A list of Working Papers on the last pages

No. 122, 1984

THE FIRM AND FINANCIAL MARKETS IN THE SWEDISH MICRO-TO-MACRO MODEL (MOSES)

- Theory, Model and Verification

by

Gunnar Eliasson

April 1984

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"The man of science like the man in the street has to face hard headed facts that cannot be blinked and explain them as best he can".

James Joyce

CONTENTS

Note: () means not yet ready.

PART I - THE SHORT-TERM DECISION

I FOREWORD - PROJECT BACKGROUND

1. Why?

The moving force behind this large and lengthy project has been my desire to realize a vaguely conceived goal: to model the dynamics of a capitalistic market economy. To be taken seriously the extent of the ambition had to be kept muted. Perhaps the ambition has been too large and overwhelming, particularly during a decade when macroeconometric models were confronted by the reality of the disorderly economies of the 70s.

Of course large scale modeling is needed. The economic policy problems confronting nations, increasingly require large scale models: partial analysis is insufficient, and may even be misleading. The difficulties and deficiencies of econometric techniques are not excuses to avoid such research, and are in a way exaggerated.

We believe our approach is inherently plausible. What is intuitively more natural than approaching the problem from the perspective of the decision makers (firms, households, policy makers) in the economy, and modeling their market behavior on the basis of the information they in fact have and use? In particular, this approach makes it possible to treat time in a realistic fashion. Such a micro-to-macro process model allows us to exploit the wealth of micro data that exists, and to hope for a more reliable and realistic macro analysis. The latter is the principal objective of the project - to use more detailed and reliable information to understand the workings of the entire economy better. It cannot be helped if that ambition draws us out of the mainstream of traditional economics. In the long run empirical evidence always decides what is the best way to look at a problem.

Micro-to-macro process models may appear to fall between two stools; the theoretical and the empirical. On the theoretical side two things are sometimes bothersome. A micro-to-macro model of some quality simply cannot be analyzed without a substantial input of quantitative information. To be meaningful, this input has to draw on the real world. Hence, the distinction between theory and empirical analysis gets blurred from the outset. Secondly, the improved treatment of time means that micro-to-macro models often depart significantly from the mainstream macrodynamic models of economies in many respects, for instance, in dealing with the concepts of equilibrium. On the empirical side, models of this complexity are beyond the reach of ordinary econometrics, and the relevant microeconometrics takes time to develop. Recourse to simulation is necessary. Simulation, however, does not yet pass the test of rigor demanded by contemporary theorists. It is, nevertheless, very useful for understanding economics, which is really what matters.

The broad idea behind the micro-to-macro model is the possibility of integrating business and engineering knowledge with economics into a model structure that explains the growth process. This can, of course, only be achieved at the expense of something - most notably a fair amount of sophistication, and the loss of the simplicity of classical economic models.

It has, in fact, always disturbed me that economics draws such strong conclusions from such a meager empirical base. Do we really possess the well organized intellectual structures that warrant the detailed proposals to national policy makers that have been offered by the profession, and sometimes followed by the politicians? Should the policy makers rather not ask for a more richly endowed theory, one requiring a more elaborate knowledge input on the basis of more prior empirical research? We may see, at the end of this research venture, that a shift of research emphasis away from professional sophistry towards more hard work is necessary.

2. The Background of Doctrines

Even though the main source of inspiration for this project has been - and still is - my own fieldwork with real companies (E 1976a, 1983a)* the main lines of thought embedded in the model draws on four distinct areas of economic inquiry. The model merges (1) the Schumpeterian concept of the innovative firm, or entrepreneur, and the generator of temporary rents with a (2) long-term micro interpretation of the Wicksellian idea of a cumulative process moved by a capital market disequilibrium (E 1983b).

The creative forces are those vested in the competitive market process that competes away tempor-

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* For obvious reasons references to my own publications on the micro-to-macro model will be very frequent. To soften the exposure somewhat "Eliasson" will be abbreviated by "E" throughout the book.

ary rents by driving inferior producers from the market (exit, creative destruction) or stimulating new entrants of superior competitors, or innovative behavior, in existing firms. On the whole, this Darwinian or Schumpeterian scenario of rivalrous competition was very visible already in Smith (1776, pp. 77-79 in 1976 edition) as the efficiency determinants behind "the invisible hand". So very little is really new.

It remains to explain the positive side of the competitive process through the entry of new solutions to old industrial problems and the conception of new combinations - Smith, in fact, regarded freedom of entry as the essential element of the competitive process. By leaving the introduction, or the creation of new technologies at the firm level exogenous, we are in a sense subscribing to the school of thought that emphasizes (3) non-economic factors in explaining innovative behavior in an economy. The MOSES economy is not explicit on this point. In its current formulation and interpretation non-economic factors enter exogenously in two ways;

(a) the degree to which the economy accepts change caused by anonymous competition, being embedded in the model parameters that define the market regime

(b) the degree of curiosity and extent of ambition to try new things in commercial areas and not being prevented by collective agents to pursue new ventures.

This certainly has a lot to do with the cultural setup of the nation, circumstances that are entered very simply by exogenous assumption. By this formulation I certainly pay sympathetic attention to a host of classical writers in the past; Veblen, Weber, again Schumpeter and also (!) Marshall. Current representatives would be Winter (1964), Nelson & Winter (1982) and Olsen (1982).

Only through this complex merger of theoretic devices is it possible to realize - in formal garb - the old Schumpeterian idea of an exogenous growth cycle. Growth, as exhibited through long-run differences in national wealth creation requires that the dynamics of the allocation process be made explicit at the micro level.

Bringing together important elements of thinking associated with the Austrian and Stockholm schools of economics into an empirically formatted, theoretical system has certainly been quite an intellectual challenge, that fortunately I was not aware of to begin with.

Neither was I aware of a fourth source of ideas until recently.

The conceptual framework of Coase (1937) forms the base for modeling interior, institutional change, with the special reinterpretation (E 1976a, Chapter XI, especially p. 256) that the firm in MOSES is a financially defined institution that leaks and attracts funds - thereby defining its outer boundaries - as its interior performance on the margin compares with external market performance.

There appears to be a strong similarity between the interior rules of behavior of the MOSES firms and the rapidly growing field of principal-agent analysis, that has so far not really extended into the territory of the theory of the firm. The relationship between the shirking public utility and its relatively uninformed regulator studied recently by Radner (1983) in fact has been implemented in a dynamic version, called the MIP criterion, which is frequently used in large business organizations (E 1976a, p. 236 ff.). It exists as an integrated part of the MOSES firm decision machinery.

3. When?

The Swedish micro-to-macro modeling project began in 1975 as a joint research venture between IBM Sweden, on the one hand, and the University of Uppsala and the Federation of Swedish Industries, on the other, with myself as project leader. When I left my position as chief economist of the Federation of Swedish Industries and took the position as Director of the IUI in December 1976, the IUI also entered into the research venture.

The initial objectives were to model and analyze:

- the micro processes of inflation
- the relationships between inflation, profits, investment and growth and
- to investigate the technical feasibility of this type of modeling

Those tasks were completed some years ago. We not only conceived, formulated and calibrated a new model type, but also organized and collected an entirely unique micro-to-macro database. The latter has absorbed most of the project effort since 1978. We are happy to report that a new real firm database covering 70 percent of value added in Swedish manufacturing 1976 was finally initialized in late 1982 (see Albrecht-Lindberg (1982), Bergholm (1982)).

4. The People

Among the people who have been involved in the project and should be mentioned in this context I specifically want to thank Thomas Lindberg, then at IBM Sweden who pushed me to get involved in this highly uncertain research venture. The foreseen work effort, then gravely underestimated, did not look altogether appealing. Since then, however, I have began to appreciate IBM research policy. It acknowledges that true scientific inquiries should aim for the more or less unknown and untried, and should not have a high probability of success. One important policy was to support unique projects with a sizable risk element, rather than routine variations of what is already more or less standard research. What matters for a high macro probability of achievement at the national (or firm) level is that a sufficiently large number of competent, high risk research ventures are in progress simultaneously. This is certainly a Schumpeterian idea that we have incorporated into our analysis. I do not think, however, that this is typical of academic research.

I also want to thank Thomas Lindberg's collaborators and his successors at IBM Sweden; in chronological order they were Ingemar Hedenklint, Håkan Kihlberg, Ulf Berg and Lars Arosenius. Without their initial support and interest very little would have come out of this project. Special thanks also go to Mats Heiman and Gösta Olavi, both at IBM Sweden who worked together with me translating the model from a concept into a computer program; and also to people at the University of Uppsala and at IBM Scientific Centers in Peter Lee and in Pisa, who participated in early seminar stages as the model took on a more concrete shape. I want to mention Bal Wagle, Paolo Corsi, Carlo Bianco and Ragnar Bentzel in particular.

Special thanks go to Axel Iveroth, the president of the Federation of Swedish Industries, under whose auspices a major part of the early formative model work took place - a true laboratory environment for a research project like this. In fact, much of my research on business economic planning (E 1976a) also took place at the Federation. It turned out to be a necessary preparatory study for the project, without which the firm model would have been very different, and to my mind not much like the real-world firm I always wanted to capture.

Since 1977 several new researchers appeared in the MOSES team. They have worked both on the theoretical side, and have used the model in various applications. Above all, however, they have been involved in the painstaking effort of improving the database, the computer program and the estimation and calibration of the model relationships. Louise Ahlström was responsible for adjusting demand, supply, financial and input/output macro national accounts onto a consistent framework for the model. She has reclassified the sectors according to the OECD's recommended classification for final use of products in order to fit the market orientation of the individual firm database that we use for the model. Thomas Lindberg has been working on the individual firm, financial database, and has incorporated these micro data into subindustry financial accounts. Jim Albrecht of Columbia University has spent much time at the Institute improving the firm production system in the model, and analyzing and integrating the planning survey of the Federation of Swedish Industries with the other statistical sources. The planning survey was initiated in 1975 during my time at the Federation. It was specifically designed to supply data for the model on the individual firm production system. We now have a large set of 7 year life histories of production plants that aggregate into the financial firm units. Ola Virin at the Federation has spent considerable time during these years checking and processing these data. Finally Fredrik Bergholm entered the project at a fairly late stage. He has reworked a large part of the data initialization program and the model code and program itself. He is also currently in charge of integrating a separate data set of foreign production units in the MOSES firm database (see Albrecht-Lindberg (1982), Bergholm (1982)).

5. Model Vintages

The core of the model - the firm short-term production planning models and their product and labor market enviroments - has remained basically the same since 1977 (see description in E (1976b and 1978a)). However, since 1978 a great deal of additional work has been invested in the MOSES micro-to-macro model. For one thing, it has been transformed from a theoretical construct into a working empirical model. The huge database work, which was never planned is now nearing completion and will be presented in a separate publication.

Secondly, several extensions of the model were made between 1976 and 1978. The version now used in preliminary empirical work is not adequately represented in the earlier publication, even though the core short-term micro-to-macro market processes have remained more or less unchanged.

The whole (micro specified) manufacturing sector has been submerged in a complete 10 sector input-output framework. That means that the individual firm in the 4 manufacturing sectors purchases inputs from both the 4 manufacturing sectors and the 6 other sectors. Firms have their own "standardized" input-output tables (see supplement at the end). A complete government sector has been added as an 11th (macro) sector, with the complete tax structure of the Swedish economy specified (see E 1980a). The government can manipulate the traditional fiscal policy instruments. Moreover, the principal policy variable of the public sector is new recruitment of public employees, to the extent that people are "available" in the labor market at the wages offered.[1]

Potentially more important than this, however, are two other extensions: a nontrivial monetary component of the entire system and a long-term investment planning model of the individual firms. Those extensions are presented in full detail for the first time in this volume.

Earlier extensions of the model have been empirically tested to allow policy simulation experiments (see Chapter VII). These earlier extensions add well-known Keynesian features to the system but do not change the core micro processes of the model, and therefore do not change its dynamic properties. But the newer extensions to be described in this volume - long-term business planning at the firm level and the monetary system - do affect the dynamics of the entire model economy. We are currently working to incorporate the new money and financing dimensions, and to move the extended model from a theoretical construct to a working, empirically validated model.

Properties of the earlier version of the model were critically dependent on the short-term production decision and the pivotal roles played by endogenously determined wages, profits and prices. The new version endogenizes the long-term growth decision, the interest rate and the trade-off between today and the future.

Since 1977, the bulk of our work effort has been devoted to building a systematic micro-to-macro database, and to calibrating the model. This has been made possible by access to the resources of a large research institution and by designing other micro-oriented projects at the Institute to share in the database work. During the last few years very few have, however, objected to the good sense in diverting a substantial part of research resources away from macro analysis to micro based studies.

Even so, much remains to be done to complete the database. And far too little has been accomplished in utilizing the database for estimation of micro relationships (see Chapter VII).

6. This Publication

This publication is technically oriented. It aims at adding what the earlier publications lacked in model documentation. We have had to strike a compromise between necessary detail and overview. Shortcomings here will have to be made up for in a later, more popular presentation that does not aim at being complete. We begin, however, with a brief overview of the model to establish what is new. Then we proceed, in Chapter III, to a description of the long-term investment financing decision of the individual firm, and of the way that decision interacts with the short-term (quarterly) production decision. In a sense this chapter describes the MOSES firm model in detail. Again, this chapter draws on earlier drafts written in 1977 and 1978,[1B] which were used as blueprints for the coding and programming of the model.

In the next chapter (IV) there is a fairly detailed account of the monetary sector and the process of interest rate determination. This chapter draws, more or less directly, on an earlier draft written in 1977.[2]

A separate publication, on estimation from the database and in the empirical application of the model, is planned. To keep the number of pages of the present volume within reason, we have limited ourselves to a very brief description of the empirical side of the model in Chapter VII.

