organized for efficient large scale value production, not as an efficient innovator.

We also find that small units, with high knowledge intensive production, usually engaged in service production tend to separate off from the big firms (Eliasson 1986). This is one reason for the rapid growth of the business service sector. The increase in capital market efficiency, furthermore, has forced divestiture of a number of large and not well managed firms, illustrating the point made earlier, that organizational change really should be treated as endogenous and market determined. None of this, except entry and exit of given units, is explicit in the model. Hence size distributions of firms (in normal experiments) feature remaining firms at each stage. What we can see there (Figures IX and X.B) is that concentration tendencies are very slow – due to competition – and really of no consequence in the perspective of a decade or two. The very large firms may even experience distress and shrink in size. The position in the size ranking is by no means stable (Figure X.B shows firms ranked as in 1988 for each consecutive year).

8.6 Is productivity growth the desired macro performance variable?

This whole intellectual exercise has – so far – been conditioned by the standard mode of thinking in economics; price taking agents, and a stable preference structure of society being reflected in exogenously given prices. This becomes very wrong in the experimentally organized economy which introduces economic processes in the form of (inter alia) price and quantity setting agents and endogenous institutional change (inter alia through exit and entry) to paraphrase Åkerman (1950). Thereby the whole foundation of classical welfare economics is removed. We have to come up with something new to have anything to say on policy. This problem is not at all easy. I am working on it but am not going to solve it today.

There are, however, a few remarks that should be made in the context of productivity analysis. Under the price taking assumption productivity growth tends to be proportional to the rate of return. For labor productivity this can immediately be seen from (5). For total factor productivity growth the same relationship becomes more tricky and not always true (see section 7.6).

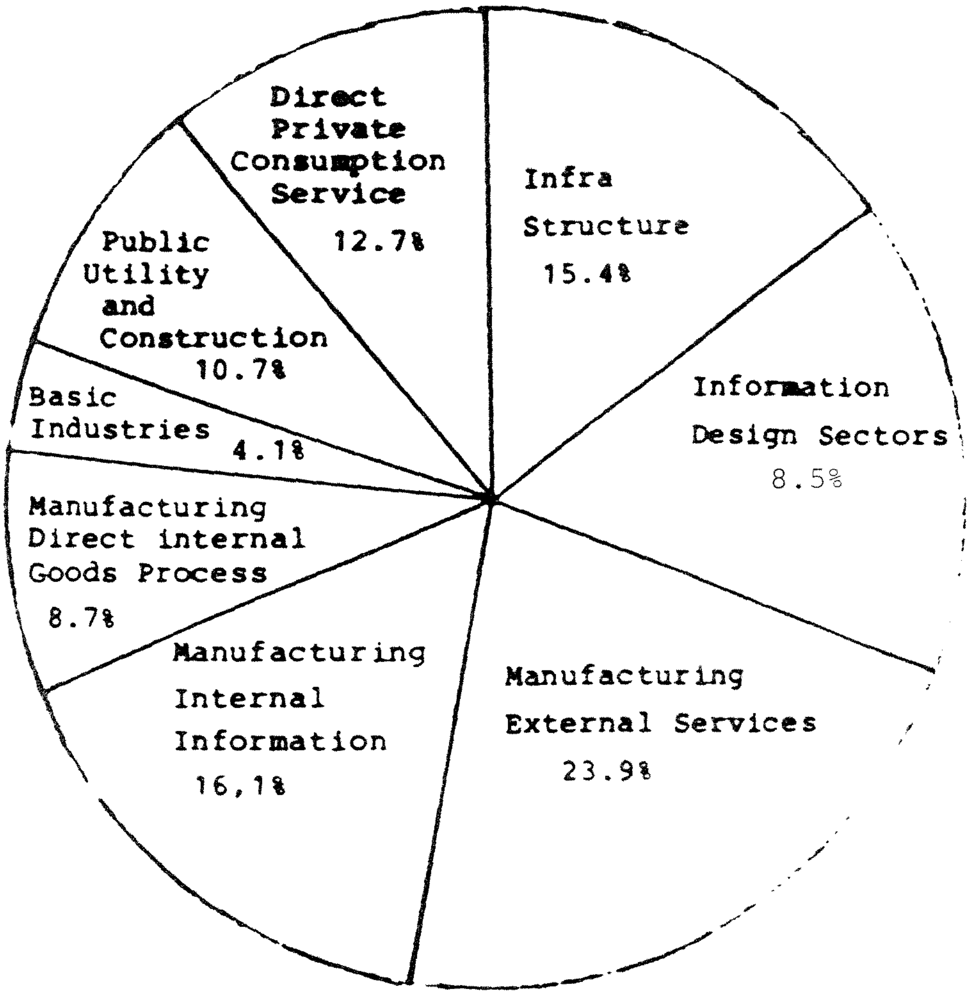
Generally speaking, rates of return are price weighted productivity measures. If preferences of society have been costlessly and perfectly transformed into optimal resource allocations through perfect markets we would expect maximum productivity to obtain.

The trouble is the compensation for innovators and entrepreneurs and industrialist owners, as reflected in excess return in markets, the ε in (14). If competition is so intense as to remove ε the macro economy is destabilized for reasons explained in the previous section, and total productivity tends to disappear, as we have just shown. However, this result is achieved on the assumption of given prices.

If relative prices, on the other hand, change endogenously through the market process two disturbing things occur. We cannot say much about the welfare consequences of economic growth and productivity change becomes partly dependent on the change in relative prices.

This observation carries directly over to the question of whether more productivity growth is a good thing. Subsidies in the 70s increased the allocation of resources into the crisis industries (shipyards, standard steel etc.). By the standard measure this meant raising productivity, for a long period, since productivity growth in these, hardpressed firms was exceptional for a while. On the other hand, reallocation from low profitability into high profitability, low productivity sectors; e.g., from hardware capital intensive engineering into service industries would have lowered productivity growth by the standard measure.

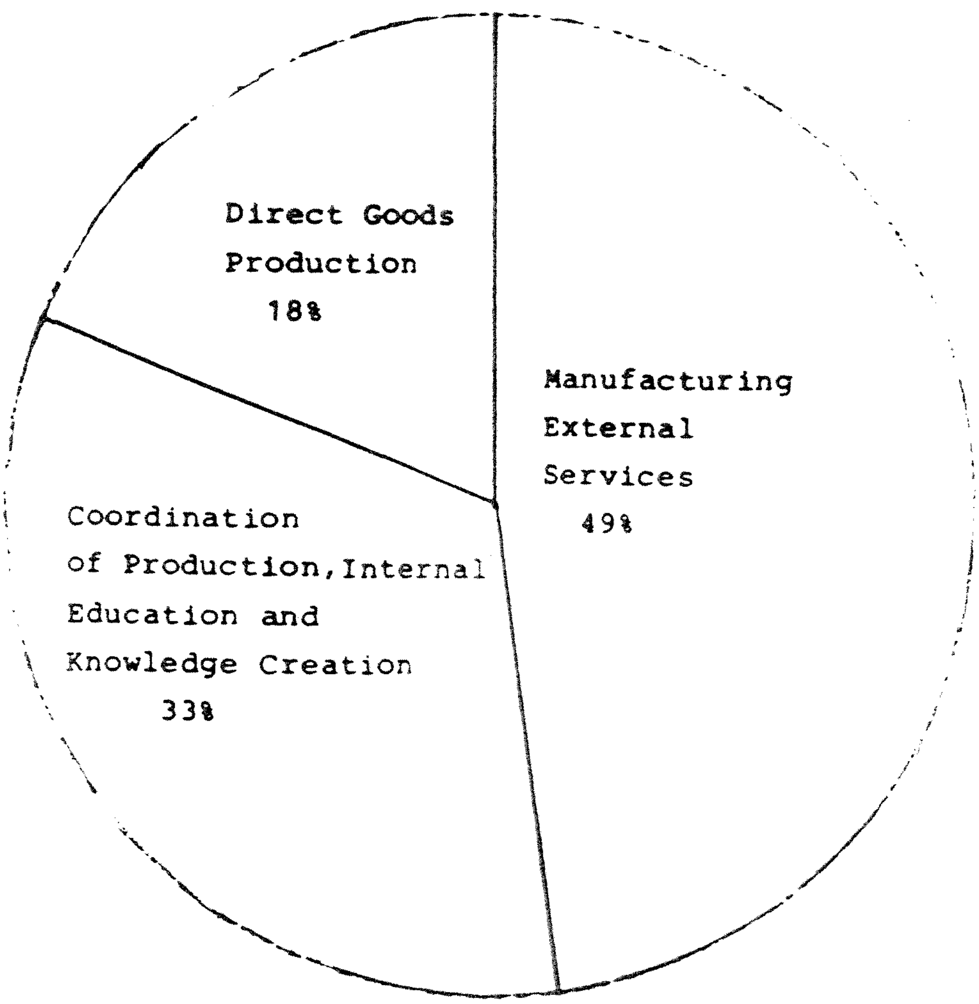
Figure I.1 The information economy
– GNP components
– Percent



Total: is GNP

Source: Eliasson (1989a)

Figure I.2 **The industrial engine**
– Manufacturing and related service production
GNP components

