CHAPTER I

The MOSES Model —Database and Applications

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The true method of discovery is like a flight of an aeroplane. It starts from the ground of particular observation; it makes a flight in the thin air of imaginative generalization; and it again lands for renewed observation rendered acute by rational interpretation.

Alfred North Whitehead

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Introduction

Theory should never be separated from measurement, and the limits of measurement carry over to theory and understanding. The quantitative model is the intellectual intermediary that integrates our choice of priors with facts into comprehension.

Good economic measurement is, however, much too serious a matter to be mechanically accounted for. Economics has a long way to go to develop a scientifically based measurement tradition. When it does, it would, I am convinced, despite the principal handicaps of measurement in social sciences, put the bulk of mainstream theory at peril. I personally dislike the academic tradition that has developed an intermediate caste of applied specialists between highbrow pure theorists and lowbrow data gatherers, the former estimating or testing their models from remote ivory towers, without even touching the data, let alone participating in the design of measurements and data collection. I much prefer heroic, but visible priors in model and measurement designs to "econometric results" replete with concealed methodological conveniences. No science can develop good theory without having its influential, innovative theorists being very curious about what goes on in the labs. Hence, the reader will have to put up with a few philosophical, introductory pages on measurement design.

The lead theme of this book is that cross-sectional characteristics matter for macroeconomic behavior. When aggregation through dynamic markets is explicitly modeled, we may not even need macro theory. The problem is, however, that macro representation confronts us at all levels. Even if we do not like macro modeling at the national or sector levels, the firm is a macro entity. Thus, choice of optimal micro unit becomes a critical, analytical concern where theory and database design have to be dealt with simultaneously. The MOSES[1] modeling project, hence, through learning and experience rather than through prior design, has become a much more ambitious research project than originally conceived. What was once the idea to clarify the macroeconomic implications of the all pervasive, boundedly rational behavior of firms, observed in Eliasson (1976a), now also includes the ambi-

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[1] for Model Of the Swedish Economic System.

tion to generalize these implications to the conceptual level of what I have called (Eliasson 1987) the *Experimentally Organized Economy* (EOE), and to derive the appropriate measurement system to capture such an economy in *The Knowledge Based Information Economy* (see Table 1A) and to analyze its properties through the micro-to-macro model MOSES. As it happens this modeling has been a very creative experience, generating ideas about the more general conceptual design and how to design and organize the appropriate measurement system. In fact, the research design of Table 1A is a method to systematize standardized case information through prior theory and modeling such that the macroeconomic implications can be derived. The MOSES model includes a very large such sample of cases. The overriding theoretical problem (at level 1 in Table 1A), as I now see it, is to what extent these cases, or a larger sample of cases, aggregated through well researched prior theory of market behavior will tell economically interesting stories about future such cases.

Hence, the first chapter of this Database book on the Swedish Micro-Macro Model (MOSES) includes a brief account of the model (Section 3), the conceptualization of the experimentally organized economic environment in which firms of the model are operating (Section 2) and an overview (Section 4) of the rather wide ranging database work associated over the years with the MOSES project, as an introduction to the subsequent, more specialized chapters. Section 5 explains how the statistical systems are used by the firm itself. The chapter concludes (Section 6) with some applications of the model, designed to illustrate the importance of good economic measurement.

1 The Theory and Measurement Design of the Knowledge-based Information Economy

Adam Smith (1776) coined the concept of productivity advance through division of labor. By breaking the work process down into finer and finer elements economies of scale in the small could be achieved. These scale effects became the drivers of the macroeconomy. Work specialization, however, came at a cost. It required *innovative knowledge* to be created.

The more elaborate work specialization, the more resources needed to *coordinate* production. Hence, there are explicit transactions costs associated with organizing a specialized economy. Such organization can be achieved through *competition in the market* by what Adam Smith called the invisible hand, and through *management* or *administrative method* in production units ("hierarchies"). The relative efficiency of the two methods determines the size structure of administrative units, or firms in the economy, as suggested by Coase (1937), and hence of the market structure.

Determining the division of labor and thereby the *information technology* to coordinate economic action is also a prime function of markets. It includes the entry and exit of firms, or the recombination of firms, the movement of people with competence between firms and within firms (internal labor markets). The complexities of the sorting and selecting mechanisms of the markets, the *filter* in a large measure characterizes the economic system.

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

The first conclusion coming right out of Adam Smith's original idea is that macroeconomic *growth theory has to be based on a theory of the organization of markets and of hierarchies* to capture what goes on in a growing economy.

The other fundamental understanding, also coming right out of Adam Smith, concerns the limits of productivity advance through increased division of labor or improved work organization, or the openness of the economic "system". While neoclassical theory needs a narrow convex space to achieve the transparency of insight necessary for the existence of approximate, full information equilibrium, this restriction was not considered necessary to impose by Adam Smith, or anybody before Jevons and the marginalists. The openness of the economic system, the size of state space or of the set of business opportunities (E 1990b, 1990c)[2] is fundamental to the state of information of the economy and, hence, of measurement.

The open system of the Swedish micro-to-macro model features an extremely large opportunity set made up of all existing firms and the performance characteristics embodied in their organization, all possible new firms, defined by the algorithms that determine their entry and exit behavior, and a number of exogenous (known) facts. This opportunity set, even though

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[2] I have been involved in this project since its beginning. My name will therefore pop up in more than numerous references. References to Eliasson without coauthor will therefore be to E only and year.

far smaller than the real opportunity set featuring far more unknown detail, is still sufficiently large to prevent the kind of transparency required of neoclassical modeling (see E 1991c). Hence, the Swedish micro-to-macro model features a large number of individual firms that operate according to *the same classical principles* but with different quantitative characteristics, and in different phases, states that in turn derive from their past evolutions. Thus boundedly rational behavior of each individual agent together constitutes the fundamental non-transparency of the opportunity set which in turn forces boundedly rational behavior on each agent.

The unpredictability to each agent of local economic systems behavior precludes the possibility of the economic system of ever reaching a state of full information equilibrium, and hence creates the local unpredictability that was its origin (E 1991c). With such characteristics an economy has to be *experimentally organized* (E 1987). The outcome of individual decisions cannot be assessed until they have been tried in the market (a business experiment), and the outcomes ex post exhibit non-stochastic behavior. The micro-macro model (like the real economy) is bounded, but can, for certain (not unplausible) parameter values, exhibit grossly unstable behavior that would, for the real economy exceed what is normally considered acceptable from a welfare point of view. Macro stabilization would therefore continue to be a policy problem, but the information requirements on the economic adviser/policy maker to improve the situation would be enormous and very different from what they used to be in the Keynesian world (E 1983, 1991c).[3] It is obvious that the preconceptions in this respect that enter the design of your theory strongly influence your understanding of what goes on. Similarly, the way firm decision makers view their environment fundamentally affects the design of their information and decision systems that we use to load the model with data. Good quality measurement and specification of agent characteristics, hence, are necessary for understanding the dynamics of an economy. This is also the raison d'être for the micro-to-macro database design of this book.

This is also the philosophy behind the growth theory embodied in the M–M model economy to be sketched here that, in turn, serves as the design

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[3] These phenomena are well known to those familiar with the literature on non-linear systems dynamics [see, e.g., the July 1991 (Vol. 16, No. 1–2) issue of *Journal of Economic Behavior and Organization*].

for the MOSES micro simulation model, and the systematic micro-to-macro database upon which this model operates. The theme of this paper is that *theory, model and measurement cannot be separated.* Thus, I have to devote some space to presenting the micro-to-macro model from the point of view of both theoretical foundation and database design. The M–M model can be seen as a vehicle to systematically integrate theory and measurement. The model can also be regarded as an instrument to systematically generalize from case observations (E 1976a, 1984a, 1990e) to the national level via explicit aggregation through dynamic markets. Since the model as such has been recently documented in several publications (Albrecht et al. 1989, Bergholm 1989, E 1977, 1978a, 1985a, 1986, 1989b, 1991a,b,c) this presentation will be sketchy, and I will concentrate on the definition, place and use of certain critical variables in the model. I conclude with a few applications in Section 6, specially designed to illustrate the Salter (1960) curve initial state representation of the model and the interaction of price and quantity setting behavior of agents in dynamic markets.

This idea is reflected in the organization grid of the model economy that coordinates all economic action. It can be viewed as a complex *structural memory* that embodies the state of organizational technology of the economy, and of all its firms that control the coordination, innovation, selection and learning mechanisms of the economy. This memory is continually updated by the ongoing economic process. It makes the model economy *path dependent.* Simulations on the model, hence, become sensitive to *initial conditions* that keep influencing future model behavior for years. This path dependence, I consider a desired property of the model economy. I believe economies to be strongly path dependent. This is part of their dynamic *evolutionary* characterization, and they should be modeled accordingly (E 1991b,c). The degree of, or absence of path dependence is an empirical question which greatly influences economic systems behavior. To make convenient a priori assumptions in that respect will therefore unavoidably lead to errors of unknown size and direction. The important empirical question is the degree to which the organizational memory that controls the coordination, innovation, filtering and learning mechanisms of an economy has its roots in the past, how it operates, and to what extent it can be decoded, understood and manipulated, or policed.

Path dependence and sensitivity to initial conditions pose special demands on quality of measurement. Empirical studies become sensitive to *errors of measurement in the initial state* description of the economy from which all analysis of a path-dependent system has to begin. This is our key empirical problem, not parameter estimation. This also illustrates—I repeat—the importance for economics to *integrate theory, modeling and measurement* systematically, something the economics profession has painstakingly avoided by prior designs of models that make them invariant to initial state descriptions. In doing this, economics has avoided benefiting efficiently from the learning process that characterizes scientific progress; theory guiding measurement design, improved measurement and testing forcing a redesign of, sometimes, a radical change in theory.

A related and growing problem with economic measurement on the output as well as input sides is the *quality* dimension. The output of an advanced economy, notably what is produced for the open market, is dominated by a quality change component that more or less determines the value of output. Quality is difficult to measure and it is inherently heterogeneous. It matters increasingly for consumer satisfaction and the more so, the more quality on the input side matters. This means that economic measurement increasingly measures less and less well what is becoming more and more important (E 1990a).

There are limits to the extent to which qualities can be captured by more sophisticated correction techniques. The problem is heterogeneity, meaning that there is a variety of applications of each unit of input and a variety of equally satisfying uses on the output side. Hence, there is no unique method of correction. This fundamentally disturbs welfare analysis, but it is also well recognized as a problem in business decision making and solved in this context, as it is always done, through approximations (see E 1976a).

It is now easy to understand that the organizational memory of the economy is complex and for all practical purposes intractable to the individual agent participating in the economic process. A large part of resources used by the agents are devoted to "decoding" this memory to be able to improve their positions. We call this "learning" or intelligence gathering. The ability of decision makers at large to capture the structure and development of the memory in an unbiased way gives the economy its important dynamic properties. We do not assume agents to be capable of learning immediately and fully at no or known costs, as in rational expectations and efficient market theory. We rather study the consequences of costly information biases in the economy. We observe already here that the four types of information processing activities in Table 1B account for the bulk of cost applications in the advanced manufacturing firm (see Figure 2).[4] Hence, the efficiency and reliability of these information processes dominate macroeconomic behavior.

The ambition of the micro-macro economy is not greater detail in output, but to *understand macroeconomic behavior better through systematically using the wealth of internal microdata constantly collected, analyzed and used by decision makers themselves.* "Systematically" here means formulating a relevant theory through which microdata can be explicitly aggregated dynamically through markets to a macro representation of the economy. This means modeling explicitly the innovating, filtering, learning and competition processes of agents, accounting also explicitly for the limits of their view ("insight") into state space or the opportunity set. A statistician might rather say, that the MOSES model simulates the accounts of the national economy from micro firm data through a non-linear, dynamic model.

This, finally, spells out the general problem of measurement in social sciences, the fundamental instability of the *unit of measurement.* You don't find more stability as you look for further detail. The macro aggregates, on the other hand, derive their stability from the law of large numbers, concealing underneath them a wealth of microeconomic variation and mobility that normally cancels out in the aggregate, but that constitutes the dynamics of the ongoing economic processes that one should want to understand. The *optimal observation unit,* hence, is neither the most stable, nor the most detailed. It is *the unit that makes sense as a decision unit,* i.e., the most monolithically controlled decision unit that enjoys maximum autonomy in the various markets in which it operates. Since profits is the ultimate objective of commercial activities, this means that the financial market will become the dominant, controlling market of business behavior. Pricing in the financial markets will exercise a strong leverage on prices in all other markets.

All this means, that however deep into detail you try to bring your measurements, the ambition to measure will always have to stop somewhere by establishing an arbitrary scale or classification scheme. The unit of

[4] Since the design of the MOSES model unavoidably had to be guided by existing economic theory and measurement, we initially missed the extent of resources used up in information processing as categorized in Table 1B. This was so despite my own prior interview work (E 1976a). I became aware of this embarrassing oversight when collecting data to test the model. We are now modifying the model to accommodate the new information. Its design fortunately makes this easy.

measurement—the firm or division—is the finest and at the same time a reasonably stable unit of account that can be observed. Very few firms attain the age of the world's oldest joint stock company, Stora Kopparberg, that turned 700 years in 1988. It is represented in Figure 1 through its reasonably stable *name* and the associated financial ownership characteristics. Underneath its aggregate "financial surface", however, the internal structure of Stora Kopparberg exhibits the same recurrent instability that kills most firms along the way as autonomous decision units, and steadily creates new entities that in turn, most of them, perish. The firm, in fact, is very much represented by its *internal statistical system* designed to support its autonomous decisions. Since the objective is profits this statistical system has a strong financial bias (E 1976a, Ch. XI). The various categories of work carried out inside the financial boundaries normally blend into one another, but are separated by boundaries that, to the extent possible, correspond to natural dividing lines to support internal profit control. Table 1B represents such a taxonomy that is very general in principle but that will have to be arbitrarily applied.

The reader should observe, however, that we here encounter a fundamental problem of all sciences, the limits of understanding, determined by the limits of measurements. Competitive markets that make up the driving and disciplining mechanisms of the entire economy also require reliable information (or measurement) systems to perform their functions which are the markets themselves. The better the measurement function the less competitive the economy and vice versa. The fundamental uncertainty principle also rules in economics, a fact of life that firms, designing their own internal statistical information systems, have well understood (E 1976b, 1990e; also see Section 5), in fact, much better than the economics profession.

2 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 of Table 1A. It explicitly integrates theory and measurement. All information activities, except one, internal education, occur explicitly in the model. As described in more detail below and in Chapter V, the individual firms of the MOSES model reside in four manufacturing sectors, or rather markets for manufacturing goods. All individual firms are interacting with other manufacturing firms, with other sectors and with the rest of the world (assumed to be in steady state) through product, labor and financial markets. When seen from above the MOSES model appears as an eleven-sector Leontief–Keynesian sector model with endogenous investment and dynamic demand feedback.

2.1 The Unit of Observation

The idea of the model is to represent the autonomous behavior of agents in markets, through their own statistical (information) systems and the ways they interpret and decide on the basis of these data. It is, hence, desirable to identify agents that are reasonably stable entities. We have chosen *the firm and/or the division* as the smallest, financially defined and most stable decision unit.

Since *internal reorganization is the essence of its productivity advance*, not even a division will exhibit a stable internal structure (E 1985a). The division, and more so the firm, however, represents the consistently most stable measurement unit you can obtain, since it maps reasonably one-to-one into a well-defined group of products, representing a common *product market* know-how, a monolithic set of *financial objectives*, and (hence) also into a reasonably well defined *incentive* and compensation *scheme* (labor market). The classification of this information system of behaving units relates their objectives (the rate of return) directly to the corresponding price (the interest rate) in the capital market (financial objectives). This is also part of the design idea of the micro-to-macro model. The financial units, however, also break up and recombine (mergers, acquisitions etc.), illustrating the arbitrariness of any measurement system you may devise. This recombinatorial technique may also be the most forceful factor behind macroeconomic productivity advance.[5] Again, however (see E 1989c), the financial unit

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[5] Until a dynamic theory of mergers and acquisitions has been formulated, it will, hence, be impossible to properly capture the aggregation process between factor inputs and macro productivity change. At the IUI we have organized our productivity studies on the design of the model. This means that productivity advance, originating in reorganizations within firms, is studied separately from productivity advance, originating in entry and exit of and investment in given firms (see E 1980a,b, 1991a, Carlsson 1989, Hanson 1986, Jagrén 1986). Interior firm productivity ("management") and external ("market allocation") efficiency are so to speak studied separately.

called a division or a firm, the information system which links together financial objectives of the firm with its incentive and production system, is a provisional technique (an "information technique") to install a higher level order on market activities, a higher efficiency, and a higher rate of return through "market coordination" than otherwise feasible.

2.2 A Salter Curve Representation of State Space (the Opportunity Set) and the Updating of Structures

Agents (firms) are operating in a state space or—as I prefer to call it—the opportunity set (E 1987, 1990b), including not only a snapshot representation of today but also all possible future combinations achievable through possible action of all agents from now into the future. This opportunity set is, of course, very large, complex and inherently heterogeneous. It is assumed to be sufficiently large to prevent any agent from having more than a very limited insight (bounded rationality). This opportunity set has a time dimension, and it includes for each agent all possible future behavior, a circumstance that makes the situation of full information infeasible, and bounded rationality[6] and tacit knowledge a necessary characteristic of agent behavior. In fact, it is demonstrated (E 1990b, 1991c) that the boundedly rational behavior of firms observed (in E 1976a) is sufficient to create the market unpredictability associated with a large, and largely (for each agent) non-transparent opportunity set which in turn imposes bounded rationality on agents. This section demonstrates that the observable Salter (1960) curve representation of the Swedish economy of the MOSES model is sufficient to create the conditions of the experimentally organized economy (EOE).

In the MOSES system the opportunity set is defined by all future, feasible Salter curves of variables taken into account by firm decision makers. It is not completely open-ended since there are, at each point in time, upper physical limits to the domain of operation of the economy. As the economy advances, the nature of these physical limits also changes, being determined by the actual path taken by the economy, being restricted by the ability of all agents to peek, at each time, into this opportunity set. In a sense, the opportunity set is updated at each point in time by the actions taken by all agents

[6] Bounded rationality is thereby more broadly defined than in the situation of asymmetric information of modern IO-literature.

on the basis of what they have been able to learn (understand) of the opportunity set. *The specification of the boundedness of an agent's rationality or understanding, hence, includes a specification of the competence of the agent to act successfully in markets.*

One way to illustrate the opportunity set and, hence, the dynamics of the micro-macro model economy is to start with a set of actual and potential Salter (1960) productivity and rate of return distributions of firms (see Figures 3 and 4).

(a) The *place* on the potential Salter distribution of an individual firm indicates its temporary competitive position (ex post).

(b) There is a spectrum of potential, ex ante such Salter distributions, exhibiting the consequences of increased capacity utilization, new entry, exit, innovation and investment.

(c) Each firm, in turn, operates underneath its own "Salter" production frontier (see Figure 2) that exhibits its potential for performance upgrading.

(d) The *shape* of the potential Salter distributions, or rather the performance spread between the best and worst agents, measures potential competition of domestic producers and the degree of competitive exposure of those positioned on the tail end of the distribution.

(e) The actual intensity of competition depends on the pressure brought on each actor by the same action of all actors, as reflected in price and quantity decisions. Rate of return demands imposed by the capital market, the position on the Salter curves and the potential to do something about its own situation determine the competitive action of each individual firm.

(f) The propensity and the potential to do something depend on what the firm knows about its own position relative to other firms. The firm, hence, engages in various kinds of *learning* activities. If it finds that its position is superior to that of other actors it may relax, even though a successful past tends to have generated high internal rate of return standards (E 1976a). If the firm finds itself in a precarious position, it knows both that higher performance is feasible and that it has to do something about its situation.

(g) Performance is upgraded through the investment decision. New, innovative entry, exit forced by competition, and investment (dependent on the expected rate of return) introduce new technology and phase out economically obsolescent technology, thereby upgrading the Salter structures continuously and endogenously.

The main experimental process machinery of the model is concerned with economic learning for coordination (internal and external through markets) and filtering. In the MOSES model ready-made "innovations" are brought into the firms with new investment. The innovative process per se is not modeled. On the other hand, productivity growth through organizational change is explicitly modeled, including the organization of market competition and the development of a "tacit" systems competence embodied in the organization of the entire economic system. The structure of the model represents a competence memory that is constantly updated and also controls all information processing in the model; in its markets and within its firms.

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 (E 1976a, Ch. XI) and placed in the Salter rankings as described above.[7] 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 participating in the ongoing market process.

Economic growth builds on dynamic coordination of micro (firm)

[7] In the early days of building the MOSES model we considered representing the MOSES structures analytically. This is perfectly possible to do, but an analytical representation would constrain the dynamics of firm behavior. Above all, it would force us to do equilibrium modeling which I did not want to do then, and does not want to do now. The point is that there is no stable analytical Salter representation in the experimentally organized economy.

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).

2.3 Firm Behavior

The above Salter curve representation of the MOSES model economy exhibits each firm as being constantly threatened from above and below by competitor firms. Its ability to cope with this competitive challenge depends in part on the nature of its intelligence system.

The firm *intelligence system* exhibits bounded rationality and tacit knowledge. Firms are characterized by rent (profit) seeking on a hill climbing (not optimization) mode, guided by perceived profit opportunities. *The landscape of immediate rent opportunities 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 environment of opportunities. Individual mistakes are frequent and unpredictability at the micro level the normal situation. The market environment is what I have called experimentally organized (E 1987). Firms, as a consequence, are organized as experimentators and specialists in fast identification and effective correction of errors (E 1990b).

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 causes a constant ex ante/ex post dichotomy (*the realization process*).

Out of equilibrium there is no way to tell how prices and quantities will move if you only have an equilibrium model. You need a process–representation of economic activity in which *learning behavior and expectations forming, decision making and the realization processes* are explicit in time. 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. From a database point of view this means that firms at each point in time read off and interpret signals from state space, from their internal accounts and their local environment from which they construe an ex ante *inconsistent* picture of their own place in state space for the next period. In terms of the MOSES firm, it tries to figure out as much as possible about the potential Salter distributions around them from the signals emitted by the model economy, mostly prices. The novel feature of the M–M economy is that each agent faces a locally unpredictable environment that it has to confront, nevertheless, through envisioning a boundedly rational prediction of its behavior. The large number of different such views is sufficient to create unpredictable behavior, and force bounded rationality on agents (E 1991c). This paradoxical situation creates unexpected solutions which relate directly to the firms' information system and economic measurement. A decision to act has to be single valued, at least just then, i.e., the decision model has to have a unique (equilibrium) solution. Failure on the part of the firm organization to come up with such a single-valued solution is disorganizing (E 1990e). Hence, *it is* only *natural to expect agents*, as we have found, *to use equilibrium, albeit different decision models*, *to relate the firm to its environment*, to be capable of operational decision making. It is therefore perfectly rational for agents to look at the world around them through a linear filter. The models, however, differ from agent to agent, and the inconsistent decisions taken on such biased information are sorted out through confrontations in markets. Ex ante, individual equilibrium (decision) models are, therefore, something very different from equilibrium models of the entire economy. Equilibrium modeling of ex post outcomes of the entire economy violates the assumptions of the experimentally organized economy.[8]

All ex ante positions taken are inconsistent when confronted in markets. They create local turbulence all over, and eventually generate a consistent new state that will again be interpreted inconsistently by all actors, and so on. The ex ante/ex post outcomes cannot be assumed to be random.

2.4 How Do MOSES Firms Learn and Exhibit Competence?

The nature of the environment of the firm, and of the realization process in particular, determines how the firm perceives itself in relation to its market

[8] The stochastic, static equilibrium model is a special case that has no raison d'être in this context, except mathematical convenience.

context. Its learning behavior is organized accordingly. It is important to understand what information the firm needs and to what extent its needs coincide with the data requirements of the model.

MOSES firms accumulate and exhibit competence 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* which 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 point in 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 endogenously changing the market regime characteristics, very different resource allocations and growth paths can be generated from the same initial state and the same, endogenous technology assumptions.

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, intermediaries and institutions that with a few exceptions are not explicit in the model. The nature and efficiency of this learning process depend 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 very little seems to have been done in this area of research.

2.5 Competition in the Experimentally Organized Economy

Competition occurs in all markets of the MOSES model. It is represented by the shape of the Salter curves, their spread, representing the potential for competition (to pay wages, interest etc) and how much of the Salter landscape, and of its individual position, that each individual firm perceives (or misperceives) through learning. The latter dictates the action taken by the firm.

Firms are forced, in the MOSES model, to innovate, or fail and exit, thus driving the macroeconomic growth machinery.

No agent is safe, since it has to take into account that those firms that are marginally inferior feel threatened by themselves, and are trying to overcome that threat by innovation and upgrading. Similarly, marginally better firms represent already a direct competitive threat to "you", and even more so since they are also afraid that you will try to overcome them, and hence also strive to improve their performance.

2.6 Market Dynamics

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 borrowing money freely. The intensity by which firms pursue this competition affects the overall competitive situation of the economy, 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. Demand feedback affects domestic economic growth. Demand feedback is, however, complicated by *price feedbacks* making firms both *price makers* and *quantity setters*. Since this statement is somewhat controversial in economics some explication is in place. Firms in the model set both prices and quantities on the basis of their expectations. The price and quantity setting procedures involve certain prior trials when the firm checks out the market, reconsiders its expectations and revises its prior quantity plans. Next, however, agent confrontations in markets, notably in the labor market, mean revisions of both prices and quantities, within each period and between periods, and, finally, the entire macro outcome of multimarket interaction of all agents feeds back on each agent. While price and quantity setting of agents in the classical model has a very particular meaning (see, e.g., Marris 1991), we model the interaction of agents in markets as classical price and quantity setting in response to a perceived (of each agent) state at each point in time. During the course of this intermediation in markets, some time may have passed, thus making the simultaneity of the classical model sequential. The main characteristic of the MOSES model, however, is that it features firms as temporary monopolists competing with each other through all markets. This is also what Arrow (1959) called for. Since all individual price and quantity decisions are taken on expected data, each round of decisions throws the economy into a new, both ex ante and ex post state, thus, as a rule making the classical equilibrium state, where ex ante and ex post are equal, infeasible.

Even though the "domestic" MOSES model economy, hence, is in constant market disequilibrium, the model economy is placed in an assumed *steady-state, global ("world") market environment*, with all competing firms embodying best-practice technology and *taking* world market prices so as to achieve capital market equilibrium, i.e., rates of return being equal to the exogenous world market interest rate. Hence, *long-term economic development of the Swedish model economy is dominated by the capital market.* Investment and growth of potential capacity at the micro level are 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 endogenized, 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 (see Section 6).

2.7 Relation to the Standard General Equilibrium Model

Personally I would say that the micro-macro theory upon which 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.* The particular advantage is the possibility of understanding the macroeconomic consequences of microeconomic phenomena. Looked at from the perspective of economic doctrines it combines (exogenous) entrepreneurial activities à la the young Schumpeter (1912), 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 Tables 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. This general competitive game among a limited, but variable, number of players is endogenously carried on.

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. All markets are interconnected through the administrative systems of firms, and the way this interconnection is organized defines the state of organizational technology of the firm. Prices in each market ultimately depend on competition among firms, and competition is ultimately driven by this organizational technology. Firms read off price and quantity signals in each market, interpret them and make appropriate (ex ante) price and quantity decisions that are ultimately modified in the competitive process. Since the organization (micro structure) of the economy and the interpretation mechanisms of the firm constitute the organizational memory of the economy that at each point in time controls overall information processes and the allocation of resources, the economy is so to speak *self-organizing* its micro structures through the experimental processes of the market. 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 micro-macro economy is regulated by the interaction of domestic (endogenous) and foreign (exogenous) prices in 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 match local supply plans. Markets do not clear, and stocks and later prices adjust. Disequilibria then feed back into next period decisions. The dynamics of the macroeconomy originates in this failure of ex ante plans to match through the *realization functions* of markets (Modigliani and Cohen 1958, 1961; E 1967, 1969). This notion can be traced to Wicksell (1898) and Myrdal (1927, 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 in which a realization function has no economic meaning.

Experience from M–M model work, however, tells that the realization function is a 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 (E 1983, 1984b, 1985a, Ch. V, and 1991c).

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 is always a large number of such ways. Hence, scientists, and especially social scientists, are all boundedly rational in their understanding of the world. 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.*

3 A Brief Mathematical Introduction to the Model

This section presents the mathematics needed to understand the measurement design of the Swedish microbased growth model. (For details see E 1977, 1978a, 1985a, 1991b,c). Focus is on the evolutionary features of the model. I thus exclude—in this mathematical presentation—the intermediate goods input/output structure of individual firms and all other production sectors than manufacturing (see Bergholm 1989 and *MOSES Code*, IUI 1989). Hence, all labor work in manufacturing, and manufacturing firms produce the investment goods. Gross production value and value added become identical.