(Part II, written jointly by myself, Gösta Olavi of IBM Sweden, and Fredrik Bergholm, contains the complete model code as it stood on XXXXXXX, XXXX. Again, that part is based on an earlier draft by

Olavi and myself from January 1978. That draft merged the two previous chapters (III and IV) with the Technical specification paper by Eliasson-Heiman-Olavi (in E 1978a).

Part III collects the whole of MOSES, and in particular those parts that are new, to make possible the analysis of an endogenous growth cycle.

Part IV summarizes the state of empirical verification of the model system.

Finally, this whole project has been conceived and scheduled much too ambitiously. For myself it has been - in my way - an attempt to model a capitalistically organized market economy. Whatever the reader may think of the result, it has been an enjoyable and instructive experience for the author. I hope the reader will be able to share with me, some of what I have learned about the functioning of an economic system.

Notes

[1] "The public sector" offers the manufacturing wage change during a previous period. People are coming forward from the state of unemployment at some reservation wage. Since there may not be people available in the market, the government employment decision has been partly endogenized.

[1B] See Eliasson, IUI Promemorias dated November 18, 1977 and July 1978.

[2] Eliasson, 1977-05-27 revised.

II. OVERVIEW OF THE MOSES ECONOMY[3]

1. The Basic Ideas

In contrast to many traditional, large-scale macro models, the MOSES model is very explicit in its treatment of long-term capacity growth, the short-term supply decision of individual firms, and the dynamics of market processes (labor, products, money). As should be the case in a growth model, long-term capacity growth is very open-ended, and dependent upon the market investment allocation process. Thus, so far the model treats most of the demand side in a more traditional macro fashion.

Micro-macro theory, as it appears in the MOSES model, combines institutional economics with a dynamical version of classical market theory.

Models or theories of the MOSES type will allow you to reason about more complex issues. You don't have to take only one variable or one problem at a time. You get used to weighing quantities against each other, which is the normal situation in most real policy problems.

In the beginning the model economy may appear strange. It is fashioned much more in the mode of thinking developed by Joseph Schumpeter than in the mainstream of postwar microeconomics. Both the business cycle and the growth process are endogenized. Markets in MOSES are characterized by monopolistic competition, or even more generally as noncooperative games. A Wicksellian monetary disequilibrium is a normal working characteristic of the micro-to-macro model, and the old Stockholm School idea of a dynamic economic process is fairly visible on the pages to come. Economic life can be seen and understood in different ways; this is the way we have chosen.

Here are some ways in which MOSES is different.

The first difference is that we are dealing with a large number of firm models, responding individually to their market environment within the constraints of a macro system.

The second difference is that MOSES is not an equilibrium model, but (in mathematical terms) a process model. Firms do not jump in phase from one equilibrium solution to another. Such positions (solutions) do not normally exist in the model except as ex ante perceived positions of individual firms. Ex post, model firms can be observed in very different "Brownian phases", on their way towards individual targets.

Third, firms are not price takers except in a momentary (next quarter) ex ante sense. They interpret current-period price and quantity signals generated by the economic process, and form their individual decisions.

Fourth, in principle firms behave rationally, in the sense that they strive, on the basis of what they know, for an improved ex ante position. In doing so they do not generally make inconsistent decisions.[3 B] Occasionally - lacking information - they make inconsistent decisions and they do not necessarily optimize in the short term. They search for improved ex ante profit positions (hill climbing) given what they know. This process recognizes search time, and is normally terminated before a global optimum is reached. Ex post decision can be proven to be both inconsistent and against the interests of the agent.

Firms can to some extent change their decision rules (- learning new rules by doing); We call this a rules of behavior approach to modeling.

This (fifth) approach means that considerable slack always exists, within firms and between firms. But a systematic effort by all firms to minimize slack in a short period of time will generally disrupt the price system of the overall economy.

A particular aspect (sixth) of this slack is that firm management is assumed to know only a restricted domain of their own, interior structure and response patterns. This makes strict cost minimization on the basis of anticipated external prices impossible, except by search (trial and error). Those assumptions correspond to known and well established facts (E 1976a) about large firms.

An unusually large part (seventh) of the empirical information of the model (as a rule represented by a coefficient matrix) than what is normal is embedded in the hierarchical ordering of the decision process within, and between, the firms, and in the initial state variables (see Chapter VII).

These, and other, novel features require a somewhat unfamiliar mathematical representation of the model. That representation may be difficult to think about, at least initially.

Any large, national model must be fairly complicated. The MOSES economy, however, is in fact quite simple and transparent in principle. Each behavioral module can be understood independently. Complexity arises out of the interaction of simple, but numerically different, behavioral decision units.[3C] The algorithm that aggregates the decison units is the dynamic market process and the endogenous price system. (To comprehend the sometimes unexpected properties of a dynamic micro-to-macro model with a large number of individually simple mechanisms that are simultaneously at work requires a form of mental control of totality that very much resembles attempts to understand similar phenomena in the real world. Some familiarity with the whole model is required. That requires substantial effort; a quite natural requirement when something new is to be understood.)

(A particular source of difficulty lies in the rules of behavior approach in specifying the model. We do not postulate rationality and consistency in decision making a priori. We base decisions on information that we know decision makers have access to. We introduce rules of behavior that we have observed in companies. We assume that firms aim at improving perceived profits, and that this is a time-consuming process that may often fail because of mistaken expectations. The market environment depends critically upon the combined search process of all agents in the market. This means that what is perfectly rational for the agent ex ante often appears as inconsistent behavior ex post. Given this set of information and given the rules of behavior as empirically observed facts, we can speculate later as to whether they are rational and to what extent they are compatible with standard micro theory. Some of our behavioral assumptions are based on accurate empirical observations. Several must be subjected to further empirical testing. This makes it interesting to experiment with the model, and to investigate why this or that behavior can be observed at the macro level, very much in the same fashion as one tries to explain what is happening in the real economy. The empirical foundations, and the realistic structuring, of the model economic system can make this a very enlightening experience from the point of view of understanding the real thing. The difference is that with the model you can always keep searching for "the reason" until you understand. Statistical information is available up to the resolution limits of the model structure (the database).)

When facing a seemingly huge, non-transparent model macroeconomic system, one instinctively asks the following two questions:

(1) What is this thing good for? I thought large-scale models had proven not to be so useful and

(2) what about all these details? Are we interested? Can they really be predicted?

Those may be both relevant questions to ask, and normal reactions to the traditional macroeconomic models developed during the 60s. But when asked in the context of the micro-to-macro model to be presented here, they simply reveal that you have not got hold of the right idea.

Beginning with the first question: large-scale models are by no means out. The majority of questions that policy-makers have to face today can only be answered with the help of such intellectual constructs. Furthermore, the failure, demise or less than successful performance of full-scale macroeconometric models in the 70s is by no means a clearly established fact. Whatever one believes, it in no way carries over to the micro-to-macro model, which is entirely different in concept.

As for the second objection: the "detail" in the micro-to-macro approach is in the empirical input. We want to improve the measurement base for macroeconomic analysis. At the output level, we are not attempting to study the fine detail, even though it can be technically reproduced. (The best analogy in that respect that I can think of is current statistical procedure, when you construct aggregate measures from incomplete and partly not so good basic data. Few people venture behind the walls of the Central Bureau of Statistics to see how the numbers they run regressions on are cranked out. They should, and they should be prepared afterwards to continue doing what they did before.)

Phrased differently, the micro-to-macro model takes the level of aggregation down to the decision unit (the firm). It endogenizes aggregation as a dynamic economic process. We are not dependent upon static equilibrium and other very special market assumptions, to obtain and interpret aggregate behavior. That should be enough to read on with a positive mind set.

(The micro-to-macro model teaches, and forces, dynamic thinking. After you have learned that, it is impossible to revert to the traditional paradigm. It does not feel right.)

We will try to ease the orientation process in the following overview. However, when reading the description, do not count equations and variables, and do not think in terms of a solution to an equation system. This is quite all right with traditional macro models, but not this time. This is a process model. Look upon the model as a set of principles at work. Distinguish between the individual firm model and the model of market processes that "integrate" the firm units into macro aggregates. And remember that the national account identities always hold at the macro level, ex post. However, the whole model economy at work should be looked upon as an automobile engine that is running. Even though the dynamics inside cannot easily be captured in logical terms, the principles can. Neither can the dynamics of the MOSES, nor the real economies. But sufficient familiarity with the principles at work, and knowledge of the relevant empirical magnitudes, make the automobile, the MOSES economy and the real economy predictable entities.

2. The Firm, the Rate of Return Requirement and the Markets

The entire MOSES economy consists of (1) a (variable) number of individual firm, production-planning and investment financing models, that are (2) integrated (and aggregated) through explicitly modelled labor, product and credit markets, all being (3) constrained by the state of technical knowledge vested in capital installations in the past and in currently produced capital goods, and the imposed consistency of a macro accounting system.

There are many ways to view the model "from above". Let us begin in the way the author finds most helpful. The growth engine of the national economy is a population of independently operating business firms. Their behavior decides the future course of the economy. The micro-to-macro model economy cannot be steered by the central power of a national government if its policies run counter to the objectives of the firms. If households had been modelled in micro, the same could have been said of them.

Firms, taken together, are central. Their decisions are taken on the basis of price signals - not quantities. A business forecaster employed by a MOSES firm would be primarily interested in the long-run relative price structure and the time profile of the expected adjustment to that structure. Only to the extent that he expects his firm to exercise some degree of monopoly power, or if he is subjected to direct quantity constraints, would he be interested in aggregate income (quantity) variables.

The first and paramount price to consider for a MOSES firm "top executive" is the rate of return requirement imposed upon him externally by his Board or by the markets for finance. His concern for profits is monolithic. As long as he follows the rules of the MOSES market game, he doesn't care how his profit target is achieved.

In order of importance he has to worry about:

a) the value of the firm as assessed in the equity market that determines his debt capacity (not yet in program),

b) his current rate of return on assets as compared with alternative profit opportunities elsewhere; the loan interest rate, which determines when he should invest, and hence his long-term production and earnings capacity, and

c) his current price, wage and productivity combination that determines his current profits and cash flow.

The actions of all firms together determine all the prices in the model economy - product prices, wages, interest rates - in what we call the market process.

The firms, and ideally the households, are the moving forces in the economic system. We will introduce the above decisions

beginning (in this Chapter II) with an overview of the entire MOSES economy, but emphasizing the short-term (quarterly) market arbitrage processes and the production decision taken by lower level operations management on the basis of an assumed fixed capacity endowment [the production frontier of the individual firm (QFR(L))] being a function of labor input. This has already been documented in full technical detail in (E 1976b, 1978a), the former being more elaborated than the latter. The code (Eliasson, Olavi, Bergholm (1984)) is fully updated on whatever changes that have later been introduced

continuing (in Chapter III) with the higher level (executive management) choice of the next period production frontier (the investment decision) and the gradual, financial commitment of the firm to a future investment plan and

concluding (in Chapter IV) with the dominant executive Board decision on what rate of return requirement to push down through the firm organization.

In terms familiar to management in real-world firms the three decision levels correspond to

a) production management - the operating budget and production plan

b) investment/financing decisions - the budget and the long-term plan

c) strategic decisions - Board level;

To the extent possible, we used the results of a series of interviews with firms (E 1976a) in modeling the internal firm decision structure. A current study of decision systems and information processing in large business organizations, (E 1983b, Fries 1983) has allowed us to reconfirm a number of assumptions of the firm model.

Besides the agents (the firms), an initial structural description of the economy, and the reaction rules of the agents in the markets, the MOSES economy runs on a bundle of exogenous assumptions.

The most important exogenous variables are

a) foreign prices (one index for each market),

b) the foreign interest rates; one long- and one short-term

c) the rate of technical change (embodied) in new investment

d) total labor supply

e) policy parameters, and

f) choice of market regime.

The model represents a general economic process moved forward in time by those exogenous factors, within the bounds set by the profit-based investment decisions and technical change in new investment vintages. Markets are, however, never fully cleared, and stocks are seldom kept at desired levels. The model economy can reside in very different states, depending upon how it has been calibrated. Some of the states that we think are close to a realistic representation of the real Swedish economy may not be resilient vis a vis a number of plausible exogenous disturbances. Those disturbances will propagate the model economy into an extended state of chaos (see E 1983a) or into an unstable macro situation, as we prefer to call this situation. It is an interesting analytical problem to study the various market designs that confer general macro stability on the model.

All markets are, to some extent, interdependent. Hence disturbed local situations or micro chaos is the normal state of affairs. All variables change from period to period, and that movement depends on the paths all firms and other agents follow in their individual adjustments. The delicate balance, between stability at the micro and macro levels, is as much an intriguing theoretical, (see Chapter VI) as it is a demanding empirical, problem. The process characteristic of the model means that there is no determinate state (solution) at a point in time where the model will come to rest. Despite the absence of random mechanisms,[4] - no stable "fixed point" or steady state growth rate seem to exist. Hence, the treatment of equilibrium and stability properties of the MOSES economy means a departure from common notions in economics. We have devoted an extra chapter (VI) to this topic.

The model has elaborately developed short-term and long-term supply sides embodied in the individual-firm planning process. There is a feedback, from the price and quantity outcomes in markets, through profit determination and cash flows via rate of return and borrowing considerations, to the investment decision in individual firms, that brings in new techniques of production. This makes structural change endogenous, albeit under an exogenous upper bound in each firm (see further Chapter V). There is another complete integration between a monetary sector and the real system (Chapter IV).