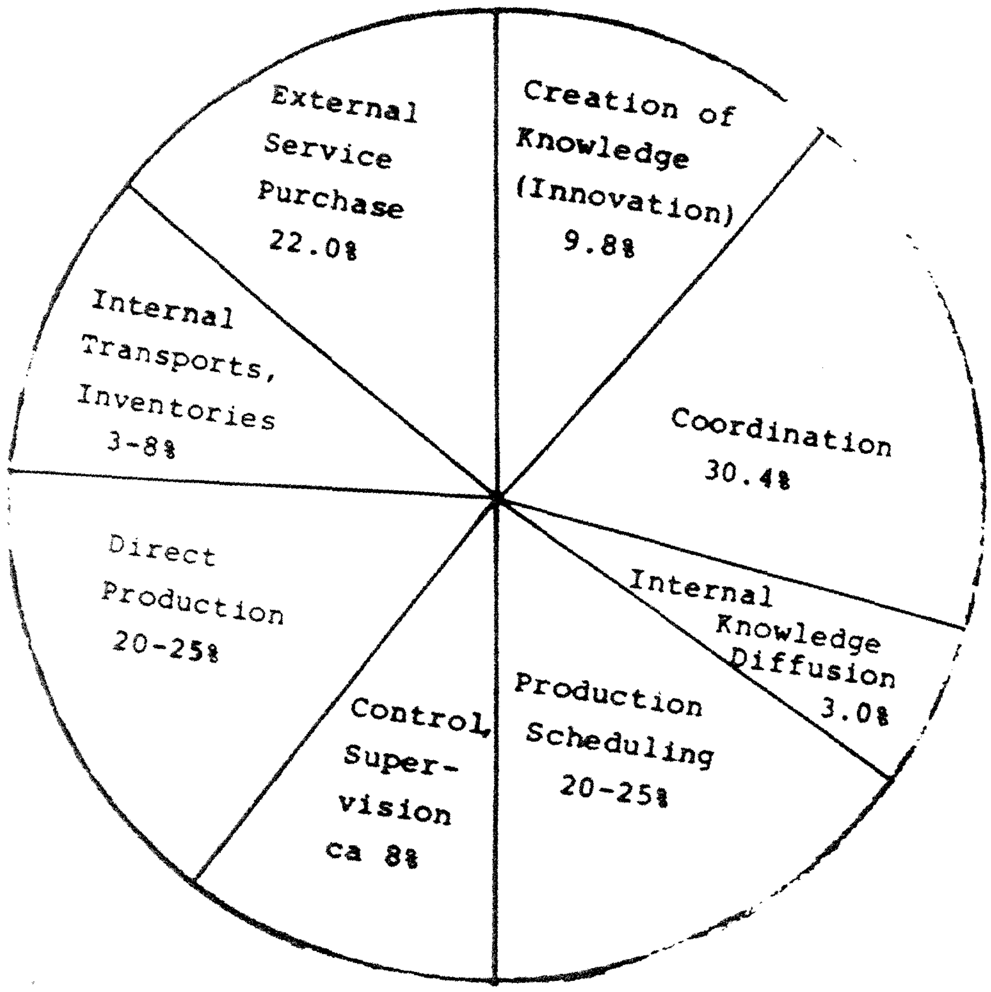


Total: is Manufacturing (1) direct goods process,
(2) internal information process, and (3) related external services in Table I.1

Source: Eliasson (1989a).

Figure I.3 Distribution of labor costs

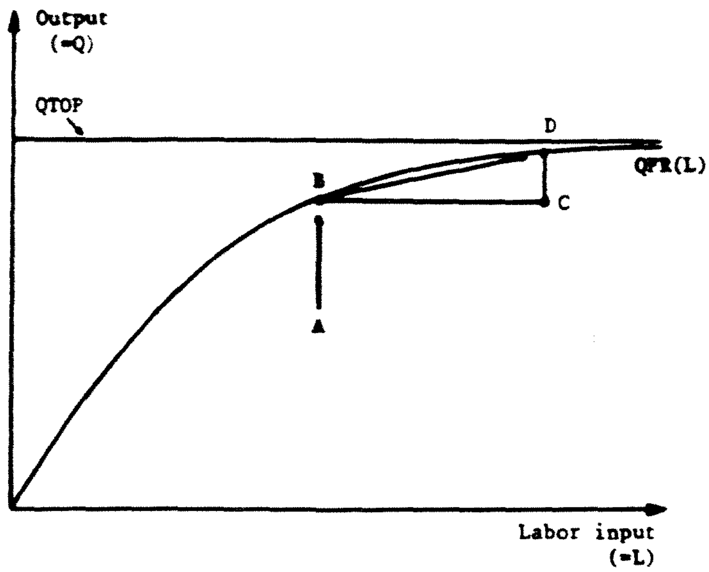
– Large Swedish firms
– Global operations
– Percent



Goods processing: 56.7 %
Total: 122 %

Source: Eliasson (1989a).

FIGURE II PRODUCTION SYSTEM (ONE FIRM)



The function describing the production system of one firm at one point in time is QFR = QTOP · $(1-e^{-\gamma L})$. How this function is estimated and how it shifts in time in response to investment is described in Eliasson (1976b, Ch. 4) and in Albrecht (1978).

FIGURE III MIP-PRINCIPLE AND PROFIT TARGETING (ONE FIRM)

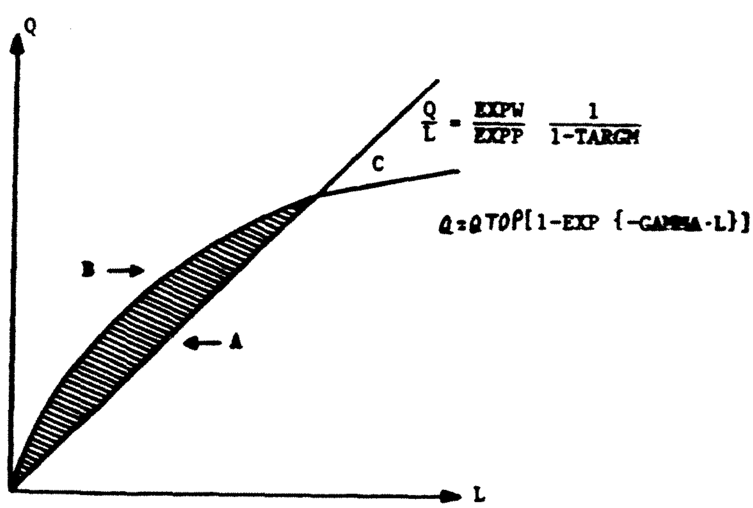
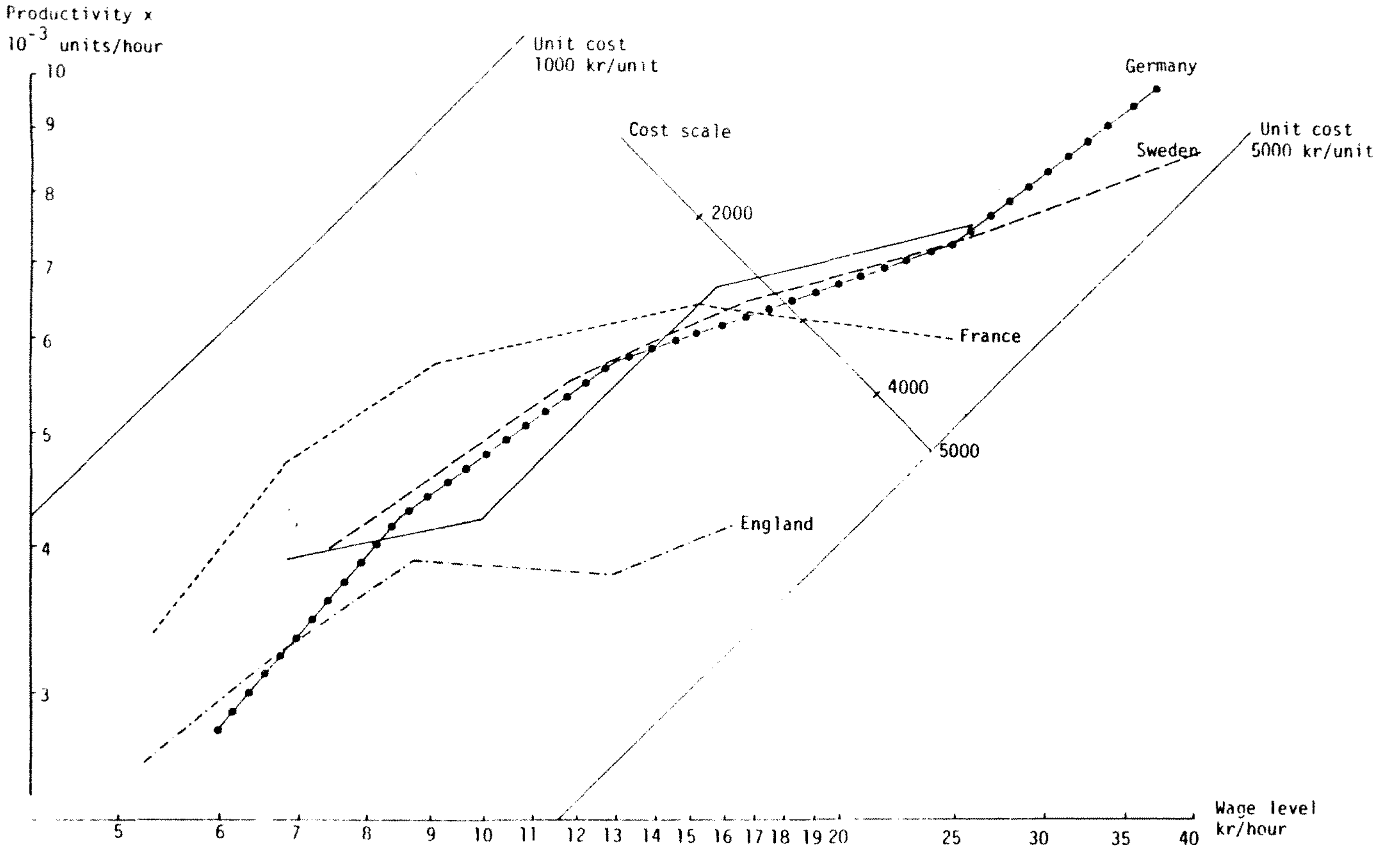


Figure IV.A **Relation between productivity, wage level and unit labor cost in five subsidiaries of a large Swedish multinational, in five european countries 1962–77**

Double logarithmic scale



Note: The Figure should be read as follows:

Labor value productivity is shown on the vertical axis and the wage per unit of labor input on the horizontal axis. Each curve of the surface represents the data for a country for that year. Obviously productivity (β) and wages (ω) are strongly correlated, demonstrating that wages in the different subsidiaries are set such that profit margins are more or less equal. The price level being the same [see (5)]. If capital output ratios are equal this means that also the returns to capital are fairly equal in each country.