3.1 Deriving the Control Function of the Firm—the Information and Short-Term Targeting System

The firms of the model are controlled through the rate of return requirements imposed by the rate of interest in the capital market. Rate of return targets control both production and investment decisions, and the interest rate is determined through supply and demand for funds in the financial system (see E 1985a, Ch. III, and Taymaz 1991). Ex ante rate of return targets guide the firm in its gradient search for a rate of return in excess of the market loan rate.

Defining the rate of return

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

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

w = wage cost per unit of L

L = units of labor input

r = interest rate

ρ = depreciation factor on $K = p^k \cdot \overline{K}$

p = product price, in this mathematical presentation equal to the value added price index

p^k = capital goods price

$\overline{K}$ = units of capital installed.

In principle the various factors (L, $\overline{K}$) *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 among firms as determined in dynamic markets.

Firm sales ($S = p \cdot \overline{S}$) over total costs generate surplus revenue, ε, or profit:

$$\varepsilon = p \cdot \overline{S} - TC. \tag{2}$$

Net profit per unit of total capital is R^N. We call the rate of return on capital in excess of the loan rate $\bar{\varepsilon}$:

$$\bar{\varepsilon} = \frac{\varepsilon}{K} = R^N - r. \tag{3}$$

The nominal rate of return then is;

$$R^N = \frac{\varepsilon + r \cdot K}{K}. \tag{3B}$$

In this formal presentation K has been valued at current reproduction costs. ε/K expresses a real excess return over the loan rate, but r is a nominal market interest rate. Ex post $\bar{\varepsilon}$ distributions over firms are shown in Figures 3.

In the micro-macro model firm owners and top management control the firm by applying targets on $\bar{\varepsilon}$, the rate of return over the interest rate. 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 main purpose of the internal information system of a firm is to establish these links, so that top management can control and simulate internal efficiency reliably, without having to get involved in operational details (E 1976a, 1990e).

The control function of the firm

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

$$R^{EN} = M \cdot \alpha - \rho + \frac{\Delta p^K}{p^K} + \bar{\varepsilon} \cdot \phi = R^N + \bar{\varepsilon} \cdot \phi \tag{4}$$

$$R^N = M \cdot \alpha - \rho + \frac{\Delta p^K}{p^K} \tag{4B}$$

$$R = M \cdot \alpha - \rho \tag{4C}$$

$$M = 1 - \frac{w}{p} \cdot \frac{1}{\beta}, \tag{5}$$

where:
M = gross profit margin, i.e., value added less wage costs in percent of S
ρ = rate of economic depreciation
$\alpha = \bar{S}/\bar{K}$
$\beta = \bar{S}/L$
$\phi = D/E = (K-E)/E$; E being equity capital and D debt
$\varepsilon = (R^N - r)K$
$R = R^N - \frac{\Delta p^K}{p^K}$ = the real rate of return.

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 $\bar{\varepsilon}$ which control 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 $\bar{S}/L$ (see Figure 2), conditional on a set of expectations on (w, p) 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.

The effective rate of return

The above definitions represent standard measurement technique, using accumulated investments as the capital measure. This capital, however, is also valued in the market place by potential new owners. This valuation, hence, depends (1) on the existence or nature (effectiveness) of such markets, and (2) on the predictions market experts make on the future profit generation potential of firms.

Equation (4) can easily be reformulated as[9]:

$$R^{EN} = \frac{\Delta E}{E} + \theta$$
$$\theta = \frac{DIV}{E}. \tag{6}$$

The corresponding market-based rate of return measure, the effective rate of return (ER), simply replaces the accumulated investment net of debt (E = K–D) with the corresponding market evaluation of E, i.e., with M. Rather than computing asset values, assuming a depreciation rate, this measure assumes the asset value, or takes it from the market, and instead endogenously determines its rate of depreciation. The accounting formulae are identical. Hence,

$$ER = \frac{\Delta ME}{ME} + \hat{\theta},$$

where

$$\hat{\theta} = \frac{DIV}{ME}.$$

In the long term

$$\frac{\Delta E}{E} + \theta$$

and

$$\frac{\Delta ME}{ME} + \hat{\theta}$$

[9] Proof: Use the definition of investment

$$INV \equiv \Delta K - \bar{K} \cdot \Delta p + \rho K$$

and insert in cash flow identity:

$$MS - rK - DIV + \Delta D = INV.$$

After some reshuffling of terms, using definitions (4) and (4A), (6) is obtained. For details of the proof see E (1976a), p. 284 ff, or on separable Additive Targeting Theme in E (1985a), p. 110 ff.

should be the same. This has not been the case, not even for manufacturing as a whole (see Figure 9A). The stock market exhibits a strong tendency to undervalue the assets of firms, compared to incurred costs for accumulating them. This makes take-over action profitable, in the sense that the same capital value can sometimes be acquired cheaper as "used" capital equipment than as new equipment. This undervaluation appears most pronounced when it comes to soft, not activated capital like technical competence and market knowledge (see Section 4.4 and E 1990b). Taxes apparently play a role behind this undervaluation as does asymmetric information, in the sense that outsiders know less about the value of the firm than do insiders.

The interesting question is how to interpret the rate of return differences:

$ER - r$

$ER - R^N$

as they develop over time and corresponding wealth difference

$ME - E$.

$ME/E = q$, or Tobin's q-value, that is the value the market puts on E compared to its accrual value from the cost side.

The convention in finance theory has become to make (ER–r) a measure of the specific risk, or the risk premium associated with investments in the firm in question. For all industry, the aggregate difference, hence, becomes the premium that investors charge on moving out of a "riskfree" reference investment, like nominal interest carrying securities, into stock.

Production frontier

Like real firms do in their internal accounting systems (see E 1976a) the MOSES model does not use explicit capital stock measures to represent the production system. The reason is the unstable identity of any capital stock measure discussed in Section 4.4. The critical "capital stock variable" in the "production function" of each firm is its potential capacity to produce that determines the shape of the production frontier in Figure 2. The information needed to estimate that curve includes the prior assumption of functional form the assumed intersection with the origin (see *MOSES Code*, IUI 1989, Ch. I, Sec. 4, pp. 31 ff.), and answers to a set of ***capacity utilization*** questions (see questions in Sec. 3f in Albrecht's Chapter III in this volume). Using assumed or estimated marginal capital output and labor productivity ratios this frontier then can be re-estimated every quarter in the model. This procedure seemingly avoids using capital stock measures but does it, nevertheless, through the capital output and labor productivity measures. Capital stocks for production purposes can, so to speak, be derived every quarter for all other data generated in the model. This method, however, mimics the ways firms themselves compute their production capacity frontiers, avoiding the direct use of capital stock measures (see E 1976a).

3.2 Long-Term Objective Function (Investment Selection)

The objective function guiding long-term investment behavior selects 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.

$$r_i = F\,(r,\phi)$$

$$\frac{\partial F}{\partial \phi} > 0.$$

The $\bar{\varepsilon}$ of an individual firm is generated through technical improvements (innovations) 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" $\bar{\varepsilon} = 0$ across the market. As a rule this state is never achieved (see Figures 3). Unused capacity may make the firm less inclined to expand capacity, even though long-term investment is expected to yield $\bar{\varepsilon} > 0$. More important, however, is the fact that realized investment comes much later than the current quarter and that firms continue to make mistakes.

3.3 How Do Firms Upgrade Their Performance—Four Kinds of Boundedly Rational Behavior

Innovation is largely a learning activity, spiced with an element of combinatorial creativity. The main learning activity, and cost in the experimentally organized economy and in the MOSES model occur *through the learning from and the absorption* of (respectively) business mistakes. This has strong implications for the state of information and equilibrium properties of the economy, and hence for the appropriate database design.

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.

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 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 (see E 1985a, pp. 102ff, 280 ff).

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, interest rates and profits) and transform them into expectations. These transformations include correction learning and risk attitudes acquired from past mistakes. The self-coordinating properties of the entire company depend significantly on the specification of these intelligence gathering and expectations functions (see E 1977, 1985a, p. 154, 1991c).

There is, however, also the theoretical problem of whether the representation of the underlying fundamentals of the economy—its "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.

III *Competitive selection (the filter)*

The Salter (1960) 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 above), and through interior process efficiency (item IV below) survive in the long run.

IV *Learning about interior firm capacities*[10]

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

The MIP-targeting principle rests on four facts of life in all business organizations (E 1976a, 1977, 1985a, pp. 107ff, 1991c):

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

[10] A complete description of the firm from a database point of view requires that the character and estimation of the production frontier are presented. This is also where some of the most interesting features of the database design is to be found. See Albrecht's Chapter III in this volume, E (1978a, 1985a), *MOSES Code*, IUI 1989 (pp. 48 ff), and Figures 4 and 5.

(2) The experience that if targets are set *below* what is maximum possible, actual performance will be lowered to targets.

(3) 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"! Another reasonable method is to document superior performance of a competitor. "They can do it. Then we should also be able to!"

(4) 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. MIP-targeting establishes an acceptable profit plan to constrain and force efficiency on production planning.

MIP-targeting is illustrated in Figure 2. It builds on the assumption of top management 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, not 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 an upward transfer of 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. The internal statistical (information) system of the firm supports that objective, and the MOSES firm model imitates this learning process. If new technology stops being created and introduced, targeting will eventually push the firm onto the feasibility (production) frontier.

Aggregation in MOSES

From above the MOSES model appears as an eleven-sector Leontief-

Keynesian sector model with certain dynamic features (see *MOSES Code*, IUI 1989, pp. 15 ff.). The standard assumptions of aggregation needed for such a sector model are, however, not satisfied in the MOSES market environment. Hence, one would not expect a standard macro model to perform well over a long time when estimated on simulated MOSES macrodata, without constant re-estimation of parameters (see Antonov and Trofimov 1991). The idea with MOSES is to make macro modeling unnecessary by moving the level of aggregation down to a natural, deciding and behaving entity, the firm or the division. Aggregation is endogenized through the dynamics of markets of the MOSES model economy. To the extent that market competition does not force recombination of interior units of the firm or the division that we model, we have no problem. This is, however, not true, and decision units constantly change character, making internal institutional structures endogenous. This internal institutional change is not modeled in MOSES. We aggregate over existing firms and divisions, including new entrants and accounting explicitly for exits.

Since the manufacturing firms reside in one of the four MOSES manufacturing sectors (markets) that in turn are sectors in an eleven-sector Leontief–Keynesian sector model with demand feedback, aggregation has to be exact at the initial state beginning of 1982. After that aggregate ex post data for the four manufacturing markets (sectors) are computed very much as is done by Central Bureaus of Statistics, by constructing various quantity indexes.

4 The MOSES Database

The database requirements of the MOSES micro simulation model are sizable. This section summarizes the principal composition of the data sets that have been compiled in the context of the MOSES project. The fundamental idea of micro-macro modeling is to systematize *the wealth of microdata that exists and to integrate them through the model for improved understanding of macro behavior. Hence, aggregation is made dynamically explicit through markets.*

MOSES is a dynamic micro-to-macro model that provides a satisfactory theoretical base for a consistent micro-to-macro database design. This is especially so when it comes to integrating production and financial data. The manufacturing sector is currently (the 1982 database) populated by 250 individual, real firms or divisions that set prices and wages, plan output, sell goods at home and abroad, recruit people and borrow money to invest and increase capacity. Firms act within the restrictions of rate of return targets that depend on the interest rate (see Section 3 above), demand from households and competition from all actors in the market. In making their plans each firm attempts to predict the behavior of other market agents, using statistical methods (intelligence gathering and expectations forming). They always fail more or less. Hence, the realization of plans in the market confrontation, where all ex ante/ex post inconsistencies are sorted out, provides the real short-term dynamics of price setting and quantity adjustment of the MOSES model. We have found that the initial state representation of the model matters importantly for dynamic simulation results. Internal database quality (consistency) is imperative for avoiding peculiar macro instabilities in simulations due to statistical errors. The internal information systems of firms are, however, also afflicted with the same kind of quality problems. Hence, adjusting database information to achieve consistency might mean that errors that in fact affect firm decisions are removed, as well as the corresponding effects on MOSES simulations.

4.1 Sample Strategy and Sample Design

This is not the first time micro panel data are being collected. Most such surveys, however, have been smaller in scope, or consisted in systematic reorganization of existing statistical files. Besides that, firm panel data, until very recently, has been a no-man's land. Most work has been done on panels of individuals or households, being inspired by Orcutt's early micro simulation work. The pair Ruggles and Ruggles at Yale University have pursued the latter ambition rigorously over many years, and it is sad that the economics profession has not put a higher value on such very long-term scientific efforts than it has, to the detriment of scientific progress. Many of the problems associated with creating consistent data sets from existing statistical files (registers) have been discussed also by Postner (1986, 1988). On this score it might be said here that one of the most well prepared household panels was designed partly as a complement to the MOSES modeling project, one idea being eventually to complement MOSES with a micro household sector (see

Eliasson and Klevmarken 1981, E 1982a, Klevmarken 1986). The project was designed comprehensively and ambitiously from the beginning, rather than sequentially as the MOSES database work, a strategy that was the best but proved less practical, due to the large costs. There is, of course, a huge sample design problem to consider in this context. While the complexity of the MOSES model prevents the use of standard simultaneous estimation techniques (we "calibrate"; see Eliasson and Olavi 1978, Klevmarken 1978, E 1985a, Ch. VIII, Brownstone 1983, Taymaz 1991, Ch. 3), the size of the database also prevents the use of recognized sampling techniques. Also practical and cost considerations have made it necessary to compromise. A modeling project of this kind, in fact, should not start too ambitiously. It should *grow ambitious*. Hence, database work builds on combining data from samples of firms, full coverage surveys, and the use of existing register data. Depending on country and model the mixes of these components will vary.

Cross-sectional characteristics have to be right, initially

First of all, in any economy some individual firms disproportionately influence the entire macro economy. It is, hence, desirable to have all large and/or particularly influential firms in the sample. This is possible for small countries like Sweden, if you have good contacts with firms, but difficult in a large economy, like the U.S. economy. The problem is that one *cannot assume* a priori that differently selected clusters of small groups of large firms will not create significantly different developments of the macro economy. This would have to be assumed if a MOSES-type economy were to be applied to the U.S. economy, where also large firms have to be sampled. The MOSES database for Sweden covers all large firms every year through the planning survey, even though we do not use the whole sample in the current initialization (see below).

Desirable and undesirable inconsistencies

The planning survey is the core firm data input, tapping firm internal data bases directly for critical financial and real variables, that are as internally consistent as the firm's own internal data sets.

So far small firms have been "synthetically created" through a technique whereby the residual firm is "cracked" into a number of firms such that the consolidated aggregate of real and synthetic firms agrees with the corresponding National accounts' aggregate of the whole industry (Albrecht and Lindberg 1989). A random sample of small firms, providing planning survey information, will soon be available for MOSES experiments. The problem we are trying to solve is not that individual firms may create significant and undesirable macro effects, at least not in the time perspectives we consider, but that the *distributional characteristics* across the whole initial state have to be reasonably right. Distributional characteristics matter significantly for macro behavior, as we have learned. As realism in this respect has been increasing, through an increase in the number of real firms, the model macro economy has also begun to exhibit increasingly more realistic behavior.

The integration of survey data with register data causes additional problems of consistency that have been discussed elsewhere in this chapter. The ex ante decision position of a firm is always errant to some extent, but we don't want the natural errors that generate dynamics in the MOSES economy to be influenced by bad data, only the bad data that firms themselves use.

The only way of avoiding this important problem is to collect data on the internal economy of the firms directly from the firms. To do that from the start would, however, not have been recommendable. At the beginning of this project (in 1975) no research pertaining to this problem, except my own study (E 1976a) on internal business information and planning systems, existed. My own study was excellent guidance to begin with, but the looks of an appropriately designed, full-scale firm database we have only recently understood. We have also learned that it is perfectly O.K. to collect data on the internal economy of a firm from different, often inconsistent sources within the firm, since this is exactly what is done within internal firm information systems. The problem is that one has to know how these systems are designed, built and maintained (E 1990e). Even though we are currently developing a method of asking for both financial and production data at the same time (see Braunerhjelm's Chapter IV in this volume), this is not the correct method—since this is not the way firm management gathers their own internal data centrally—albeit a convenient method. The analysis of these data is therefore understood only by those who have an academic experience from both business administration and economic theory, and indeed by those who have also an experience from actual firm management.

Splicing of firm data from different sources

For the time being, data on the production system of firms and divisions originate in the units' own cost accounts and assessments of executive staff of the same unit. Large firms are represented by several such units. For the very large firms (like Volvo or Electrolux) several units, notably non-manufacturing units, and foreign units are lacking. We do, however, possess separate information on foreign units and also data on the entire global enterprise. The problem that we have in creating viable domestic firm units is to allocate the assets of the total enterprise on its constituent divisions, having only partial data on capital, e.g. on inventories (see Albrecht's Chapter III in this volume), and machine capital and buildings (replacement valuation) for some years. This very complication means that a complete and consistent micro-to-macro database only exists for the base years 1976 and 1982, while the panel over all years refers to the enterprise as a whole (financially defined) and to the planning survey units.

4.2 General Comments on the Qualities of Microdata

The key problem of implementation has been to define a unit (of measurement) that *operates reasonably autonomously* as a price and quantity setting decision unit in all the three markets of the model—the product, labor, and capital markets. There is, however, also the practical problem of not taking measurements beyond the level of disaggregation where they can be carried out with reasonable precision; and precision is needed as we have learned. The strategic decision taken was to use the statistical information system of the decision unit itself, designed on the format of the decision maker (E 1976a); a decision process that we also try to mimic in the firm model. This means that real errors, inconsistencies and biases in measurements that enter firm decisions should also be reflected in micro behavior.

The unit chosen was the small *firm* or a *division* of the large firm. Production decisions are taken at the division level. The division maintains a statistical information system related to production decisions and control, and reports systematically upwards to the group or firm level (corporate headquarters, CHQ) in financial terms. The relationships between CHQ and group and division levels are becoming increasingly decentralized, making it increasingly difficult to collect operations data at (or even ask for via) CHQ. This in itself is a matter of firm modeling concern. It directly affects the data base design.

Using the MOSES model as a database organizer

The statistical system of the MOSES economy can best be presented (briefly) as follows. MOSES is a complete macro system. When seen from above it appears as an 11-sector Leontief-Keynesian growth model with dynamic demand feedback through investment and consumption. A novel feature is price feedback through explicit dynamic markets. To achieve that the manufacturing sector of the macro model has been replaced by individual firms that *interact with one another* in the three markets (for products, labor and capital), under the constraint of the rest of the economy, and with a "steady state" price-taking assumption for the international market environment.

Each manufacturing firm operates in one of four markets that correspond to four industries; *raw materials processing*, *intermediate and semi-manufactured goods production*, *durable goods manufacturing*, and the manufacture of *consumer nondurables*. Hence, the accounts of the macro system have been reclassified to reflect market categories. The OECD *end use classification code* has been used. This has required a radical reorganization of all macro accounts, including the input/output table (see Ahlström 1978 and Nordström's Chapter V in this volume). The market/product reorganization of macro accounts has uncovered a host of related definitional problems, many of which still remain to be attended to. First of all, one completely misses both the importance and the dynamics of manufacturing industry when viewing it through the goods processing taxonomy of the standard statistical accounts of the national economy (E 1990a).

Each industry consists of a number of firms, some of which are real and some of which are synthetic. Together, the synthetic firms in each industry make up the differences between the real firms and the aggregates of the four industries, or rather market totals in the national accounts. The real firms of the 1982 data set of the planning survey cover more than half of manufacturing employment and production in the base year (see further Albrecht's Chapter III in this volume). The normal runs of the model, however, use only the 225 real and synthetic firms that inhabit the manufacturing sector, 154 of which are real firms, or divisions. These firms cover only some 30 percent of manufacturing employment (see Taymaz' Chapter II in this volume). The model is based on a *quarterly* time specification, corresponding to a common production planning mode.

The model runs on data from (essentially) three different sources; (1) a separate, annual survey carried out jointly by IUI and the Federation of Swedish Industries (in fact originally designed in 1975 to fit the model exactly, see Albrecht's Chapter III in this volume, E 1976b and Virin 1976), (2) financial data for the firms, and (3) a complete set of macro national accounts statistics. Complete GNP accounts are generated *by quarter* during model simulations.

The planning survey, as mentioned, covers a much larger part of manufacturing industry than the firms currently used to initiate the model in 1982. There are two problems that restrict the use of real firm data. First, a history of each firm is needed for inclusion in the MOSES data set. Firms drop out of surveys and it is difficult to maintain a panel of a large number of firms for five consecutive years. Second, the planning survey data have to be complemented by financial data (see Taymaz' Chapter II in this volume). The consolidation of two data sets for each firm currently requires a major effort. This problem restricts the scope of the sample of firms used in initial data sets. It can be overcome by more prior database work, or by redesigning the planning survey, to include also financial data which has to some extent been done in some recent surveys (see Braunerhjelm 1991). Braunerhjelm (in Chapter IV in this volume) presents a design of a conversion matrix that requires data that *are* normally available at CHQ and that can be used to consolidate division, planning survey production data, with data on foreign subsidiary operations and corporate financial data. The possibilities of doing this depend on the possibilities of collecting a common set of data from the three data sets (financial, operational, foreign) from the same source within the firm. As mentioned above, the increased decentralization of firms, relying increasingly on internal markets for coordination, means that the data needed for consolidation become less and less easily available at CHQ. The conversion matrix, however, has been designed to require exactly the data CHQ needs to coordinate and control its own divisional activity (also see E 1990e). The automated initialization procedure, finally, makes it easy to expand the number of firms as more data are being readied. New entry, furthermore, if realistically modeled, rapidly increases the number of firms of a simulation (see Taymaz' Chapter VI for more on model sensitivity to number of firms).

There is, of course, a practical limit to the number of firms that can be both accommodated in model runs and constantly maintained on a panel format in the database. This means that the firm population residing in the MOSES model is dominated by divisions of the large firms (operating as individual decision makers) and some medium-sized firms, a few small firms, and some large, synthetic residual firms that make up the difference to the national accounts data for each market.

The general problem of inconsistency

A frustrating problem, discovered late, when the full-scale model had just been implemented, was the "general inconsistency" between the consolidated firm accounts and corresponding accounts of the National accounts. The sensitivity to initial conditions of a dynamic model of the MOSES kind means that the macro model economy reacts strongly to initial inconsistencies in the databases (errors of measurement) as if they were "real" ex ante inconsistencies created by the ways firms "interpret" information on their competitors. The macroeconomic consequences of such errors often accumulate for years (path dependency), creating now and then phases of seemingly "chaotic" behavior.

At this stage we had to make a decision: to rely on the high quality micro database we had and give up using well-known national accounts data as a benchmark to establish the statistical size of the entire economy; or to modify microdata to achieve initial state consistency. We preferred the first alternative, but nevertheless used the second. The National accounts' presentation of the economy is the officially authorized statistical representation, and we thought it wise—for the time being—to stay with it.

The problems of consistency are not trivial and relate to the main problem of informational efficiency of the economy discussed earlier. It has been thoroughly discussed by the pioneers in the field like Postner (1986, 1988), Ruggles (1987), Ruggles and Ruggles (1986, 1987). The deep insight (see, e.g., Schelling 1958) relating to the informational assumptions of economic modeling is that complete consistency is not feasible and that good national accounting systems should not aim for consistency, but rather "keep track of its inconsistencies" (op. cit., p. 329). In my interpretation (see above), this means that a full information equilibrium is a non-existent state.

On the overall design of the micro-macro database

The MOSES database task can now be summarized as follows. There are four different types of data sets involved. The *first* set concerns the *firms.* We need a complete representation of (a) the financial decision structure of the firm, of (b) the production structure of its constituent parts (divisions), and of (c) a statistical observation of where exactly the financial and real (production) entities cross the Swedish border. We furthermore (*second*) need a macro representation of the Swedish economy organized in such a way as to be an exact consolidation (aggregation) of all the firms in the data set, including one or more artificial firms, making up the difference between the real data set and the national economy. The micro-macro link then depends very much upon how we define the total economy.

Since the choice will be the official national accounts definition of the Swedish economy, the firm data sets and the variables and sectors measured will have to relate to an inappropriate statistical design. Hence, a *third* data set is needed to achieve a relevant representation of the production system of the economy, notably total value added generated in goods and associated service production up to their final end uses. This restructured definition of manufacturing which includes a significant upstream and downstream private service production has been planned to be included, but is not yet part of the MOSES model design.

The *fourth* data set is the rest which includes the household sector (the HUS-project) and an analytically relevant representation of the public sector, notably its provision of *infrastructure* and *welfare* services. This data set is to some extent available, but not yet part of the MOSES model design.

4.3 The Necessity to Redefine the Concept of Manufacturing

Manufacturing firms are increasingly operating simultaneously across both the private service and manufacturing sector accounts, and within several subsectors. Their statistical denominations change constantly as a consequence of the relative efficiency of operating various activities within the firm, relative to hiring the services in the market. We have already shown that the manufacturing firm itself essentially is a private service producer. Mergers, acquisitions and divestments add to complications, and while a firm may carry the same name and a reasonably consistent set of financial accounts for 50 to 100 years,[11] its interior life is constantly being revolutionized, quite often to the extent that the firm fails (E 1980b). Maintaining a set of panel financial life stories for divisions, hence, is very difficult, and for firms as a whole we get stranded with the group that happens to have survived. The only way of controlling for such *sample selection bias* is to use a model of the MOSES kind to generate the whole sample.

When all horizontal and vertical resource use, associated with making the goods of the manufacturing sector and distributing them to their final uses in the household sector in Sweden or abroad (including associated services and qualities), has been accumulated, the traditional manufacturing sector (3000 in the National accounts' code), making up almost 25 percent of GNP today, has been boosted to a "production engine" that (including related services) generated almost half (48.7 percent) of GNP in 1985. While manufacturing as traditionally measured, and especially if you include basic industries (1000+2000), has been steadily decreasing since 1950 (see Table 2), the extended manufacturing sector has in fact increased its GNP contribution slightly since 1950, and significantly if you add in foreign manufacturing production (see Table 4). Not only external, manufacturing related services increase. International 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 knowledge-intensive service production.

[11] or for about 700 years. See Figure 1.

4.4 Asset Structure of Firms

Even though not yet explicit in the model design, the rate of return requirements of a MOSES firm corresponds to a portfolio management decision model. Hence, the "old fashioned"[12] flow structure of the M–M firm model has a matching set of asset accounts that are generated in the model, but that—except for the influence of the debt/equity ratio on the local interest rate—exercise no additional influence on firm decisions.

How to look at the experimentally organized economy through equilibrium glasses

Theoretically, and practically there is nothing irrational in this procedure. Firms, in fact, avoid using asset measures in their internal accounting, the main reason being that assets are never well defined and, hence, too easy to manipulate (E 1976a, pp. 156 ff). Asset measures are reasonably well defined in static equilibrium, but in static equilibrium your flow model is a reliable approximation (or image) of your asset model. If you reason and compute ex ante as if you have placed your firm in a future static equilibrium setting, then you can use a flow model, or a portfolio model. They are mirror images of one another. And firms do. As I have argued above (and learned from empirical studies; E 1990e) a firm decision model must be an equilibrium model capable of coming up with single-valued solutions (decisions). Firms achieve that by assuming static expectations on all prices, including the interest rate, to be able to compute. The raison d'être for the M–M model of firm behavior, hence, is compatible both with actual firm behavior and a particular interpretation of the classical model (see E 1990e). In order to form a consistent view of its decision problem, facing an experimentally organized

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[12] The firm model shares significant characteristics with the old financial planning model, and it should do, since this *is* the way firms structure their internal decision processes as reflected in their internal information systems (E 1976a). Does this mean that firms behave irrationally in terms of modern finance theory? Not at all. For the reader updated on modern, post Modigliani–Miller–Markowitz–Sharpe modeling, significant market imperfections are shown to require the use of simple signaling devices, of the rules of thumb type, described in the early corporate finance literature. Under such circumstances the restrictions on the optimizing processes of the firms become more important than the optimizing itself. The new, now "rationally founded" models look very similar to the old financial models. See Miller (1988) or Harris and Raviv (1990, 1991).

economy, the firm has to simplify through narrowing down its mind set. A most natural such simplification is static expectations which allow the firm to compute in accordance with standard financial formulae. Since firm management can revise its position whenever it wants to, the error committed is only the irreversible part of the decision following from the position taken just then, which is normally small. One could then say that constantly making temporary static equilibrium decisions that are constantly being revised is a rational method of decision making which is also perfectly compatible with the design and use of the internal information systems that guide the firms through an experimentally organized and basically unpredictable market environment (E 1990e). Hence, asset accounts are not needed for internal control. The flow accounts have an exact ex ante mapping into the asset accounts, and under static expectations the rankings of the ex ante rates of return correspond to the rankings of present value computations. The theory or model of the firm, however, then also has to explain *how firms revise their decisions*, and the theory or model of the entire economy has to be explicit about *how* all revisions of plans upon revised ex ante perceptions eventually realize themselves into ex post behavior. This is exactly what the MOSES model does.