Two observations should be made here. First, no single exogenous variable dominates the growth path of the economy. Each bundle of exogenous assumptions, including technical change in new investment vintages up to the horizon (we have tried

80 years!), is compatible with substantial variation in long-term growth rates of the economy, depending upon the settings of the market-response parameters in (most importantly) the firms (see E 83a).

Second, we have found, from experimentation on the model, that a fair amount of internal consistency between exogenous assumptions is needed if disruptive changes in the macro economy are to be avoided (see further Chapter VI). For instance, the initial micro productivity and rate of return structures have to be roughly in line with the exogenous development of foreign prices, the interest rate and the technical change assumptions for new investment. If not, structural adjustment may be abrupt. We know from Swedish experience during the middle seventies that the government then intervened in various ways, e.g. by changing the exchange rate or by industrial subsidies. Thus exogenous assumptions are also subjected to some endogeneity, in the sense that policy makers have to change them to prevent macroeconomic behavior from becoming unreasonably disruptive. Even policy makers are - to use Assar Lindbeck's word - endogenous. However, just as aircraft builders can design computer-simulated test flights in which wings collapse, we can design experiments on the MOSES economy that subject individuals to extreme hardships. From them, we can learn about optimal macro policy designs.

Statistical consistency at all aggregation levels is in fact an important property of the model. The initial, statistical description of the economy requires great care. The model is fitted into the national accounts macro framework. The manufacturing sector is broken down into (a variable number, currently four) sectors that are populated by individual firms.

In parallel with the model development effort, a time-series micro firm database has been developed. In the beginning, all firms were "synthetic" in the sense of being chiseled out of the aggregates, while preserving a) across-firm distributional characteristics, to the extent those were known and b) the consistent macro accounts when aggregating across firms. As additional data on real firms have been accumulated, they have been entered into the database. The real firms of each sector have been reconsolidated, and synthetic disaggregation has been applied again to the "synthetic residual aggregate firm" of each sector. There exists a computer program to perform this consolidation and disaggregation[5] (Albrecht-Lindberg (1982), Bergholm (1983a)).

3. Overall Macro Structure of the MOSES Economy

Another way to familiarize oneself with the MOSES micro economy is to look at its macro mapping in Figure II:1. The macro lay-out a ten sector Leontief input-output model combined with a Keynesian demand feedback, in the firm of a Stone-type, nonlinear expenditure system. The endogenous supply mechanism that is our prime concern in this presentation resides at the micro level, and "disappears" in this aggregation. The novelty of the micro-to-macro approach is most easily visualized by seeing four manufacturing cells in the input-output system (shaded) as replaced by market cells inhabited by individual firms. They are the RAW,

Figure II:1 Macro Delivery and Income Determination Structure of Swedish Model

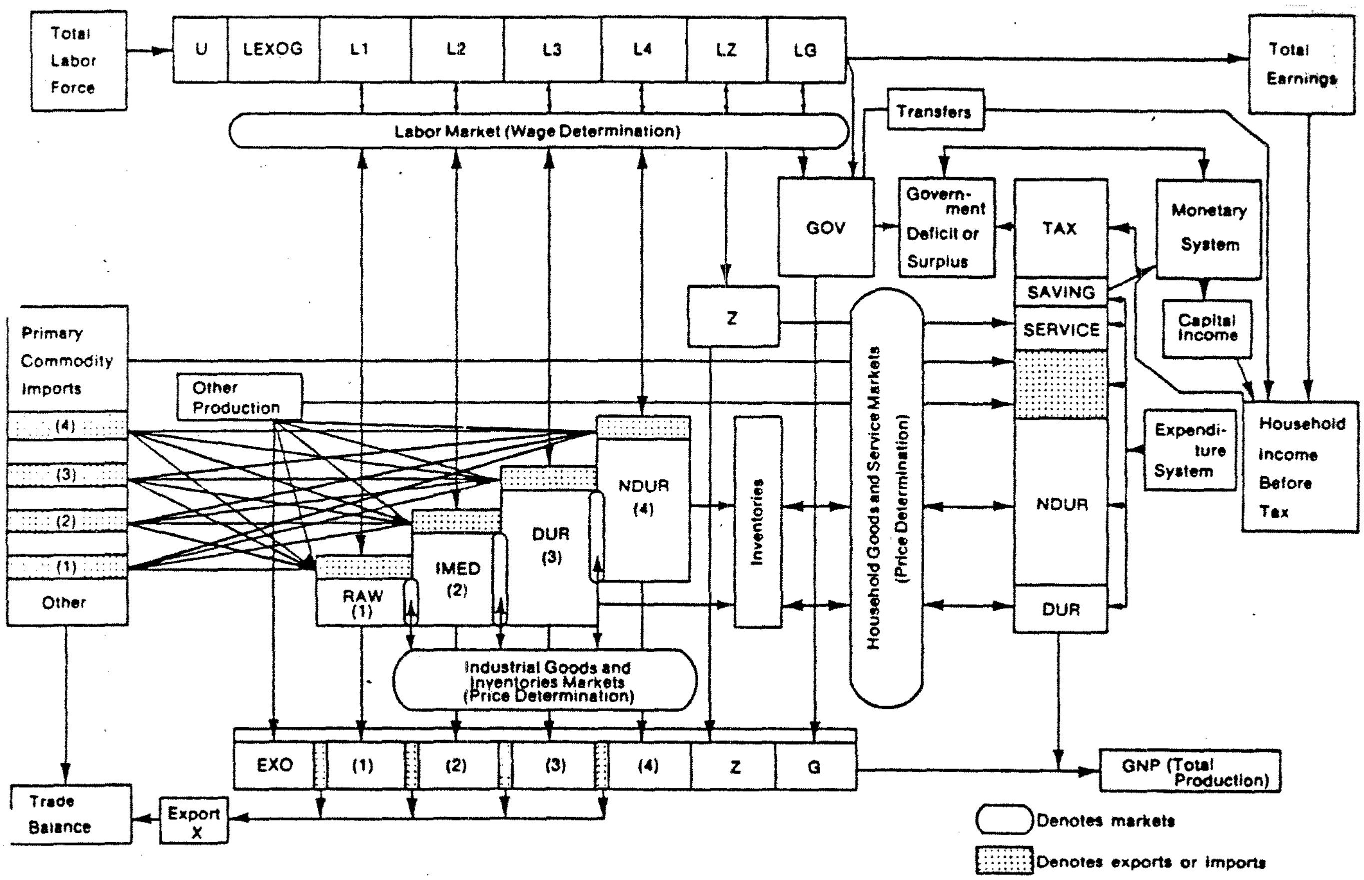


Figure 2.1. *Macro delivery and income determination structure of Swedish model. Sectors (Markets): 1. RAW = Raw material production; 2. IMED = Intermediate goods production; 3. DUR = Durable household and investment goods production; 4. NDUR = Consumer, nondurable goods production.*

IMED, DUR and NDUR markets, respectively, in Figure II:1. To obtain this, the whole statistical classification system of the input-output matrix and the national accounts had to be transformed onto a market oriented classification scheme[6].

Second, each firm is represented by a firm planning model, the outline of which is shown in Figure II:2.

Third, each firm is linked to all other firms and to the rest of the macro economy by explicitly

Figure II:2 Business Decision System (one firm)

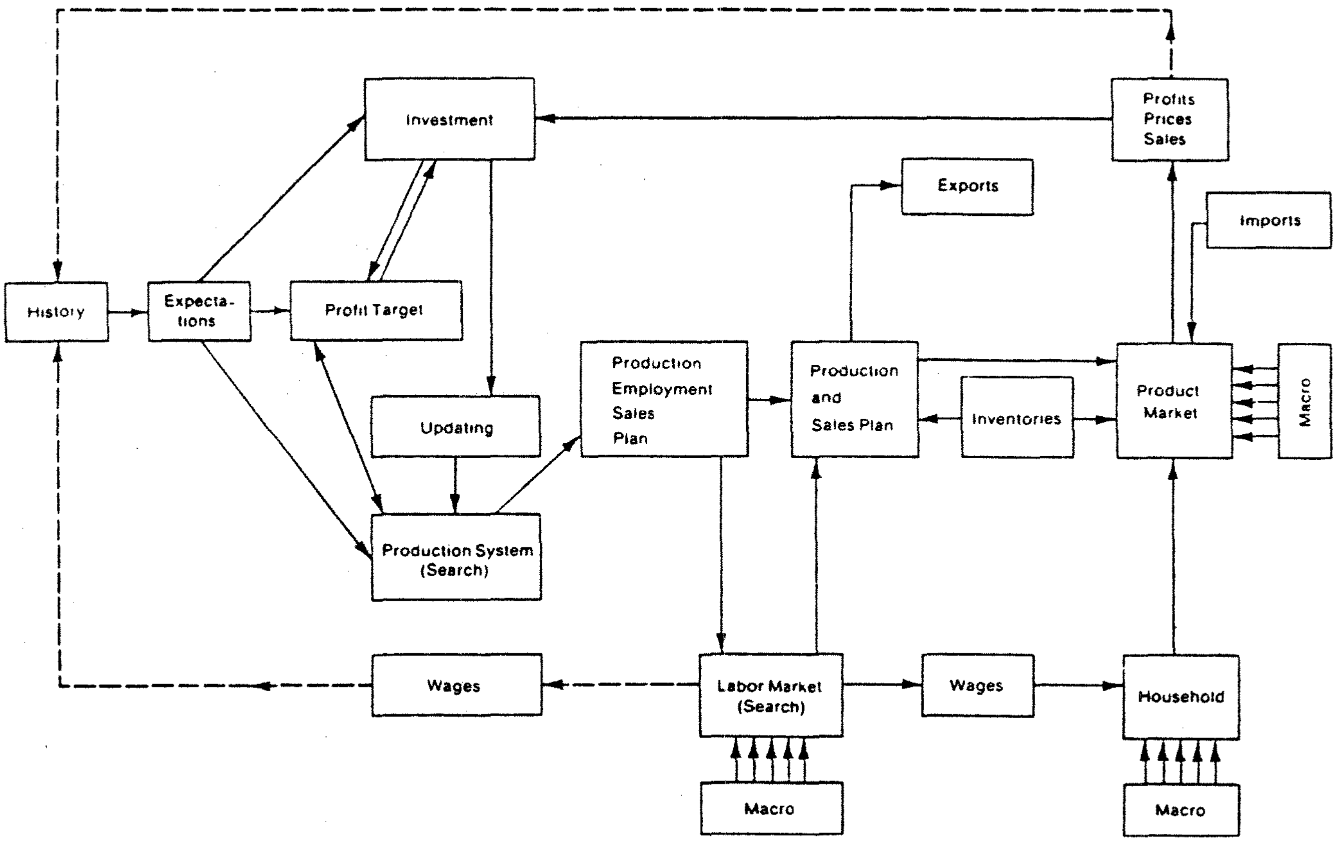


Figure 2.2. *Business decision system (one firm).*

represented market processes. The labor market process will be only briefly sketched below. It has been described in detail in Eliasson (1978a). The money market process will be presented in Chapter IV.

4. Technical Change at the Micro Firm Level

Technical change enters the individual firm (plant) through new investment. Each firm is individually characterized in the database. Parameterization of behavioral rules will also be individualized when enough panel data on firms have been accumulated to make this possible. Labor productivity (MTEC) and new investment expenditure needed to obtain one unit of output (INVEFF), both at full capacity utilization, are entered exogenously at the firm level. Hence the whole market-allocation machinery of the economy, most notably the firm investment decision, explicitly links technical change at the firm level with technical change, or productivity growth, at the industry level. The importance of this allocation machinery in the "real world" has been illustrated by two independent estimates (one through the model) that indicate that less than 50 percent of total-factor productivity growth measured at the total manufacturing level can be explained by labor productivity growth in best-practice plants[7].

To explain exactly how "technical change" enters the firm we need a brief overview of the firm financing, investment and production systems.

5. The Firm and the MIP Principle

The firm or the entire business decision unit - to be expounded in full detail in Chapter III - is centrally controlled by a rate of return targeting formula that links rate of return requirements as expressed in the capital markets to the operating units of the business organization. The targeting formula integrates contributions to overall profitability from different units in an additive fashion. It will be demonstrated in Chapter III that

The Nominal Rate of Return to Net Worth (=RRNW) (II:1)

is a linear combination of

a) + profit margins in each of all production lines

b) - the rate of depreciation of assets

c) + the rate of inflationary appreciation of assets

d) + financial leverage (the company, or firm, nominal rate of return over and above its average borrowing rate times the debt-equity ratio)

In the large, modern corporation each of those components has an organizational counterpart. And each exerts a controlling influence on various in- and outgoing cash flow streams.

We will deal with d) and the long-term growth decision in Chapter III.

Our earlier model presentations have been preoccupied with the short-term (quarterly) production decision, exercised through short-term profit-margin targeting, under a). The argument is that Corporate Headquarter Managers impose top-down profit margin targets on operating divisions that are based on <u>past profit margin</u> performance. Targeted profit margins are gradually pushed upwards "from below" under the constraint that ex ante profits in monetary terms are not allowed to decrease. We call this the <u>Maintain or Improve Profit</u> (MIP) principle (see E 1976a, p. 291 f.).

It is well understood in any large business organization, that the major task of top management in a large firm is to apply well-calibrated profitability requirements to its constituent parts (divisions, profit centers). That is normally done without explicit knowledge of the underlying process of realizing these targets. The important rule is to locate the performance band above what is normally feasible, but below what is an unreasonably high target (E 1976a). Performance adapts automatically to the lower end of the target spectrum. Unreasonably high targets are not taken seriously within the organization. Such rules generate certain asymmetries in firm behavior that we also have in a MOSES firm. Slack targeting generates slack performance. Unreasonably ambitious profitability requirements push the firms to contract or close down, even though a well-calibrated target slightly above what is feasible may put the firm on a cumulative expansion path that generates rapid value "creation" and a high rate of return on equity. In unstable market environments that are "difficult to predict" well calibrated targeting is difficult.