Source: Grufman, A, 1982, Relative Competitiveness of Foreign Subsidiary Operations of a Multinational Company 1962–77, IUI Working Paper No. 69, 1982.

Figure IV.B Change in productivity, 1969-81

Percent

A. Labor productivity in the production of a particular part which remains identical over time

A - Labor Productivity in the Production of a Particular Part which Remains Identical Over Time

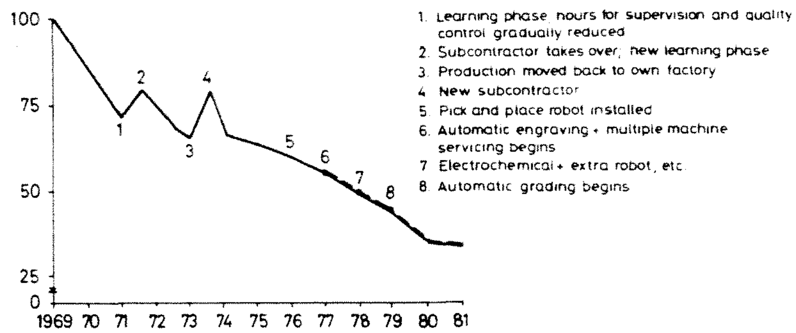
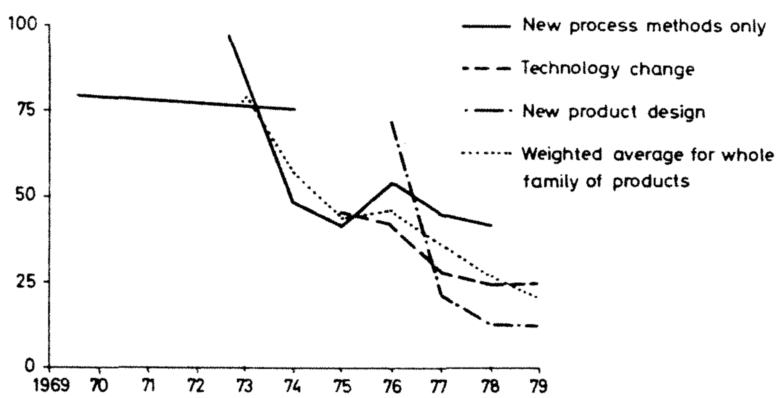


Figure IV.C Total factor productivity for a family of sophisticated engineering products



Note: The figures show the use of factor inputs (labor hours in A and a weighted index of all factors in B) per unit of output.

Source: P. 64 in Eliasson, G., Technological Competition and Trade in the Experimentally Organized Economy, IUI Research Report No. 32, Stockholm, 1987.

Figure V.A Annual change in manufacturing labor productivity and rate of return over interest rate