How to value assets

The valuation of assets, however, places the outside investigator in an uncomfortable position. His problem often requires a stock measure. Capital can be exactly measured from the investment cost side under the exogenous assumption of a rate of economic depreciation of its value from use or time. This is the standard measurement procedure to obtain capital stock estimates for production function analysis, capital stock measures which are assumed to be independent of the economic decisions affecting production. The capital stock so obtained, hence, should in principle be independent of the rate of return to which the assets have contributed.

The second approach would be to use outside expert evaluations, like the stock market evaluation. This measure, however, is dependent on the future profits expected to be generated by the application of the same capital stock, and the competence of market experts to make reliable such predictions (i.e., the efficiency of the market). In the context of the experimental organization of the MOSES model economy we know for sure (see E 1991c) that the stock market experts will be unable to produce unbiased estimates of these capital values. Such estimates will always be imperfect measures, however well informed the market experts are, since the state of full information is not defined.

The stock market capital measure will inform the outsider of the imperfect value that market experts put on assets. It carries no information on the production value capacity of the firm. On the other side, the cost accrual measure tells about the resources applied to hold the capital stock, at prevailing imperfect market prices. In principle, this measure should indicate the production potential at given market prices.

If markets were perfect and in static equilibrium the two measures would coincide. Hence, as the two measures bracket the "true" capital stock one desires to know. Measuring both, hence, should be more informative than measuring only one. And if one could design a model to stimulate more or less perfect markets, one could obtain better measures through narrowing the brackets. The crux is theoretical. If arbitrage costs associated with moving closer to equilibrium are large, such arbitrage costs would have to be part of the determinants of the "true" equilibrium capital stock. If such costs escalate unlimitedly, as you move closer, the equilibrium becomes unattainable. This appears to be the case in MOSES (E 1985a, Ch. VII, E 1991c).

The origin of invisible assets

An even more serious problem is the absence of certain capital and investment categories in the accounts of firms, making it difficult for firms to identify the sources of their profits. Both firms and government central bureaus of statistics use outmoded, statistical classification systems (see below). Statistical information systems are part of the internal information systems of firms imposed as a prior information or presentation filter that biases the data. They are as difficult to change as changing a language of a nation. These problems belong to the theory of database design. The problem is that in both cases lacking, or biased, information influences the decisions of firms or policy makers.

Also this "problem" has a past in the history of economic doctrines, notably capital theory and the "problem" of the absence of the diminishing returns that the convexity assumption of economic theory requires. I won't discuss (here at least) the problem of whether capital really exists as a measure distinct from the profits generated, even though this is a highly relevant database problem. The problem that, nevertheless, still remains to be explained is why total value added is systematically larger than recorded factor payments, after imputing a market interest rate to all measured assets, i.e., why on the average, and in the long run (see Figure 9B) $\bar{\varepsilon} > 0$ in eq. (3). This can be shown to correspond to the presence of increasing returns (see E 1990c). Knight (1944) suggested that such non-decreasing returns had to do with the presence of unrecorded knowledge. McKenzie (1959) addressed the problem of $\bar{\varepsilon} > 0$ directly, suggesting that it depended on the presence of knowledge capital, its rents being properly measured but the corresponding capital not being accounted for. To get the full theoretical picture, however, we have to remember that the $\bar{\varepsilon}$ is what is called the risk premium in modern finance theory, implying that whatever is not accounted for by factor payments, or imputed interest rates, is the residual payment to owners for taking on the financial risk, as it shows up ex post in firm accounts.[13]

All this considered, we have found it necessary to design a new database categorization to model M–M behavior relevantly. Since this database book not only accounts for existing inputs and outputs of the model but also for possible future improvements of the model, and the corresponding database needs, some of the work done will be documented here.

Capital can be measured in many ways, each method relating to a particular purpose. The value of capital always has something to do with (1) the present value of expected future profits. This is a wealth measure, and wealth considerations always creep into direct measurements, like insurance values and answers to direct questions, as in Table 5A. Indirectly the stock market puts a value to the capital (assets) of a registered firm every day. This measure, however, is also influenced by the competence of stock market experts to predict future firm profits and the financial environment of the firm. This expertise appears to be very limited, indeed (see E 1990b). Capital and production theorists, however, need a *technically defined capital measure* to put into their production functions. The distinction between the wealth-

[13] i.e. $\bar{\varepsilon}$ = RR–IR in Figure 9B. Personally, I have difficulties accepting that the average risk of investing in a representative basket of manufacturing stocks should be on the average 3 to 4 percent (average 1951–88) higher than the interest on government bonds.

oriented (profit-based) and technically defined capital measure has been the source of controversy for years, and it is safe to say today that the distinction cannot be principally or theoretically drawn, only arbitrarily, also making capital stock measurements for production function analysis an arbitrary affair. That is O.K. if one knows what one is doing. There are at least two ways to proceed. (2) Stock measures are computed through corrections and adjustments of book data from the official balance sheets. Such measures are, of course, very close to wealth measures. The third (3) method is to cumulate investment data, making assumptions about depreciation rates. This method has been used to get Table 6A, and the first column for 1985 in Table 5A. Again, profit considerations unavoidably creep into the depreciation assumptions, a circumstance that reveals, that the shift factor in production function analysis is dependent on changes in "excess returns" to measured capital or $\bar{\varepsilon}$ (see E 1987, pp. 90f, 1990c, 1991e). The economic content of total factor productivity growth also reveals itself when we use the MOSES model to decompose the productivity measure (see Section 6 below, E 1991e and Carlsson 1991). There is nothing principally different in applying these methods to compute hardware and software capital stocks.

How to make invisible assets visible

For future MOSES work we need a revised balance sheet that accounts also for the intangible capital that is not activated, but that can be activated (see E 1990a, p. 89) according to Table 3. Data to complete this table have been collected in recent surveys. At this point I have two comments to Table 3. First of all, if positive assets under B exist they will generate extra profits in the long run, that will appear, in traditionally designed books, *as if* generated by visible capital under B. Even if no extra profits ($\varepsilon \leq 0$) are recorded it may, nevertheless, be the case that B-assets exist and generate large profits, only that visible capital is employed in loss operations. There are numerous illustrations of this "aggregation error" from firms that are clearly "visible" in the sense that old industries have developed profitable sidelines with small visible assets that cover the losses of old, hardware production.

Second, some may, nevertheless, argue that intangibles are intrinsically unmeasurable. I agree to the extent that tacit knowledge cannot, by definition, be directly measured, even though it generates profits, and that– for that reason – it can neither be properly evaluated by "market experts" nor traded in "perfect" markets. This creates a deficient "lemons" market in corporate values that hampers manufacturing performance (E 1990b). The bulk of "invisible" assets, however, still consists of fairly "routine" investments in activities that have as well defined reproduction values as machinery and buildings. They share with the "visible capital" in Table 3 the general problems associated with measuring all kinds of capital. If we still do, we will find that these "invisible assets" are sizable compared to "visible assets" (see Table 5A).

4.5 *Sources of Data* [14]

The MOSES database covers systematically the most important business activities. To be consistent with the corresponding macro data, they have been brought together from the base years on a modified sector design (see Ahlström 1978 and Nordström, Chapter V in this volume). The design of the micro database has been formatted on the MOSES model. As has been mentioned, the planning survey was designed to suit the exact needs of the MOSES model. This survey has been carried out annually since 1975. It also provides useful information for a variety of other research activities (see Albrecht 1978a,b, 1979 and Albrecht's Chapter III in this volume).

The complete database, however, requires that several databases be merged. The following databases make up almost a complete listing of sources:

1. *Financial data for business group (global operations); panel beginning in 1965.*
   Source: Internal data from corporate accounts, by year (see Taymaz' Chapter II).

2. *Division data, production process oriented; panel beginning in 1974.*
   Source: Separate surveys (the "planning surveys") carried out annually by the Federation of Swedish Industries and IUI on all large firms, by

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[14] The data to be presented have been selected and organized to give an idea of the content of the MOSES database. Jörgen Nilson has done most of this work. He is also responsible at the institute for continued updating and access to the MOSES database.

division or establishment (see Albrecht's Chapter III).

3. Random sample of *small firms and subcontractors* using the same questions as the planning survey. This survey was first carried out for 1986, then for 1988 and again for 1989. This time the *firm* was the unit of observation. This survey has partly served the purpose to help develop a questioning technique to collect financial and production data under §§1 and 2 above simultaneously (see above and Braunerhjelm's Chapter IV).

4. *Foreign subsidiary operations.* Three special surveys by IUI covering all subsidiary operations of Swedish companies 1965, 1970, 1974, 1978 and 1986. A new survey is currently being planned for the year 1990 (see Braunerhjelm's Chapter IV).

5. The *content of manufacturing production*, covering resource use according to Table 1B and Figure 8 but at a somewhat more aggregate level for the years 1982, 1985, 1988 and 1989.

6. A *modified planning survey* including *adjusted balance sheet data* of firms as well as planning survey information, covering large firms 1988 and small firms for the years 1988 and 1989 (see Braunerhjelm's Chapter IV).

7. A planning survey to *private service* producing firms, tested and planned for 1989, but so far not carried out (see Braunerhjelm's Chapter IV).

8. *Macro national accounts* (see Nordström's Chapter V).

9. *Historic firm data panel* to study long-term growth characteristics of firms. (First done for Atlas Copco, MoDo, Ericsson and Sandviken in Eliasson 1980b. Also see Jagrén 1988).

10. *Synthetic micro data set* (see Supplement I and Taymaz 1991, Sec. 3.4).

11. *Exogenous data*, notably historic data on technical change at firm or division level. See Carlsson (1981).

Some of these data sets are presented in the following chapters. Supplement II to this chapter gives a complete list of all data sets plus references to sources.

The planning survey as a whole is not a random sample. Data are collected on all large manufacturing divisions (establishments) in Sweden of all firms with more than 200 employees. This means a coverage of some 60 percent of Swedish domestic manufacturing employment. We use a subsample of the planning survey sample as a base point for the other databases. Divisions and foreign subsidiaries can be grouped together to fit the financial groups under 1. Coverage on foreign subsidiary operations (under 3) is 100 percent for the years in question. For practically all large firms a significant "residual" up to the total remains when our units have been consolidated. Some divisions are simply missing, or they are engaged in non-manufacturing activities (wholesale distribution of other products, commercial cleaning (Electrolux, until recently), banking, data processing etc.). Our procedure has then been to define a residual up to the corporate group level. This consolidation work is still in progress, and will be documented later.

To create life histories of individual divisions is difficult. The response rate is reasonably high—consistently in the neighborhood of 85–90 percent—and particularly so if we consider the extent of questioning and the confidential nature of several questions.[15] (For details, see Albrecht's Chapter III in this volume.) Non-response, however, varies from year to year, and the life history sample, consequently, is much smaller than the number of responding firms of one particular year. The current life history sample consists of some 100 divisions and is used to initiate MOSES simulations beginning in 1976 and in 1982. The MOSES model, however, has been designed to avoid being dependent on this particular problem. Besides the initial state description which is not very demanding, only four historic (5 years) variables are needed; *prices* (for the market), *sales*, *wage costs*, and *profit margins*. These data are fairly easy to maintain for a rather large sample on a panel basis.

[15] There are two reasons for the high response rate, the most important reason probably being the good contacts with the firms that IUI entertains together with the Federation of Swedish Industries. However, we also believe that our database idea, to ask questions on the format of the internal statistical systems of firms, matters significantly for the high response rate. The questioning reveals that we understand what the firms are doing and use their own internal information for (E 1976a, 1984a, 1990e).

The problem of sample representativity in MOSES analysis is handled in what we call the initialization process. Each division is placed in one of the four manufacturing final product markets; (1) *raw materials*, (2) *intermediate products*, (3) *durable goods* for manufacturing investment as well as household durables, and (4) *non-durable household consumption goods.* Consistent aggregation up to the levels of official national accounts is imposed. A residual firm (division) is computed for each of the four markets. To achieve this consistency through all levels of aggregation has been no minor task. The aggregate national accounts data have been redefined to fit the "market format" and "massaged" significantly to fit together at the macro level. Even so, the residual firm, or rather firms, since we cut the residual into several synthetic firms, in MOSES simulations tend to be afflicted with peculiar characteristics reflecting, we believe, the quality of official statistics (see further Albrecht and Lindberg 1989).

The MOSES model has, of course, not been a sufficient reason for carrying on a major micro-to-macro database activity like this one. We have also chosen not to make MOSES dependent on a full-scale database activity year after year. There are too many research institutes that have (almost) killed themselves on such ambitions. The full-scale format is, however, directly matched by the input and output formats of MOSES.

There have always been supplementary users of the MOSES database, especially the planning survey, which is currently a main information input in business cycle forecasting at the Federation of Swedish Industries. Current research at IUI, to a large extent, also leads a symbiotic life with the MOSES database. For a project to draw on the database it also has to chip in on complementing and updating the base and on carrying out estimation work on the model. Supplement II and the following chapters give more detail on the content of the MOSES firm/division database.

The macro database and the macro part of the model are not presented in this paper. The macro accounts, as mentioned, have been reclassified to fit the OECD end user classification. This has been done to make it possible to classify divisions or firms in *markets*—in a meaningful way—and to link their accounts systematically with the macro accounts. The input/output table has caused most trouble in this respect (see Ahlström 1978, Bergholm 1989). For details on the macro database, see Nordström's Chapter V in this volume. For information on how the micro units interact through markets with the rest of the economy, the non-manufacturing part, modeled as a traditional Leontief–Keynesian sector model, see E (1978a, 1985a), and *MOSES Code* (IUI 1989).

Part of the M–M modeling ambition has been, not only to capture the dynamics of the endogenous growth cycle but, also to study the nature of firm establishment, growth and exit. We have therefore carried on a historic firm panel database work (E 1980a, Jagrén 1988), and special studies on the new entry characteristics of markets (Granstrand 1986, Hanson 1986, 1989, E 1978a, pp. 52ff, 1991a). On this, earlier IUI studies have provided valuable information, notably du Rietz (1975, 1980).

A "synthetic database" from 1990 has been created in conjunction with the transfer of MOSES to PC. To make MOSES portable a deidentified micro dataset had to be created. This was done by calibrating the model on historical data (time-series and cross-sectional) from 1982 through 1990. The nonlinear nature and complexity of the MOSES model make "reverse-identification" impossible.[16] The so simulated firm and macro data sets will, hence, be made available for outside use. This synthetic database work will also be further extended (see Supplement I and Taymaz 1991, Sec. 3.4).

An equally important "database" task has been to establish consistent projections of *exogenous variables*, the most important being prices in foreign markets, assumed to be in a steady state (for an explanation, see E 1983, pp. 313ff and E 1991c), and projections on the performance characteristics of best practice, new technology, embodied in new investment. This amounts to an entirely separate empirical inquiry, where Bo Carlsson has been instrumental in loading MOSES with relevant assumptions (see Carlsson 1981, 1991, etc.). We expect to be able to do more on this within an ongoing project on new technology, factory automation and economic growth.

4.6 Cross Sectional Characteristics—the Salter Structures, Used to Represent Initial States

It is impossible both to explain and illustrate the MOSES micro-to-macro database in full detail, not even in a Database book. In the following sections I will put together a cocktail of tables and figures that convey an idea of the

[16] and for the same reasons prevent the external observers from learning the parameters of (decoding) the structural model. See E 1991a, and Antonov and Trofimov (1991).

content and size of the total MOSES database, beginning with an illustration of "firm dynamics", that can only be captured through micro-macro theory.

The MOSES model aggregates quantities through the dynamics of market pricing, and prices (price indexes) through the dynamics of quantity setting at the micro level. Expected market price dynamics, however, controls quantity setting in markets. Both sides are sequentially interdependent, even though there is no one-to-one mapping (duality) as in static equilibrium. I will here illustrate the dynamic properties of the most important of all prices, namely $\bar{\varepsilon}$, and relate $\bar{\varepsilon}$ to a variable of considerable, recent interest, namely productivity.

The most important initial state representations of the model are shown in Figures 3 and 4, exhibiting cross sectional distributions of returns over the interest rate (or $\bar{\varepsilon}$ in equation (3)) and labor productivities (or β in equation (5)). All the other data also "exist" in the initial state description, but $\bar{\varepsilon}$ is particularly important since it drives the investment process of the individual firm and defines profit margin targets (imposed through the capital market). β together with profit margin targets initiate MIP-targeting (see Figure 2) that determines the production plan. Together the shapes of the so-called Salter (1960) curves of $\bar{\varepsilon}$ and β set the standards of competition in the markets of the model. Initial states for many years are shown in the figures. We have already observed that preserved diversity of structure is vital for macro systems stability. Apparently the real Swedish manufacturing sector went through a precarious phase of "potential" macro instability in the midst of the 70s that we have reproduced in simulation experiments (E 1983, 1984a, 1991c. See also Figures 3 and 9). We have also learned over the years that reasonable consistency of internal firm data and micro-to-macro data is important for reasonable macro behavior of the model. The real world exhibits some inconsistency which is part of the characterization of the dynamics of the economy. But extreme inconsistencies usually signal a crisis situation and tend to affect macro behavior strongly. Hence, we have to be careful in getting a realistic design of the initial state measurements. Figure 4E shows that we have a problem. The labor productivity distributions of the raw planning survey data are significantly higher than the corresponding 1982 initial state of the MOSES model. The reason for this (discussed also in Section 4.2 above) is that, using the raw planning survey data, the residual firm making up the difference to the corresponding National accounts' data becomes an extreme and unrealistically low performer. We have therefore adjusted planning survey data to achieve a reasonable distribution and the adjustment had to be large.

4.7 *Cross Sectional Dynamics*

Firm dynamics arises in the intersection between financial and real markets. The pivoting variable is $\bar{\varepsilon}$ in equation (3) which controls the firm investment and production decisions, and is traded in the form of claims to future profits (wealth) in the stockmarket.

Internal firm dynamics

Figure 2 shows the internal firm production planning process. Figure 5A shows the consequences for the same firm for the years 1982, 1992, and 2002 in a simulation, the path of labor input/output combinations and the shifting of production frontiers, the boundary B in Figure 2. The vertical distance between actual position and the corresponding production frontier corresponds to the shaded area of unused capacity in Figure 4D which firms quantify in the planning survey.

The stability of profits

The expected rate of return over the interest rate influences investment and, hence, productivity. Expectations concern prices (see equations (4) and (5) and the text) and new technology associated with new investment. Many researchers have attempted to test the old Schumpeter (1942) hypothesis of continued concentration through the establishment of permanent monopoly positions in markets (Mueller 1977, 1985). There is a host of methodological problems associated with the testing of this hypothesis, notably the problem of sample selectivity. The large firms remaining in the market "at sample time" are those that have survived ex post, like Stora Kopparberg in Figure 1. To test for Schumpeter (1942), we would need a huge, historic panel, accounting also for the firms that have vanished, i.e. most firms (Jagrén 1988). Nobody has properly done that. A shortcut would be provided by using the MOSES model as a prior in sample design (the entry and exit features, see Supplement I) which would show, that out of a large initial sample there would always, after 50 to 100 years, be a small group appearing to exhibit great permanence of profits. However, even these long-term surviving large firms (see Figure 5B) experience turbulence, that now and then kills a few of them. The figure follows 42 large industrial groups in the MOSES Database over four five-year periods. Average $\bar{\varepsilon}$ for each firm for the period 1966–70 is related to the corresponding average $\bar{\varepsilon}$ for 1971–75, 1976–80 and 1981–85, respectively. The three scatters are drawn in the same figure, using different point characters. Regression lines have been computed for each scatter. A certain stability in the average individual firm $\bar{\varepsilon}$ exists between the first three five-year periods. The second and third periods were the crisis years of the 70s. All performance rates came down but relative positions were maintained. During the last period, however, a new set of firms came out as winners and broke the ranking of the past. The oil crisis has dramatically changed market conditions for the large Swedish firms. During the years 1976–80 new market conditions established themselves. These new conditions, have only marginally changed the product and production orientation of the firms, only their price structure. Three, once very large firms, however, went out of business and are not part of the sample. We did not have time to do the same computation for 1986–89, but I would expect part of the early correlation to have been restored, since several firms have successfully reorganized themselves internally, and old relative prices have partly returned. This comparison would also require the removal of some failing or acquired firms, reinforcing the false picture of "stable" profit rates.

Productivity and the rate of return

Labor productivity is essentially a price-corrected profit margin (see equation (5)). Similarly, but in a more complicated way, $\hat{\varepsilon}$ relates to total factor productivity growth. Despite all the problems of measuring productivity, high rates of productivity growth, or higher productivity rates, are considered socially good (see e.g. Solow 1990). Firms are, however, not really interested in productivity per se. They first of all want to capture the good consequences for them by fetching high rents through operating in the right market price environment. They are interested in the return to investment, or in $\bar{\varepsilon}$. There should, however, be some sort of Adam Smithian harmony in the sense that higher rates of return correspond to high productivity performance. It had better be, since Bo Carlsson and Erol Taymaz (see Carlsson 1991, and Carlsson and Taymaz 1991) have shown that the main determinant of macroeconomic growth in the 20- or so year perspective is the ability of markets to reallocate new investment and people to the most *profitable* activities. If the most profitable activities are not the most productive there may be a problem, and this was clearly the case for a ten-year period, beginning in the mid-60s.

Figure 5C, however, also shows that there is no strong correlation between the rates of return to capital and labor productivity; neither across firms nor over time. What does this tell? It partially explains the fact that macroeconomic growth has been slow (which is true for that period) and suggests inefficient factor (re)allocation in the economy to be the reason, i.e., a dynamically inefficient use of existing resources. Part of this inefficiency has to do with labor, another part with capital. Labor can be moved and to some extent retrained. Capital installations may, however, be irreversibly sunk, and a permanent waste. There is no way of testing this hypothesis except through dynamic micro-macro simulation. This was done in Eliasson and Lindberg (1981). It was found there that misallocated investment, induced by the corporate tax system, involved a direct loss, if scrapped. This loss was, however, of minor importance compared to the production loss from continuing production at low and negative rates of return, locking up labor that could have been more productively employed elsewhere. The really large production loss, however, came from the fact that labor supply to the rest of the economy was lowered, pushing up wages and causing not only inflation but also a slower growth in other firms. The results of Carlsson and Taymaz (1991) are, hence, radical in their implications. Contrary to the policy advice flowing out of standard production function analysis, the problem of (for instance) the Swedish and U.S. economies is not lack of traditional technical innovations, but lack of competitive market performance. If there is a traditional problem it is not (for the economy) lack of new technology, but the inability (lack of receiver competence in firms) to convert globally available innovations into industrial scale production (E 1990c).

How the interest rate controls wages and productivity growth

The above is a two-dimensional description of a multidimensional economic process. Real dynamics arises from the simultaneous interaction of all markets. Only then will it be possible to explain how price dynamics and macroeconomic growth interact. The most interesting link runs from interest rate determination in financial markets, via profit targeting in firms to the consequent investment and production decisions. To understand what is going on the whole "model machinery" of the M–M model has to be turned on. This is done in Section 6.3.

4.8 *Export Characteristics and Foreign Operations of Firms*

Swedish firms are very export intensive (see Figures 6A, B). The development of the export ratio is endogenously explained for each MOSES firm model. Swedish firms are, however, also very international (Table 4), with sizable operations abroad, most of foreign activity being oriented towards marketing and distribution or final production close to the customer. Figure 6A shows the distribution of export rates 1982, 1986 and 1988 from the planning survey. Apparently the proportion of firms with high export ratios was larger in 1988 than in 1982 and 1986. A similar comparison 1988 (Figure 6B) of export ratios from two independent surveys, the planning survey and the same distribution from the firm survey (Braunerhjelm 1991), exhibits some differences, the firm survey having more domestically oriented units and, hence, overall lower export ratios. The reason is explained in Figure 6E that shows that small firms and subcontractors (not in the planning survey) have systematically lower export ratios than the larger firms.

Apparently (Figure 6D) the correlation between the degree of internationalization and the rate of exports out of Swedish plants is rather small. It was higher earlier (Swedenborg 1979). The reason appears to be higher productivity (Figure 6C) and higher rates of return (cf. Figure 6F and see Figure 1 in Braunerhjelm's Chapter IV in this volume) in foreign production than in domestic production, providing incentives to move new investments out of the country (Braunerhjelm 1990, 1991).

The computation of rates of return in different parts of one firm poses a well-known, difficult problem in database design and use. The allocation of profits, and to a lesser degree value added within the firm, depends on the internal transfer prices used in registering transactions within the firm. It is often argued that firms manipulate transfer prices to show profits where they want them to be, to avoid taxes. The answer to this claim (E 1972a, 1976a) is that each chosen transfer price system always, and to some unknown extent allocates accounted profits arbitrarily, but that once an arbitrary system has been determined firms tend to stay with it for a long time. If transfer prices are changed too often the information value of the internal statistical system of the firm is reduced, something that is potentially far more costly than saving a few dollars in avoided taxes (see further Section 5 below). The common transfer price inadequacy pointed to is that domestic CHQs do not charge their subsidiaries for technical and R&D services delivered from home, hence, biasing foreign subsidiary profits upwards. Such arguments, often formulated to make a political point, only reveal lack of knowledge. It is true that multinational firms normally do not explicitly charge their foreign subsidiaries fully for R&D services delivered from home. Such changes are more frequently lumped together with other costs as an overhead charge in the price paid by the subsidiary. Hence, direct data on the charges to foreign subsidiaries tend to be underestimated. The bulk of the marketing investment of a multinational, furthermore, resides in its foreign subsidiaries, and this marketing investment is normally larger than the R&D investment at home (see Table 5A, and E 1985b, p. 53). The international marketing network and know-how often determine profitability on all other assets, something East European firms are currently realizing. The proper charges on foreign subsidiaries of the parent, hence, might be much larger than the profit margins recorded in the internal books, and probably larger than the presumed undercharging for R&D services. Hence, one might more credibly make the reverse statement that foreign profits are underestimated, and Figure 6F supports that view. The large international firms have exhibited, since the mid-70s, systematically higher rates of return on their total (foreign and Swedish) operations than domestic Swedish manufacturing, including the domestic parts of the large international firms.

4.9 Comparison of Small and Large Firms and Subcontractors

Figure 7A shows size distributions of firms/divisions 1982 and 1986 by number of employees. The size distributions exhibit a slight drift towards larger units, but on the whole they are quite stable.

Figure 7D relates the size of the firm (production value) to its return over the interest rate in 1988. The correlation is positive but not very strong, suggesting the presence of scale economies that cannot, however, be directly explained by international size (see above).

Apparently the differences are to be looked for in the definition of categories. Subcontractors earn on the average less than large and small firms (Figures 7B,C), even though their labor productivity is high. The spread in performance rates (productivity and $\bar{\varepsilon}$) is much higher for the small firms and for subcontractors than it is for the large firms (Figure 7E), even though the wage cost levels are very equal.

4.10 *Content of Operations*

The fact that firms, defined as decision units, should not be represented as production establishments is a source of concern in firm panel studies. The "softening of manufacturing business" into service producers makes it inexcusable not to collect data on private service producers also. To represent firms in models as "production plants" is simply wrong. As can be seen from Figure 8 this is as far from reality as one can go. Manufacturing firms are dominant service producers and information processors (E 1990a). These data sets for 1978, 1982, 1988 and 1989 include information to be used in the future to improve the MOSES firm model. The very fact, however, that a large and growing intersection between the manufacturing and the private service sectors is occupied by firms that can no longer be classified neither as manufacturing nor service producers, makes it necessary to consider reorganizing the entire classification system of industrial statistics (see E 1990a). To that end a planning survey to private service producers has been designed and tested, but not yet carried out (see Braunerhjelm's Chapter IV in this volume).