The separation of decision making within corporate organizations expressed in the separable additive targeting formula and the MIP targeting principle are empirically well-established practices in firms (E 1976a). A MOSES firm is modelled as a set of adaptive decision rules on the basis of those principles. They recognize the basic environmental uncertainty that currently faces each firm. We argue below (see Chapter VI) that this set of rules specifies a very rational, albeit cautious, profit-seeking entity. That entity will generate a statistical performance flow that is indistinguishable, in econometric tests, from that generated by the classical profit-maximizing firm at the firm and industry levels.

Given the above conceptualization of the internal management problem, the setting of well-calibrated profit targets is a trial and error (search) process, even within the firm. The reason for this unorthodox modeling is very simple. Top management in the firm does not, and cannot, know what is technically possible to achieve! The procedure could be mathematically represented as search by trial and error for an optimum position. But in a dynamic MOSES economy that optimum for the individual firm changes from period to period.

Mathematically the internal trial-and-error process of a MOSES firm makes use of a graded search algorithm. The firm seeks an improved position in terms of chosen targets (hill climbing) of a kind that is used in complex mathematical optimization problems to approximate a solution. Search in MOSES is, however, given a time dimension, which means that global optima are rarely reached by micro agents and the global optima move endogenously from quarter to quarter.

Hence, in the micro-to-macro model aggregation is not performed under the assumption of static equilibrium. Aggregation functions - if we want to construct such things - are therefore not stable over time. The central mathematical devices that hold the activities of the model economy together, and perform the "aggregation function", are the separable additive targeting fomula, explained verbally above, the MIP criterion, and the market processes that link all firms together.

Since the profit targeting process is a dominant feature of the model, and affects both firm behavior and macroeconomic behavior, we add some further detail here, drawing on the extensive interview study that preceded this project (E 1976a). I do argue on the basis of those studies that anybody who wants to study or model the dynamics of an industrial economy with the ambitions to <u>understand</u> what is going on <u>has to</u> recognize the nature of the profit targeting process described here.

We begin by restating the salient, underlying features and conclude with a simplified mathematical formulation.

The MIP principle captures three facts of life true of all large business organizations;

(1) It is difficult for anybody, and especially for top CHQ managers, to set internal targets for the organization that are close to the global optimum. Management simply does not know the production frontier of their own organization well enough to do that.

(2) It is important for target credibility within the organization, that reasonable targets be set. If targets are unreasonably high, they are not taken seriously. One good standard for being "reasonable" is actual performance achieved in the recent past. It was possible then!

(3) A general management experience is that substantially higher firm macro performance can be obtained, if either a good reason for the extra effort needed can be presented ("crisis situation"), or if a different technical investment solution is chosen (other firms are better), - and time to adjust is

allowed. The scope of possible improvement and the time needed is always subject to different evaluations. The main point, however, is that operations management does not possess the information necessary to prescribe a better and workable solution, and there is no way for them to get that information. It is always in the interest of decision units within the firms, subjected to CHQ target pressure, not to reveal the information necessary for an accurate top level appraisal. Even if they happened to have all the information needed, there would be no practicable way to transform this information into a workable top down order or plan. Much "planning theory" is naive on this central point.

Hence, corporate management must act by persuasion, exhortation and coaxing.

<u>It is, however, always reasonable to demand a small improvement in performance over and above what was previously achieved and measured</u>. Exactly there lies the rationale of the MIP principle built on (1), (2) and (3) above.

It can be demonstrated (see Theorem 2 in Chapter III) that the additive component (a) in the nominal rate of return to net worth (RRNW) above is:

$$(a) = M^{*}\alpha \qquad \text{(II:2)}$$

where:
M = (gross operation profits)/(value added)
α = (value added)/(capital stock)

and where:

$$M = 1 - \frac{w}{P} * \frac{1}{Q/L} \qquad (II:3)$$

w = total wage (costs) per unit of labor input (=L).

Top management of the firm is now "pinched" by two facts. The Board and the share owners are demanding a rate of return on their equity (=RRNW) expressed by the formula above: Just how will be explained in Chapters III and IV. (II:2) and (II:3) also demonstrate that RRNW can be translated into a M requirement. This is the first fact.

The second fact is that demands for compliance with that top down requirement must be tempered by what is feasible and reasonable. If the difference is large and negative, there will be "market" pressure brought on top management to improve at lower levels.

If this improvment is too slow in coming, we will show (in Chapter III) that resources tend to leave the firm organization, to be invested elsewhere.

This situation of differentiated information endowment between principal and agents or, between top (CHQ) executive and lower operational (division) levels has been shown to be very typical of large business organizations (E 1976a). The MIP-targeting device is applied to force information of the upper limits of the feasibility set to surface, and to be reimplemented to force increased performance on the part of reluctant lower level operations management. This situation is very similar to the bargaining design between a public utility and its regulatory authority analyzed recently by Radner (1983)[7B].

We will demonstrate in this chapter that one major vehicle for profit improvement in the short term is improved productivity. That is all the more so if we adopt (which we will not do) the classical assumption of the firm as being a price (p) and wage (w) taker. Then (see (II:2) above) the only variable available to raise the profit margin is labor productivity (Q/L). As revealed by practically all short-term planning cases studied in (E 1976a), this is also the variable that can in fact be improved upon in the short term.[8] There are two reasons:

First (mentioned above), there always exists slack of unknown extent in large organizations

Second, the (a) component in (II:1) above can always be rewritten as a weighted average of profit margins of all profit centers, product groups and statistically separable production units within the company. This means that productivity improvements (and hence profit margin improvements) can not only be achieved by raising local productivity rates, but also by changing the product mix - and by shifting the production organization towards a mix with more high productivity activities, and/or higher margin yields, because of better w/p ratios. Don't forget that average productivity improvement depends on the weights.

MIP targeting can now be represented fairly simply as:

$$MHIST := \lambda * MHIST + (1-\lambda) * M \qquad (II:4a)$$

$$TARGM := (1-R) * MHIST * (1+\varepsilon) + R * TARG(M) \qquad (II:4b)$$

$(\lambda, R) C (0,1)$, $\varepsilon \geqslant 0$ but small.
:= is alogol for make equal to.
MHIST is a historic performance measure computed as in (II:4a).

TARGX is an exogenous target requirement (e.g. of the best competitor) that can be weighted, to the extent desired, by $R \in (0,1)$.
ε is the improvement factor demanded.

This is all we need to proceed to the quarterly production decision to be enacted in a MOSES firm.

Approximate versions of this set of decision rules are used explicitly, or implicitly, in most large and decentralized corporations. Profit-margin targets are decomposed into cost and productivity targets. In turn reporting and control routines are run in terms of those variables.

6. Long Term - Investment Decisions

The short-term (quarterly) production planning sequence (see below) takes place within a <u>given</u> production feasibility frontier. This section is a preview of Chapter III, which deals with the <u>choice among future production frontiers</u>. Technology enters in the long-term capacity-augmentation phase through an outward shifting of the production frontier through investment, and prior to the production decision.

The micro-to-macro model has two alternative formulations of the individual-firm investment decision. One is a sophisticated investment financing version designed for individual firm "dialogue experiments"; the second is a less elaborate version. In this overview we don't have to distinguish between the two. Chapter III is solely devoted to the "sophisticated" firm model; the current operating version of the investment decision is presented in Eliasson-Lindberg (1981).

New production techniques are embodied in new investments, and affect the MOSES economy in at least five ways:

(1) The technical performance characteristics of a unit of new investment (called MTEC and INVEFF) [8B], which are exogenous.

(2) The amount invested (endogenous).

(3) Allocation on firms (plants) of new investments (endogenous).

(4) The rate of utilization of installed investment (endogenous), and finally

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

DMTEC is a central experimental variable in this volume. It is entered exogenously, and can be specified by quarter and firm. Figure III:3 illustrates part of the capacity-augmenting phase.

This makes the model "truly dynamic", in the sense that growth is endogenously determined, subject to an upper technology constraint. The micro model is combined with traditional Leontief input-output and Keynesian aggregate-demand systems. Thus price determination and income generation are combined in a theoretical (albeit numerical) model, the overall macro structure of which (excluding the monetary side) was shown in Figure II:1. The internal planning and decision process of one individual firm was pictured in Figure II:2.

7. Short Term - Production Search

Expected percent changes in sales, product prices, wages and targeted profits are used in the three micro specified market contacts of the firm in the model - investment (the interest rate), production planning and the labor market (wages) and the product market (prices). Each firm's expectations about prices and its profit target combine, with the constraints of technology and with the actions of other firms, to produce a final (quarterly) output. The reader should note that we have simplified our exposition by excluding purchases of services, intermediate goods and raw materials. We have done so throughout the bulk of this book, even though a very elaborate purchasing algorithm (a set of individual firm input-output coefficients) applies to each firm (see supplement to Chapter VII). This means that, throughout the main text, value added and sales volume differ only to the extent that finished goods inventories vary in relation to sales.

Production planning is carried out individually within each firm. Within that block, each firm chooses a preliminary planned output and labor combination (Q,L). The algorithm by which a (Q,L) plan is chosen is intricate. Figure II:4 illustrates the principles.

Each firm faces a set of feasible (Q,L) combinations (a short-run production possibilities set) each quarter. That set is defined by

$$Q = QTOP*(1-\exp(-\gamma \cdot L)). \qquad (II:5)$$

The feasible set is determined by the firm's past investments, as they are embodied in QTOP and γ. Investment between quarters pushes this set outward.[9] To the set of feasible (Q,L) combinations of the firm corresponds a set of satisfactory (Q,L) combinations. A quarterly profit margin target (TARGM) defines "satisfying". This target is calculated as defined above. The basic targeting is done on a yearly basis, with quarterly adjustments, and profit margin targets adapt gradually as experience on what is possible to achieve is accumulated.

As shown above (see (II:1)), a profit margin target (TARGM) can be derived from the rate of return target. Bad profit experience can make the firm lower its target in the short term. That normally will affect long-term development negatively (see Chapter III); immediately through smaller cash flows and less investment and in the longer term through less investment and perhaps also less profitable investment that keeps future cash flows low.

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

Given TARGM and price and wage expectations, a planned (Q,L) combination is called satisfactory if the expected profit margin meets the profit margin target, i.e. if:

$$\text{TARGM} \leqslant \left[\text{EXP}(P^*Q) - \text{EXP}(W^*L)\right]/\text{EXPP}^*Q \qquad \text{(II:6a)}$$

(II:6a) is exhibited by the straight line in Figure II:4. If we combine (II:5) and (II:6a) we obtain the feasible and satisfactory area (shaded). This can also be expressed as:

$$\frac{Q}{L} \geqslant \frac{\text{EXPW}}{\text{EXPP}} \cdot \frac{1}{1-\text{TARGM}} \qquad \text{(II:6b)}$$

A shorthand expression for the satisfaction of this inequality is to say that SAT(Q,L) holds.

Expectations are of an adaptive error correction - learning type based on a smoothing formula, similar to (II:4a). Risk considerations ("aversion") are brought into expectations-forming through a standardized variance measure in the expectations variable. If variance in product prices increases, firm management tends to underestimate future prices, and vice versa for wages. This makes profit target satisfaction tougher, and forces (Q,L) closer to the frontier and possibly down left along it (contraction). The expectations side of the model is discussed in great detail in (E 1978a, Section 4.2).