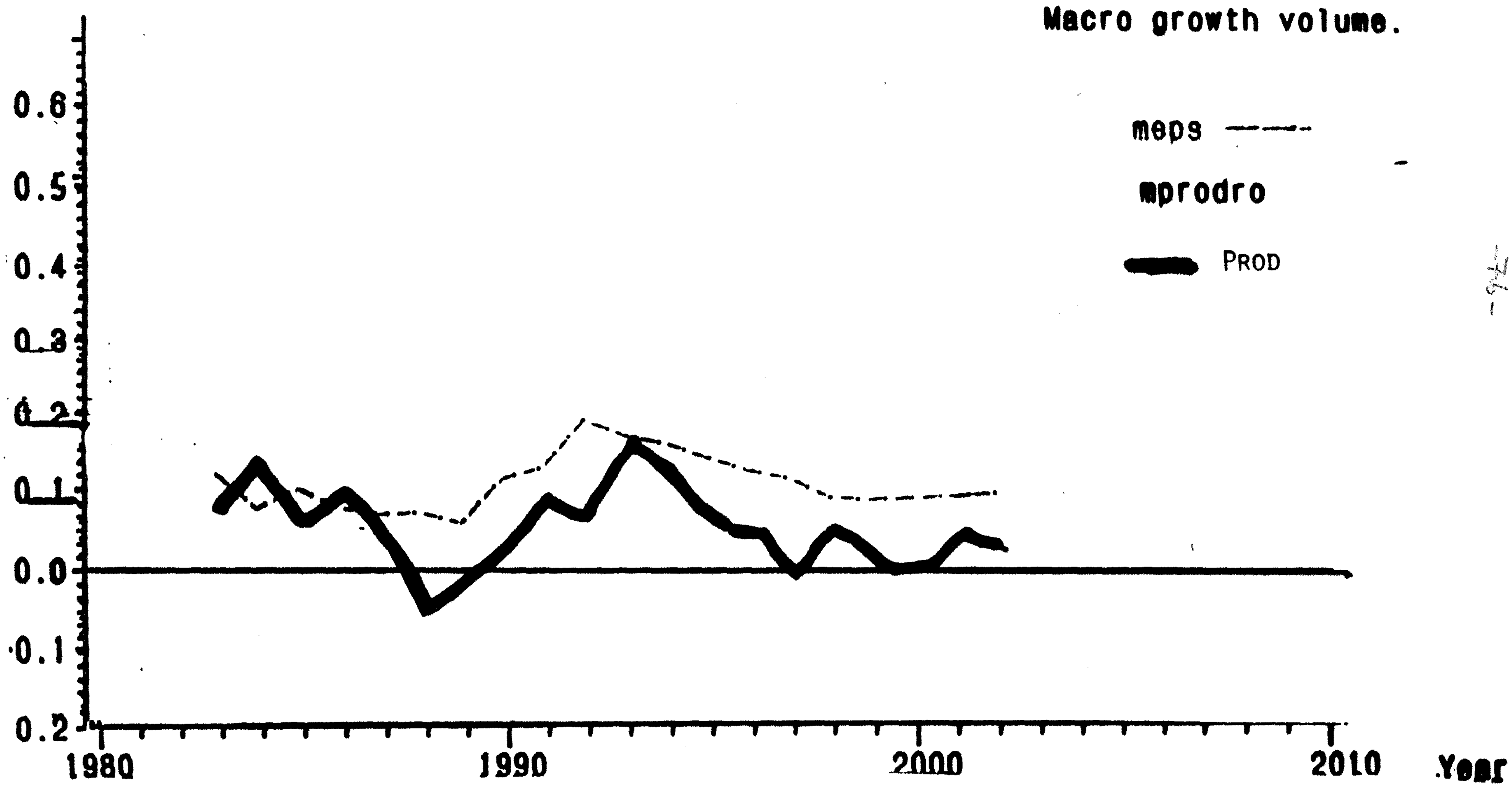


Figure V.B Labor hoarding and change in labor productivity

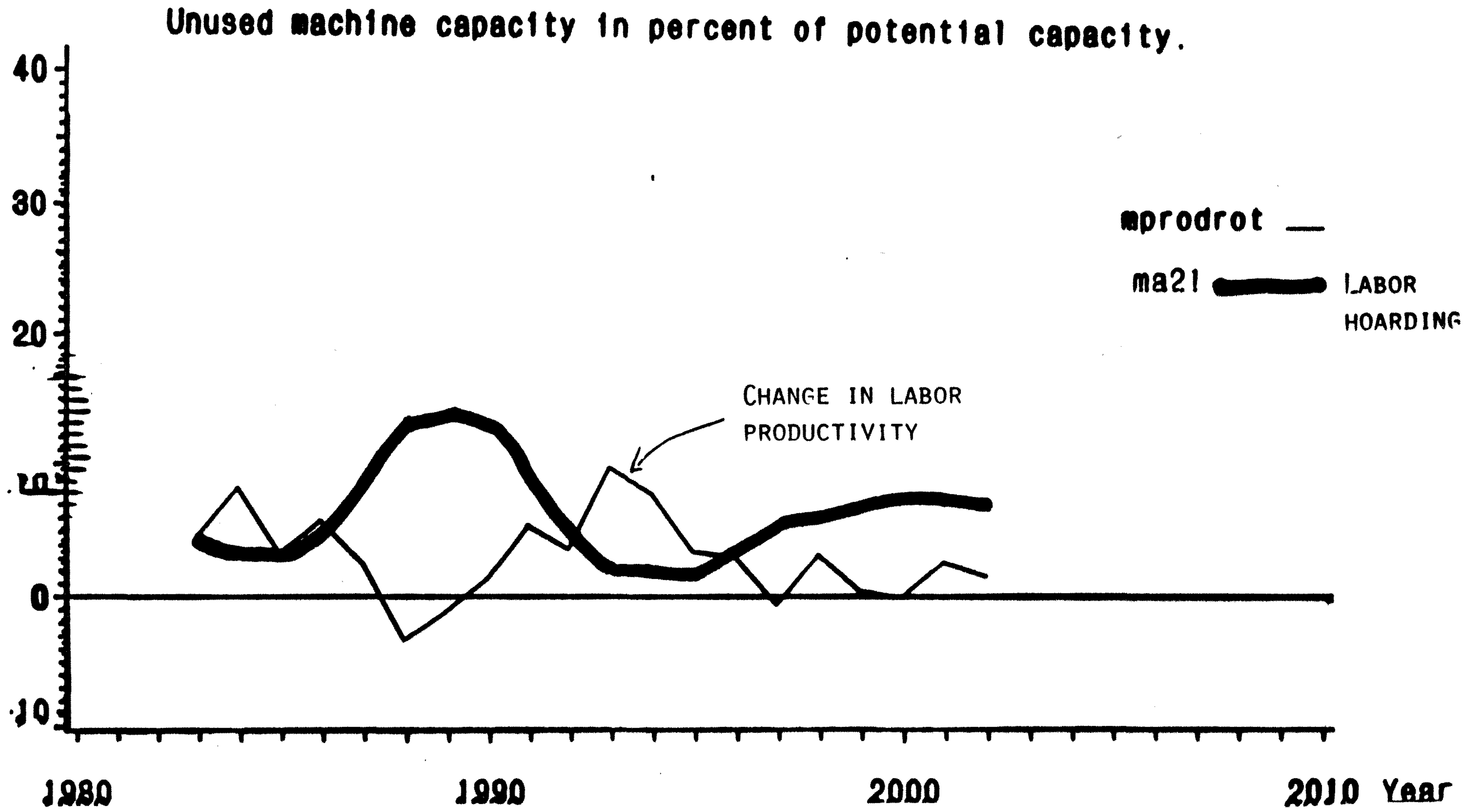


Figure V.C Unemployment and labor productivity change

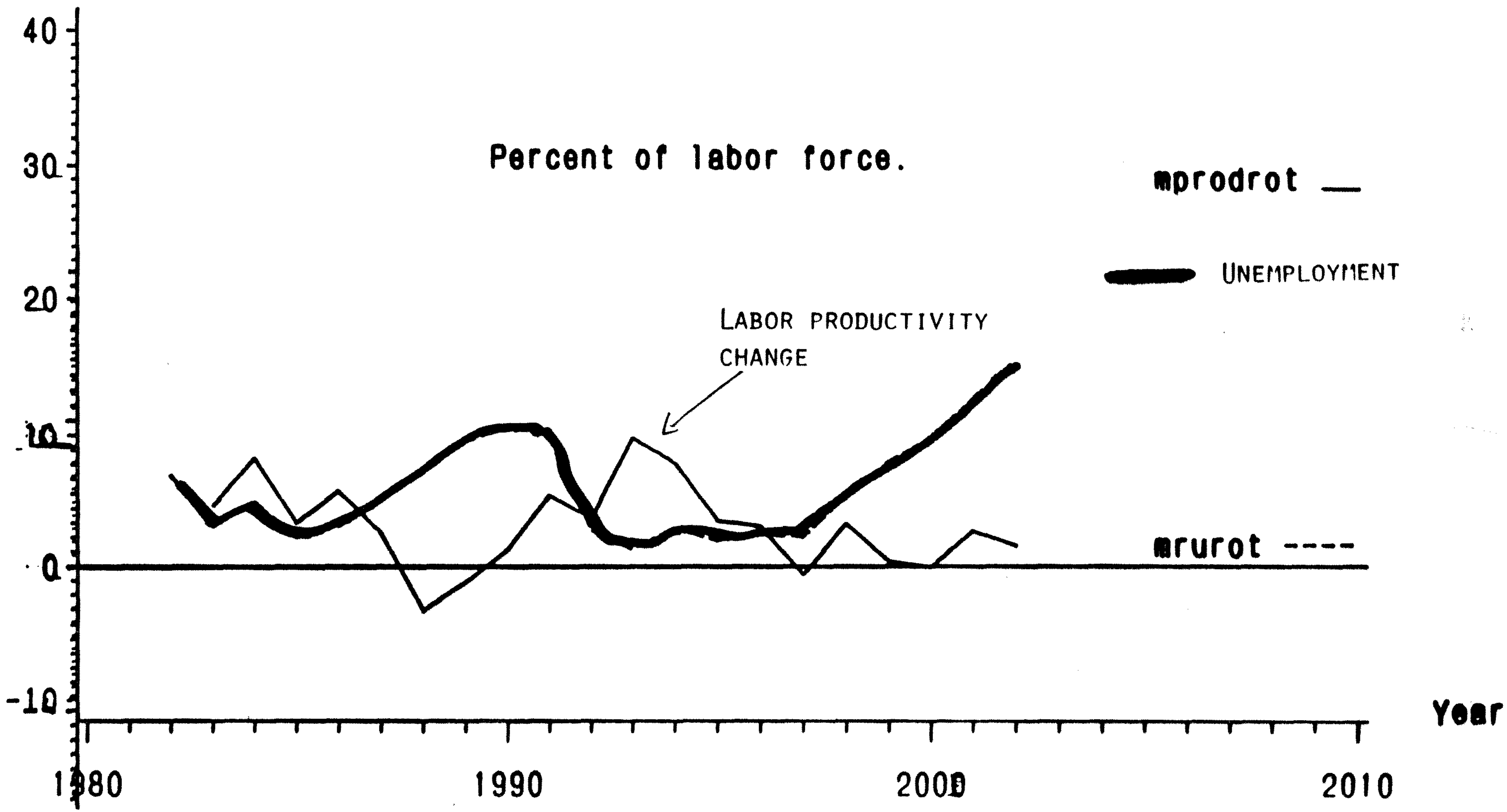
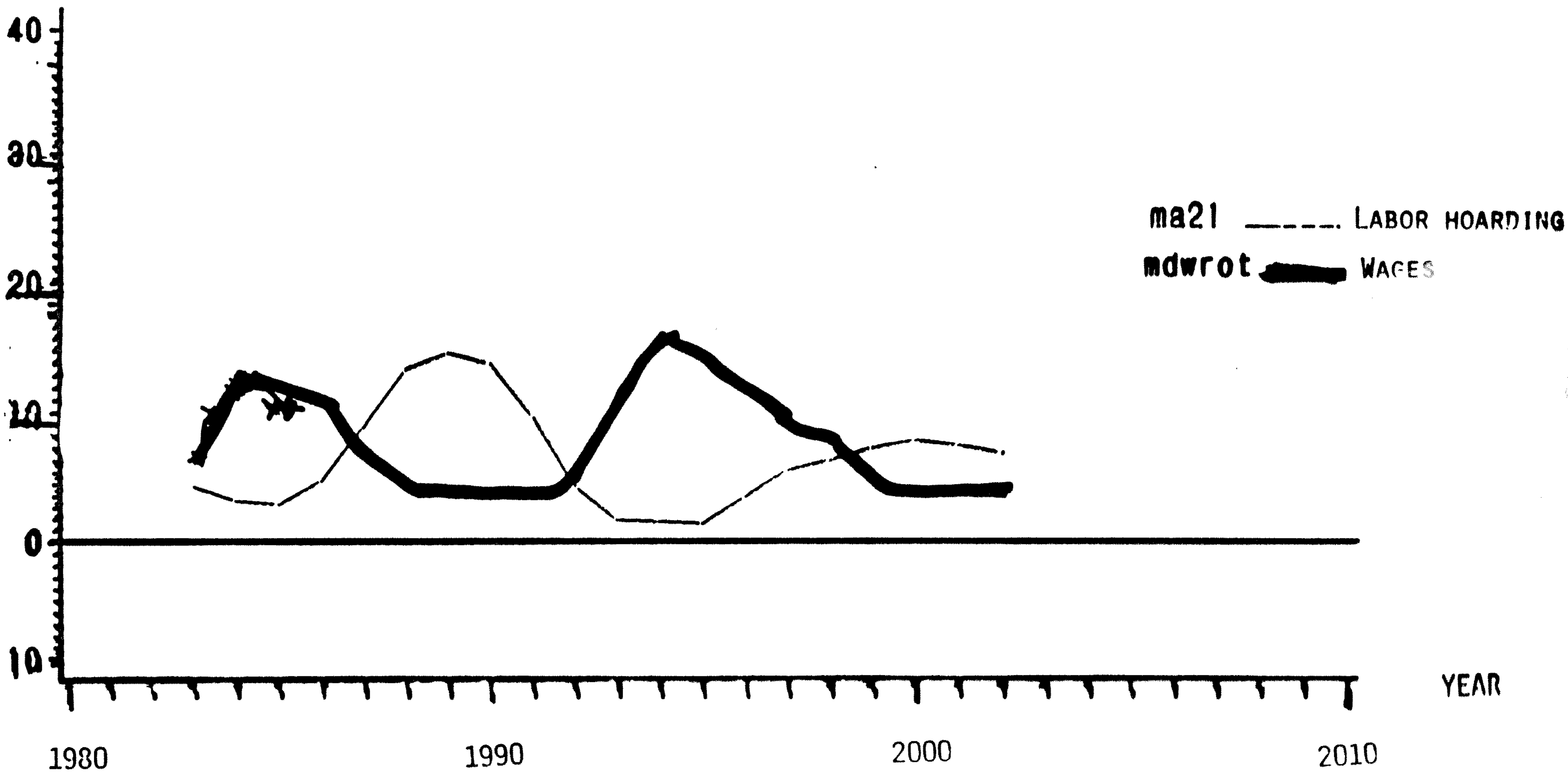