4.11 *Asset Structures of Different Firm Categories*

The "softening of manufacturing" is also reflected in the balance sheets. Tables 5A–C give a summary presentation of the corresponding (to content of production) data in the balance sheet. These tables exhibit relative sizes of different asset categories that are expected to influence firm performance. The "soft capital" appears sizable compared to hardware capital. The problem (already discussed in Section 4.4) is how to measure those categories. With additional survey and econometric work, however, these data are expected to be an important source of information for improved specification of firm innovative and profit behavior. (Pontus Braunerhjelm is working on this project. See also Eliasson and Braunerhjelm 1991).

For one thing the two sets of data for identical firms 1985 (composed from different sources) and 1988 (direct questions) exhibit fair consistency. When the 1988 group is enlarged to include also basic industries, the machine and plant item, as expected, increases as a percent of the total.

Columns (4)–(6) offer an interesting comparison. The small resources invested in marketing capital and knowledge (marketing and R&D) in subcontractors compare with the higher (11 percent) investments in R&D spending in small firms, and with the very high investments in both marketing and R&D on the average in the whole sample (21+10 percent). The 10 percent investment in marketing is probably downward biased because the sample includes a too low proportion of Swedish multinationals (of columns (2) and (3)) which exhibits much larger investments in marketing.

4.12 Macro Financial Time-Series Development

To compute macro national accounts data sets and I/0 tables we have used official statistics, as detailed in Nordström's Chapter V in this volume. The macrodata set (e.g. GNP composition etc.) used for MOSES historic calibration of National accounts' categories has only required relatively easily available time-series material.

The data situation has, however, been much more complicated on the firm financial side, especially in computing the residual firms, making up the difference between consolidated real MOSES firms and the National accounts' representation of the entire manufacturing sector. Official statistics could not be used. Fortunately, such data existed within IUI, being the result of database work over the years, including my own research (E 1967, 1969, 1972a,b, 1974, 1976c). This database work was continued by Södersten (1978, 1985, and Södersten and Lindberg (1983, 1984). Tables 6A,B and Figures 9A, B exhibit the results. There are more detailed data sets from 1976 and 1982 on the MOSES industry/market break-down used for initialization. The time series material of the tables has been used for calibration of MOSES.

Figures 9 have been particularly demanding, since they require that many different sources of data be used. They give a rather vivid account of the dramatic shift in business conditions that occurred in the 70s, a disequilibrium situation that the economy is still suffering from. One could also speculate whether the steady lowering of the average industry $\bar{\varepsilon}$ during the entire postwar period (Figure 9B) has something to do with the macro problems of the Swedish economy. Simulation experiments on the MOSES model economy would say yes, but the underlying mechanisms are complex. For the first twenty-five years the real rate of return declined, while the real interest rate (IR) was politically kept low, probably contributing to the downward trend in the rate of return, through creating a less disciplined investment project selection. The low interest rates were politically possible as long as the Swedish economy was a financially rather closed system. When international financial market arbitrage opened up the financial system of Sweden in the early 80s, a strong increase in real interest rates outpaced the ability of firms to increase their rates of return. Contrary to the past, however, the high real interest rates forced firms to check wage increases to stem the downward trend in $\bar{\varepsilon}$ (see Section 4.7 above).

5 The Firm, Its Organization, Its Statistical Information System and the MOSES Micro Database

In this section I compare our database needs for the model with the corresponding information support needs of CHQ management to identify the optimal sourcing point in the firm and the nature of the data that we will obtain.

5.1 Access to Information and the Nature of Corporate Decisions

Control and coordination are the key purposes of internal information systems of large business firms. The firm's top management (CHQ) recognizes that they are facing a largely unpredictable environment and (in addition) that they have only limited information on the internal capacities of their own organization. They, nevertheless, have to make up the "mind of the firm" so as to be able to reach single-valued decisions. Hence, it becomes very natural for firm management at each point in time to narrow down their perceptions of the environment they are facing to be able to quantify and compute. This is essentially the same thing as to design an equilibrium model as the (boundedly rational) filter through which the firm sees the world around itself. In that trivial sense firm management optimizes. The most competence-demanding part of the decision, however, is the act of delimiting the opportunity set, i.e., of setting the restrictions of the trivial optimization, i.e., to decide what aspects of reality to exclude from consideration. The design of statistical information systems of firms are based on these considerations (E 1976a, 1990e). This fact has to be recognized when firms are asked to give statistical information about themselves. The data put together have been designed to serve a particular information purpose within the organization, *as firm management sees its decision problem.* This conceptualization exhibits great heterogeneity among firms. This is what I observed already in my 1976 study on *Business Economic Planning*, namely *bounded rationality*, even though I was not aware of the term, at the time. The quality of the data received will be best when one understands why and how the firm organizes its own internal statistical system, how it uses the information and when the questions asked relate to questions the data are supposed to answer. This is also the way we define and use micro databases in the MOSES context. Separate and elaborate formal (statistical) systems are needed to control and to guide the various activities of a large business organization. We tap them directly and model the use of these data for decision making within firms.

At this stage it is not difficult to see why *a financial definition of the firm* as *the observation unit* is the natural one. The financial group operates under a fairly well defined, and tight monolithic control system. Responsibility upwards is towards owners and the capital market. Downwards and inwards the firm is run through administrative controls that transform the externally imposed rate of return requirement into more detailed operations criteria. A statistical system related to the same entity exists and can be tapped directly. It is bad empirical methodology to cut the unit of measurement some other way and to lose this source of high quality data that firm management uses for its own purposes. And the main purpose of MOSES modeling has been to tap the existing wealth of internal firm data for a better understanding of firm and of macroeconomic behavior.

To attempt to extract more information from firms than corporate management finds useful to collect, and to go beyond the explicit knowledge that can be communicated outside the business organization means asking for data of doubtful information content which the statistical investigator might as well cook up on his own.

Theorizing and research then naturally divide into understanding the interior decision machinery of the financial unit, on the one hand, and how the financial units interact in markets, with each other and with households, on the other. Together this is micro-to-macro theorizing. And for research to be properly and relevantly conducted economics, business administration and engineering have to join forces.

The MOSES model applies the same set of algorithms to a large number of firms. These algorithms mimic the capital budgeting and production planning process of a firm as financially controlled (from levels 0 and 1 in Table 7) production systems (levels 2, 3, 4, 5). The databases used provide quantitative measurement to specify and initiate these algorithms differently for each firm, and to place them in the macro market framework of the rest of the economy.

5.2 Limited Internal Insight

To look through the various layers of management—to make the firm interior transparent—is almost as much of a problem for central management of the firm as it is for us. It is completely wrong (E 1976a) to assume, as was standard practice in economics for many years, that top firm management is fully informed about interior firm life.[17]

Complexity and "muddled insights" rule, when it comes to running big corporations, and interior statistical reach from Corporate Headquarters is, indeed, very limited. In general, CHQ has reasonable control down to product group level (see Table 8), not more. The product group is the finest classification level where well-defined interfaces with both final goods and factor markets (input goods, labor) exist. In fact, product groups are defined accordingly. At this level profit responsibility can be monitored without synthetic transfer-pricing arrangements. Most decisions, except investment and finance, can be delegated. Finance and investment decisions are kept

[17] The break in this tradition did not emerge from theorizing about the firm, but in the (principal agent) literature concerned with efficient monitoring of public utilities.

central, largely because of the difficulties of measuring capital inputs and monitoring rates of return (E 1976a).

The natural aggregation of data, hence, runs from product groups through the division to CHQ. Division management controls a bunch of product groups, and CHQ management controls a bunch of divisions. The data sets used to run operations at each level are different, due to the more limited market contacts the further down you go, and the different nature of operations. These data sets are not necessarily consistent, and they are becoming less so the more decentralized the firm is. This poses a particular problem in MOSES database work, since both financial and production decisions are integrated in the firm model, and the data needed cannot really be accessed at one location. We can model the CHQ investment and financing decision and how it is converted into targets and production plans at division level. The model that drives the realization of plans into ex post data is, however, controlled not only by the division, but also by the realities of the division that the CHQ is not aware of. Despite these problems we are working on a revised survey form that collects all the data needed from CHQ (see Braunerhjelm's Chapter IV).

When it comes to operational control, the concept of capital is as badly defined as capital theory tells. Data on capital are regarded as more or less useless for internal control purposes and corporate headquarters management avoids such concepts, because the measurements used can be manipulated by those who are to be controlled (E 1976a).

5.3 The Unstable Identity of the Observation Units

There is one additional element of complexity that frustrates corporate managers, namely the impossibility of maintaining a reliable centralized information system when the institutional (organizational) structure of the firm changes. This difficulty has to do with the identity of our observation unit. *Internal reorganization is the main vehicle for achieving productivity gains at corporate levels.* Internal reorganization, however, diminishes, or even destroys the information content of internal databases. There is no general solution to this problem. Corporate managers have learned to work with "deficient" information systems which to my mind precludes generalized (all purpose) database designs. I will leave the subject at that (see further E 1990e).

It appears that firm management, the survey people, and the theorist have a common problem here, *if* the theorist has done a good job. Figure 8 gives a principal illustration of the problem. The firm organization and the measurement system overlap partially (taxonomy level). The degree of overlapping depends on the purpose of the description, what it is supposed to be good for (use level). The intended use affects the optimal decision theory to use to organize facts for a particular purpose, i.e. to guide database design, but this is only possible when one's intended use is fairly stable. The feasibility of generalized measurement systems to cope with a multitude of intended uses is currently a topical concern to management (E 1984a, 1990e). Firms which produce similarly composed products for very different markets illustrate this problem. Certain machines can be used both in agriculture, certain manufacturing processes and in private households, the only difference being that larger sizes are more frequently used in industrial applications than in homes. The same factories, however, produce the same components. Hence, proper profit control requires a dual organizational system. The solution is normally to define divisions by market type and then organize a separate production organization (sometimes also divisionalized) from which market defined divisions buy components or product systems. The internal organizational design and corresponding information systems are therefore very complex, and internal databases are rarely consistent. Swedish organizational designs often make it difficult to collect data on prices, profits, finance and production from one single source.

5.4 The Profit Control Hierarchy

The major ambition of top level executives is to control a complex business organization without all the time getting involved in lower level operations problems. The executive level in Table 7 carries the ultimate responsibility to the owners of the firm. The task of managing the innovative function rests there, at least in theory. Control (total systems coordination) is always managed at the next level, i.e., between levels 0 and 1 in Table 7. Effective coordination (control) is achieved through setting reasonable profit targets against which formalized reporting and control can be applied. At lower (process) levels (market, product/process, distribution) the executive people do not know *how* these processes are run. They need information (database) support from the level below to set reasonable targets, i.e., not overly high, and definitely not too low. This task is always engineered through the *budgeting process* (E 1976a), supported by the cost accounting system of the business units. The method is to learn from records of past performance to set targets for future performance on the same, similar or standardized activities. This is what I have called MIP-targeting, (see E 1976a, p. 236ff and E 1991c) The finer the measurement grid—the more perfect the overlap in Figure 10—the more precisely these targets can be set. However, the more dynamic the interior firm organization the more difficult it is to maintain a detailed measurement system, and the more difficult it is to precisely estimate what is reasonable performance. If dynamics, however, moves the right way, profitability is not the major problem. The deeper into the organization one looks the more organizational float one encounters. The technique of efficient database design for control purposes, hence, is to find a rough compromise between precision in controls and costs associated with achieving control, and curbs on reorganization to maintain a viable measurement system.

5.5 How Far into the Firm Can CHQ See?

Table 8 gives an idea of how this compromise looks in practice. This table also suggests the technical limits of resolution that the outside economic investigator has to accept. There is no meaning in asking for more details since the Corporate Headquarters people do not know themselves, and they have abstained themselves from attempting to get more detailed data, because the measurement system of the firm is not reliable at lower levels of aggregation. (As a rule, confidentiality limits stop the investigator long before that). In a large business entity, Corporate Headquarters' (executive level in Table 7) routine access to data never reaches below the *product group level* (3) in Table 8. Product groups are defined and organized to be the minimal unit of profit and cost control accessed from CHQ. CHQ control often stops at the division level. At product group level standardized cost comparisons are possible. Factor prices are normally market prices. At the division or subsidiary levels all prices related to the physical side of production are normally market determined. The division, therefore, is the appropriate elementary unit to observe statistically over time. It is usually organized for one particular external product market and exhibits a well-defined decision autonomy. The product group definition sometimes can be used for the same purpose and one finds different solutions in different companies. It is impossible in practice (and theory) to base panel data on anything below the product group level. As a rule, access—from CHQ level—to data below division level is very difficult. The product group level sometimes corresponds to what is often termed a production "activity" in input/output analysis, but this concept is not very useful, because in a firm a process or an activity is only one part of a much more complex and integrated product group activity. Product groups are rarely stable units when management reorganizes the firm into a new combination. Reorganizations of firm activities occur below level (3) in Table 8.

6 Applications and Illustrations

In conclusion I will demonstrate certain aspects of MOSES database work through two applications. *First*, a non-linear, dynamic economic system of the MOSES kind is path-dependent and sensitive to initial conditions and prone to exhibit phases of non-predictable behavior. I will discuss this verbally, with reference to several publications on the model. *Second*, one novel feature of the model is that it exhibits price and quantity setting behavior of firms. The model mimics a general monopolistic game among a limited, but *variable* number of players (there is endogenous entry and exit), all of them being strongly influenced by the joint outcome of their dynamic interaction, transmitted through pricing in three markets, all activity being "dominated" by pricing in the capital market. The applications will illustrate how ex ante rate of return targeting interacts with wage setting behavior of firms and affects production growth. I won't go through the analytical part. This would be a separate paper (see Eliasson and Lindberg 1986). But the presentation allows me to illustrate both the rich initial state description of the MOSES database, the nature of the competitive potential of its firms and of industry as exhibited by the Salter structures of the model economy, and one particular detail of the calibration of the model. First, the dynamic properties of the model system.

6.1 Micro-Macro Dynamics

Dynamics in the micro-macro model arises out of the confrontation in markets of many, very differently perceived, and inconsistent decisions. Price adjustment resolves the issue and creates new quantity adjustments—the plan realization process. This realization also reallocates resources in the economy and creates endogenous new entry, and exit of defunct firms. Hence, the composition of production structures and output (the organizational "state" or memory of the model) is affected by the development of relative qualities of entering, incumbent, and existing firms. This micro life is normally quite turbulent (E 1991a). We know that stable macro development requires Brownian motion-type behavior at the micro level. We also know that if sufficient diversity of structure in terms of Salter curves cannot be maintained through simulations, latent structural instability develops (E 1978b, 1983, 1984b, 1991c).

We observed above that the endogenously evolving structural or organizational memory of the model defined its state of technology, or the "organization technology" that at each point in time coordinated all activities in the economy. Erratic price and quantity signals, being transmitted back and forth between the micro and macro levels, affect the evolution of that memory through the learning mechanisms by which firms attempt to forecast future development of—for them—important variables. The normal macroeconomic consequences of a disturbed and inflating relative price system were lower predictability and lower productivity development.

6.2 Path Dependency Creates Non-Stationary, Non-Learnable Behavior

Initial conditions keep playing a role for as long as we have managed to run the model (a hundred years or so, by quarter). Sometimes small variations in the initial setting cumulate in importance for long periods, then reversing themselves. Certain combinations of initial states and market characteristics, notably very fast price arbitrage (efficient markets) can generate a collapse of macro output and a long period of stagnation, a development entirely unpredictable from earlier historic data generated by the experiment. The model appears prone to such volatile, unstable behavior the closer its operating range comes to what may be characterized as a steady-state equilibrium growth path (E 1984b, 1985a, Ch. VII). All facets of this exotic behavior have not yet been explored, neither numerically nor theoretically. Suffice it to note, however, that these results have been a persistent property of the model from its implementation (see, e.g., E 1978a, p. 118), but were looked at with skepticism at the time by 'Besserwissers' of the profession. With unpredictable chaotic behavior having been demonstrated to be an expected mathematical property of a wide class of non-linear dynamic systems—to which MOSES belongs—these properties are now more widely accepted. The important learning experience, however, is that such economic systems are not easily controllable entities from a central policy point of view (E 1991c). A host of policy conclusions associated with the controllable steady-state equilibrium models, or the manipulable macro demand models of the 60s, have to be revised.

We observed earlier that the market exercises two important functions; a disciplining (competition) and a signaling (information) function. The more efficient the disciplining or growth-promoting function, the more organizational change forced on the model structure, and the more unreliable the signaling functions of markets. There is an optimal balance between the efficiency of the two functions (E 1983, 1985a, Ch. VII). This fundamental uncertainty in itself, however, prevents the state of full information equilibrium from being attainable. It arises out of the path dependency and, hence, the non-stationarity of the realization process (E 1991c) which makes classical, statistical learning infeasible. Antonov and Trofimov (1991) have carried out an interesting set of experiments on the model that illustrate the "limits of learning" in a dynamic, experimentally organized market environment. They introduce "statistical bureaus" in the MOSES model which produce forecasts of relevant firm expectations variables that the firms can use, or have to use depending upon the experimental setting. The forecasts of the statistical bureaus are generated by traditional macro models (Keynesian or neoclassical—there are two statistical bureaus), estimated on the macro output of the model during a simulation and constantly updated, as such forecasting models are used by "real forecasting institutes". In a reference case each firm uses its own adaptive learning functions. In another experiment (the central planning experiment) all firms are forced to use the forecasts of one statistical bureau. Whichever bureau is "enforced" macro growth performance of the model economy suffers in comparison with the reference simulation. On the other hand, when firms are free to choose between their own forecasts and any forecast of two statistical bureaus, in any inconsistent combination they find best according to partial fitness criteria for individual expectations variables, macro performance of the model economy improves. The reason is simple. With the increased variation in outcomes made possible by the "free" and often inconsistent behavior of all firms, new superior business plans are realized by pure chance, such that economic growth in the long term improves.

Our growing set of micro-macro databases is currently used to calibrate the model in an attempt to ascertain the range of numerical structures of the model that is compatible with observed variations in micro outcomes, to establish the propensity of the so calibrated model to generate different, desirable or undesirable structural developments. Some of these attempts are illustrated in Taymaz (1991). This work so far has repeatedly indicated the critical significance of good quality measurement, especially of initial conditions. If you don't know "where you are" when you run a model experiment, or carry out a policy measure on a real economy, as a rule you have little control of the policy results.[18] We have also learned that there is no end to such experimental work from which a glimpse will be offered in the next, final section.

6.3 *Price and Quantity Interaction—How the Interest Rate Affects both Wages and Growth in Output*

This experiment illustrates the macro sensitivity of the model economy to the nature of price-quantity interactions at the micro level; and the importance of a balance between stable and flexible relative prices to achieve stable macroeconomic growth.

Figure 4C presents three sets of data on Swedish manufacturing; value productivity and wage cost distributions ($p \cdot \beta$ and w distributions in equation (5)), real initial state data for 1982, and real and simulated data for 1985. The reader should observe from equation (5), that the profit margin (M) is a linear function of the difference between $p \cdot \beta$ and w, and how M in (4) relates

[18] For policies—I hasten to add—on which standard macro models gave very precise, albeit incorrect answers in the past.

to various rate of return measures. The first observation is that the "calibrated" reference case of the model (see Ch. VIII in E 1985a) projects Salter productivity and wage distributions quite well (see also Taymaz 1991).

Second, and this was one reason for the experiments, the firm's objective is to keep $\bar{\varepsilon}$ in equation (3) positive and as high as possible in the long run. The firm strives to achieve that through ex ante hill-climbing behavior. Hence, the interest rate, r, affects both price and quantity decisions of firms. If the interest rate is high, firms have (1) to improve productivity, or (2) to hold back wage increases to maintain profit standards, or both. The choice between (1) and (2) in the MIP-targeting and labor wage-setting search processes is endogenous in the MOSES model. Hence, *a high interest rate policy operates directly on wages through forcing firms to raise their profit margins through increasing productivity and/or holding back wages.* The sensitivity of wage-setting behavior to capital market conditions was the reason for the study (Eliasson and Lindberg 1986) from which the illustrations have been taken. The shape of the Salter curves defines potential competition. You can design an aggressive MOSES market experiment in which firms compete fiercely with each other, and for labor in the labor market (fast markets), and a slower market scenario in which firms are not at each other's throats (see further E 1983, 1991c). The fast market scenario creates a "mini cost crisis". When the best (top left on Salter curves) producers bid up wages to get labor, low end producers are killed and exit, forcing remaining producers to step up productivity ($p \cdot \beta$ in equation (5)), inter alia through laying off labor,[19] thus running up unemployment in the economy. The overall outcome is much higher productivity in the medium term (10 years or so; see Figure 11), higher output and lower average rates of return (lower average $\bar{\varepsilon}$) and much higher unemployment. The economy is operating closer to "static equilibrium". In the longer run (ca 20 years), however, the output level suffers significantly relative to the "slower" reference case. The reason is less investment, because of a lower rate of return compared to the interest rate (see Eliasson and Lindberg 1986). If the interest rate is lowered, however, investment increases and long-term output is higher (E 1984b), provided cost inflation can be contained. The latter test has not yet been run in this particular experimental setting. It is, however, my

[19] Firms that want to continue in business cannot hold back wages, because then they will lose labor to raiding firms.

conjecture—being rather familiar with the properties of the model—that if new investment, induced by a lower interest rate, is not sufficient to maintain sufficient diversity of Salter productivity distributions, the cost inflation generated in the fast market regime, reinforced by sloppy wage setting, due to the lower interest rate (see equation (5) again) will generate inflation and a macro output collapse, when low end producers operating on the right end of the Salter curve exit 'en masse'. If and when this happens is entirely an empirical problem, that cannot be analytically resolved, only through improved measurement. This closes the circle.

SUPPLEMENT I

Using the M–M Model to Generate Structural Data

Any data set that you may use contains certain priors associated with its presentation. Questions have been formulated, definitions made and adjustments imposed to obtain consistency. When respondents are asked to provide data on a different format than their own, they will have to enter judgment, which will "pollute" data.

You may have data for some years, or you may miss some data for some firms. You may then attempt to fill in the holes through interpolation, making certain assumptions about how the missing items depart from trends and structures you may have in the rest of your data set. You may even want to eliminate certain properties of your data set by filtering out systematic elements like cycles etc., or creating composite data by weighting several data series together. All sampling techniques are based on prior assumptions about what you are looking for. Each statistical classification system incorporates a hypothesis about what you are going to use the data for, a circumstance that will clearly influence your results when you later test this, or some other hypothesis. However you do it, priors enter your statistical output.

The large effort needed to create micro panel data sets causes particular problems, essentially making it impossible to test certain hypotheses that require a full-fledged micro data set. One might therefore want to create a statistical method whereby existing data sets are more efficiently exploited through the introduction of priors, based on exogenous (to the data set) information. This method is commonly used in other fields. Computer enhancement of pictures or pattern recognition are methods whereby blurred pictures are made more clear or are interpreted by computer programs that extract images out of the blur.

The micro-macro model is an enhancement instrument through which the statistical representation of reality can be more exactly made, and data generated that are perhaps of a much higher quality than those produced "by hand" in bureaus of statistics. The MOSES model is internally consistent, and hence generates internally consistent data sets. It then treats those data through the behavioral decision machinery of all its agents and the market process. These behavioral equations have been estimated by the application of standard statistical methods, and/or calibrated on historic data. If the parameterization is accepted as a prior exogenous information source some nice data sets, "that do not exist", can be created, in which fragmented statistical information has been merged with exogenously researched and consistent assumptions.

The MOSES Model traces a large number of variables over time using a rather modest initial statistical input. Through a simulation

– consistent quarterly national accounts data on the manufacturing sector and

– firm panels of financial and production data

can easily be generated. This is a use of the model that we may pursue in the future. This is also a possible technique of deidentifying confidential micro data sets. You run the calibrated model for several years and then take out the microdata for a particular year. Reverse econometric engineering, i.e., identifying the original, confidential data set, is impossible for exactly the same reasons that made it impossible for an external observer to identify the code of the model from observing its performance. An attempt in this direction has been made in conjunction with making MOSES portable (see Taymaz 1991, Sec. 3.4). The model has first been calibrated on historic data from 1982 to 1990, including also an attempt to reproduce cross sectional characteristics along the way. The surviving population of firms as they look in 1990, after the simulation, including new entrants is then transferred to a disc together with the simulated macro database. The plan is to make this "synthetic" macro database available for outside use.

SUPPLEMENT II

Summary of the Various Surveys together Making up the MOSES Database

1. Production—planning survey

The core micro-unit of the MOSES economy is the firm or the division. A firm may be represented by one or more divisions that produce for a particular market. This survey is limited to domestic establishments. Data needed are:

for historic period

- value added
- sales
- profits
- market price index
- wages

for initial period

- employment
- ingoing and outgoing inventories
- unused machine capacity
- unused labor capacity
- export ratio
- capital use per unit of value added
- etc.

This allows us to estimate a short-term production frontier for the unit (for production planning) and a shift function of the production frontier in response to investment. This is described by Albrecht and Lindberg (1989) and in Albrecht's Chapter III in this book.

2. Financial unit—the firm

We need a balance sheet, a profit and loss statement, and a cash flow balance for the financial unit. The balance sheet distinguishes (on the asset side) between production assets (replacement valuation), inventories, and other assets. On the debt side, external debt is explicit and net worth is computed as a residual between total assets and debt.

The financial database draws on an external analysis of company (group) accounts. There are significantly more detailed data in the database than needed for MOSES simulations. These data are, however, very useful to compare with the more detailed output of MOSES experiments for individual firms.

The observation unit of the financial database is viewed as the theoretical decision unit or basic measurement unit that we have discussed above. There is an elaborate *initialization* program, presented in Albrecht and Lindberg (1989), that initiates the set of real and artificial firms through which the model is run.

We are currently experimenting with a questionnaire that collects both financial data from the firm (globally defined), and production data on the division from the same source, namely the CHQ of the firm. This questionnaire would then combine the planning survey, the external financial analysis and the (not regular) IUI survey of Swedish multinationals on a less detailed format. On this see Braunerhjelm's Chapter IV in this volume and above.

3. Foreign subsidiaries

An extensive database on all foreign production establishments of Swedish firms exists for the years 1965, 1970, 1974, 1978 and 1986 (see i.a. Swedenborg 1979, and Swedenborg, Johansson-Grahn and Kinnwall 1988).

This database includes information on:

- employment
- value added
- profit margins
- etc.

in foreign subsidiaries and in domestic operations.

Investment data have been collected in the recent surveys and have been computed for 1974–1978 by Bergholm (1983).

Preliminary work has been carried out to connect foreign subsidiaries with the matching planning survey units. Only a minor fraction of this database will (eventually) be used directly as inputs in MOSES simulations. The database will, however, be used as a test material for model performance. A new survey of Swedish multinationals is currently being conducted for 1990.

4. Small firm sample

The planning survey units are mainly divisions of large firms. Data on a complementary sample of small firms were collected for 1986, 1988 and 1989, this time using the *firm* as a financially defined decision entity, as unit of measurement. For more on this see Braunerhjelm's Chapter IV in this volume.

5. Content of establishment (division) production activities

These surveys have been appended to the regular planning surveys. Data on internal firm-type of activity, markets, R&D etc. by costs and employment have been collected. These surveys are recent and exploratory. A new survey is currently being collected. This information has not yet been integrated in the MOSES model design. The survey was, however, initiated to make it possible to deal with the institutional characteristics that have been discussed in this paper. The same establishments as in the planning survey have been questioned. See Eliasson, Fölster, Lindberg, Pousette and Taymaz (1990) for a summary presentation, Tables 5A, C and Figure 8 for illustrations, and for sources:

Year: 1978
Source: Eliasson, G., 1985, De svenska storföretagen; Chapter I in Eliasson, Bergholm, Horwitz and Jagrén, *De svenska storföretagen—en studie av internationaliseringens konsekvenser för den svenska ekonomin*, IUI, Stockholm 1985, p. 53.

Year: 1982 (The IUI service survey):
Source: Eliasson, Carlsson, Deiaco, Lindberg and Pousette, 1986, *Kunskap, information och tjänster—en studie av svenska industriföretag*, IUI,

Stockholm, p. 17, and Chapter IV (Pousette, T. and Lindberg, T.). Also see *The Knowledge Based Information Economy*, IUI, Stockholm 1990.

***Year:* 1988, 1989**
Source: See Braunerhjelm (1990, 1991) and Chapter IV in this volume.

6. Firm capital structure—soft capital

This data set includes both data on the content of production used to generate a revised balance sheet for the 10 largest firms (see E 1990a, p. 80f and 1990b), and data from a separate survey in which firms were asked directly to provide estimates on "soft capital" (see Braunerhjelm 1990, 1991, Chapter IV in this volume, and Eliasson and Braunerhjelm 1991). Table 5A summarizes these data sets. Chapter IV explains the data.