The firm now chooses a point within the "lens-shaped" area of Figure II:4 that is both feasible and satisfactory. This is done by specifying an

Figure II:3 Production system (one firm)

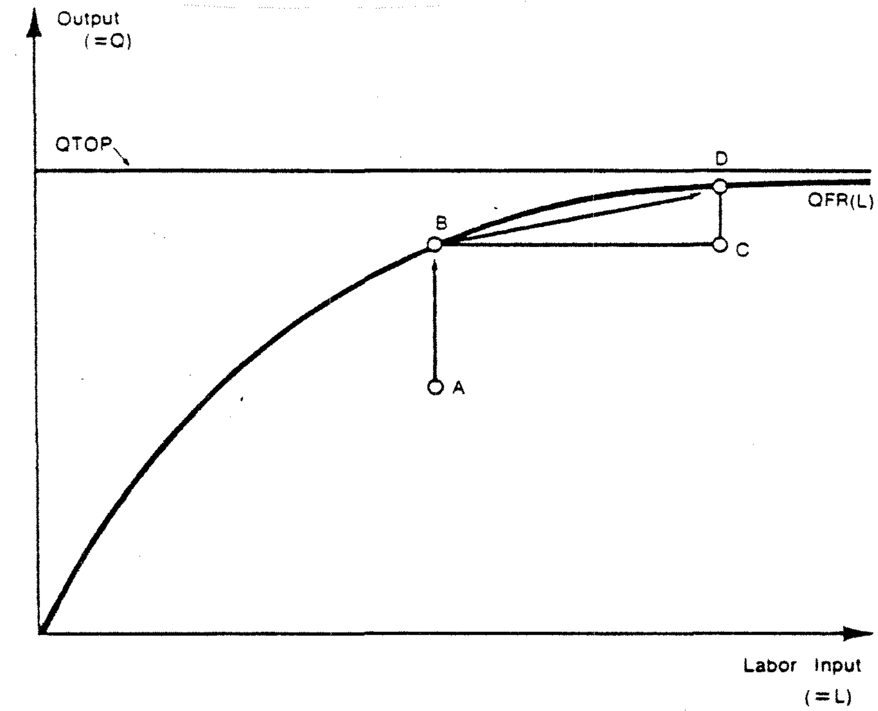
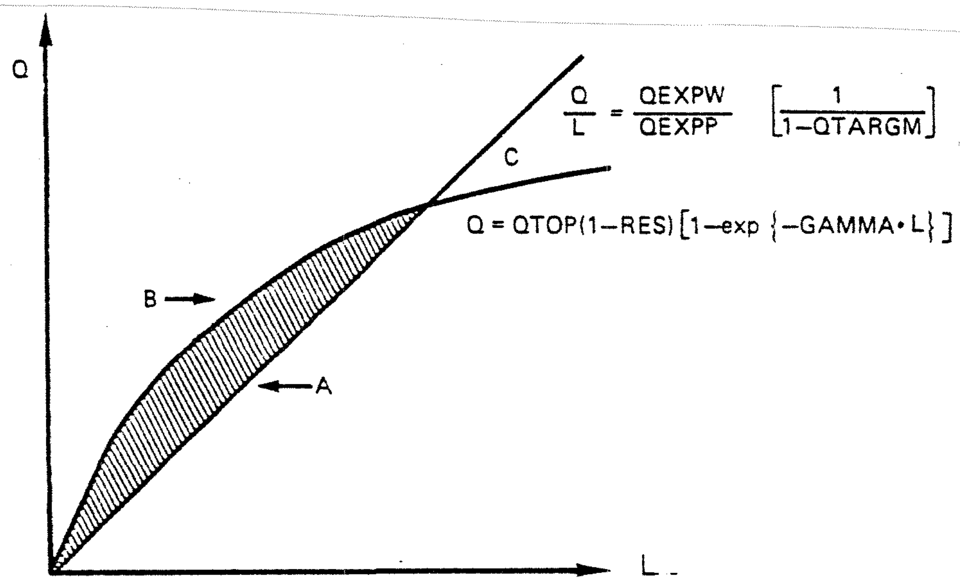


Figure 2.3. *Production system (one firm). The function describing the production system of one firm at one point in time is QFR = QTOP · (1 = e* $^{-\gamma L}$*). How this function is estimated and how it shifts in time in response to investment is described in Eliasson (1976b, chapter 4) and in Albrecht (1978b).*

Figure II:4 Profit targeting (one firm)



initial set of (Q,L) points and the rules for adjusting those points if they do not fall within the feasible and satisfactory lens area. Note that it is labor productivity that is adjusted.

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

This search for SAT(Q,L) continues under the constraint that expected profits

$$Q \cdot EXP(P) - L \cdot EXP(W)$$

do not decrease compared to an earlier, established position, including the initial one. If such a decrease occurs, search is terminated for this time (quarter) and the expected M position reached is accepted temporarily.

The first trial step is taken in the following way. The firm has inherited a labor force, net of retirements, from the preceding quarter. This is the initial level, L. The firm then computes a trial expected output volume[10] as

$$EXPS / EXPP$$

This output plan is adjusted for desired inventory change.

Search is guided by comparison of the productivity ratio to an equally scaled expected price ratio. The initial positioning of L, and a corresponding expected sales volume, establish an initial activity level of production. The search path into the shaded lens area may, however, lead onto B, and down along it, to a premature collapse of operations. This may not be incompatible with rational behavior in the sense that the firm deliberately chooses to lower its expected profits to find a quarterly (Q,L) combination within the shaded area. As mentioned, this is prevented by a supplementary rule that stops further search whenever expected profits begin to decrease.

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

Why do firms ever operate at a level below the output frontier QFR? Why aren't the firms pushing on for higher profits? If this is your interpretation, forget QFR. We have made it explicit as a structural description of the firm and of the industry for you, not for the firm management. Firm management never calculates such things. CHQ generally manages the divisions under the presumption that:

$QFR(L) - Q > 0$, but small.

There are then two reasons for a large positive gap $QFR(L) - Q$, synonymous with labor hoarding.

(a) CHQ does not know, and takes no action
(b) Cyclical reason.

In the cyclical case CHQ knows that it can increase output with only insignificant additions to labor costs. In a recessionary situation there are still many reasons for not increasing output. The market simply won't take more. In the oligopolistic market situation that prevails prices would only go down, and lowering price to capture a larger market share in a cyclical downswing could start a price war. The alternative to lay off labor is not good either if the firm expects future market expansion, since rehiring labor is usually associated with wage drift.

With this interpretation QFR(L) only functions as a stopping rule in the production-planning process. Work on improving productivity goes on all the time. It is, however, time-consuming, and rarely "completed" within one period. Target non-satisfaction may force the pushing for higher efficiency to speed up a bit, but improvements normally stop when production plans hit QFR(L). The stopping point is, however, endogenized within each period, depending upon which way search goes, and over time when QFR(L) shifts because of investment.[10B]

There are other ways of illustrating this with real-world examples. First, labor hoarding or operations below what is feasible, given installed or employed resources, are phenomena that are always observed and measured at the micro level. Within a complex production system (e.g. a factory), one always finds numerous points of slack, because a complex production system cannot be made perfect and fully utilized, at all points, everywhere and always. Indivisibilities are cases in point. New investments that expand capacity cannot always be fully utilized during the first five years. But they require some minimum number of assigned workers to be used at all. Demand may be insufficient. The firm does not want to flood the market with its products (Nicolin (1983)). This gradual utilization of initial slack may be an important explanation of the so-called Horndal effect (Lundberg (1961)) or learning by doing phenomena (Arrow (1962)), as it is in this model.

Smooth operation at the final output level requires that internal buffers be constantly maintained to accomodate interior flow disturbances. A similar analogy can be made of one firm as a part in a complex delivery system, an industry. Some firms are operating at full capacity, others are not and the state of slack across firms is measured every year in the planning survey on which the model is based (see Chapter VII). Each year some firms are operating at full capacity, but most are not. We also know, from more or less crude empirical studies (see for instance E1976a), how firms adjust their output plans in a stepwise fashion.

Production search has been tailored to mimic such procedures within firms. In a positive sense, this suggests the empirical validity of the representation of a firm production system of the kind used in MOSES. One may, however, still want to know more about why firms do not make use of the existing short-term profit potential that comes with the slack. Such reasoning can be presented in two ways. One could introduce time-dependent adjustment costs. If we restrict our discussion to the time dimension of adjustments in output, we know that adjustments are made in discrete steps - as in the model. Those steps are bracketed, in sizes, by what is technically feasible and what can be done without disrupting other aspects of firm operations. That duration could be interpreted as an implicit recognition of adjustment costs and a formulation of how they work. This formulation amounts to introducing a lag structure. The adjustment cost can be indirectly estimated each time. Neither of those explanations is, however, convincing if management knows the exact shape and position of its production frontier. A rational management should then explicitly weigh the costs of getting onto it against the corresponding benefits.

(But they do not, in the model or in reality. True, they have supplied the data that have allowed us to estimate their QFR functions at a point in time. Those data originate in the firm's financially-oriented costing and budgeting procedure. Such crude, aggregate measures are never used in actual production planning, in part because they have no operational meaning (see E 1976a). To firm production management, the QFR is a "soft upper limit" of the domain within which it can operate. Next period planning is carried out on the presumption that actual operations (Q) is below, but close to QFR. QFR can even be pushed through if the payoff is there. We have explicitly allowed for that possibility by introducing the concept of REServe slack (see E 1978a, p. 188). But, the important point is that the firm has to deal with the <u>fact</u> that it doesn't know its internal production structure with sufficient accuracy to get close to its production frontier - except by time-consuming trial and error procedures. Numerous examples can be reported on from the interviews in E 1976a. There is a world of difference between the state of knowledge that resides at Corporate Headquarters - the MOSES firm decision level - and on the shop floor. For example, in one case (see E 1976a, pp.xxx), Corporate Headquarters initiated the building of a production-programming model to reveal bottlenecks and to minimize costs by a more efficient utilization of resources. It appeared that the programming model spotted some, but not all, of those bottlenecks. Production management of the facility, however, knew about them all, and work was under way to remove the most costly ones. Modeling work was terminated very soon, and Corporate Headquarter management felt confident in continuing drawing production plans without knowing the location of their QFR's more than very approximately. Not even management of a typical engineering work shop normally knows the process well enough to give orders on how to do the job (E 1980c). This management dilemma is solved very ingeniously by resorting to a stepwise search for improved positions (MIP). MOSES firms behave this way: we call this the rules of behavior approach to modeling.

In fact, if someone could hold all price expectations fixed and equal to actual prices indefinitely (which both violates the basic idea of the model and is technically impossible), continued quarterly search probably might eventually take the firm to the (Q,L) combination that maximizes profits.[10C)]

When a feasible and satisfactory (Q,L) point in Figure II:4 is reached, the firm's preliminary plan is set at the minimum Q such that SAT(Q,L) holds. If SAT(Q,L) does not hold, and if the point is in region A, then the firm adjusts by planning to lay off workers. If this does not help, the firm's preliminary plan is to set the minimum Q and the maximum L where SAT(Q,L) holds. If in B, the firm plans to increase employment. If this expansion moves (Q,L) into the lens area, then the firm establishes a preliminary plan at the minimum feasible Q and L.[11]

Production planning has now been completed. Expectational variables have influenced production plans in the following way. The ratio of wage and price expectations, constrained by TARGM, first defines the set of satisfactory (Q,L) plans. This set intersects the set of feasible (Q,L) plans to form the set of acceptable (Q,L) plans. Which plan is actually chosen within this set depends upon the initial trial (Q,L) plan, the adjustment for desired inventory changes and a set of search rules. That is because (M,TARGM) differences and the sign of CHM as a rule generate different search paths.

Each firm now has a planned employment and output level. But taken together those plans may not be feasible. Firms must confront one another in the labor and product markets to resolve the remaining inconsistencies.

8. Short Term - Labor Market Search

Each firm enters the labor market with a planned (absolute) change CHL in its labor force.

If CHL $\leqslant$ 0, the firm begins to lay off workers with the notification delays required by Swedish law.

If CHL $\geqslant$ 0, the firm will start looking for additional labor in the pool of unemployed or, more typically, by trying to bid labor away from other firms.

[It is important to note that firms are the active agents in search; labor waits passively. This is in sharp contrast to the mainstream of labor market search literature; that difference is, in part, a result of the current format of the model (micro production system and so far a macro household sector).]

Ideally, search should go on from both sides, the relative search intensities being a way of characterizing the labor market. However, if we have to choose one side, <u>it is far more convincing empirically, for Sweden, to have the firms as the active search agents</u>. Choosing labor as the sole search agent would mean uncritically applying theoretical specifications developed for the U.S. labor market to Sweden.

Normally, it is possible to pack several related ideas into one mathematical specification. Even though my original thinking about the labor market in MOSES was along the lines presented above, I could now motivate the same model specification differently. Think of search as the open up of vacancies through a labor market agency, rather than as active search for people by firms. This information would then reach people unemployed or on jobs according to some specified diffusion process, for instance the stochastic one we use. The same comparison of wage levels would occur and people would change jobs as before, but it would be explained differently.

As the model is now specified, there are two problems in this respect. Workers may quit firms in a disruptive fashion, even though there are preset limits to the maximum fraction of quits per unit of time. This is a theoretical problem, even though experimentation with the model so far does not suggest that it is a large problem.

The other aspect is that we have to preset the number of searches per period (=NITER) quite arbitrarily. NITER is estimated (or calibrated) when we try to fit macroeconomic model behavior to macro data, but that estimation procedure is not satisfactory. There is a simple way to remedy this. First, when the informational interpretation of SEARCH is used, only one person at a time (the one informed by, say, an ad) should leave or decide to stay. That would probably improve the specification of the model. Firms would respond by changing their wage structure in response to several losses of employees, rather than one big one.

Second, the number of allowed searchers would have to be increased for each firm to be able to fill its vacancies. We would then interpret search as a time consuming activity, specified in real time, in the labor market part of the model. The maximum number of searchers from any one firm can be made dependent on total search going on in the market, which in turn is limited by a time constraint. It would be both formally and empirically easy to revise search specifications along those lines. It would, however, drive computer simulation costs through the roof. Hence, even if specifications are strictly as described initially it would be perfectly all right to interpret labor market search as an approximation to the two-way information exchange just described.

Raiding of another firm for labor can be successful if the wage offer of the raiding firm sufficiently exceeds that of the raided firm. Expectations now enter directly into the labor market confrontation - the wage offer of a firm depends upon the wage level it expects will prevail, i.e. upon EXPW. The firm may restrain its expectations during the first quarter of search as it learns about wages in other firms. That search process eventually finalizes quarterly wage levels and employments for each firm.

The dynamics of the labor market process are so important for the overall properties of the MOSES economy that we will add some detail to our earlier description[12].

Let W be the wage paid by a firm in the preceding quarter. Then its wage offer is computed as

WW = W + öl*(EXPW-W).

Firms are now ranked according to their relative demands for additional labor, as voiced by CHL/L.

They choose to raid either the pool of unemployed or another firm. The probability of being raided is related to the size of a potential target's labor force. As suggested above this relative size can also be interpreted as a measure of the probability of one employee receiving the information (the signal) that vacancies with the wage offer (WW) have been opened up in the raiding firm. An upward probability bias can be (and normally is) applied to the pool of unemployed. Raiding can be global across all firms, or be selective, and restricted to a particular kind of firms, say in one sector[13].