Figure V.D Labor hoarding and annual wage change



-79-

Figure V.E Labor productivity in manufacturing and GNP
– annual growth

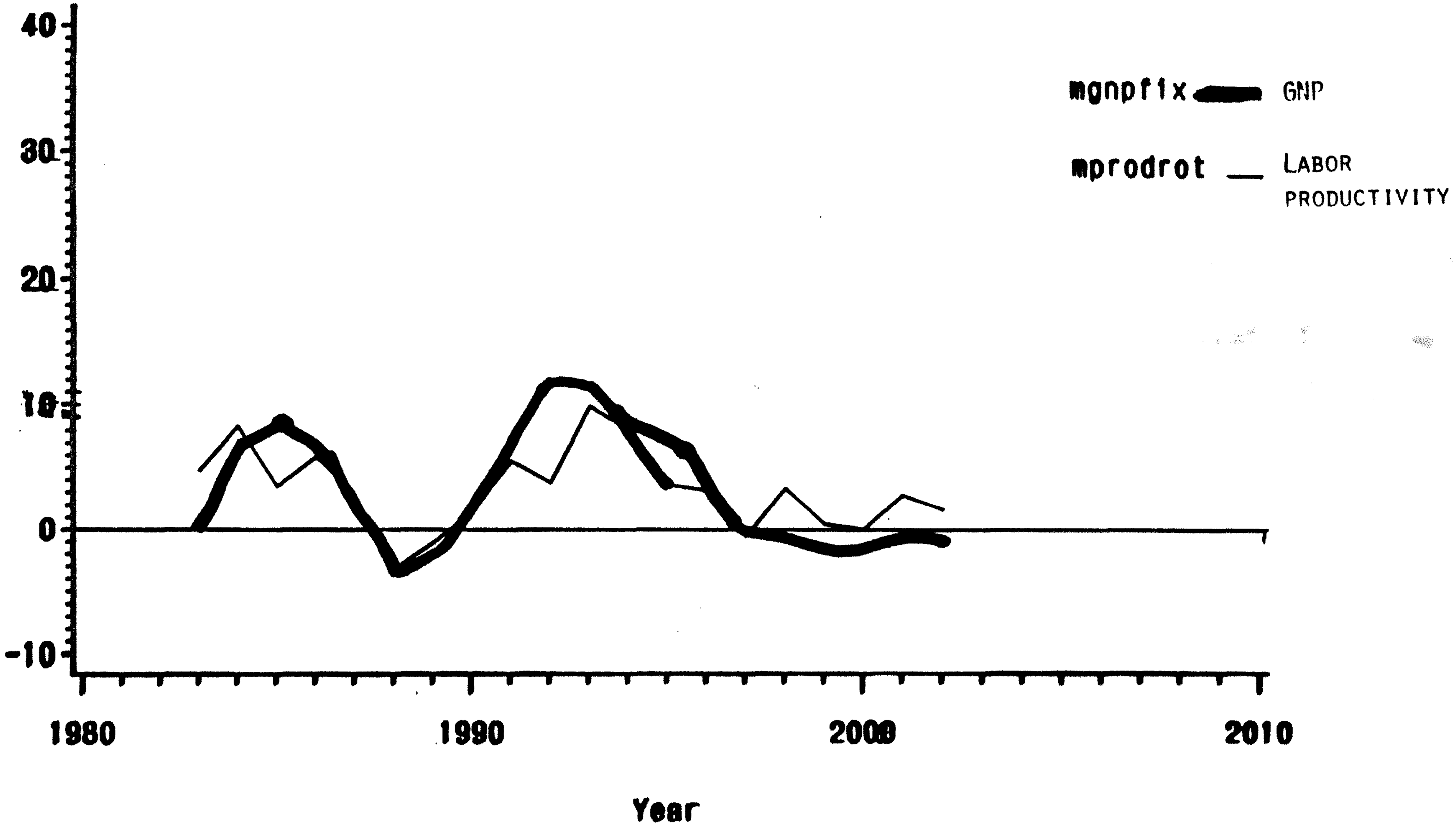
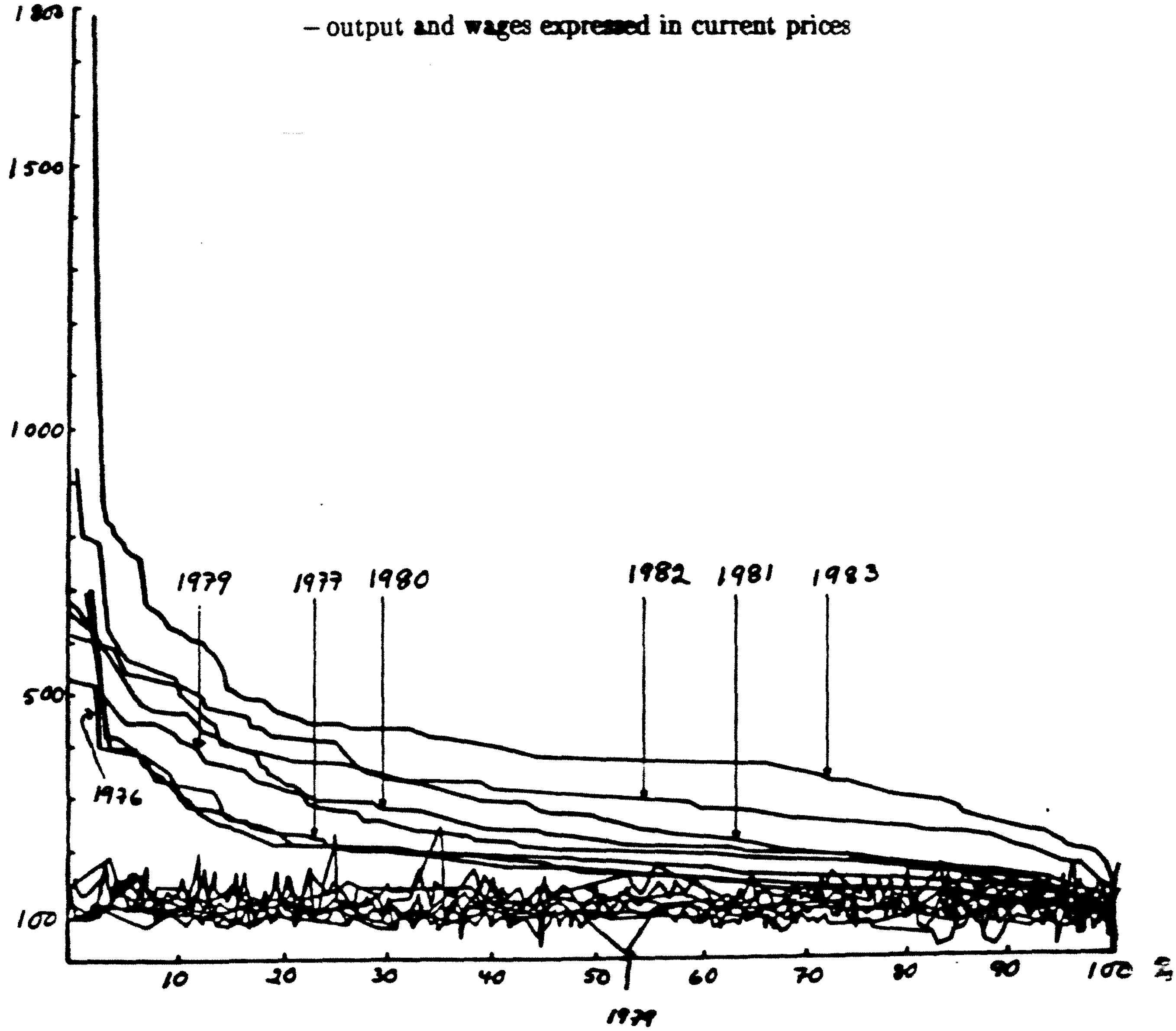


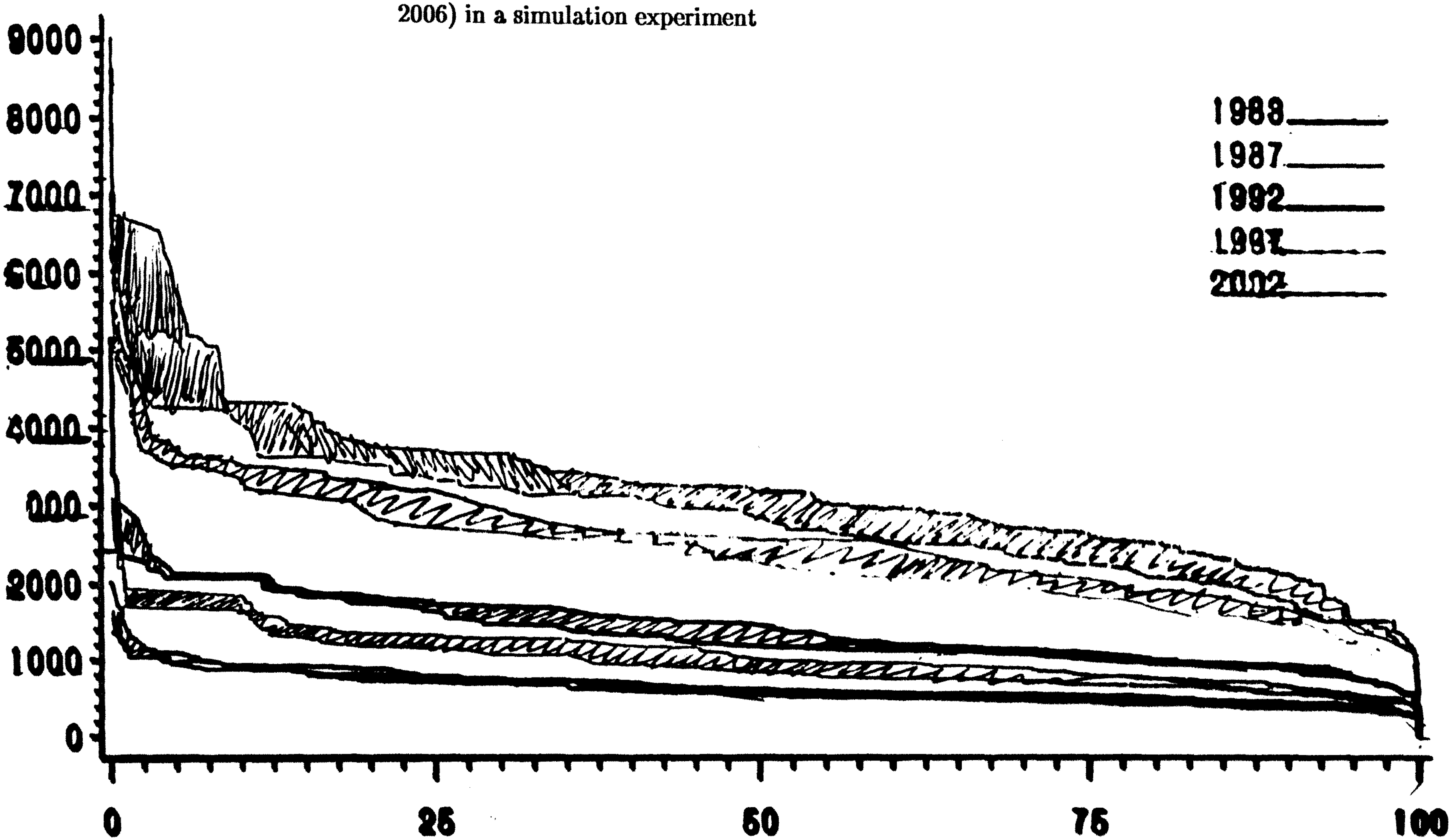
Figure VI.A Distributions of labor value productivity and wage costs
– distributions over firms in Swedish manufacturing in order of descending productivity, 1976-83
– output and wages expressed in current prices