This work marks the beginning of a new capital measurement project at IUI that has just been started.

Table 1A Levels of ambition of the micro-macro modeling project

Tasks	
1. Choice of Problem	
2. Conceptualization/ Theory	The Experimentally Organized Economy (EOE)
2. Measurement	The Knowledge-Based Information Economy
3. Modeling	The Micro-Macro Model (MOSES)
4. Application/Analysis	

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

1. COORDINATION (organizational structure)	The invisible and visible hands at work – competition (in markets; Smith 1776) – management (of hierarchies; Chandler 1977)
2. INNOVATION	Creation and exploitation of new business opportunities (Schumpeter 1912) – innovation – entrepreneurship – technical development
3. SELECTION (organizational change)	Incentives for change – entry – exit – mobility
4. LEARNING	Knowledge transfer (Mill 1848) – education – imitation – diffusion

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

Table 2 Swedish GNP decomposed according to end use classification

		1950	1970	1980	1985
1	Primary goods production	13.0	5.6	4.1	4.1
2	Manufacturing and related service production	45.3	49.6	47.0	48.7
	a) Manufacturing according to the National accounts (SNR code 3000)	30.3	28.0	23.7	24.8
	b) related services	15.0	21.6	23.3	23.9
3	Public utilities and construction	10.5	11.3	110	10.74
4	Service production for direct private consumption	(14.9)	13.9	12.3	12.7
5	Infrastructure (health, research, education and insurance)	–	13.5	17.2	15.3
6	Information design production, including social distributional charges	–	6.1	8.4	8.5
7	Total GNP at production costs				
	a) percent	100.0	100.0	100.0	100.0
	b) Billion, current SEK	30.4	154.0	469.3	748.9

Source: Condensed version of Table I.6 in E (1990a, p. 79).

Table 3 The complete balance sheet of a firm

A. ***"Visible" capital***
1 Machines, buildings, inventories (replacement valuation)
2 Financial assets, net
3 Total visible assets (replacement valuation) [(1) + (2)]

B. ***"Not visible" capital***
4 Software
5 Technical knowledge
6 Marketing knowledge
7 "Educational" capital
8 Entrepreneurial competence

9 *Sum*: Total assets (replacement valuation) according to the revised books

10 Debt
11 Net worth (9 – 10) according to the revised books
12 For comparison: Market value

Table 4 Swedish foreign manufacturing employment
Number of people

	1960	1965	1970	1974	1978	1986
In goods production	105 510	147 290	182 090	221 110	227 110	259 820
In percent of Swedish domestic manufacturing employment	12	16	20	24	26	33
Total foreign employment	–	(172 117)*	(224 800)*	292 400	300 000	369 800
In percent of Swedish domestic manufacturing employment	–	(18)*	(24)*	31	34	48
Total domestic manufacturing employment	**880 260**	**938 915**	**921 780**	**929 200**	**874 230**	**777 270**

* Excl. employment in not goods producing and not marketing or distribution subsidiaries; 15 520 in 1974.

Source: Compiled from IUI surveys of Swedish foreign investments.

Table 5A **The composition of capital in Swedish firms**
Percent

	9 largest manufacturing firms, global operations, end of		17 largest manufacturing firms, global operations, end of	Planning survey firms, end of 1988		
	1985*	1988	1988	all sample	sample of subcontractors (ISIC 38)	sample of small firms (ISIC 38)
	(1)	(2)	(3)	(4)	(5)	(6)
1. Machinery and buildings	54	50	70	62	89	80
2. Software	n.a.	7	6	5	2	4
3. Technical know-how (R&D)	17	16	13	21	4	11
4. Marketing	20	19	6	10	3	3
5. Education	10	8	5	2	2	2
6. Total (percent)	**100**	**100**	**100**	**100**	**100**	**100**
7. Debt	65	66	77			
8. Market value; end of year in percent of (6)	30	37	51			

* *Source*: Table 5B.

Source: Eliasson (1990a,b), and Eliasson and Braunerhjelm (1991).

Table 5B **The composition of capital in the 10 largest Swedish manufacturing firms**

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

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

Sources: Eliasson (1990a, p.80, 1990b).

Table 5C **Quality of employed labor**

	Small firms 1990	Subcontrac-tors, 1990	Large firms 1988	Large firms 1982
Executive staff	5	3	2	4
Specialists, middle management	9	7	11	12
White collar	16	15	29	20
Blue collar	46	35	25	–
No training and low education	24	40	33	64
Total	**100**	**100**	**100**	**100**

Sources: Braunerhjelm (1990, p.138, 1991, p.40, Chapter IV in this volume), and Deiaco (1986, p.142).

Table 6A Macro balance sheets of Swedish manufacturing, 1949-1988
Current prices

Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1949	16.4	6.7	3.6	11.8	38.5	10.9	27.6	.	38.5
1950a	18.0	7.4	3.9	12.4	41.7	11.7	30.0	.	41.7
1950b	10.7	7.5	3.5	10.7	32.4	12.6	19.8	.	32.4
1951	16.5	9.3	4.1	11.4	41.3	15.3	26.0	.	41.3
1952	19.9	11.0	3.7	11.4	46.0	15.8	30.2	.	46.0
1953	19.0	10.8	4.6	11.6	46.0	15.6	30.4	.	46.0
1954	19.3	12.4	4.6	12.0	48.3	15.9	32.4	.	48.3
1955	21.0	12.8	4.2	12.8	50.8	17.4	33.4	.	50.8
1956	23.6	13.9	3.9	13.3	54.7	18.6	36.1	.	54.7
1957	24.5	14.7	3.6	13.6	56.4	19.4	37.0	.	56.4
1958	25.0	15.7	4.7	14.2	59.6	19.7	39.9	.	59.6
1959	26.0	15.4	6.4	15.6	63.4	21.5	41.9	.	63.4
1960	28.9	15.4	4.8	18.0	67.1	24.2	42.9	.	67.1
1961	31.4	16.4	3.9	19.4	71.1	25.8	45.3	.	71.1
1962	36.0	18.5	4.8	19.8	79.1	27.4	51.7	.	79.1
1963	38.7	19.6	5.1	21.3	84.7	29.3	55.4	.	84.7
1964	42.8	21.3	5.8	25.1	95.0	34.5	60.5	.	95.0
1965a	47.1	23.5	5.9	30.0	106.5	40.8	65.7	.	106.5
1965b	47.1	22.8	6.3	29.0	105.2	42.4	62.8	37.8	105.2
1966	50.4	24.5	5.4	32.2	112.6	47.1	65.5	39.1	112.6
1967	55.8	24.0	6.4	34.7	120.9	51.0	69.9	40.0	120.9
1968	59.5	23.7	7.3	36.9	127.3	54.4	72.9	40.3	127.3
1969	60.7	25.3	6.6	43.3	135.9	61.4	74.5	41.7	135.9
1970	67.9	30.7	6.6	49.3	154.5	73.7	80.8	45.2	154.5
1971	75.4	33.1	7.5	52.9	168.9	81.2	87.6	46.6	168.9
1972	82.9	32.7	9.7	56.7	182.0	87.7	94.3	47.5	182.0
1973	93.4	34.6	11.3	62.1	201.3	94.3	107.0	50.2	201.3
1974	113.0	45.1	12.4	73.1	243.5	109.2	134.3	60.4	243.5
1975	133.0	59.3	12.7	89.8	294.8	138.1	156.7	71.0	294.8
1976	154.5	66.6	12.4	96.5	330.0	152.7	177.3	74.5	330.0
1977	179.0	63.9	13.5	119.9	376.2	177.2	199.0	77.1	376.2
1978	201.3	66.0	17.1	137.9	422.2	192.6	229.7	89.1	422.2
1979	219.7	72.2	20.3	138.9	451.0	208.2	242.8	86.3	451.0
1980	243.3	81.7	20.3	165.1	510.5	227.2	283.3	108.3	510.5
1981	269.7	87.1	22.5	183.5	562.9	248.9	313.9	116.9	562.9
1982	301.7	93.1	27.1	210.7	632.7	271.6	361.0	135.6	632.7
1983	332.5	95.3	33.3	240.4	701.5	284.9	416.6	164.4	701.5
1984	346.6	105.2	35.4	295.7	782.8	322.7	460.1	191.9	782.8
1985	368.6	111.9	30.6	337.2	848.2	355.8	492.5	.	848.2
1986	395.0	112.5	33.2	410.3	951.0	405.9	545.1	.	951.0
1987	421.3	114.5	35.9	485.1	1056.7	460.3	596.4	.	1056.7
1988	461.6	120.4	30.7	551.9	1164.5	511.4	653.2	.	1164.5

(1) Machinery and buildings
(2) Inventories
(3) Cash and bank deposits
(4) Other assets, incl. receivables
(5) Total assets
(6) Total debt, long and short term
(7) Net worth (residually determined) [(5)-(6)]
(8) Thereof: Equity according to the books
(9) Total liabilities (5)

Note: Initial values for stock of machinery and buildings end of 1949 have been computed as in Eliasson (1972b, 1976c). Depreciation assumptions for the whole period are 3.3 percent for buildings and 12.5 percent for machinery. This is a change from earlier tables in the references. The change has been motivated by the Hulten and Wykoff (1981) study. Until 1965 data have been based on the above studies by Eliasson. For 1965 we have used a different set of data from the Central Bureau of Statistics which is close to the National Accounts' definition of the manufacturing sector. Both data sets are coded for 1965.

Sources: See Table 6C.

Table 6B Profit and loss statements, 1950-1988

Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1950	.	.	8.9	0.6	.	.	.	.	.
1951	6.7	5.5	12.2	1.0	4.5	0.5	0.4	4.7	0.9
1952	7.6	3.6	11.2	1.2	2.5	0.5	0.4	2.6	0.6
1953	7.7	3.6	11.4	1.1	2.5	0.5	0.5	2.5	0.8
1954	8.3	4.1	12.4	1.1	3.0	0.6	0.5	3.1	0.9
1955	9.1	4.1	13.3	1.2	2.9	0.6	0.5	3.0	1.0
1956	9.7	4.5	14.3	1.4	3.2	0.6	0.5	3.3	0.9
1957	10.4	5.0	15.4	1.4	3.6	0.7	0.6	3.8	1.0
1958	10.9	5.1	16.0	1.4	3.7	0.9	0.6	3.9	0.9
1959	11.3	5.8	17.1	1.5	4.3	1.1	0.8	4.7	0.9
1960	12.8	6.1	18.9	1.6	4.5	1.0	0.8	4.7	0.9
1961	14.3	6.2	20.5	1.7	4.5	1.1	0.9	4.7	1.0
1962	16.0	6.5	22.4	2.0	4.5	1.6	1.1	4.9	0.9
1963	17.5	6.5	23.9	2.1	4.3	1.7	1.2	4.8	1.1
1964	19.0	7.9	26.9	2.3	5.6	1.9	1.4	6.0	1.3
1965a	20.8	8.8	29.7	2.6	6.3	2.4	1.7	6.9	1.3
1965b	15.3	7.7	23.0	2.6	5.1	1.2	1.2	5.1	1.3
1966	18.7	6.7	25.4	2.8	3.9	1.3	1.5	3.8	1.0
1967	20.1	6.8	26.9	3.0	3.8	1.4	1.7	3.5	1.0
1968	20.2	7.4	27.7	3.2	4.2	1.6	1.8	4.0	1.2
1969	27.8	9.2	37.0	3.3	6.0	1.9	2.1	5.8	1.3
1970	32.6	9.8	42.4	3.7	6.1	2.2	2.6	5.6	1.3
1971	35.4	9.3	44.7	4.1	5.1	2.2	2.9	4.4	0.9
1972	37.2	10.2	47.4	4.5	5.6	2.4	2.9	5.1	1.2
1973	38.9	14.7	53.6	5.1	9.6	2.7	3.1	9.1	1.5
1974	46.7	21.6	68.4	6.2	15.4	3.2	3.8	14.8	1.3
1975	59.3	18.0	77.4	7.4	10.6	4.1	5.2	9.6	2.0
1976	66.3	15.6	82.0	8.5	7.1	4.5	6.5	5.1	1.7
1977	67.8	13.0	80.8	9.8	3.2	6.7	9.2	0.7	1.6
1978	74.7	12.8	87.5	11.1	1.7	7.3	10.3	-1.3	1.8
1979	79.0	21.8	100.8	12.0	9.7	8.2	10.9	7.0	2.1
1980	88.4	24.3	112.6	13.3	11.0	11.0	13.8	8.2	1.8
1981	93.9	23.8	117.6	14.7	9.0	12.4	17.1	4.3	2.6
1982	98.7	31.7	130.5	16.7	15.0	15.6	18.8	11.8	3.4
1983	105.1	45.1	150.2	18.6	26.5	16.1	17.6	25.0	4.8
1984	117.2	52.0	169.2	19.4	32.7	19.5	20.9	31.3	5.5
1985	129.1	48.3	177.4	20.7	27.6	24.5	21.4	30.8	6.2
1986	139.8	48.4	188.2	22.2	26.2	25.9	21.3	30.8	7.5
1987	148.0	55.2	203.2	23.6	31.7	27.4	21.3	37.9	8.6
1988	159.0	63.2	222.3	25.7	37.5	31.5	24.3	44.7	10.7

(1) Wages and salaries incl. social charges
(2) Gross operating profits
(3) Value added [(1)+(2)]
(4) Economic depreciation
(5) Net operating profits before financial charges [(2)-(4)]
(6) Interest and capital income excl. capital gains
(7) Interest costs
(8) Net profits before tax [(5)+(6)-(7)]
(9) Corporate income taxes

Sources: See Table 6C.

Table 6C **Macro cashflow balances of Swedish manufacturing, 1950-1988**

Year	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1950	1.4	.	.	.	.	.	.	.	.	.
1951	1.8	.	0.4	0.3	0.9	.	5.5	.	.	.
1952	1.7	1.3	0.4	0.4	0.6	4.5	3.6	0.4	0.5	4.5
1953	1.5	0.9	0.5	0.4	0.8	4.0	3.6	0.6	-0.2	4.0
1954	1.8	2.0	0.5	0.4	0.9	5.6	4.1	1.2	0.3	5.6
1955	1.9	0.8	0.5	0.5	1.0	4.7	4.1	-1.0	1.5	4.7
1956	2.1	1.3	0.5	0.5	0.9	5.3	4.5	-0.4	1.2	5.3
1957	2.0	0.8	0.6	0.5	1.0	5.0	5.0	-0.9	0.8	5.0
1958	2.4	2.7	0.6	0.5	0.9	7.2	5.1	1.8	0.3	7.2
1959	2.7	2.8	0.8	0.6	0.9	7.7	5.8	0.2	1.8	7.7
1960	3.2	0.8	0.8	0.6	0.9	6.3	6.1	-2.5	2.7	6.3
1961	3.9	1.5	0.9	0.7	1.0	7.9	6.2	0.1	1.6	7.9
1962	4.2	3.4	1.1	0.8	0.9	10.4	6.5	2.3	1.6	10.4
1963	4.3	2.9	1.2	0.8	1.1	10.3	6.5	2.0	1.9	10.3
1964	4.1	6.2	1.4	0.9	1.3	13.9	7.9	0.8	5.2	13.9
1965a	4.7	7.2	1.7	1.0	1.3	15.9	8.8	0.8	6.3	15.9
1965b	4.7	.	1.2	1.0	1.3	.	7.7	.	.	.
1966	5.3	4.0	1.5	1.0	1.0	12.9	6.7	1.4	4.7	12.9
1967	5.6	3.0	1.7	1.0	1.0	12.3	6.8	1.6	3.9	12.3
1968	5.6	2.7	1.8	1.0	1.2	12.3	7.4	1.5	3.4	12.3
1969	5.9	7.4	2.1	1.1	1.3	17.7	9.2	1.5	7.0	17.7
1970	6.6	11.4	2.6	1.1	1.3	23.0	9.8	1.0	12.2	23.0
1971	7.0	6.9	2.9	1.1	0.9	18.9	9.3	2.1	7.6	18.9
1972	7.7	5.6	2.9	1.2	1.2	18.6	10.2	2.0	6.5	18.6
1973	9.2	8.8	3.1	1.2	1.5	23.9	14.7	2.6	6.6	23.9
1974	12.0	22.6	3.8	1.4	1.3	41.2	21.6	4.7	14.9	41.2
1975	13.7	31.3	5.2	1.7	2.0	53.8	18.0	6.9	28.9	53.8
1976	15.1	13.7	6.5	1.7	1.7	38.7	15.6	8.5	14.6	38.7
1977	13.6	21.8	9.2	1.9	1.6	48.0	13.0	10.5	24.5	48.0
1978	12.2	23.7	10.3	2.2	1.8	50.2	12.8	22.0	15.4	50.2
1979	13.8	10.4	10.9	3.6	2.1	40.7	21.8	3.3	15.7	40.7
1980	18.2	35.8	13.8	3.3	1.8	72.9	24.3	29.7	19.0	72.9
1981	18.2	26.0	17.1	3.8	2.6	67.8	23.8	22.3	21.7	67.8
1982	17.5	37.8	18.8	5.2	3.4	82.6	31.7	28.2	22.7	82.6
1983	20.8	38.1	17.6	6.6	4.8	87.8	45.1	29.4	13.3	87.8
1984	24.7	67.1	20.9	7.3	5.5	125.6	52.0	35.8	37.7	125.6
1985	31.4	43.5	21.4	8.4	6.2	110.9	48.3	29.5	33.1	110.9
1986	32.9	76.3	21.3	12.9	7.5	150.9	48.4	52.3	50.2	150.9
1987	38.4	79.5	21.3	12.2	8.6	159.9	55.2	50.3	54.4	159.9
1988	42.0	67.5	24.3	14.0	10.7	158.6	63.2	44.3	51.0	158.6

(1) Investments in machinery and buildings
(2) Net change in inventories and accounts receivable
(3) Interest payments
(4) Dividend payments
(5) Corporate tax payments
(6) Total uses [(1)+(2)+(3)+(4)+(5)]
(7) Gross operating income
(8) Financial income, incl. capital gains
(9) Net borrowing
(10) Total sources [(7)+(8)+(9)=(6)]

Sources: Eliasson (1967, 1972b, 1976c), Södersten (1978, 1985), Södersten and Lindberg (1983, 1984).

Table 7 The functions of a large firm

0	Executive
1	Finance and control
2	Market
3	Product/process
4	Distribution
5	Administration

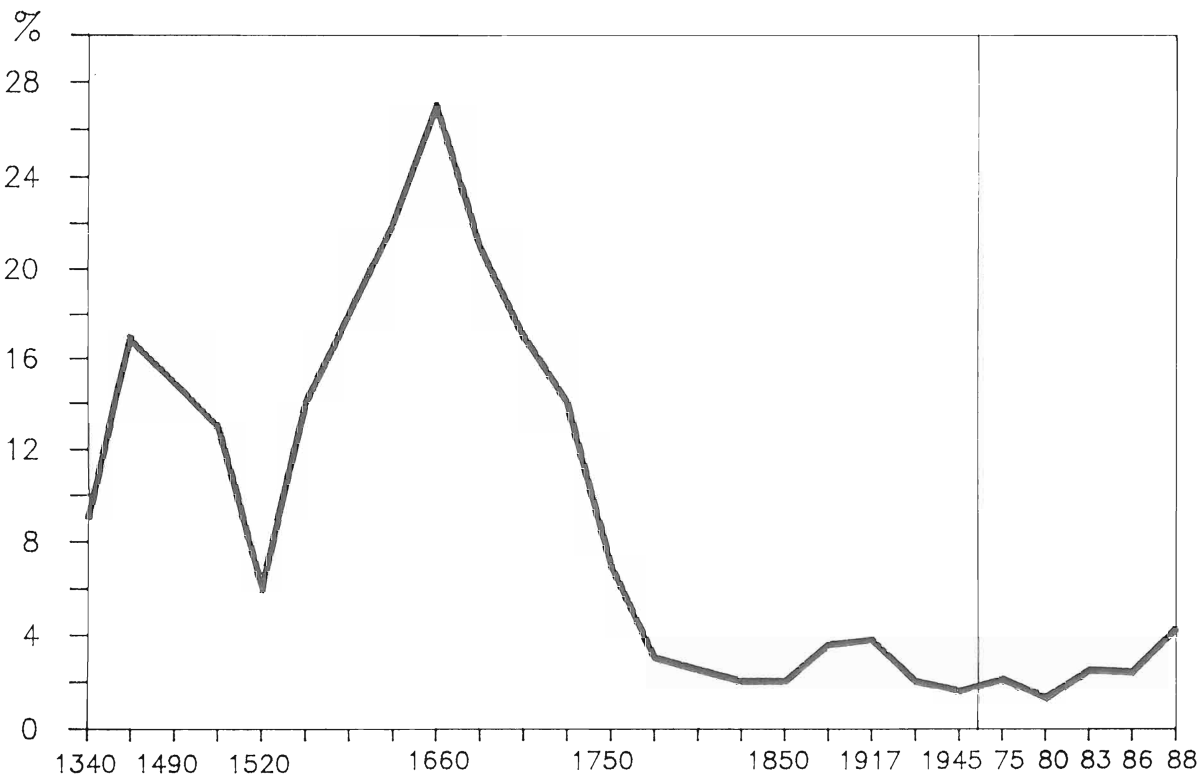
Table 8 Organizational hierarchies

(1) Level of aggregation	(2) Organization	(3) Activity	(4) Target (performance criterion)	(5) Database (measurement system)	(6) Market contact surface
(1)	Group (concern)	Financial guidance	Rate of return on net worth	Balance sheet & profit and loss statement	I,L,P,K
(2A)	Division	Financial and profit control	Rate of return on total capital	Profit and loss statement and partial balance sheet	I,L,P
(2B)	Subsidiary	Profit control	Rate of return on total capital	Profit and loss statement and partial balance sheet	I,L,P
(3)	Product group	Factory production	Profit margin	Profit and loss statement	I,L,P
(4)	Product	Process	Costs	Cost accounts	I,L
(5)	Component	Process element	Cost element	Cost accounts	I,L

I = Market for intermediate goods
L = Labor market
P = Product market
K = Credit market

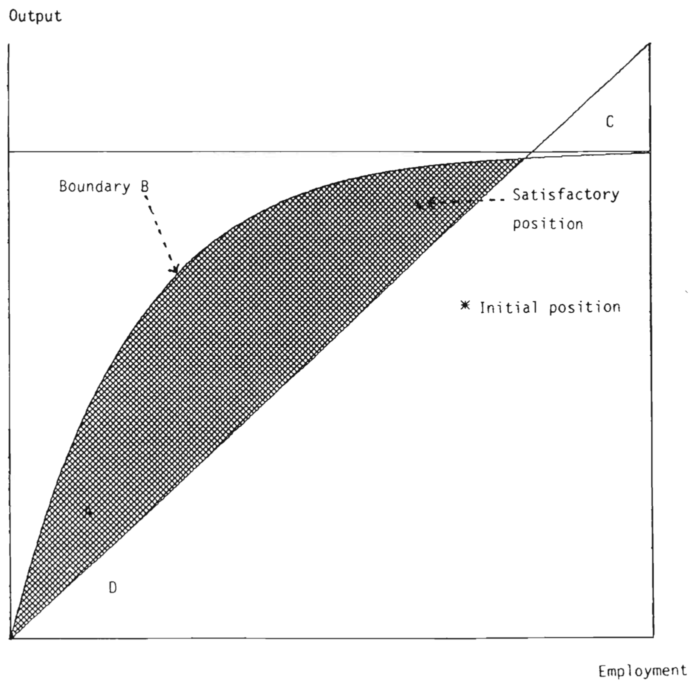
Source: Eliasson (1987, p. 72).

Figure 1 **The share of Swedish manufacturing output of Stora Kopparberg, 1340–1988**
Company turn-over in percent of total manufacturing and mining production



Source: **MOSES Database** (Lars Jagrén).

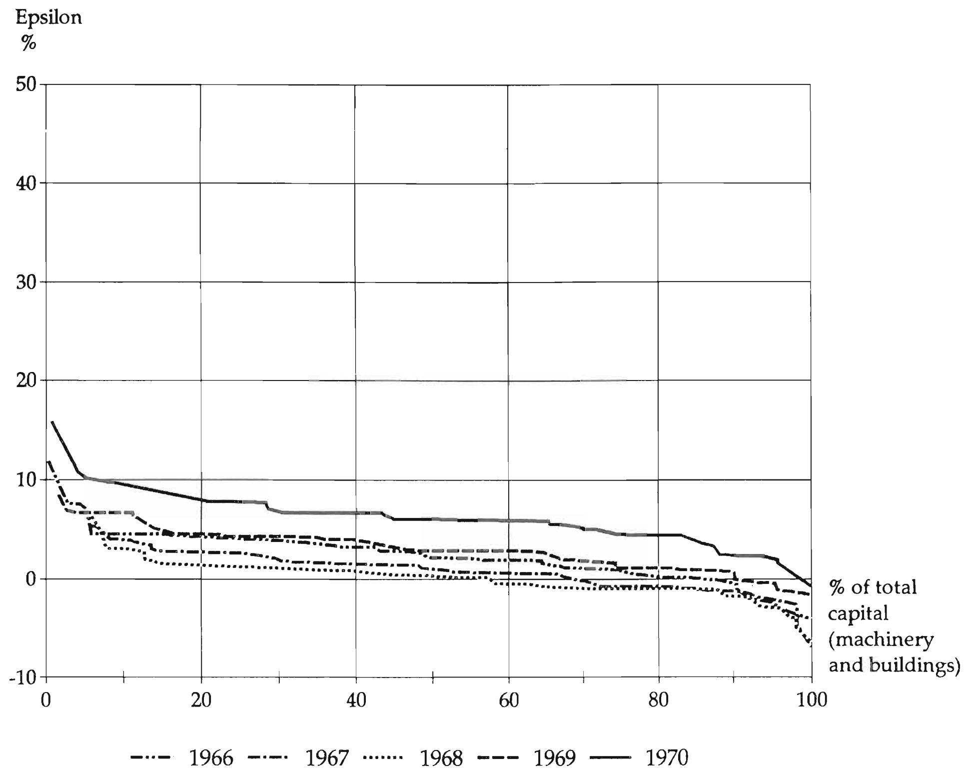
Figure 2 MIP-targeting in real MOSES firm, first quarter 1983



Explanation: On the basis of data, initially from the planning survey, then on from data endogenously created in the model, each firm computes the *boundary* B, the production frontier. The *"Profit Target Line"* through the origin is computed on the basis of past profit margins and expected prices in equation (5). The boundary and the profit target line delimit the feasible and satisfactory area of production (shaded) within which the MOSES firm can be, and desires to be. From its initial position, algorithms determine how the firm searches its way into the satisfactory, shaded region, bounded from above by the production frontier B.

Source: Eliasson (1991c, p. 161).

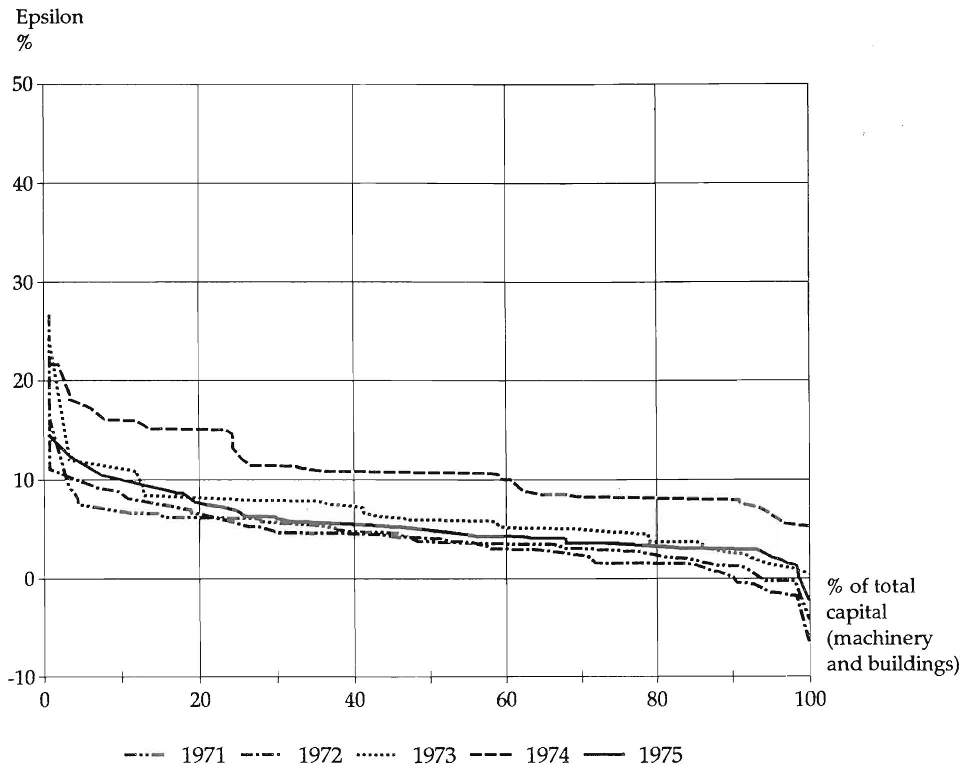
Figure 3A **Distributions of rates of return over interest rates (epsilon), 1966-1970**



Note: The epsilon is defined as $[R^N\text{-}r]$ in (3). We have computed the real rate of return on total assets by removing the capital gains factor in (4B) and then deflated the long-term interest rate r with the consumer price index. In computing depreciation charges we have used the reported rate of depreciation "according to plan" in the books and applied that rate to the depreciated capital stock according to a replacement valuation. All firm accounts are consistent. The depreciation method used in these figures, however, differs somewhat from the one used in the macro accounts in Tables 6. The above method happens to be most practical in these illustrations. In the MOSES model, however, all calculations are properly and consistently done each quarter for each firm. The definitional problems that may arise concern the use of the macro accounts for calibrating the model historically.