Let i index the raider and let j index the target. An attack is successful if WW > (1+ö2)*WWj, and labor in the amount of MIN(ö3*Lj,CHLi) is transferred from j to i. If j indexes the pool of unemployed (which is of size LU), then the attack is always successful and MIN(ö3*LU,CHLi) workers become employed in firm i. When an attack succeeds, (CHLi, CHLj, Li, Lj) are adjusted in the obvious way, and the raided firm adjusts its wage offer upwards by

CHWWj = ö4*(WWi-WWj).

But if the attack fails, then it is the attacking firm that adjusts its wage by setting

CHWWi = ö5*(WWj*(1+ö2) - WWi)

The parameters $ä_i$ in the interval (0,1) determine the speed of response at each confrontation to wage discrepancies in the labor market.

When all firms (for whom CHL > 0) have gone through this iteration a predetermined number of times, the search process has been completed for the <u>quarter</u>, and wage levels are set.

We have learned from repeated numerical experiments with the full model that the stability of the price system - and hence of structures and growth as well - depends critically on the intensity and scope of this labor market arbitrage (see Chapter VI).

(There is one feature of the wage setting process that the reader may already have noticed. Wages at the firm level are sticky downwards, even though bad economic times may lower the average nominal wage level through a change in the composition of labor. We thought of this as a highly realistic feature of the model, but it confers significant macroeconomic properties to the whole model economy, especially when it comes to engineering a fast recovery from a deep recession. It would be desirable to have the degree of stickiness of wages endogenous. For Sweden this would mean to repeal the union agreement and to offer a lower wage for everybody in the firm or a substantial reduction of employment if the offer is rejected. Technically this can be easily accommodated. Whenever target satisfaction forces larger layoffs than X percent the firm offers the lower wage for everybody that will allow it to keep Y percent of those threatened by layoff.

Wage costs at the firm level can also be lowered through a decrease in payroll taxes.

The reader may have noted that the wage offer and labor search sequence embedded in the model seem to imply that the incidence of a payroll tax increase is 100 percent backward onto wages, in the sense that firms have already determined output plans and now offer a wage level that meets their profit targets.

This specification appears to contradict empirical evidence that suggests a 50-50 percent division between forward and backward shifting. But that interpretation of the model is wrong. Firms attempt in their plans to shift the entire increase of the payroll tax backward in the form of lower increases in (cash) wage increase offers. They may not succeed. Some of the adjustment is absorbed in the form of lower - than targeted - profits. Some in the form of higher incomes and more inflation. The final extent of forward and backward shifting over a sequence of quarters depends on the action of all firms, and upon how those actions affect both output volumes and prices. We know only that, in the long run, the firms will have to comply, one by one, with a rate of return requirement set in the credit system.[14])

9. Foreign Competition, Foreign Trade and the Exchange Rate

The export and import functions of the model are supply-based.

<u>Each firm</u> changes its export ratio (X) in response to the differential between the foreign price (PFOR) and the domestic price (PDOM)

$$CHX = F\left[\frac{\mu*PFOR-PDOM}{\mu*PFOR}\right]$$

$F'>0$

μ is the exchange rate

There is no other explanatory variable, and it is important to understand that with the short period decision specification with no quantity constraints presumed we do not need any additional explantory variables. This formulation can be demonstrated to mean (roughly) that the ratio of deliveries to foreign markets and the domestic market shifts toward export as long as a positive difference persists, between profit margins on export and domestic sales, for the producing firm.

We do not want any other factors influencing the division of total supply between shipments abroad or in domestic markets; the speed of adjustment of relative profitability changes is the only relevant factor. The speed of adjustment may vary, and depends on a number of circumstances. Within a short period, firm-based decision model like MOSES, with no quantity constraints imposed, it would be misspecification to introduce quantity variables (like market growth) together with the price variables. Market size and market share can appear as proxies for profitability, or they can affect speeds of adjustment. For instance, if you have a large foreign market share, you do not rapidly divert all sales to domestic markets in response to a temporary price difference in favor of domestic markets.

(Quantity (income) variables would enter if we remove the assumption that firms perceive themselves to be price takers in foreign markets, which we may eventually do.[14B]

The above specification of the individual firm export function also exhibits another feature that may not be desired. Negative PFOR changes in firms with large export shares may generate such large, next period drops in planned exports, that even next period sales at home drops, even though domestic sales are relatively profitable[14C]. Firms with very large export shares (above 70 percent) are either operating in bulk markets (pulp, etc.) where no alternative domestic outlets exist and such abrupt, total sales decreases may be realistic, or are heavily established, with large investments, abroad. The latter firms may rather take a temporary drop in export profits and maintain export sales in order not to endanger the value of its foreign market investments. Respecification on this is currently in progress (see Chapter III).)

Two additional things should be noted here.

First, the main factor that keeps export ratios from converging towards 1 or 0 is that domestic prices respond (through quantity adjustments within the entire model economy) to the diversion (or vice versa) of supplies to foreign markets and hence diminishes the (PFOR-PDOM) difference. This (and the corresponding mechanism on the import side) is the main mechanism transmitting foreign prices into the model economy. One "equilibrium" property of the model is that, in the very long term, all prices and quantities in the economy will force PDOM to converge to PFOR. The duration of that adjustment is an empirical question. This is also the (only) way foreign business cycles are transmitted to the MOSES economy.

Second, the firm may appear to be a price taker in this formulation. It is in one sense: foreign markets absorb all that the firm can, and wants, to deliver at the given foreign price (=PFOR). The firm responds to foreign price changes by adjusting foreign deliveries from quarter to quarter. The domestic price, however, responds to the volume of shipments of all firms and from abroad, both during the quarter and from quarter to quarter.

One might argue that foreign prices too should be sensitive to the volume of shipments. If this is considered important, one should insert an <u>export price</u> between the domestic price and the foreign price, and they make the departure from the foreign price dependent upon the sign of Swedish shipments relative to world shipments. That means introducing a downward-sloping foreign demand curve as well. Only under such assumptions would we want a quantity variable in the export function.

Again, the possibility for meaningful empirical specification depends on our access to individual firm data. At our level of aggregation (all manufacturing is divided up into 4 sectors), it makes little sense to expect the volume of foreign shipments of all firms in a sector to vary the average price fetched in export trade in proportion to the foreign (world market) price. If it made sense, and empirical support could be presented, such an endogenous export price could easily be inserted. It should be noted, in addition, that we do not need this specification to generate situations like the 1975/76 cost crisis, when Swedish firms were said to be pricing themselves out of foreign markets. With our market concept, such an effect is nicely captured by declining relative export margins due to domestic inflation, and declining overall profit margins and rates of return due to a general domestic cost inflation. What we plan to do is to assume that firms can invest in production and marketing facilities abroad to obtain a higher individual price than PFOR. That price will, however, depend negatively on sales volume abroad at each given size of the foreign investment. All other firms will be assumed to be price takers. This refinement of the export function is not yet in the model. Hence, its presentation has been moved to Chapter III, Supplement I, where it is entered as part of the foreign investment decision.

Imports are treated in an analogous manner, but this time there is only one aggregate import ratio function in each market.

$$IMP = F \left[\frac{PDOM-\mu *PFOR}{\mu *PFOR}\right]$$

Also note that PFOR is always given in an "average" (tradeweighted) foreign currency that is translated into Swedish crowns through the exchange rate (see further Chapter IV).

10. Short Term - Product Market

The final quarterly, domestic product market confrontation is between firms as suppliers, on the one hand, and households and firms as demanders, on the other. That confrontation is specified at the market level: i.e. price and quantity adjustments are computed on a sectoral-average basis, rather than firm by firm. Demand is also affected by the total wage bill as determined in the labor market. This time, quantity demanded rather than quantity produced responds to price within each quarter. Consumers are the active agents in product markets within each quarter, and supplies are pre-determined from the immediately preceding output decisions, except for possible inventory adjustments. From quarter to quarter, however, supplies respond to prices, both in domestic and foreign markets. Thus firms' expectations directly affect final product-market outcomes only through the initial prices and quantities offered. Firms also indirectly affect the operation of product markets through the wages they offer and the total amount of income that consumers thereby have available for expenditure.

Some clarifications of the product-market process may help at this stage. Firms observe differing average price levels on their products. That is because there are differing export and domestic sales mixes, and because the foreign domestic price difference of each market, and each firm's export ratio, are endogenously determined in the model. Moreover, the same domestic price is charged by all firms. The reason for that simplification is a real-world fact: the unavailability of price data for individual firms. It does not make sense to model differing price levels. (Note that we have data on, and model, individual firm wage levels). This particular specification means that firms compete, as a group, with prices against foreign producers, but against each other in terms of achieved rates of return. Even though wage levels differ across firms, this in practice means competing via production efficiency. Full-price arbitrage is assumed within each market each quarter. In model terms, that means that output is properly adjusted for quality, and scaled to measure comparable "utils" across firms in each market. If a SAAB automobile is 30 percent better than a Volvo automobile, output measures are scaled to represent supplied automobile utils (or rather sector 3 utils) that each fetch the same price.

11. Some Properties of the Model System

The distinction between theoretical and empirical analysis becomes blurred in a project like this. Compared to standard macroeconometric models built around an equation system, an enormous amount of empirical information resides in the specification itself of the micro-to-macro model. Furthermore, the MOSES system cannot be put into motion without first specifying initial (startup) structures. In macroeconometric models, estimated coefficients pick up most of the information embodied in the initial structures (the state variables). We will go over this again in Chapter VII. This overview chapter is, however, the place to summarize the theoretical and/or empirical (as you wish) properties of the entire model system.

Until recently, most analytical work on the model had been concerned with sensitivity analysis aimed at ascertaining the properties of the overall economic system.

Thus far this analytical work has not been systematically organized, but has been exploratory. The summary results reported here, hence should be considered as hypotheses that are being subjected to further testing (see E 1983a).

Only a few of the tests made have been designed to allow empirical or theoretical conclusions. We find, tentatively,

(a) <u>that</u> the less structural diversity (productivity or profitability) across micro units (firms) in the initial state of the economy, the less stable the macro economy vis à vis externally administered price shocks; and that such shocks normally cause lasting damage in the form of lost growth,

(b) that the "domestic" price system, once significantly disturbed, takes a long time to stabilize (above 5, close to 10 years) even though the external (exogenous) market environment is artificially stabilized by assumption. Price "overshooting" appears to be a characteristic feature of the model economy (See E 1978a, p. 105 ff., Genberg (1983)),

(c) that a certain level and distribution across firms of unused capacity (cyclical slack) is needed to maintain a stable relative price structure during a growth process,

(d) that the Le Chatelier-Brown principle is at work in the micro-to-macro model economy. Reversal speeds are sensitive to the state as described by (a) and (b), and shocks of various kinds can "prematurely" trigger reversals. Countercyclical stabilization policies normally generate expected positive short-term effects that are followed by reversals. The long-term effects of countercyclical policies on economic growth may very well be negative, if policies have been biased towards stimulation. More specifically, the model economy can be made to perform excellently by short-term criteria (high utilization rates, currently, efficiently allocated labor, etc.) for extended periods of time, only eventually to develop a more shock-sensitive supply structure,

(e) <u>that</u> if you attempt to stabilize quantities (q), e.g. through countercyclical policies, that policy eventually destabilizes prices (p), which distorts labor and investment allocation. Vice versa, if one attempts, through price controls etc. to "stabilize" prices (p), one removes incentives to adjust resources to meet demand, and hence, one eventually destabilizes quantities. The optimal mix is all an empirical question that we will return to in Chapter VI,

(f) <u>that</u> the simulation experiments imply a basic, underlying tradeoff between macroeconomic and microeconomic stability. The closer to steady state output growth at the macro (industry) level, the more "Brownian motion" over time in the growth rates among firms,

(g) <u>that</u> different (size, time, sign) price shocks require different market regimes for optimal adjustment,

(h) <u>that</u> it is virtually impossible to settle the micro-to-macro model economy used for simulation experiments down on a "steady" long-run macro state, strictly defined, for more than a couple of decades, except at the expense of a significant reduction of the growth rate. The reason seems to be the absence of sufficient micro "instability". The model incorporates an endogenous <u>exit</u> of firms, but no <u>entry</u>. Hence the model is afflicted with gradual "structural decay" in the very long term, meaning less structural variation and more market concentration. The diminishing vitality in the competitive market process that followed appears to have been detrimental to steady growth in the very long term. This sensitivity may diminish when we have introduced market entry as a standard feature of the model,

(i) that sustained growth along an endogenously determined trend is associated with long and short cycles in economic activity around this trend.

The micro-to-macro model - being a growth model - is especially well suited for studies of dynamic efficiency. If market price signalling is erratic, biased or dramatically unstable, strong negative allocation effects occur. They combine dramatically with supply structures characterized by deficient diversity. For instance, if the tail of the distribution of low-performing firms is too short, almost all firms in a sector can be forced to shut down in the model. That causes large and sudden disruptions in supply and demand conditions, which may be further aggravated by erratic relative price responses (through the allocation mechanisms).[16] In the recently concluded study on the macroeconomic effects of the Swedish industrial subsidy program, those disruptive effects also appeared very strongly when subsidies to large, ailing basic-material producers are withdrawn.[17] This has helped to highlight the restrictive nature of traditional equilibrium assumptions.