Explanation: Individual firms or divisions have been ranked by falling marginal value productivity (thousand SEK per effective man year). This is the upper schedule. The matching wage cost schedule is shown below. A vertical line combines value productivity and wage cost of the same firm. Since averages for firms have been used the time representation should be discrete; one column for each firm or division, its step length indicating the size of the firm in terms of percent of total value added in manufacturing industry. The large number of units makes this representation graphically impossible.

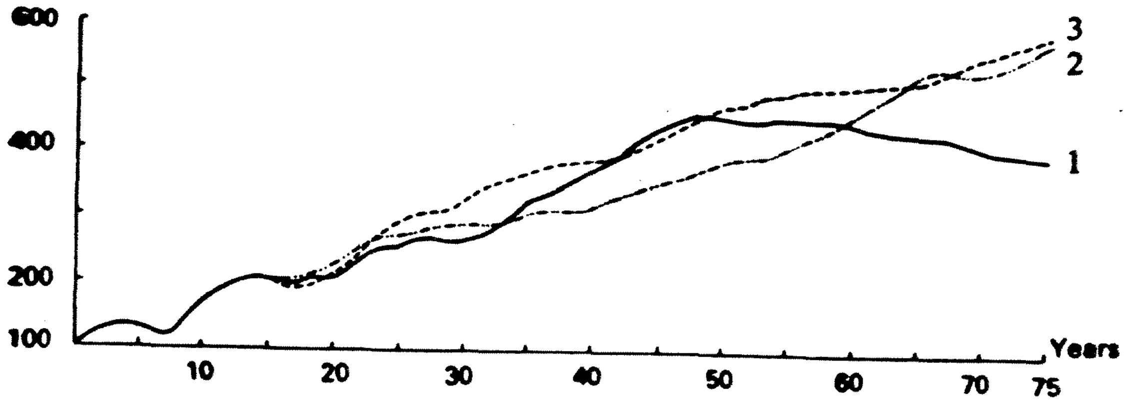
Source: Eliasson–Lindberg (1981).

Figure VI.B Actual and potential (Salter) productivity distributions over firms for selected years (1983, 1987, 1992, 1997, 2006) in a simulation experiment



Note: Shaded areas show difference between potential and actual distributions. The corresponding macro development can be seen in Figures V.

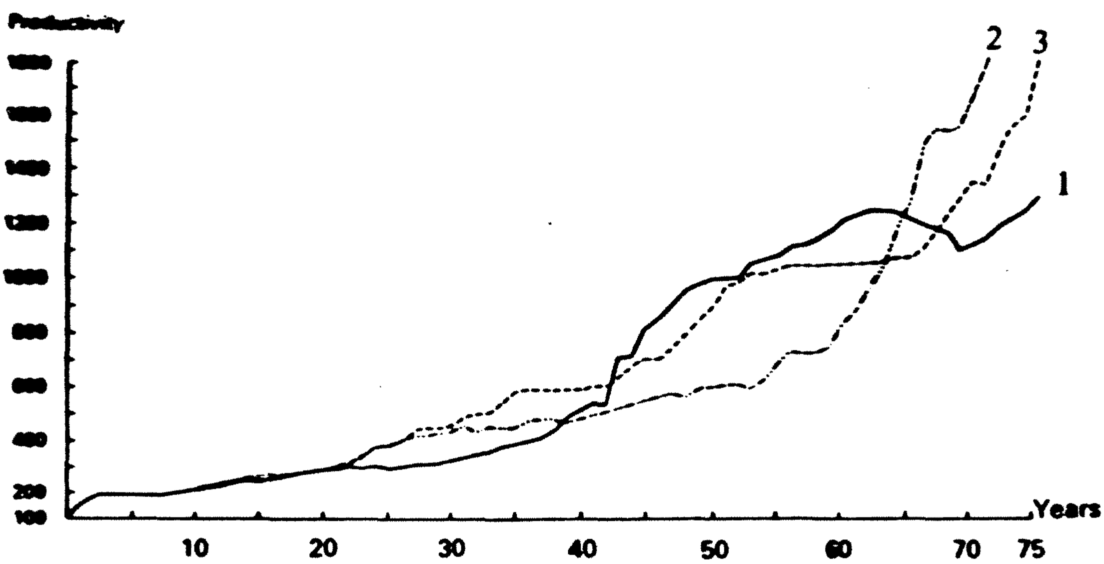
Figure VII.A The impact of entry on production



1 = No entry
2 = Normal productivity entry
3 = High productivity entry

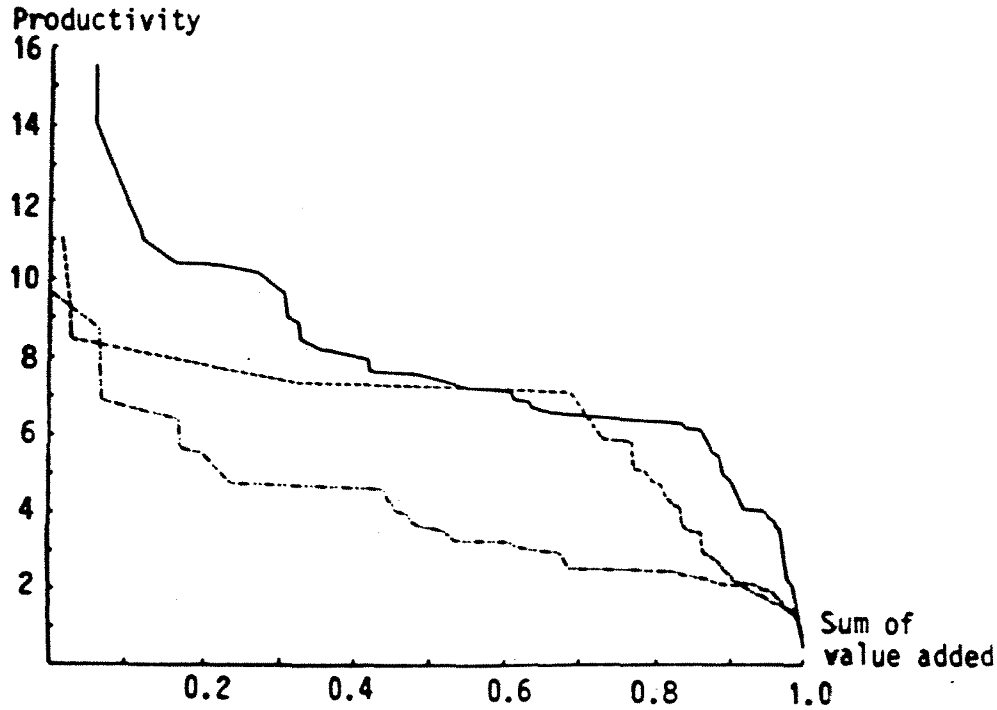
Source: Hanson (1986).

Figure VII.B The impact of entry on productivity



Source: Hanson (1986).

Figure VIII Productivity distributions for firms in year 30



——— all firms in year 30, including new entrants

- - - - remaining original (year 0) firms only

··-··-·· all firms in year 30 in simulation experiment with no entry, everything else the same.