Source: Own calculations from annual reports, Findata etc.

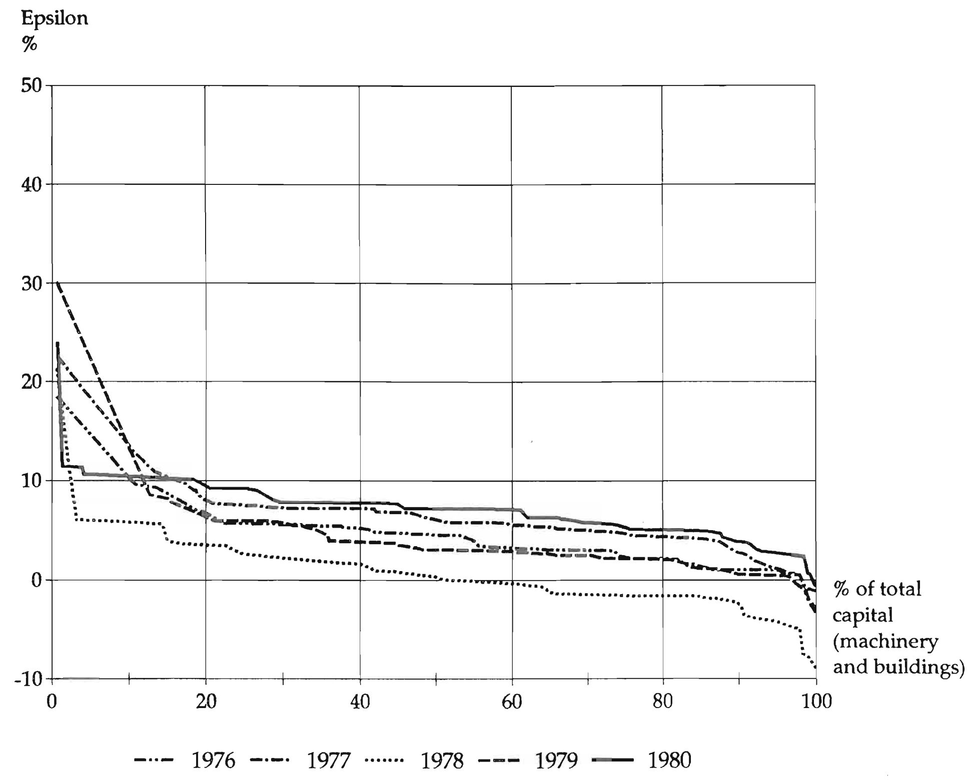
Figure 3B **Distributions of rates of return over interest rates (epsilon), 1971-1975**



Note: See Figure 3A.

Source: Own calculations from annual reports, Findata etc.

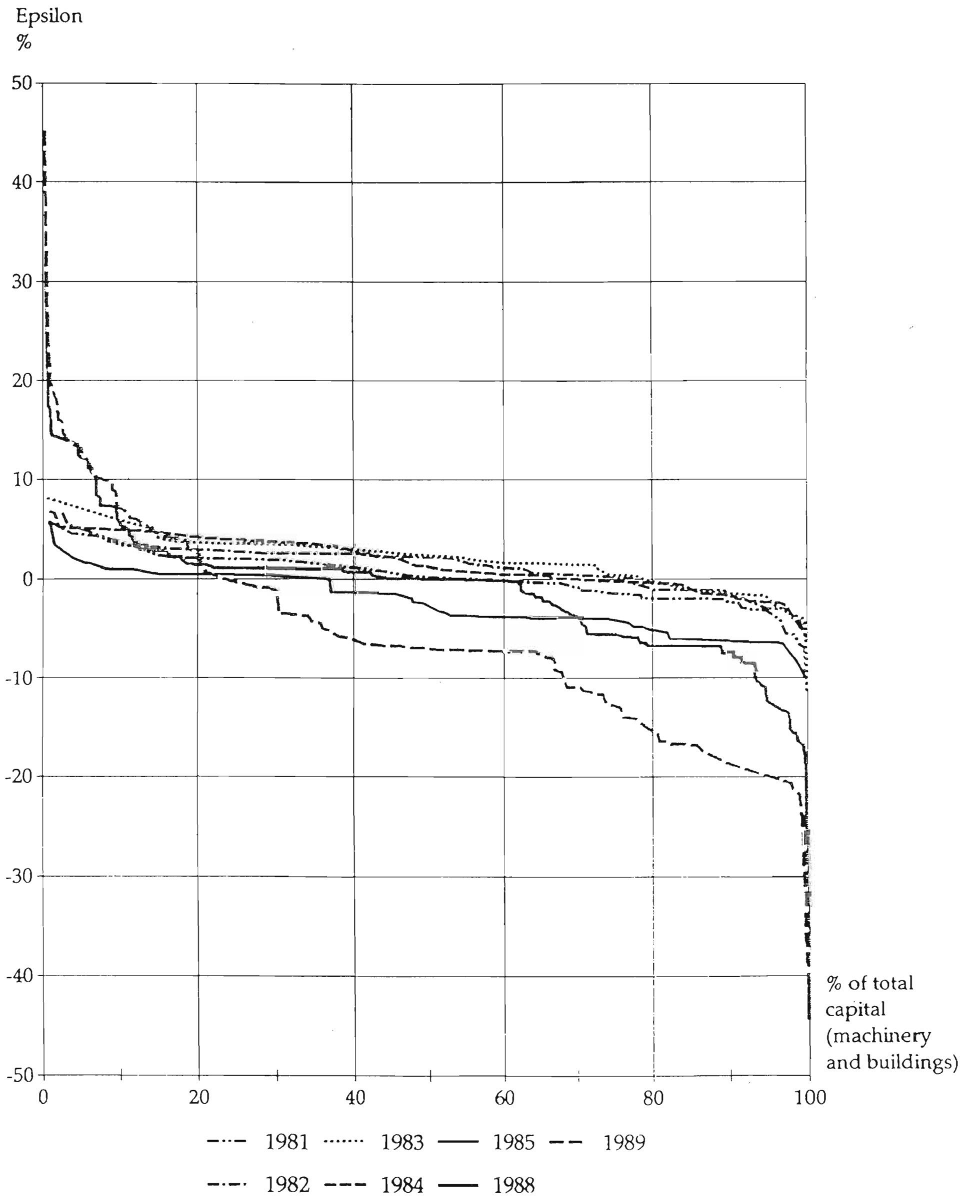
Figure 3C **Distributions of rates of return over interest rates (epsilon), 1976-1980**



Note: See Figure 3A.

Source: Own calculations from annual reports, Findata etc.

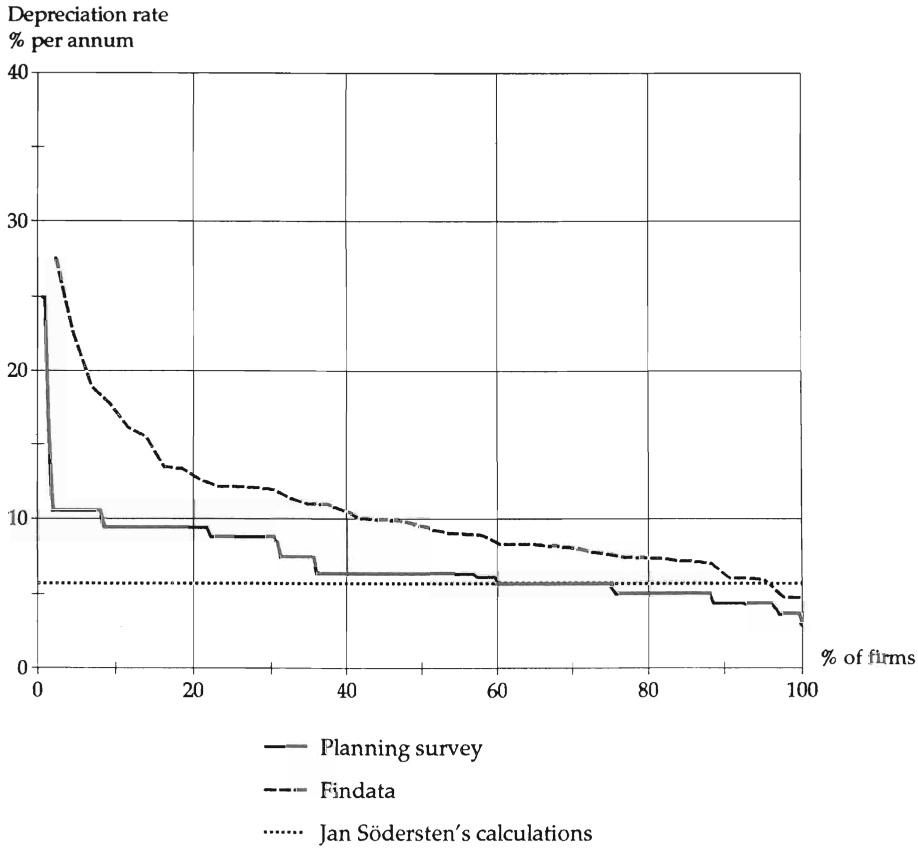
Figure 3D **Distributions of rates of return over interest rates (epsilon), 1981-1985, 1988, 1989**



Note: See Figure 3A.

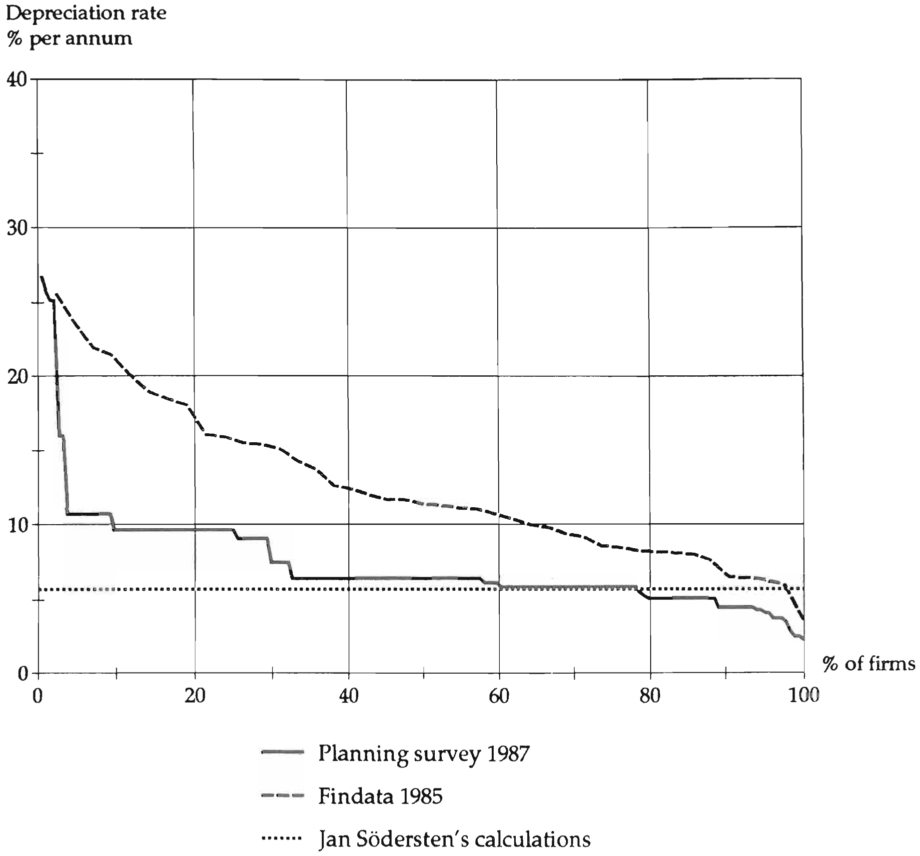
Sources: 1981-85: Large firms: Findata.
1988: All firms: IUI firm survey (Braunerhjelm 1991 and Chapter IV in this volume).
1989: Small firms and subcontractors: IUI firm survey (Braunerhjelm 1991 and Chapter IV in this volume).

Figure 3E **Depreciation rates 1978 according to different sources**



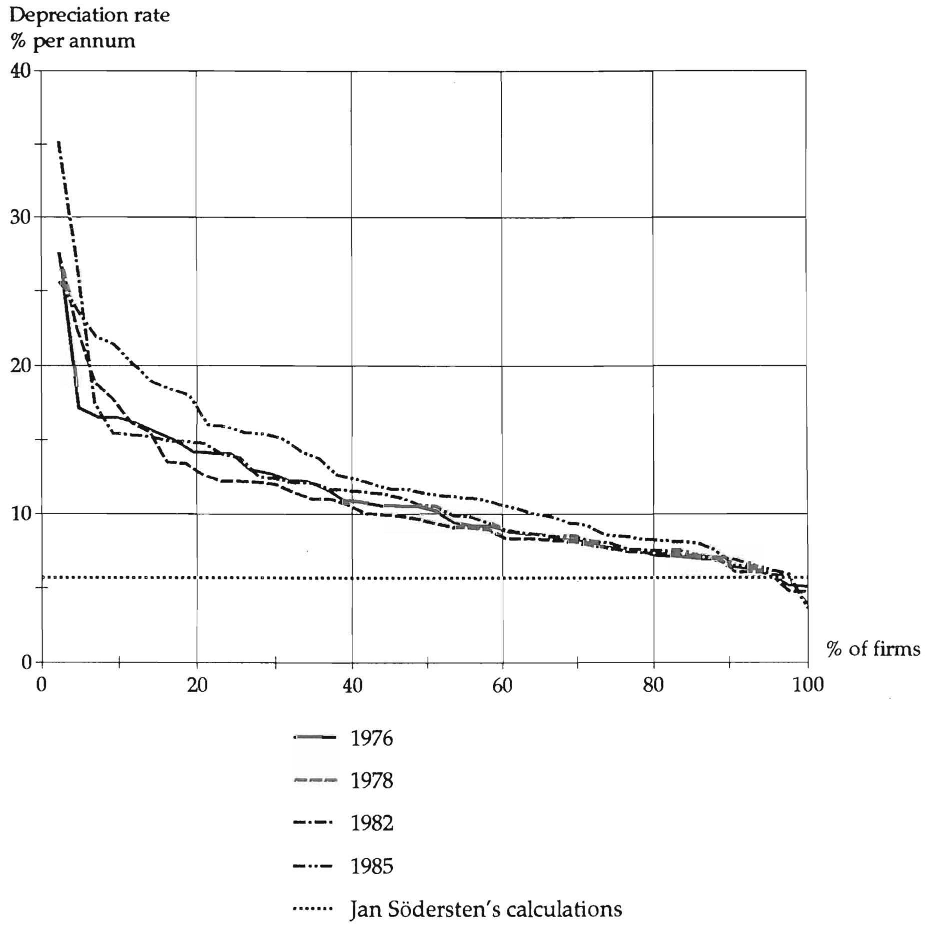
Explanation: The planning surveys of 1978, 1987 and 1990 requested depreciation rate or life-length estimates from divisions or firms as they should apply to replacement valued capital.
The Findata depreciation rates by firm are explained in note to Figure 3A.
For explanation of Jan Södersten's calculations, see Södersten (1985). These estimates are used in Tables 6A, B, C.

Figure 3F **Depreciation rates 1985 and 1987 according to different sources**



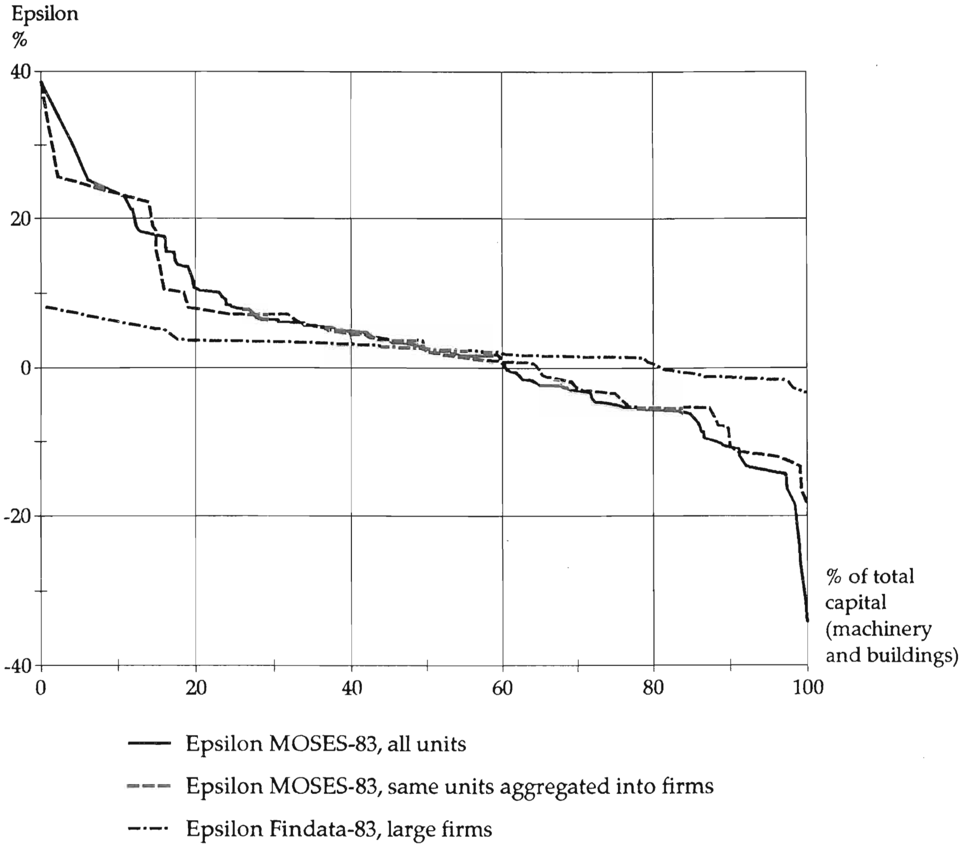
Explanation: See Figure 3E.

Figure 3G Depreciation rate distributions, different years



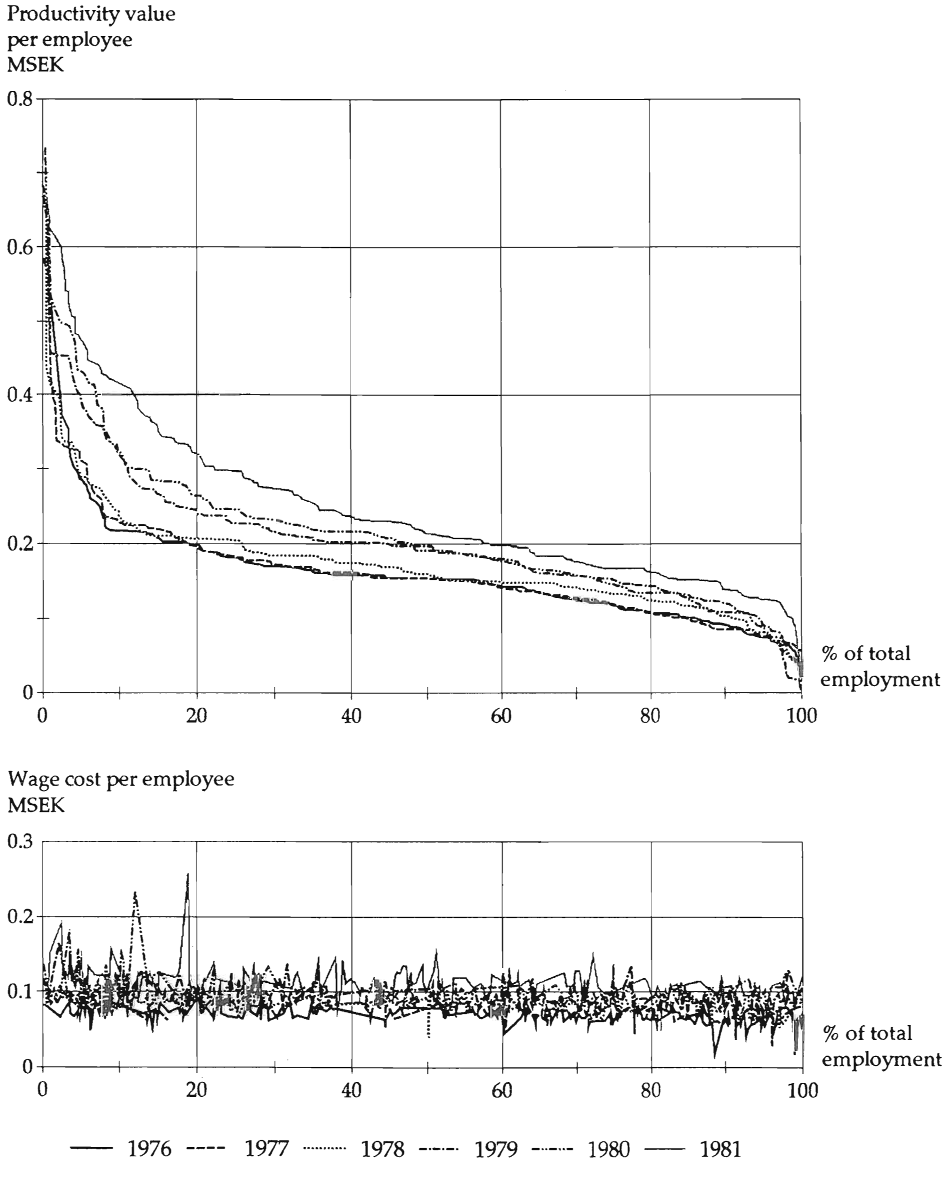
Explanation: See Figure 3E.

Figure 3H Epsilon distributions from two different sources, beginning of 1983



Explanation: The three distributions use somewhat different definitions and illustrate the consequences of aggregation. The MOSES-83 distribution is the first simulated year after the initial year, 1982. The *aggregated* MOSES-83 distribution is the same distribution, except that all divisions belonging to the same firm or group ("koncern") have been aggregated. The Findata-83 distribution includes the 29 largest Swedish manufacturing firms.

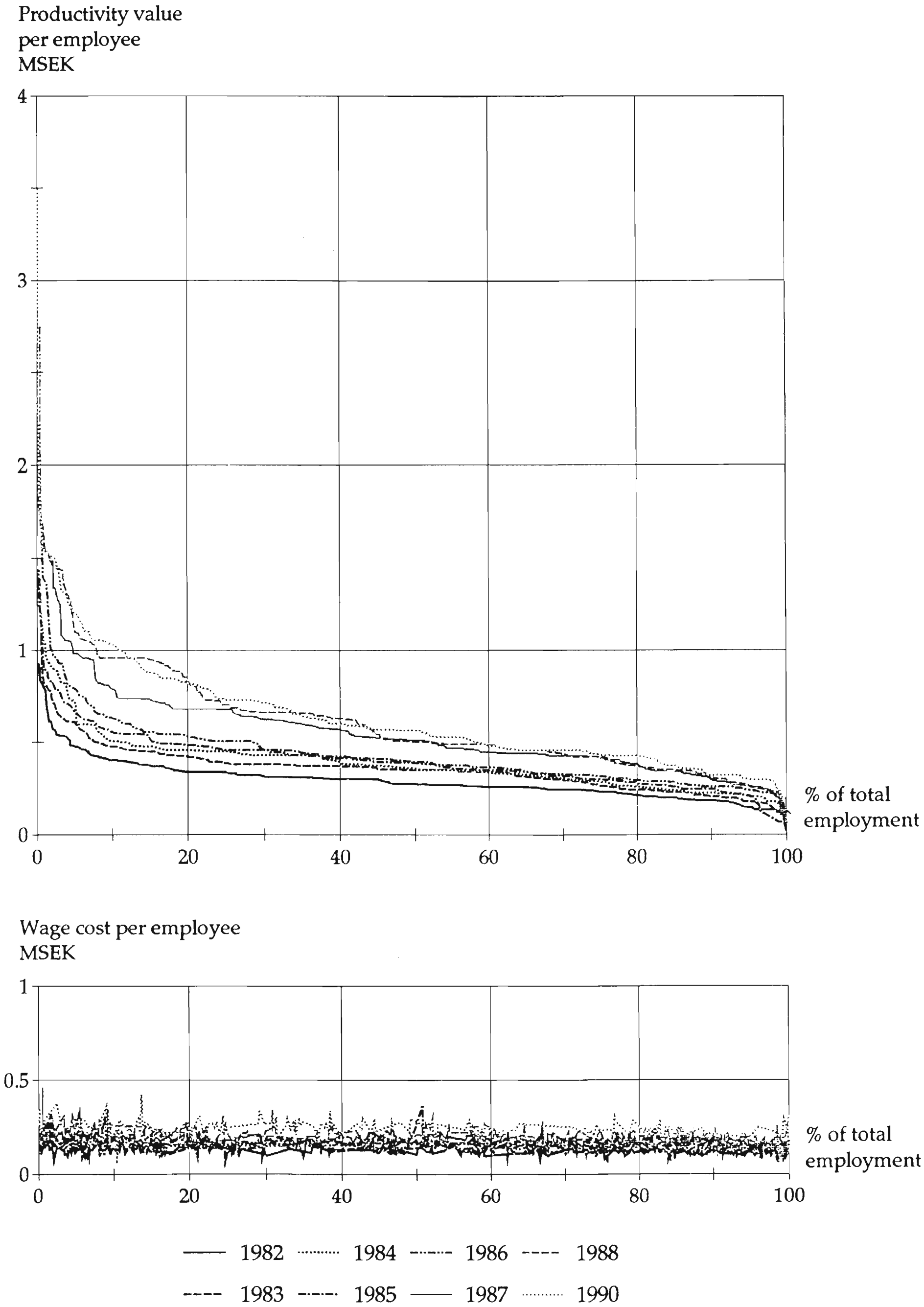
Figure 4A **Labor productivity and wage cost distributions, 1976-1981**



Note: Productivity value per employee minus wage cost per unit of labor equals gross profit per unit of labor.

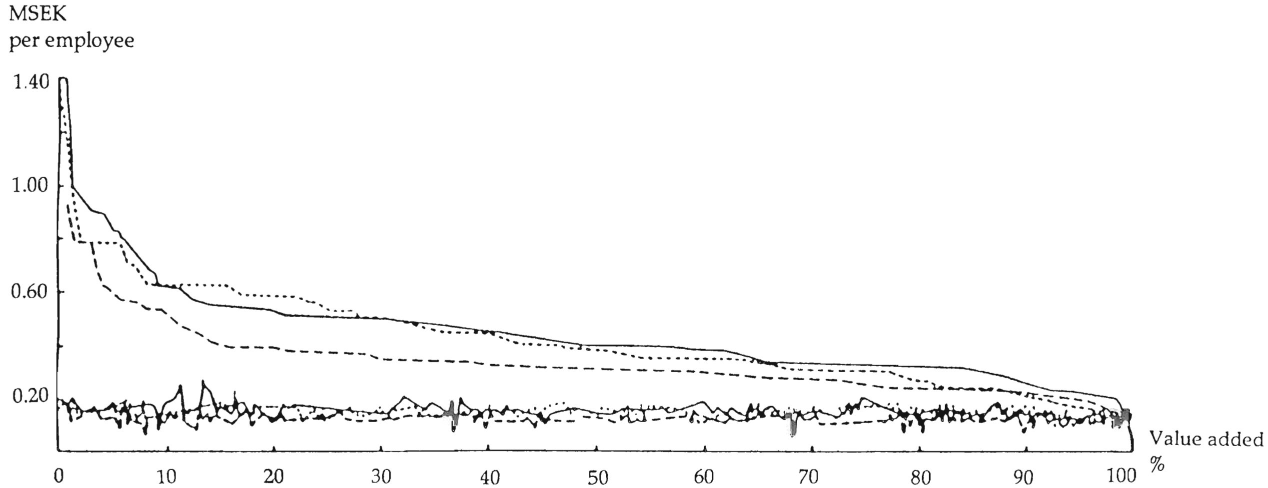
Source: Planning surveys, 1976-1981.