One important part of dynamic resource allocation experiments is the time dimension of supply responses. Short-term (quarterly) supply (the production decision) depends on the expected profitability of employing people under a capacity constraint. Long-term supply depends on the expected profitability of investing, and in addition to the short-term profitability of producing. This means that long-term growth is sequentially guided by an array of expected, and realized, quarterly factor and product prices under an upper technology constraint associated with new investment. Long-term capacity to supply, hence, is very openended, as it should be in a good growth model. We have found that the economy tends to operate well below output levels that are feasible, and that various interferences with the price system may lower growth below what is technically feasible (E 1978b, 1983a and Eliasson-Lindberg (1981)), that technical change at the plant level only generates growth with a very long delay (E 1979), but that positive adjustment of prices - if substantial and smooth - generates a large and growing supply effect within a 2-5 year period (Eliasson-Lindberg (1981), Carlsson-Bergholm-Lindberg (1981)).

Part of the reason for the negative growth effects are the long <u>transmission times</u> of <u>price disturbances</u> through the model economy. Those long transmission times upset the relative price structure, and make it difficult for individual firms to interpret and predict price and wage signals in the markets.[18] A brief period of high prices and profits easily turns into wage overshooting, and a cost crisis that may take years to correct itself, if the initial disturbance was strong enough, investments were hurt and firms grew cautious as a consequence of serious expectational errors. (As mentioned, the model has exhibited good performance in tracking price transmission through the economy and longer term growth rates. Recent calibration efforts within the subsidy project have also improved cyclical performance considerably).

Some of the less palatable conclusions that have emerged from model analysis can be traced to the initial positioning (initial condition) of the economy, emphasizing the importance of high-quality data for a proper understanding of economic phenomena. Econometrically speaking, the bulk of the information embedded in the estimated coefficients of a macroeconometric model appears in the initial state variables in a micro-to-macro economy. For instance, economic policies - like changing the exchange rate (see (E 1977)) - produces widely diverging macroeconomic effects depending upon the extent and distribution of slack (the cyclical state) of the model economy when the policy is enacted.

Further applied work will require ascertaining the empirical basis for the behavior of the entire system, especially at the micro and market levels. Much empirical analysis of the life histories of individual firms remains, and some of this work is taking place in the context of a separate study of the macro effects of corporate income taxation and industrial subsidies. An estimation project on the positioning and shifting of individual firm production frontiers is in process, partly to make the model empirically useful as an instrument for analyzing the efficiency and stability properties of the Swedish economy.

12. Sundry Thoughts on Theory and Large Scale Modeling

Simplicity is a virtue in economics, as in all other sciences, but only if it is not obtained at the expense of relevance. Relevance is difficult to define but easy to understand. Even though this book deals with an "artificial", mathematical structure that contains many intriguing problems, we are studying a representation of a real national economy when we analyze the internal problems of the model. Moreover, the model pretends to be a fair representation of the Swedish economy. When internal assumptions are found to be wrong, because they do not fit Swedish reality, we change them for something better - if we know what is better. Only insofar as it helps us in that endeavor, is economic theory of any use to us.

(If you believe, for instance, that short-term price interdependence across markets strongly affects macroeconomic behavior for long periods when the economy is pushed by strong, erratic movements in foreign trade prices, then any thinking on the economics of the 70s that does not recognize this must be nonsense. Such across-market interdependencies can only be dealt with in dynamic large scale models, and preferably micro-based models.)

Often you cannot discriminate a priori between excessive detail and relevant features and you have to keep both until empirical tests have allowed you to discard irrelevant parts of your theory. It is good to have a theory that is rich in potential empirical content if you plan to try it by powerful tests. This is the essence of any learning process.

The three equation model can only explain one or two partial phenomena. You can work with a large number of mutually inconsistent small "educational" models to understand one problem at the time. To understand a more comprehensive "whole set of problems" you need a larger model, and one argument we are attempting to drive home in this project is that this comprehensive analysis will prove that your partial analysis is often misleading.

Three equation models furthermore evade empirical testing, by their very design, being far removed from any empirically relevant situation that can generate data. On this score one should advocate more large scale modeling, simply to force empirical discipline on the profession.

In the physical sciences you can approximate controlled experiments, keeping some aspects of reality unchanged. This allows you to test partial (small) models. That is more difficult in the social sciences, although it can often be done in principle. You may want to simplify by highlighting certain "basic principles" to your students. That may be a viable argument in the classroom, although I take the liberty here of expressing my doubts. If simplification is by way of disregarding basic economic processes that are truly endogenous to the principle you are highlighting, one rather breeds misunderstanding to the lot. Fortunately, blundering in economic policy by industrial nations during the 70s has set up a tremendous economic experiment. That experiment has dealt a devastating blow to current theory. We have been fortunate to have this experiment to draw on, when testing our micro-to-macro model.

It does not follow that good theory has to be a non-transparent mess of details. The requirements on theory in economics that I want to lay down, however, probably means that we have to part with the analytical ambition - at least until some breakthrough in mathematics. Numerical analysis or simulation has already entered the scene in other sciences, and there is no reason why it should not do the same in economics. It needs not mean a departure from either analysis or simplicity, but it will mean a dramatic change of the way one approaches problems in economics.

Let me illustrate. A national economy is necessarily a complex machine. You cannot see through it in one glance. Hence our strategy has been to look at one piece of the machinery at a time, or at any larger part from a safe distance, where enough details can be discarded to allow a clear view. (You have a number of specialists on joints, screws and bolts in the car, and you have the driver. But they talk different languages and cannot communicate when the car breaks down.) Walras' conception of the market auctioneer is a case in point. The auctioneer relieves you of the problem of explaining <u>how</u> the market was cleared and economists have skillfully avoided the <u>how</u> problem since then by simply assuming that if the situation at hand offers economic incentives for change, then rational agents in the market will grab the opportunities and move the economy towards a state with no incentives for, and no, change. Heureka! That is all fine until one realizes - and surprisingly few have - that <u>how</u> determines <u>how long</u> this process will take. And <u>if</u> the process does not converge, then something very different is needed to understand. No wonder that the assumed or imposed equilibrium plays such an important role in economics. Macroeconomics was the ingenious solution for getting out of this stylized world of stable, optimal conditions of classical static economics that the empirically and historically-oriented economists could not accomplish at the time.

Keynes himself - the "innovator" - was quite aware of the shortcomings of his construct, essentially a statistical classification scheme upon which some simple "behavioral rules" were superimposed. That simple change of paradigm was nevertheless a tremendous leap forward in applied economics. It is to be deplored that academia has distilled out an IS-LM version for classroom and econometric exercises that is probably as far removed from Keynes' intentions as it is from the world around us.

The original Keynesian idea of forging theory and measurement is still as useful in capturing the idea of micro-to-macro theory. Theory and measurement are two integrated things. Measurement in economics can be performed today with much higher resolution than in the thirties. You don't have to mix structure and behavior to the same extent as has been necessary in national accounting. (Rather than mixing the birds with the landscape, we allow them to fly freely. Given time and sufficient numbers they may even change the landscape. The rules that guide the birds in flight may be represented quite simply in theory. For that reason you do not want to give up a very high resolution map to guide the flying, if you can have one[20].)

(Furthermore, if the conditions for flying (weather, visibility and landscape) are affected by the flying, you do want to have that particular macro-to-micro aspect updated with high resolution as well in your mapping. This is the essence of micro-to-macro theory and measurement, together constituting a model. We aim at improving our understanding of macroeconomic behavior by relating it directly to a base of micro information.)

Notes

3 This overview chapter is very much based on my model description, in (E 1976b). Sections 7 and 8 on the short-term production decision and labor market search also draw on the well-structured presentation in Albrecht (1978a).

3B The decision process in the firm is hence of the gradient type. See also Simon's (1955, 1972) concept of "bounded rationality". This is the only meaningful way to define rationality, if each decision maker faces a situation where he or she or it cannot choose between a set of given quantified options. The same conclusion follows if the game situation is truly uncertain - as it is in the MOSES market world - such that you cannot meaningfully attach "subjective risk equivalents" to your expected outcomes. We will come back to this problem in Chapter VI, where we discuss equilibrium and stability concepts in the MOSES context.

3C See also Simon on "the Science of the Artificial".

4 There is one exception to this. See Eliasson, A Micro-to-Macro Model of the Swedish Economy, IUI Conference Reports, 1978:1, p. 74.

5 See F. Bergholm, (1983a).

6 See Ahlström (1978). The classification scheme corresponds to the OECD "end use" classification system. Also see Albrecht-Lindberg (1982).

7 See Eliasson (1980b) and Carlsson (1981).

7B Radner's target specifications, however, were static, and would lead to distortions in the long run, while the business targeting designs observed in (E 1976a) are very sophisticated and dynamic exerting a continuously upgraded pressure to perform as performance increases and vice versa.

8 See also Grufmans (1982) study of the internal cost adjustment of a multinational company.

8B Labor productivity of new investment. There is another exogenous factor called INVEFF that takes care of capital productivity. See Chapter III.

9 The actual model production system is somewhat more complicated. For instance, it allows for a "soft" slack region (called RES) to be created above the feasibility set, that is "available" under certain, strained conditions.

10 Or rather sales volume.

10B It is still easy to agree that the simple search algorithms used (See E 1978b, pp. 185-192) are too simple. Search in many directions should be allowed. Given the nature of QFR(L) as seen from the CHQ point of view, randomized interior search would perhaps be a realistic procedure.

10C It is not technically difficult to investigate the properties of the entire model system in that respect through simulations.

11 One extra complexity arises when there is no Q in the initial interval that is both feasible and satisfactory at any L. This always occurs in Region C and can occur in Regions A and B. The firm can reduce its planned output or shift its production possibilities set by the activation of "slack" or it can close down as a measure of last resort. It would take us too far to go into the complexities of this here. See further(E 1976b, 1978a).

12 A full description can be found in (E 1978a) pp. 137-148 and 218-227.

13 By identifying firms by regions search can also be confined within actual geographical areas. Such applications, to be meaningful, do, however, require a very large number of firms, more than the 150 firms we currently use in a simulation. For the time being, both access to firm data and prohibitive computer costs prevent such simulations.

14 It just happened that a series of experiments with payroll tax changes on an old version of the model produced results that may not comply with these of Holmlund (1982). In (E 1980a, p.73) a payroll tax was substituted for a value added tax. The immediate (one year) incidence was a higher consumer price index in the sense that the CPI level after VAT did not fall, and no effect on wages including the payroll tax. In the longer term the CPI level stayed put, wage costs came down and producers were able to increase their profit margins.

When changing back to a VAT, removing the payroll tax, the effects were asymmetric.

14B If the microeconometric work by Horwitz (see Microeconometrics, IUI Yearbook 1982/83, p. 145 ff.) on supply and demand price elasticities in foreign trade indicates that this is empirically advisable.

14C Fredrik Bergholm discovered this property during work on the industrial subsidy study (Carlsson, Bergholm, Lindberg (1981)). At that time this property was eliminated by simply not allowing planned domestic sales to drop because of export decreases.

16 See Eliasson (1978b, Norwegian case).

17 See Carlsson-Bergholm-Lindberg (1981).

18 See Eliasson (1978a, 1983a), pp. 105-126 and Genberg (1983).

20 This means that no good and stable aggregation functions exist to use a technical language. Hence "modern" search theory is no real micro theory since it departs from micro long before any attempts to relate it to measurement are made.

PART II

THE LONG TERM

III THE INVESTMENT-FINANCING DECISION IN A MOSES FIRM

1. Introduction[21]

This chapter introduces the core machinery of the Corporate Headquarter (CHQ) growth decision. While short-term production planning as described in the earlier chapter was concerned with the utilization of existing capacity to produce a quarterly output (i.e. where to operate underneath QFR(L) in Figure 3), we are now examining the dynamic decision to change the production frontier or production capacity QFR(L). In the long-term planning process to be described here CHQ so to speak picks its (ex ante) future production frontiers and arranges how to finance them under the constraint of a rate of return requirement passed down "from above".

Before we begin to describe what is going on in the individual firm in the model I want to mention a few empirical facts that I believe have to be featured in a dynamic representation of firm behavior, and hence in the MOSES firm. They signify a departure from received micro theory. One such departure is that firms behave rationally according to a set of learned and updated decision rules. To their knowledge they take consistent decisions and they strive to improve their positions. Firms do not, however, optimize in the mathematical sense of the word. The firm operates according to a gradient approach, which is not as demanding in terms of information requirements as the so called survey approach attempting to find a global optimum. In the non-cooperative game situation that describes markets in MOSES, differentiated and segmented knowledge and the absence of a stable equilibrium makes complete overview (knowledge) by the firm both of its external environment and of its interior firm organization infeasible. If decision makers in the model have any other ideas about that, they soon learn by making mistakes, and change their rules. This is part of the rationality postulate, namely that if attempts to optimize generate mistakes, firm decision makers shift to a different set of rules. (There is never time to reach the best position within one period and in the next period the best position has moved to an unpredictable new position due to the adjustment of all agents in the markets. Hence rules of behavior cannot be derived from optimizing principles.) The rationality presumption is as we shall see the only important matter to consider in this context.

From the Corporate Headquarter (CHQ) view <u>the firm</u> is primarily a manager of financial resources (assets, see E 1976a). The firm is a group of real activities (plants) each of which has a current and an expected future capability of earning a return to employed assets. CHQ attention is solely oriented towards the growth of future earnings capacity (value growth). Decisions as to the management of employees and machines are taken at lower levels. The firm attracts resources if it is relatively successful in terms of this overriding objective and tends to lose or leak resources if not so. In the process of holding the resources of the group together and enlarging the pool, it may be profitable to add or split off real activities (plants).

At CHQ resources are treated as financial resources and success is measured by the ability of CHQ-management to make them grow in real values (NB!). It is convenient to make the distinction between managed resources (= total assets) and controlled (owned) resources (= net worth).

Success is not always easily measured. People inside and outside (for instance investors in the stock market) tend to assess results differently and both sides normally have to make do on the basis of scant information.