Figure IX.A **Concentration tendencies in investment goods market.**
– Market shares of largest, second largest and five largest firms

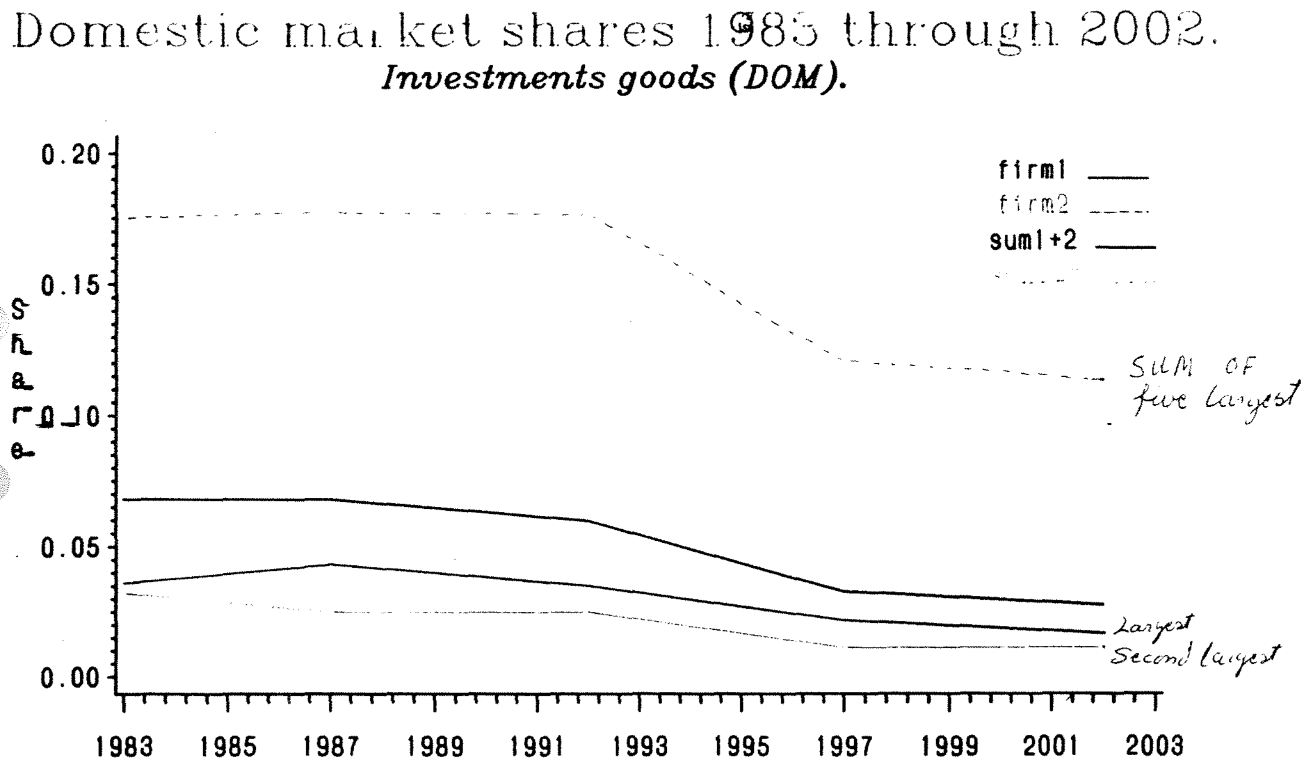


Figure IX.B **Concentration tendencies in intermediate goods markets**
– Market shares of largest, second largest and five largest firms

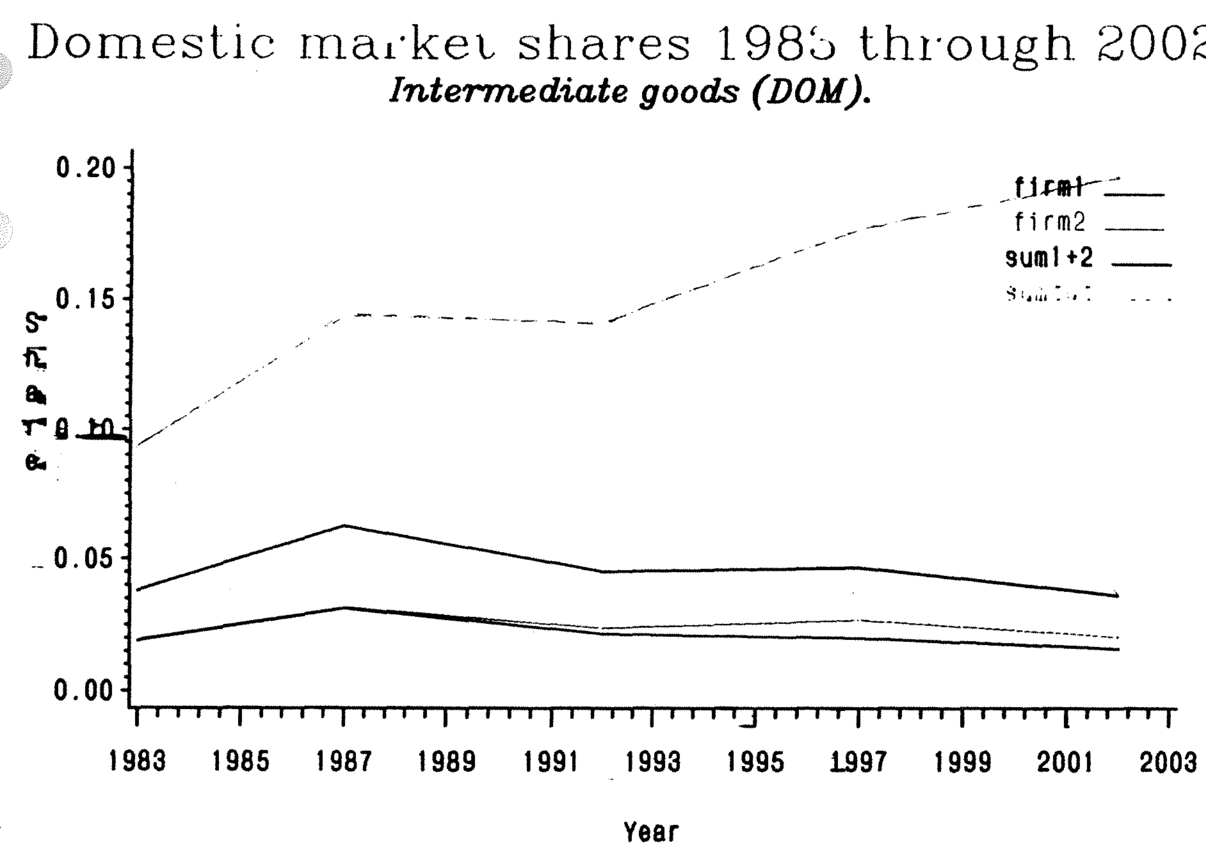


Figure X.A Firm size distributions

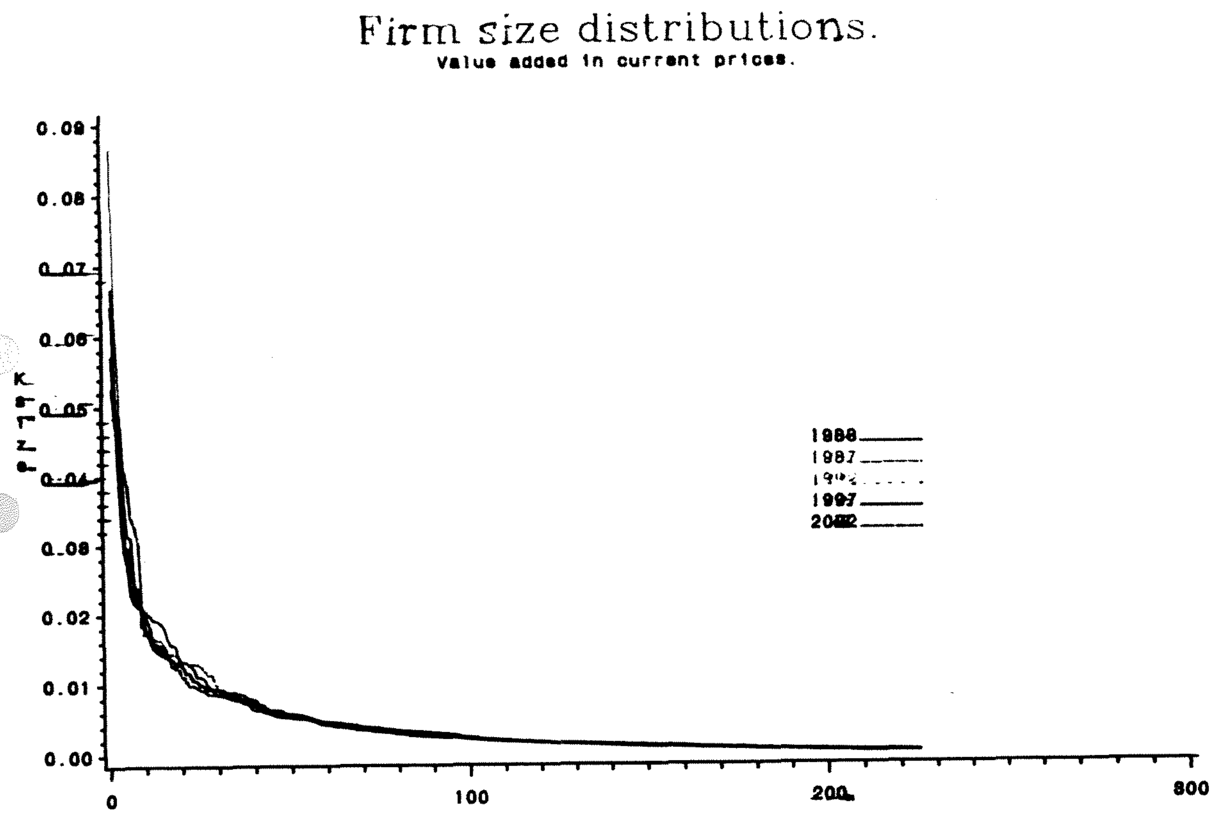
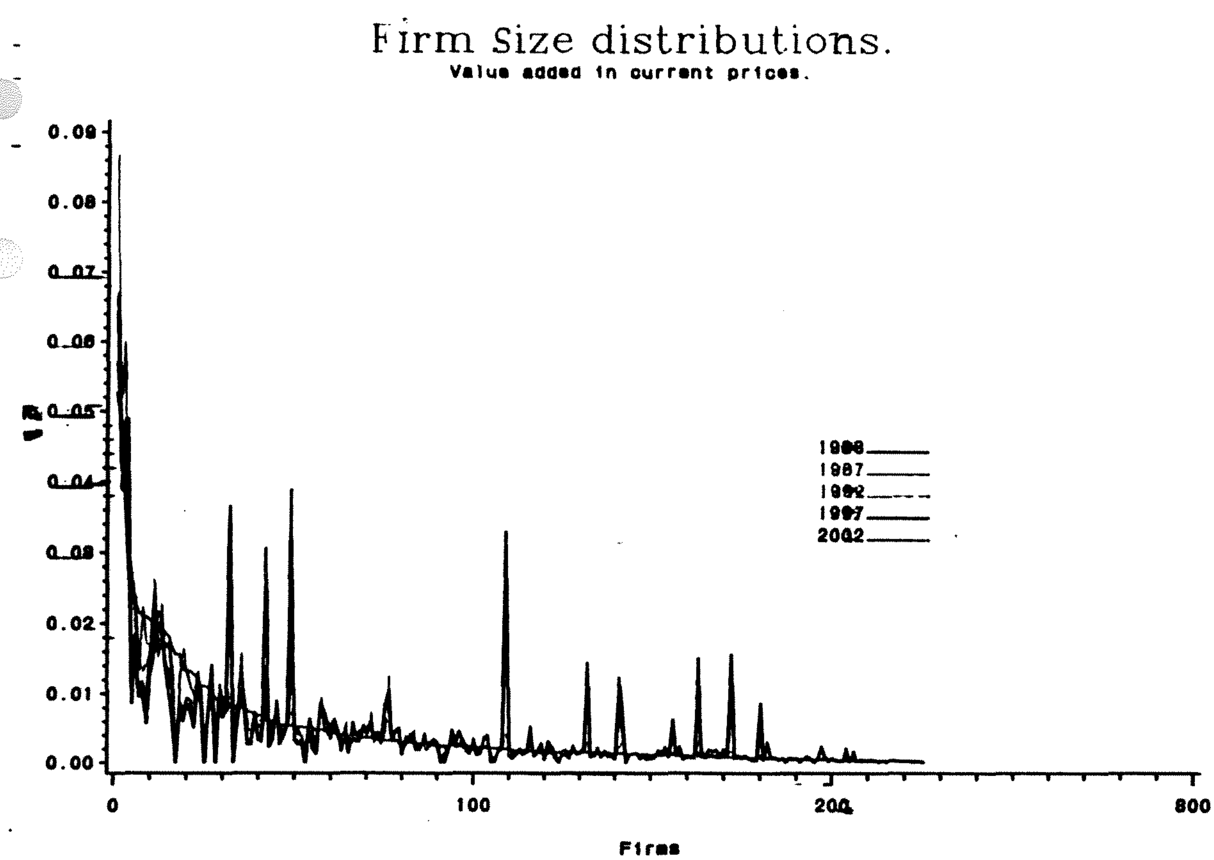