Figure 4B **Labor productivity and wage cost distributions, 1982-1990**



Source: Planning surveys, 1982-1990.

Figure 4C **Productivity and wage distributions 1982 and 1985, and simulated distributions, 1985**

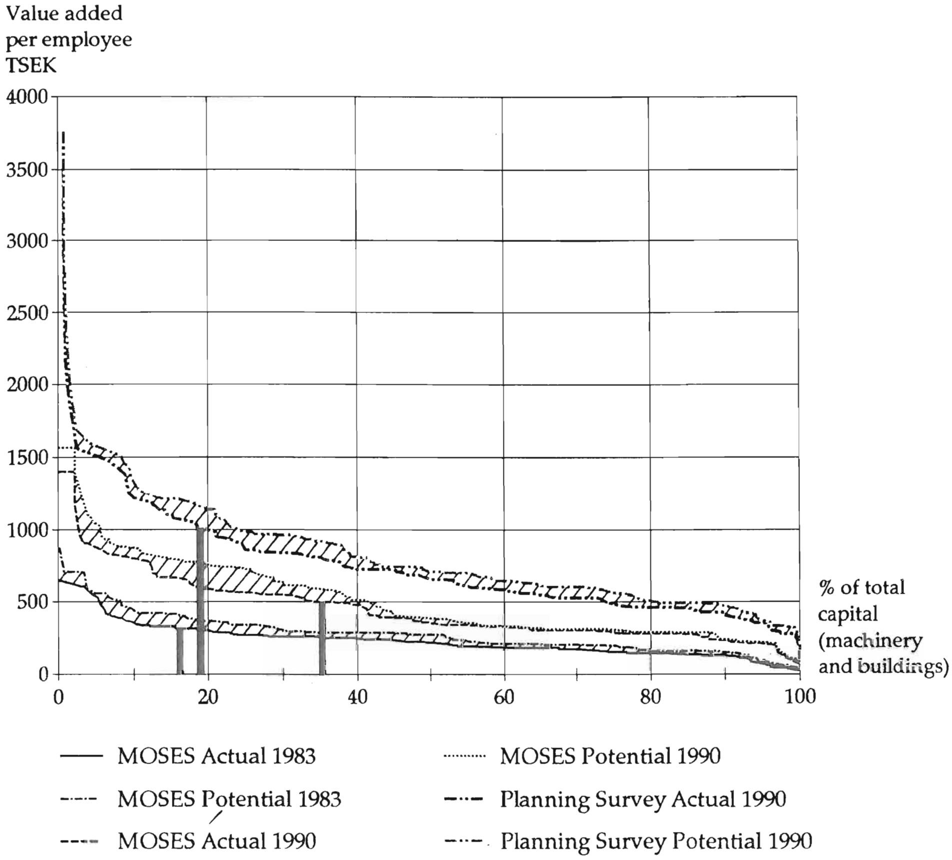


Note: The upper curves show distributions of productivity values, ranked in decreasing order over firms and weighted by value added. The lower curves show matching nominal wage cost distributions.

The simulation began on the 1982 initial database (- - -). The outcome of the simulation (.....) can be compared with real 1985 state from the database (——).

Source: Eliasson and Lindberg (1986).

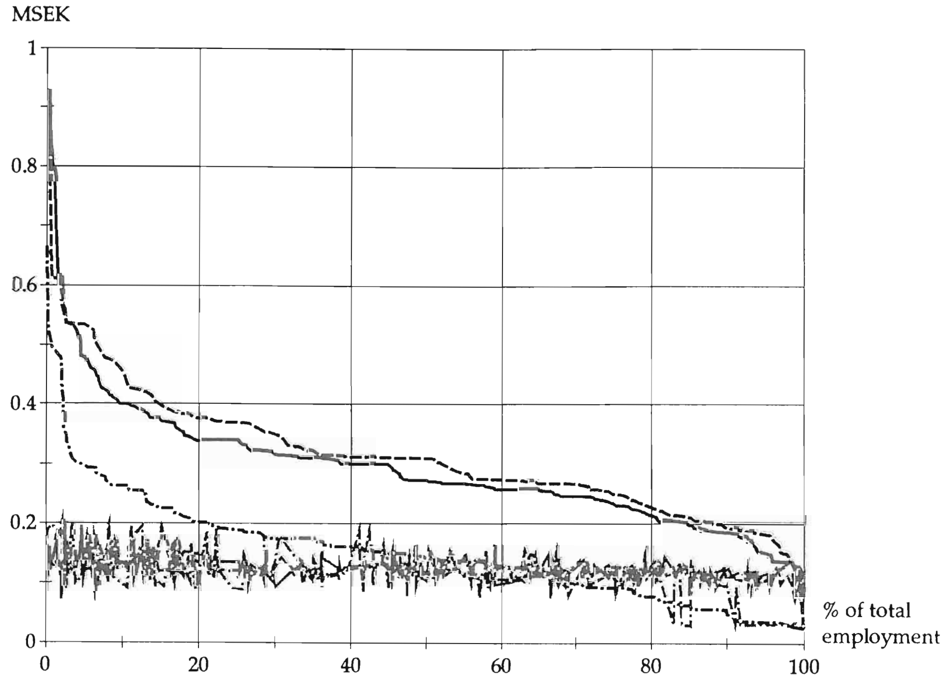
Figure 4D **Actual and potential labor productivity distributions, 1983 and 1990**



Comment: Actual and potential labor productivities, beginning 1983, according to planning survey, and same from 1990 in "synthetic" MOSES Database to be made available externally (see Taymaz 1991). The other 1990 distributions represent the entire planning survey for that year.
Shaded areas denote unused labor capacity.

Source: Planning survey 1990. See also Eliasson (1991c).

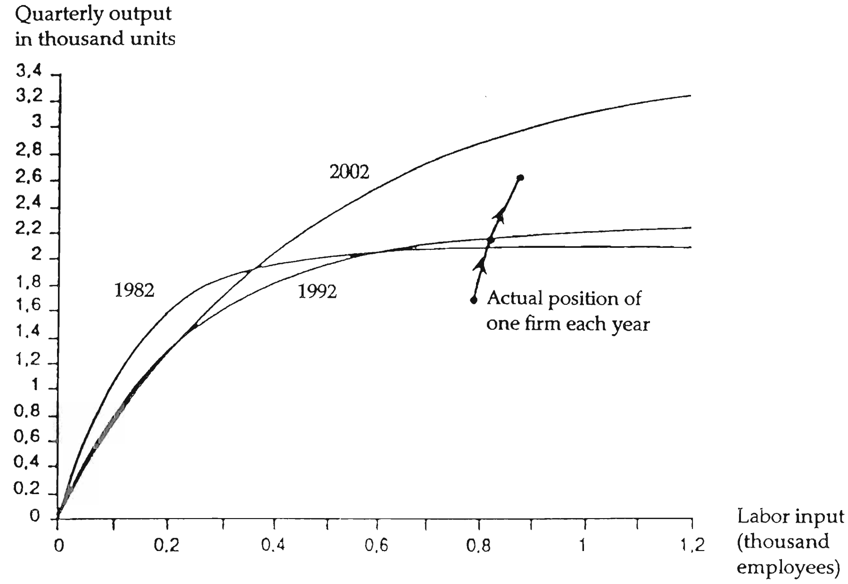
Figure 4E **Labor productivity and wage cost distribution 1982 according to:**
a) MOSES initial state, including synthetic firms
b) all planning survey sample
c) Albrecht's panel (see Chapter III in this volume)



Productivity: —— Planning survey --- Albrecht's panel -·-· MOSES initial state
Wages: —— Planning survey --- Albrecht's panel -·-· MOSES initial state

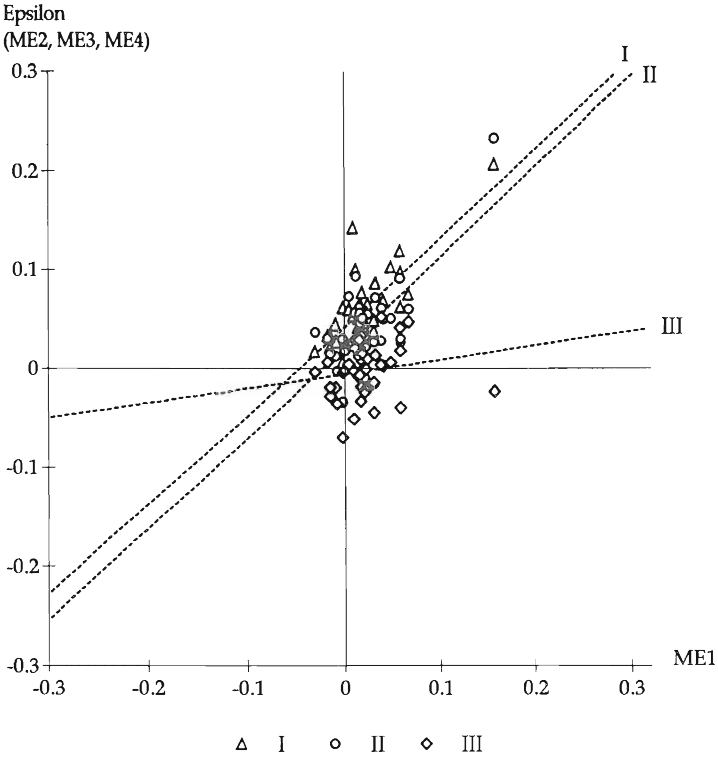
Figure 5 **Firm dynamics**

Figure 5A **Production frontiers and real firm positions 1982 (initial planning survey), 1992 and 2002 (simulated)**



Explanation: The three curves are the production frontiers of one firm (the boundaries B in Figure 2) for years 1982, 1992 and 2002, respectively. The points linked by arrows represent the position of one firm for each of the years. Apparently the firm was operating just below its frontier in 1982 (the initial year).

Figure 5B **The stability of individual firm rates of return over the interest rate (epsilon), 1966-1985**



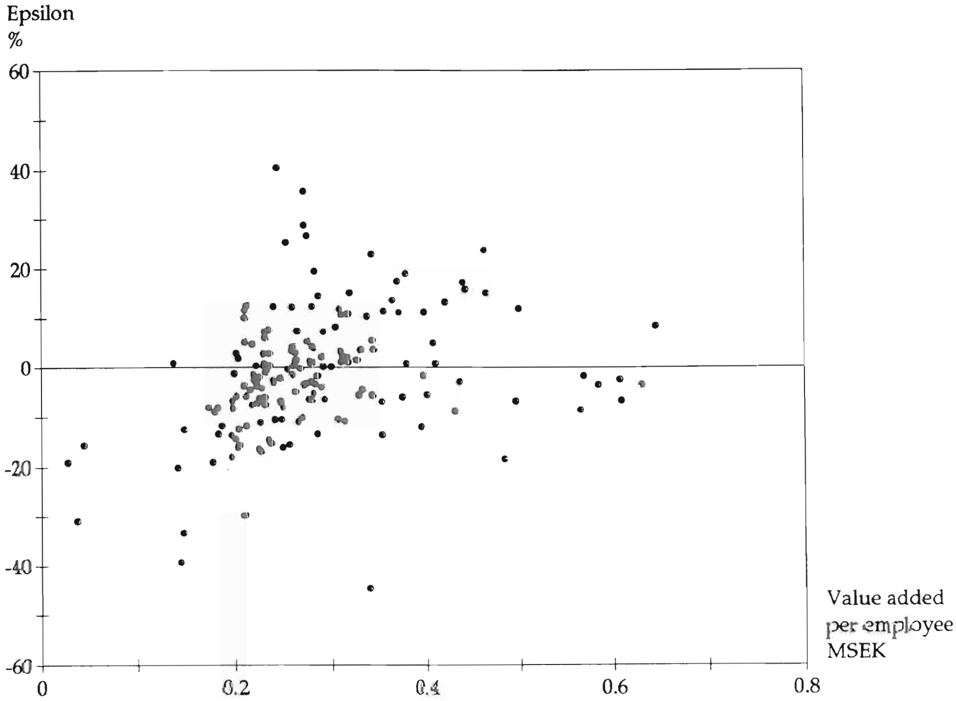
ME1: 1966-70
ME2: 1971-75
ME3: 1976-80
ME4: 1981-85

I	:	ME1 against ME2	r = 0.76
II	:	ME1 against ME3	r = 0.69
III	:	ME1 against ME4	r = 0.17

Note: ME = average rate of return over interest rate for five-year period.

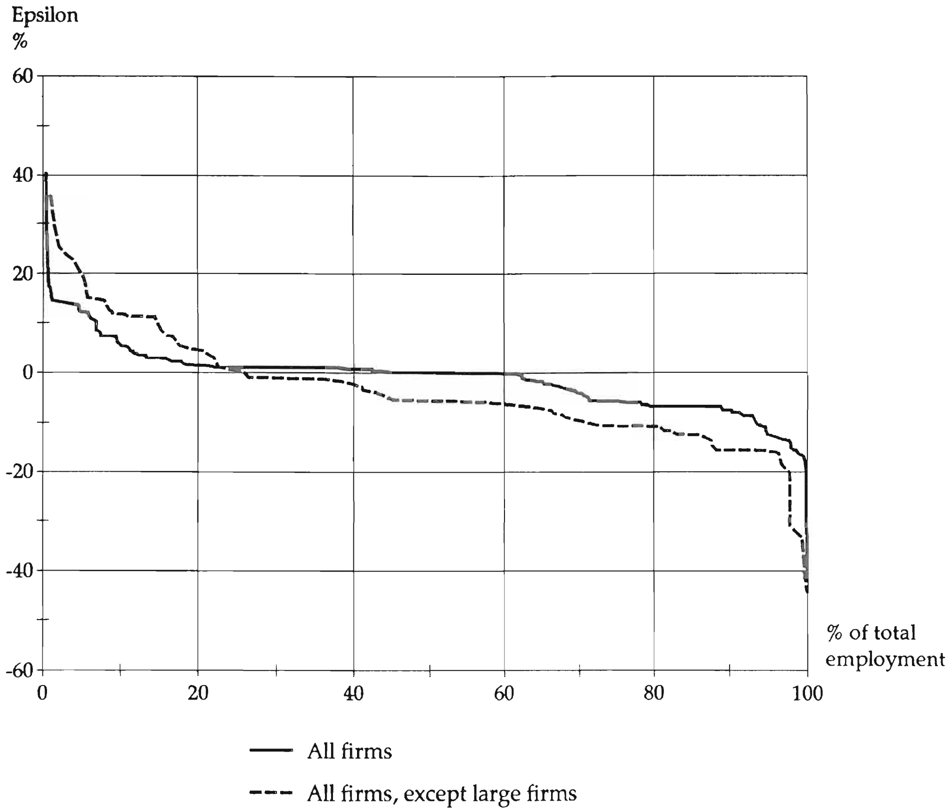
Source: Eliasson and Lindberg (1988, p. 97).

Figure 5C **Relation between rates of return over the interest rate (epsilon) and labor productivity, 1988.**



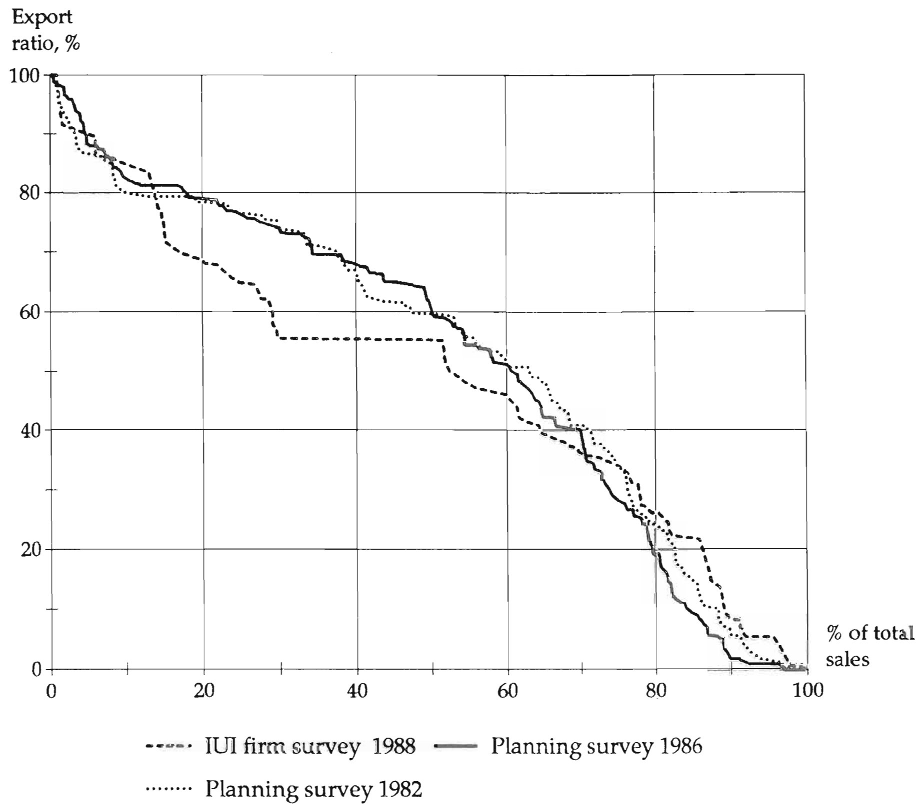
Sources: IUI firm survey 1988, and Braunerhjelm (1991, p.52).

Figure 5D **Epsilon distributions of all firms, and of all firms excluding the large firms, 1988.**



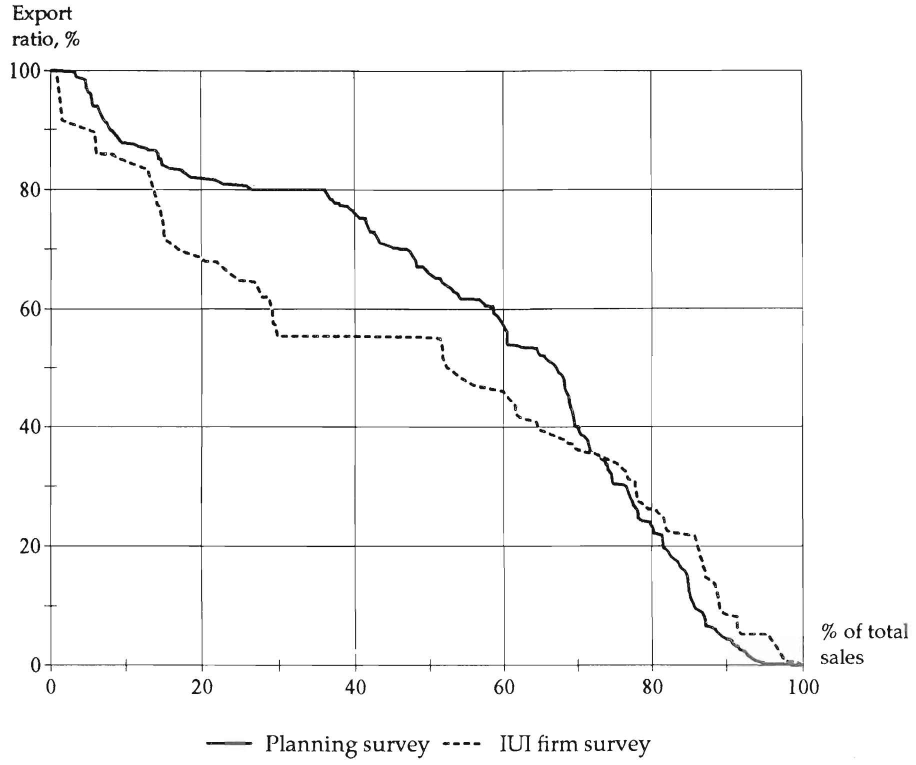
Source: Chapter IV in this volume.

Figure 6A **Export ratio distributions according to planning survey 1982 (initialization year), 1986 and special IUI firm survey 1988**



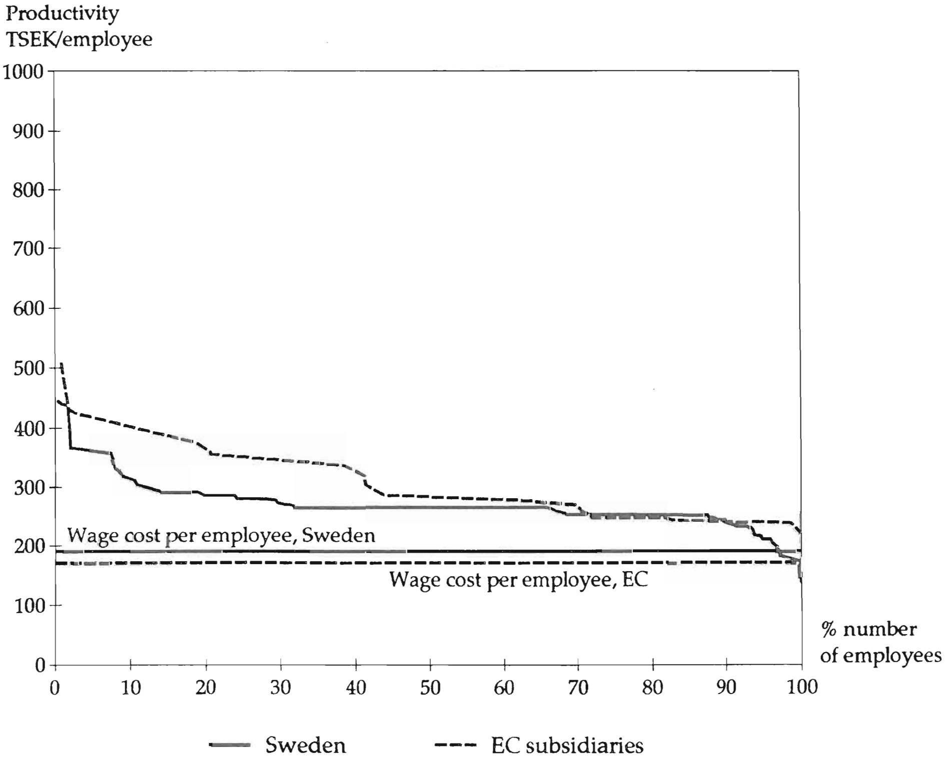
Definitions: Export deliveries in percent of Swedish gross production. This calculation uses survey data on internal group deliveries from Swedish plants to EC subsidiaries. Due to an oversight such data were not collected for internal deliveries to subsidiaries in other countries. We did, however, have data on plant investments in Sweden, in EC, and in rest of the world. These data were used to approximate non-EC internal group deliveries from Swedish plants.

Figure 6B **Export ratio distributions of planning survey units 1988, and of separate IUI firm survey 1988**



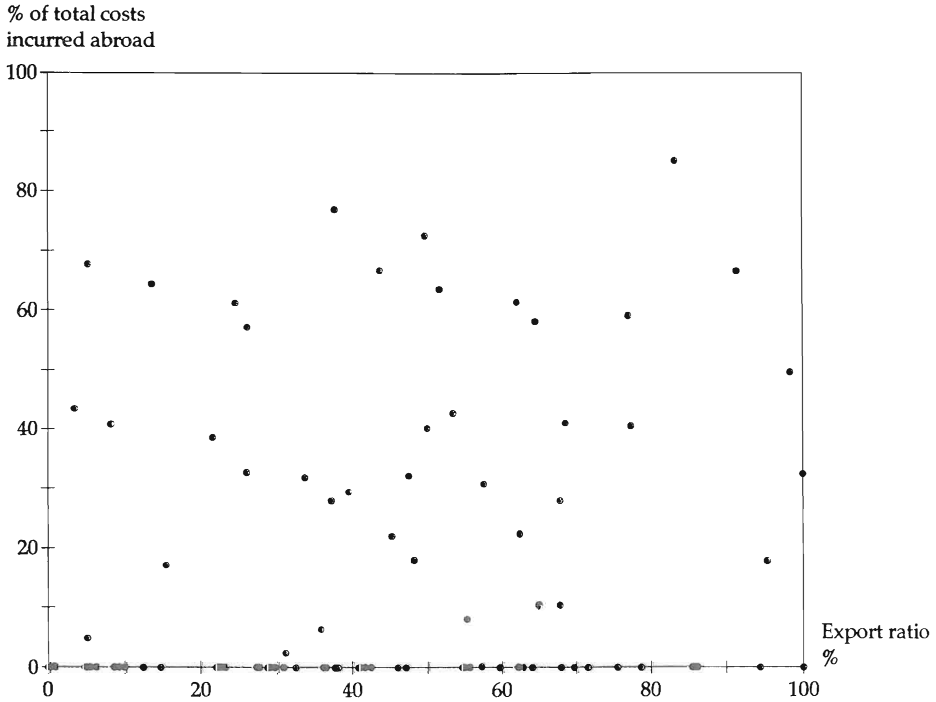
Sources: Planning survey 1988, and Braunerhjelm (1991).

Figure 6C **Labor productivity and wage distributions of domestic and foreign (EC) parts of Swedish engineering firms, 1988**



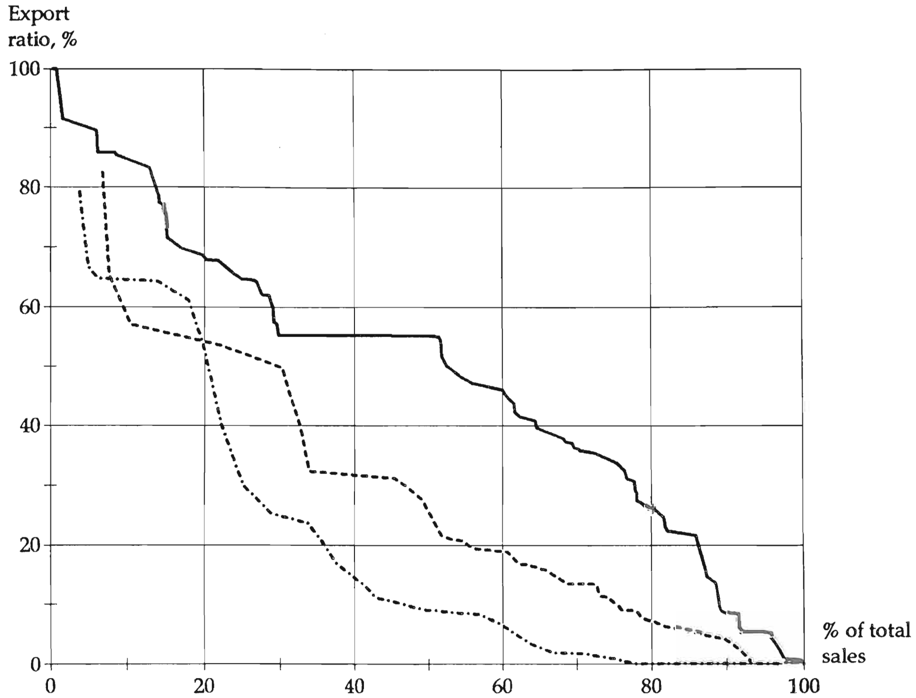
Source: Braunerhjelm (1990).

Figure 6D **Rate of internationalization and exports out of Swedish plants according to special IUI firm survey 1988**



Note: The export ratio (horizontal axis) is computed as export deliveries out of Swedish plants in percent of Swedish gross output. The foreign share of production is the share of value added abroad, in percent of total (global) value added. Export ratios are based on the same approximation as in Figure 6A.

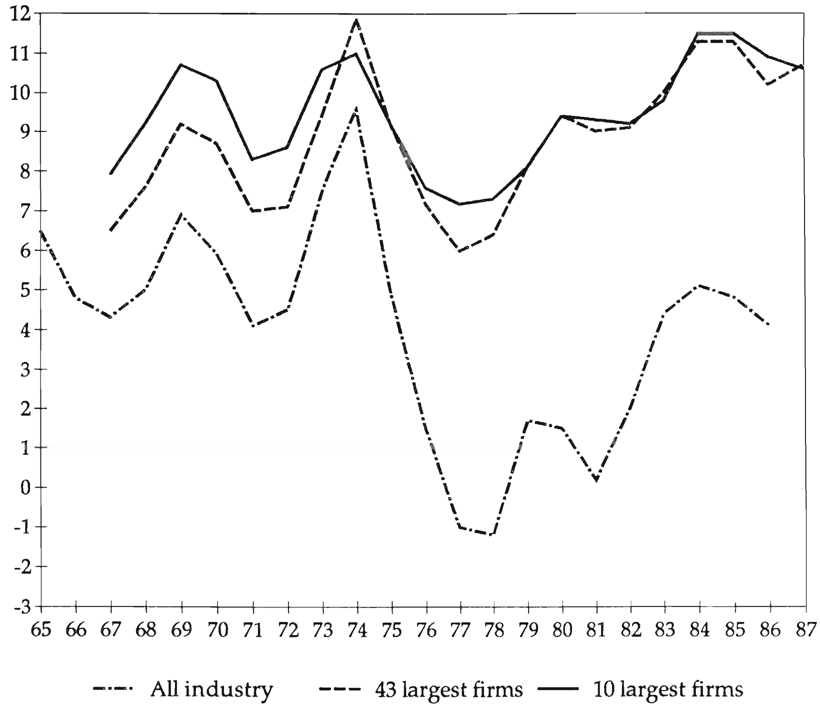
Figure 6E **Export ratio distributions 1988 of large firms, small firms and subcontractors 1988, according to special IUI firm surveys**



----- Subcontractors -·-·- Small firms —— Large firms

Sources: Braunerhjelm (1991), and Chapter IV in this volume.

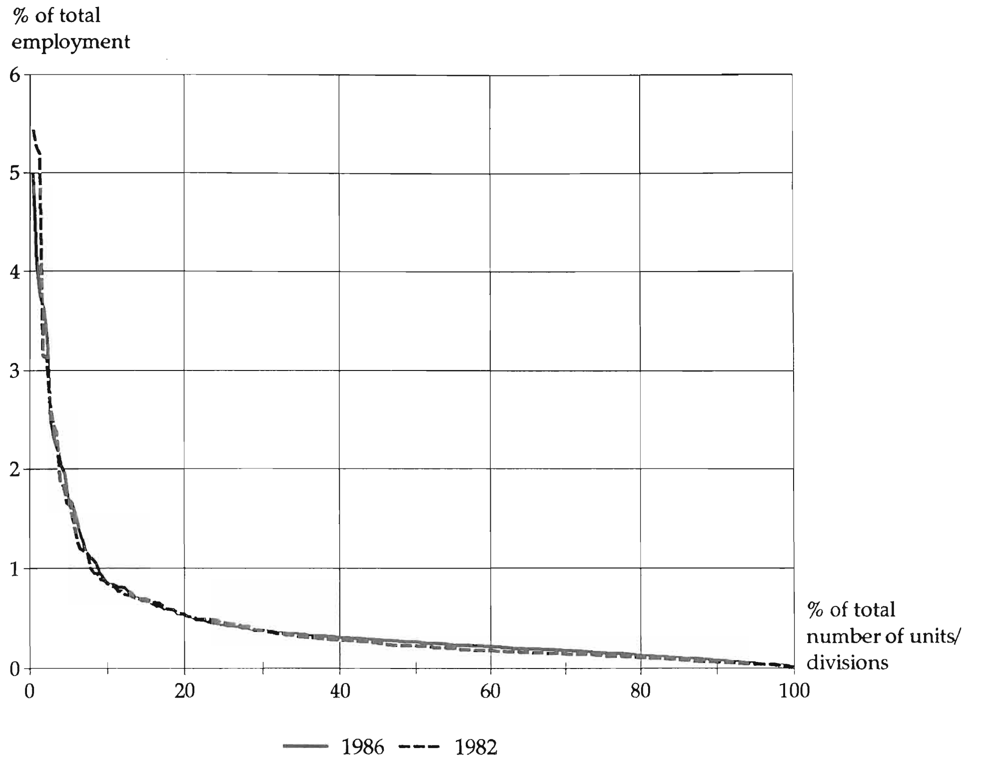
Figure 6F **The real rate of return of all manufacturing, domestic operations, the 10 and the 43 largest firms respectively, global operations, 1965-1987**



Note: The definitions of the real rate of return are identical for the three groups of firms. Please, observe that the domestic rates of return include the domestic parts of all international firms.

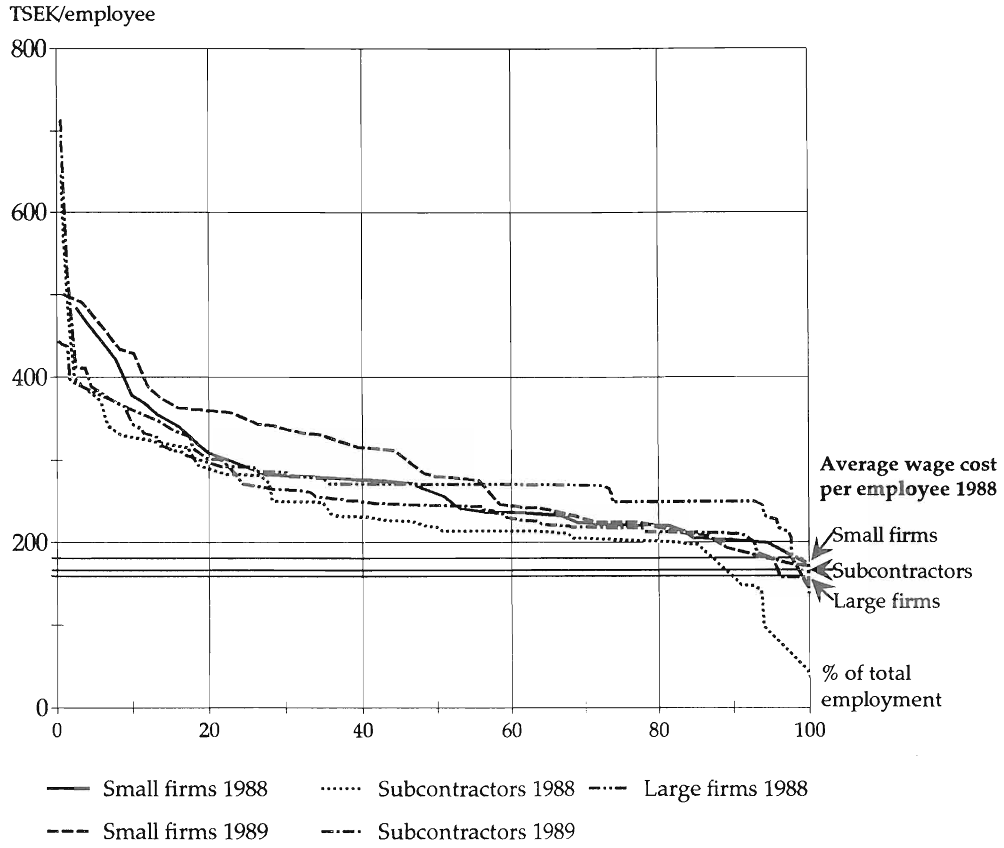
Sources: MOSES Database and Direct Foreign Investment Surveys.

Figure 7A **Size distributions of planning survey units, 1982 and 1986**



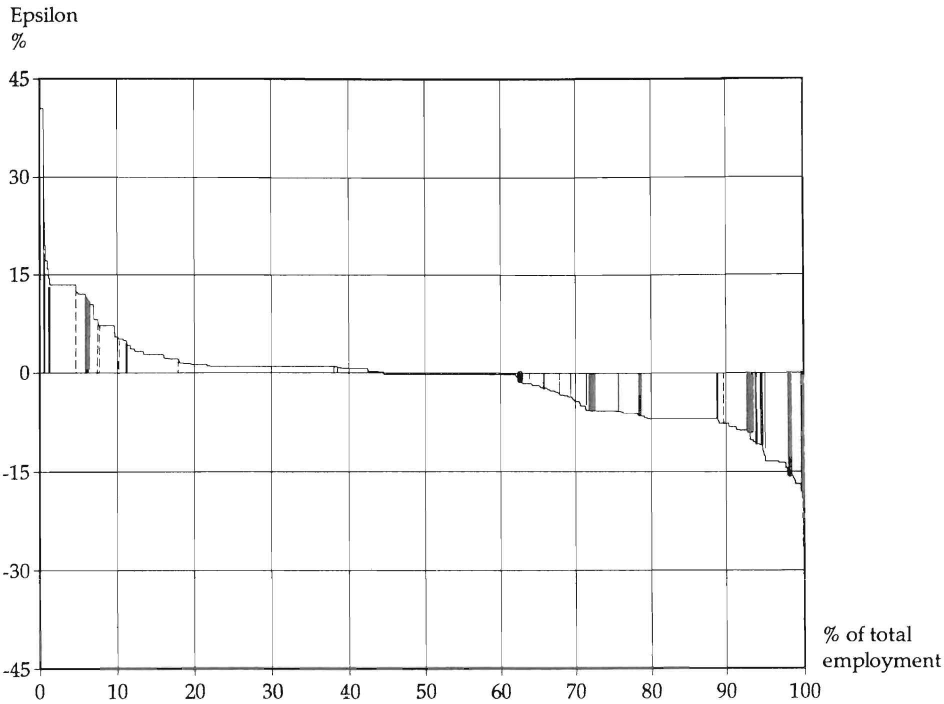
Sources: Planning surveys 1982 and 1986.

Figure 7B **Labor productivity distributions and average wage of small and large firms and of subcontractors, 1988, according to special IUI firm surveys**



Source: Braunerhjelm (1991).

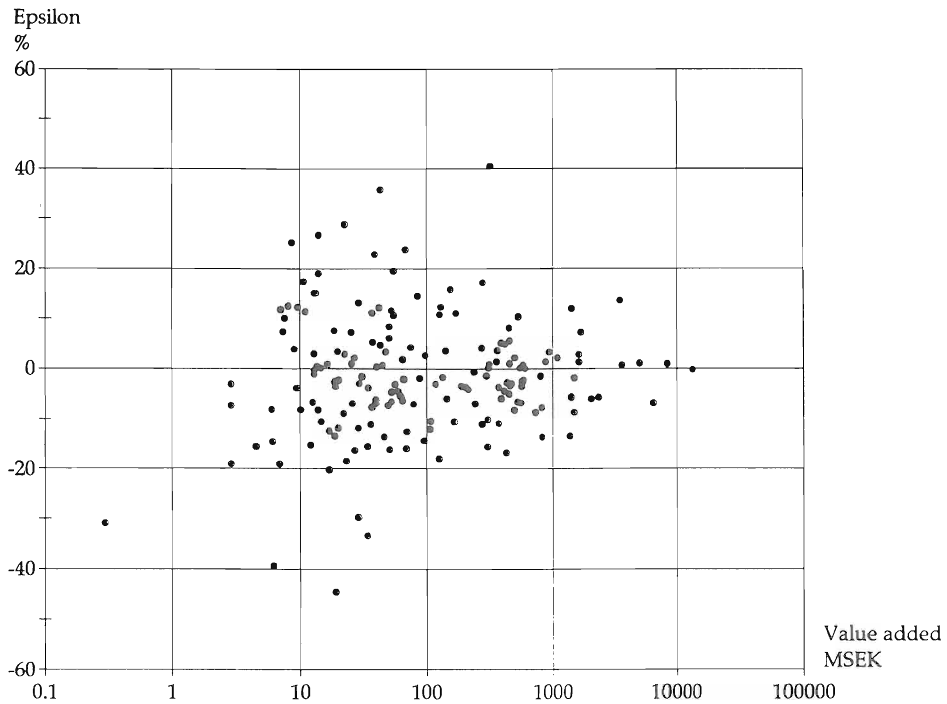
Figure 7C **Rate of return over the interest rate (epsilon) of small firms, large firms, and of subcontractors, 1988**



Subcontractors:	Black areas
Small firms:	Dotted lines
Large firms:	Blank areas

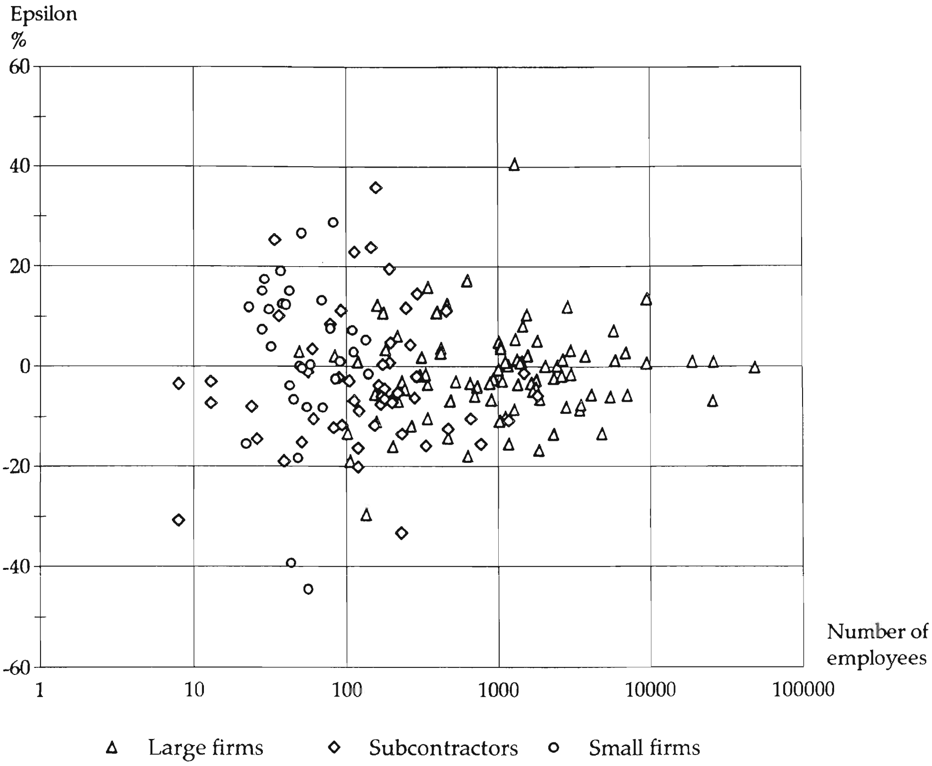
Source: Braunerhjelm (1991).

Figure 7D **Comparison of rates of return of firms of different sizes, measured in value added, 1988**



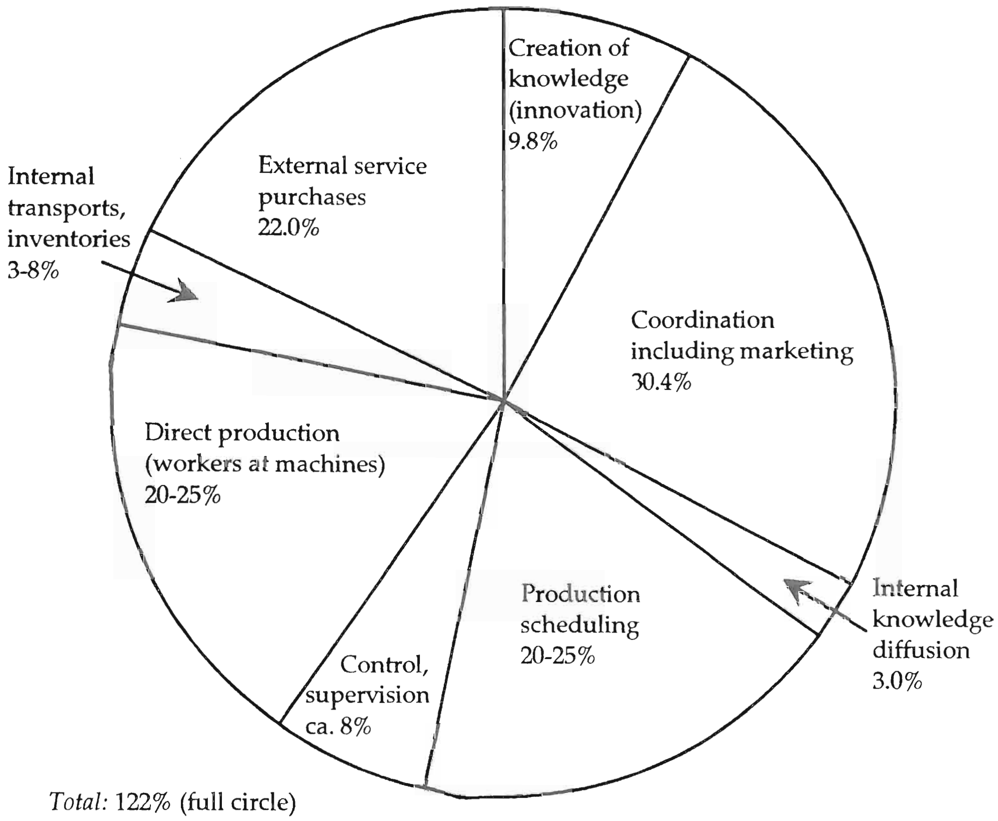
Source: IUI firm survey 1988 (see Chapter IV in this volume).

Figure 7E **Comparison of rates of return of firms of different sizes, measured by number of employees, 1988**



Source: IUI firm survey 1988 (see Chapter IV in this volume).

Figure 8 **Distribution of labor costs, percent, large Swedish firms, global operations**

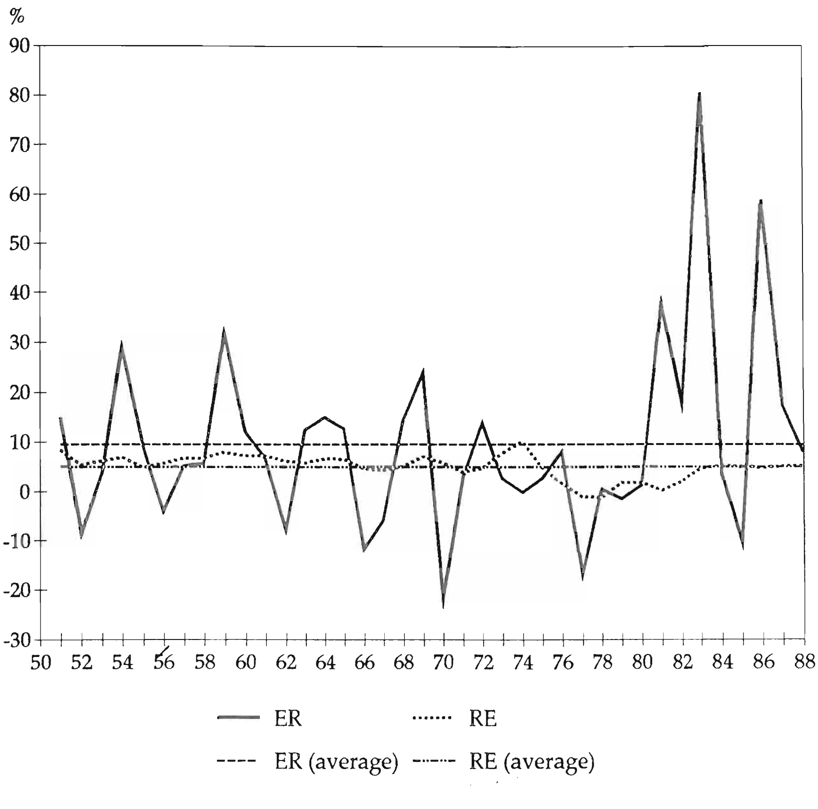


Total: 122% (full circle)

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

Figure 9 **Effective and real rates of return in Swedish manufacturing, compared to financial costs, 1951-1988**

Figure 9A **Effective real rate of return (ER), compared to the real, before tax, rate of return on equity (RE)**



Note: Horizontal lines indicate corresponding averages. ER is the rate of change in the market value of stock minus the rate of change in the consumer price index plus the rate of dividend pay-out of the market value of stock. The real rate of return on equity is the nominal rate of return minus the rate of change in the capital goods price index. See Section 3.1.

Source: See Tables 6A and B.

Figure 9B **Real rate of return on total assets (R) and equity (RE), compared to the real interest rate (IR)**

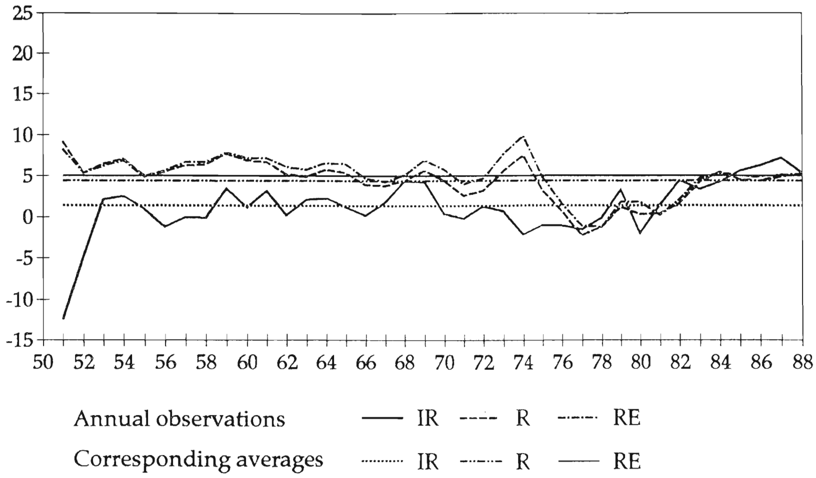
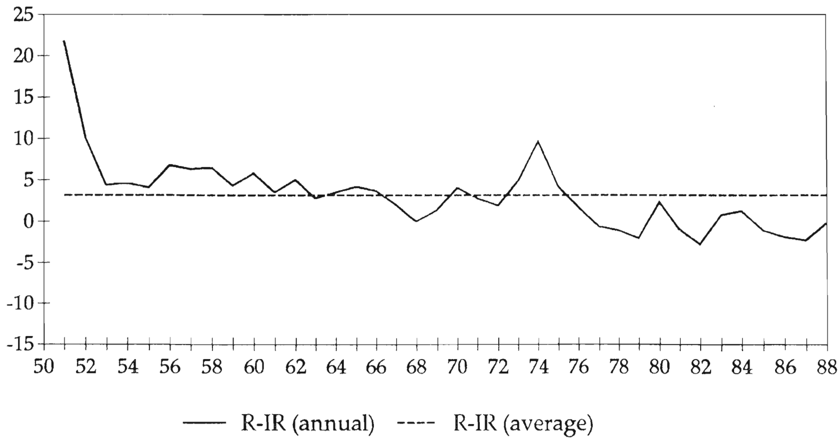


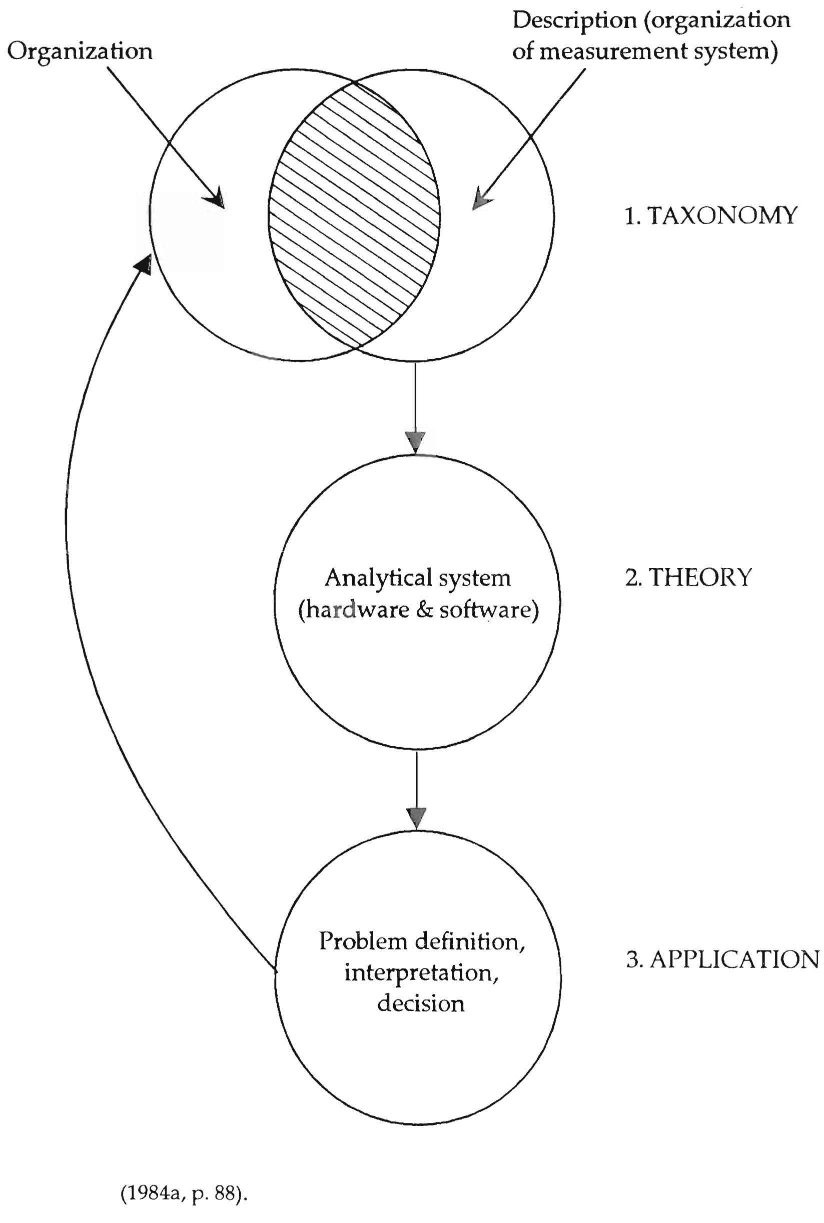
Figure 9C **Rate of return on total assets over the interest rate and equity (epsilon=R-IR)**



Note: Horizontal lines indicate corresponding averages. The real rate of return (R) is the nominal rate of return in Section 3.1 minus the rate of change in the capital goods price index. The real interest rate (IR) is the nominal interest in industrial loans minus the rate of change in the consumer price index.

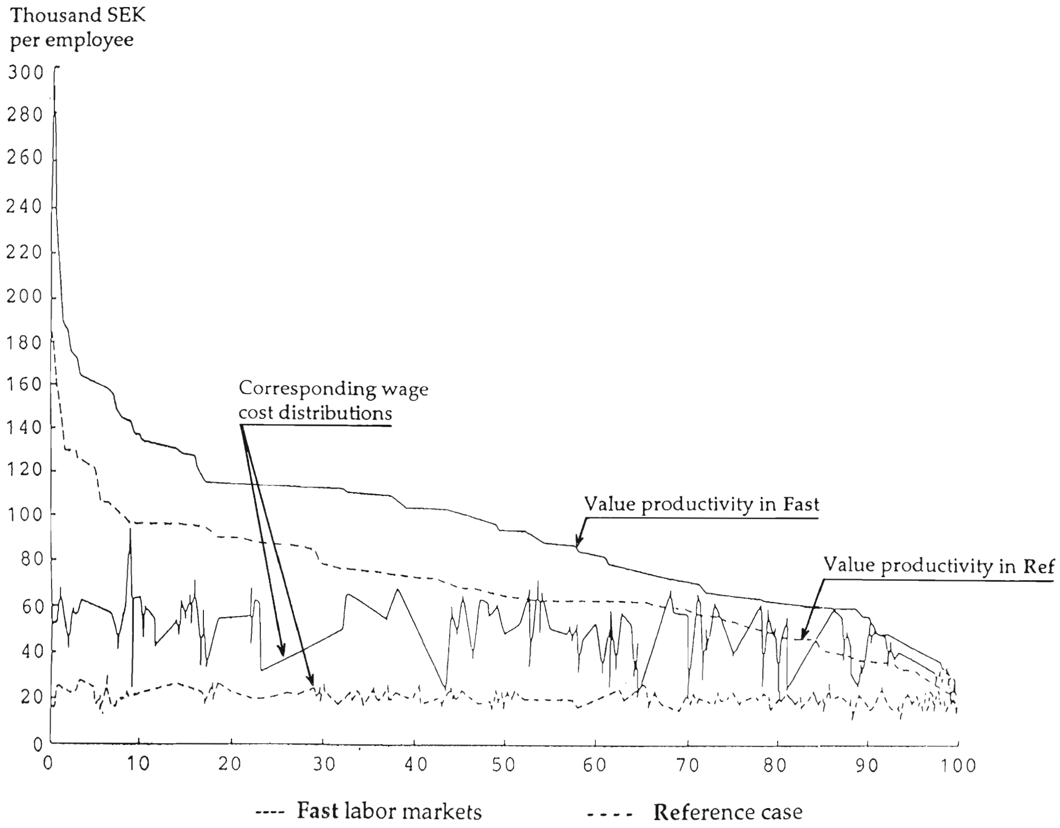
Source: See Tables 6A and B.

Figure 10 **Integrated information and control system of a firm**



(1984a, p. 88).

Figure 11 **Wage cost and value productivity distributions 1992 in reference case and in fast market experiment**



Source: Eliasson and Lindberg (1986).

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