Figure X.B Firm size distributions
– Firms ranked each year as first year



BIBLIOGRAPHY

Albrecht, J., 1978, Expectations, Cyclical Fluctuations and Growth – Experiments on the Swedish Model; in Eliasson, G. (ed.) (1978a).

Albrecht, J.–Lindberg, T., 1989, The Micro Initialization of MOSES; in MOSES Code, IUI, Stockholm, 1989.

Arrow, K.J., 1959, Toward a Theory of Price Adjustment; in Abramowitz, M. et al., The Allocation of Economic Resources, Stanford, Calif.

Arrow, K.J., 1962, The Economic Implications of Learning by Doing, Review of Economic Studies, Vol. 29, June 1962, pp. 155-173.

Bergholm, F., 1989, MOSES Handbook, IUI, Stockholm.

Carlsson, B., 1981 The Content of Productivity Growth in Swedish Manufacturing; in The Firms in the Market Economy, IUI 40 years, IUI, Stockholm.

Carlsson, B., 1987, Investment and Productivity Change in Manufacturing: A Micro–to–Macro Perspective, IUI Working Paper No. 181, Stockholm.

Carlsson, B., 1988, The Evolution of Manufacturing Technology and Its Impact on Industrial Structure: An International Study, IUI Working Paper No. 203, Stockholm.

Eliasson, G., 1967, Kreditmarknaden och industrins investeringar, IUI, Stockholm.

Eliasson, G., 1968, The Credit Market, Investment, Planning and Monetary Policy – an Econometric Study of Manufacturing Industries, IUI, Stockholm.

Eliasson, G., 1976a, Business Economic Planning – Theory, Practice and Comparison, John Wiley & Sons, London etc.

Eliasson, G., 1976b, A Micro Macro Interactive Simulation Model of the Swedish Economy, Preliminary Documentation, Economic Research Report B15, Federation of Swedish Industries, Stockholm (with the assistance of Gösta Olavi and Mats Heiman).

Eliasson, G., 1977, Competition and Market Processes in a Simulation Model of the Swedish Economy, American Economic Review, No., 1, pp. 277-281.

Eliasson, G. (ed.), 1978a, A Micro–to–Macro Model of the Swedish Economy. IUI Conference Reports 1978:1.

Eliasson, G., 1979, Technical Change, Employment and Growth. Experiments on a Micro–to–Macro Model, IUI Research Report No. 7. Stockholm.

Eliasson, G., 1980, Elektronik, teknisk förändring och ekonomisk utveckling; in Datateknik, ekonomisk tillväxt och sysselsättning, Data- och elektronikkommittén, Stockholm.

Eliasson, G., 1982, Electronics, Economic Growth and Employment – Revolution or Evolution; in Giersch (ed.), Emerging Technologies, Consequences for Economic Growth, Structural Change and Employment, Kiel.

Eliasson, G., 1983, On the Optimal Rate of Structural Adjustment; in Eliasson–Sharefkin–Ysander (eds.), 1983, Policy Making in a Disorderly World Economy, IUI Conference Reports, 1983:1, Stockholm.

Eliasson, G., 1984a, Micro Heterogeneity of Firms and the Stability of Industrial Growth, Journal of Economic Behavior & Organization, Vol. 5, Nos. 3-4.

Eliasson, G., 1984b, Informations- och styrsystem i stora företag; in Hur styrs storföretag (Central systems in large firms), IUI, Stockholm.

Eliasson, G., 1985, The Firm and Financial Markets in the Swedish Micro–to–Macro Model – Theory, Model and Verification, IUI, Stockholm.

Eliasson, G., 1987, Technological Competition and Trade in the Experimentally Organized Economy, IUI Research Report No. 32, IUI, Stockholm.

Eliasson, G., 1988a, Ägare, entreprenörer och kapitalmarknadens organisation – en teoretisk presentation och översikt; i Örtengren–Lindberg–Jagrén–Eliasson– Bjuggren–Björklund (Alla med?), 1988, Expansion, avveckling och företagsvärdering i svensk industri, IUI, Stockholm.

Eliasson, G., 1988b, The Knowledge Base of an Industrial Economy, IUI Research Report No. 33, Stockholm. Also published in 1987 as part I, (Chapters I through IV in "The Human Factor in Economic and Technological Change in OECD Educational Monograph Series No. 3, Paris, 1987.

Eliasson, G., 1988c, The International Firm; A Vehicle for Overcoming Barriers to Trade and a Global Intelligence Organization Diffusing the Notion of a Nation; Paper to the Prins Bertil Symposium on Corporate and Industry Strategies for Europe at Handelshögskolan, Stockholm, November 9-11, 1988.

Eliasson, G., 1988d, The Firm as a Competent Team; paper presented to the IUI Conference on Markets for Innovation, Ownership and Control, June 12-16, 1988, Saltsjöbaden; also as IUI Working Paper No. 207, Stockholm.

Eliasson, G., 1989a, Modeling the Experimentally Organized Economy; in MOSES Code, IUI, Stockholm, 1989

Eliasson, G., 1989b, The Knowledge-Based Information Economy; in Eliasson–Fölster–Lindberg–Pousette, The Knowledge–Based Information Economy IUI, Stockholm.

Eliasson, G., 1989c, The Firm, Its Objectives, Its Controls and Its Organization – A Study on the Use of Information in Market and Administrative Processes, and the Transfer of Knowledge within the Firm, forthcoming, IUI, Stockholm.

Eliasson, G.–Lindberg, T., 1981, Allocation and Growth Effects of Corporate Income Taxes; in Eliasson–Södersten (eds.), 1981, Business Taxation, Finance and Firm Behavior, IUI Conference Reports 1981:1, Stockholm.

Eliasson, G.–Lindberg, T., 1986, Economic Growth and the Dynamics of Wage Determination – a Micro Simulation Study of the Stability Consequences of Deficient Variation in Factor Prices and Micro Structures, IUI Working Paper No. 170, Stockholm.

Eliasson, G.–Fölster, S.–Lindberg, T.–Pousette, T., 1989, The Knowledge-Based Information Economy, IUI, Stockholm.

Granstrand, O., 1986, A Note on Measuring and Modelling Innovative New Entry in Swedish Inustry; in Day–Eliasson (eds.), 1986, The Dynamics of Market Economies, IUI – North–Holland.

Granstrand, O.– Sjölander, S., 1987, Managing Innovation in Multi–Technology Corporations, Dep. of Industrial Organization (mimeo), Chalmers University of Technology, (August).

Hanson, K.A., 1986, On New Firm Entry and Macro Stability; in The Economics of Institutions and Markets, IUI Yearbook 1986–1987, Stockholm.

Hirschleifer, J., 1966, Investment Decision under Uncertainty: Applications of the State-Preference Approach, Quarterly Journal of Economics, May, pp. 252-277.

Hirschleifer, J., 1981, The Decline in Aggregate Share Values: Taxation, Valuatin Errors, Risk, and Profitability, American Economic Review, Vol. 71, No. 5.

Lundberg, E., 1961, Produktivitet och räntabilitet, Stockholm.

Modigliani, F. – Cohen, K., 1958, The Significance and Uses of Ex Ante Data; in M.J. Bowman, (ed.), 1958, Expectations, Uncertainty and Business Behaviour. A conference held at Carnegie Institute of Technology, 1955, New York.