In particular, the current status of a firm cannot be comprehended without some expectations about the future, and here views differ a lot. We have to handle this when formulating the decision process within the firm.

CHQ decision makers in large firms normally stay at a safe distance away from the technicalities and routines of the shop floor production process (E 1976a). It is formally convenient and also realistic to separate CHQ from the physical production process by a set of operationally precise and well known financial criteria that we will develop in detail below. This makes CHQ a distant (remote) 0anager of real activities. These criteria indicate how available resources should be distributed internally (within the firm), how much should be invested elsewhere or distributed as dividends and whether external resources could or should be attracted or reduced. In order to formulate how this pool of resources grows or contracts it is convenient to begin with the traditional set of financial accounts in terms of which managers think and operate.

The top CHQ management organization is more or less a vehicle to foresee and to cope with unexpected events afflicting the firm.[22] Experience says that the ability to foresee with desired accuracy is extremely limited, and this knowledge is reflected in the set of decision rules of a firm. The long-term plan developed here is a means to minimize long-term commitments when heading in the directions that currently appear to be the right ones.

There is no such thing as "a firm decision". If not for other reasons, time consumed in searching for a decision makes a simultaneous decision of a firm entity an impossibility by definition. The macroeconomic problems of aggregation are as obvious at the firm level as they are at the national level. The top executive team of a corporation may control the movement of its vehicle better than do the decision makers in the ministries of economics, but control is still only a matter of degree. The micro-to-macro modeling technique means that the aggregation problem has been "solved" at the national accounts level, but it appears again in dealing with the unit of measurement that we have chosen instead, the firm. Hence, our concern for the aggregation problem has to be reflected in the way we model firm behavior.

When drawing up plans for the future CHQ management has to be able to partition the growth decision conceptually into a series of partial decisions. This way CHQ can draw on various sources of information within the organization and make decisions in a sequential manner without clogging up the interpretation machinery. There is practically no empirical evidence to support the traditional textbook view of a simultaneous, master solution that governs the entire firm. There may be some didactic merit to such theorizing but I doubt it on the grounds that it probably leads to misunderstandings rather than insights when it comes to interpreting essential phenomena of business life.

The partition we will be concerned with in this chapter is between long-term investment and short-term operational decision making. This partition has an organizational (empirical) counterpart in the real world.

We will adopt current practice among firms by assuming that CHQ each period adopts a provisional long-term steady-state growth projection to guide long-term commitments like investment spending. This long-term projection is always subject to revisions but it has a guidance impact on one decision in particular, namely to attract long-term debt in advance of foreseen uses. Long-term debt affects the current liquidity position and hence the ability of the firm to carry out a long-term investment program. These are the important functions of this long-term investment-financing decision block. They are new to the model compared to earlier published presentations. Besides, the quarter-to-quarter machinery of the MOSES economy (including also the final investment decision) goes on as described in earlier documentation, e.g. (E 1976b).

The long-term steady state projection will be based on the criterion that past value growth rates in real net worth at least be maintained unless external market forces make this rule unoperational.

The idea of this MIP criterion[23] is that CHQ management does not scan all possible corners of a firm interior feasibility domain, digest it and come up with the optimal master solution. Rather they look back to see what is reasonable to demand of "the firm" in terms of past performance. They devise a spectrum of performance requirements (targets) that are consistent with this performance criterion and curb activities that do not meet the criteria. The reason for this seemingly uninformed control method is both lack of information of the internal mechanisms of their own firm and lack of analytical tools to hold all information that exists together in such a fashion that an informed master decision is possible. This procedure also recognizes the fact that unreasonable demands on an individual or an organization, based for instance on the performance of the best competitor in the market, seldom produces desired ends.[24]

It is entirely irrelevant to argue about whether CHQ firm management, by these standards, are "satisfiers" or "optimizers". The distinction cannot be formulated analytically within our framework. It will, however, be intuitively clear that if all external factors governing the system (the firm) stabilize on some sort of a steady state, the MIP criterion may eventually push the firm into a state that is the best attainable under the steady, external circumstances. However, within the entire micro-to-macro model economy such steady external and internal circumstances are generally not obtainable. This does not make it worthwhile to explore the optimum or equilibrium characteristics either of the firm or the entire MOSES economy, until we have solved a series of more pressing, more interesting and more relevant problems.

2. The Objective Function of Firm Management

a) The Objective

Corporate top management in MOSES firms are concerned with the long-term value creation of the business as it accrues to the owners. CHQ management is not concerned with any internal aspects of firm life that do not affect the long-term value generating capacity of the entire organization.

We define the objective function of CHQ management as a Board requirement to maintain or raise the sum of the dividend payout of net worth and the growth rate in the net worth of the firm. The dividend policy is assumed to be supportive of the objective as to net worth. If net worth of a firm as valued by the stock market grows at a slower rate than in other external allocations of financial resources, dividends will increase and vice versa. The exact meaning of this will become clear as we go along.

This central CHQ objective is contained within and imposed upon the organization through what we call the Separable Additive Targeting Formula (see below). This formula regulates the in- and outflows of corporate funds to the benefit of the value growth objective.

As already described (Chapter II), CHQ management does not push for maximum feasible value growth over time but rather strives to improve demonstrated past performance (following the MIP principle). This is in recognition of several aspects of business life. Firm management does not know the interior capacity potential of its own organization well. Nor does it know the future market environment and even less about the longer term consequences if it pushes for immediately improved performance up to as high limits as it occasionally perceives as feasible. Corporate management opts for following a set of conservative behavioral rules and criteria. Given what firm management knows about the firm and its exterior environment, it never makes decisions that are deliberately inconsistent or that go against its objectives in terms of the objective function. Hence the MIP principle can be shown (Chapter VI) to conform to rational behavior on the part of management under a realistic set of assumptions as to what information is in fact available to decision makers. It also tends to stabilize the rates of return and the cash flows over time.

b) Separable Additive Targeting Theorem

It now remains to formulate how decisions are taken for the whole firm and what it means to aim at the highest possible or "maximum feasible" value growth rate into an unknown future. To do this we will introduce a few theorems that link the macro objectives to various activity levels within the firm.

A natural way to look at a firm is to regard it as a set of lines of business ("divisions") engaged in direct production activities. The production activities are held together by an overriding system of Corporate Headquarter (CHQ) functions, the most important being asset management and finance. Theorems 1 and 2 define the organization of the Corporate Headquarter functions and how they all link up to the goal variables of the entire firm organization. For simplicity we here disregard (a) corporate income taxes and (b) procurement of raw materials and intermediate goods, (the purchasing function) in the main text.[25]

Theorem 1 A (the separable additive targeting function).

In a consistent set of financial accounts the following relationship will hold each period as an identity:

$$\mathbf{G} = DNW + \theta = \underset{(A)}{M^*\alpha} - \underset{(B)}{\rho^*\beta} + \underset{(C)}{DP(DUR)^*\beta} + \underset{(D)}{(RRN-RI)^*\phi} \qquad (III:1)$$

provided no taxes and no intermediate deliveries exist.

G is the sum of the rate of change in firm net worth (NW) and the rate of dividend pay out of the same net worth (θ). **G** is the goal variable of the firm. It will be shown in Theorem 1 C below to be equal to the rate of return to net worth.

Symbols Used

CH( )operator = Difference per time unit
D( ) operator = Rate of change per time unit
NW = Net worth residually determined from balance sheet as (NW=A-BW)
A = Total assets, according to replacement valuation
BW = Total external debt
θ = Dividends (DIV) in percent of NW
M = Gross operating profit margin, in percent of value added ($\Pi/p\cdot Q$)
Q = Output (deflated value added)

p = value added deflator
S = Sales = Q + purchases + finished goods inventory change
α = Value added in percent of A
ρ = Rate of economic depreciation of production capital (=K1, according to replacement valuation)
β = K1/A
P(DUR) = Investment goods price index (determined endogenously in corresponding market in model economy)
RRN = Nominal rate of return on total assets (A). For definition, see below
RI = Domestic interest (borrowing) rate, endogenously determined in financial system of model (see Chapter IV)
ϕ = BW/NW(=leverage factor)

Proof

The proof makes use of the cash flow identity of the firm, the definition of investment and of definitions of various rates of return.

Note once again that for simplicity in the derivation of (1) we assume no inputs (purchases) of raw materials and intermediate goods. In the model, however, it is all there. Hence $p*Q \cong S$.

Cash Flow Identity

$$\Pi + RI2xK2 - RI*BW - DIV + \frac{dBW}{dt} \equiv INV + \frac{dK2}{dt} \qquad (III:2)$$

Definition of gross investment spending:

$$INV \equiv \frac{dK1}{dt} - \frac{dP(DUR)}{dt} * \bar{K}1 + \rho * K_1 \qquad (III:3)$$

Π = Gross operating profits, including depreciation

RI = Average borrowing rate of interest on debt (=BW)

RI2 = Average deposit rate of interest[28]. In what follows we will assume for simplicity that RI2=0 and regard BW as net debt

K1 = Replacement value of production equipment on which the depreciation rate (ρ) is applied to obtain depreciation (=ρ*K1)

$\bar{K}1$ = The corresponding volume measure obtained by deflating K1 with the investment goods deflator P(DUR)

K2 = All other assets (portfolio), replacement valuation

NW = Net worth, residually determined from: A $\equiv$ K1 + K2 = BW + NW

DIV = θ*NW

Now reshuffle terms in (2) and insert in (3):

$$\Pi-\rho*K1-RI*BW + \frac{dP(DUR)}{dt}*\bar{K}1 \equiv DIV - \frac{dBW}{dt} + \underbrace{\frac{dK1}{dt} + \frac{dK2}{dt}}_{\frac{dA}{dt}}$$

From the definition of the nominal rate of return to net worth then follows immediately:

$$RRNW = \frac{\Pi-\rho*K1 - RI*BW + \frac{dP(DUR)}{dt}*\bar{K}1}{NW} = \frac{DIV}{NW} + \frac{\frac{dNW}{dt}}{NW} \qquad (III:4A)$$

Note that A-BW=NW and that we assume - for simplicity - that RI2=0.

Now introduce θ = DIV/NW as the dividend payout rate.

It follows that:

$$RRNW = \frac{\Pi-\rho*K1 + \frac{\frac{dP(DUR)}{dt}}{P} * K1}{A} * \frac{A}{NW} - RI*\frac{BW}{NW} = \theta + \frac{\frac{dNW}{dt}}{NW}$$

Define the <u>nominal rate of return on total assets</u> as:

$$RRN = \frac{\Pi - \rho * Kl + \frac{\frac{dP}{dt}}{P} * Kl}{A} \qquad (III:4B)$$

and it follows immediately that:

$$RRNW = RRN*(1 + \frac{BW}{NW}) - RI* \frac{BW}{NW} = \theta + \frac{\frac{dNW}{dt}}{NW}$$

since

$$\frac{A}{NW} = 1 + \frac{BW}{NW} = 1 + \phi$$

(ϕ=leverage factor).

Thus:

$$RRNW = \frac{\frac{dNW}{dt}}{NW} + \theta = RRN + (RRN - RI)*\phi \qquad (III:4C)$$

But:

$$RRN = \underbrace{\frac{\Pi}{S}}_{M} * \frac{S}{A} - \rho * \frac{Kl}{A} + \frac{\frac{dP}{dt}}{P} * \frac{Kl}{A}$$

$$\therefore \frac{\frac{dNW}{dt}}{NW} + \theta = M*\alpha - \rho*\beta + \frac{\frac{dP(DUR)}{dt}}{P(DUR)}*\beta + (RRN-RI)*\phi$$

Q.E.D.

Theorem 1 A demonstrates that the objective variable (G) at each moment equals the sum of the growth rate in the value of the firm (net worth = NW) and the value of dividends distributed in percent of the same net worth. The observant reader has already noticed that the value of the firm (=NW) is defined from the capital input side. Is growth in NW a good performance measure? This question cannot be properly sorted out until we have introduced a market valuation of NW (in the stock market) and the interest rate (see below and next chapter).

Each moment G can also be decomposed into four additive components (there will be more if we consider also corporate income taxes, purchases etc.), namely contributions from current production operations (=A), a deduction for capital wear and tear (=B), contributions from capital gains (=C) and from finance, and the leverage factor (=D).

Hence, at each moment in time four different activities within the firm contribute independently to the overall objective variable. They are production operations (=A), maintenance and inventory etc. management (=B), asset management (=C)[29] and financial management (=D). It is an empirical fact of life that these four (or six if we add taxes and procurement) functions are organizationally separated in all large business organizations, (E 1976a).

If we aggregate the goal variable G over time the components of the separable additive targeting function will become gradually more interdependent. We will be faced with the impossible task of defining what exactly to mean by a sustained, maximum G or (which is the same) maximizing the time integral of G. Obviously, this requires that we define future time patterns of its constituent components. The most important such interdependency of course is that the leverage decision (D) affects profit margins in (A) via borrowing and investment. We will return to this problem after we have introduced a few supplementary theorems.

Theorem 1 B **(leverage formula)**

$$G = RRN + (RRN - RI) * \phi$$

$$RRN = M*\alpha - \rho*\beta + DP(DUR)*\beta \qquad \text{(III:5)}$$

Proof. This is the well known "leverage formula". It follows directly from (III:4C) in the main proof above.

Theorem 1 C

$$G = RRNW \qquad \text{(III:6)}$$

Proof:

Already demonstrated in passing in (III:4) above.

Theorem 1 D

The leverage factor $\phi = (BW)/(NW)$ relates to other financial variables including the gross savings ratio $\Psi = (SAV)/(INV)$ as:

$$1 + \phi = \frac{RRNW-\Theta}{\beta*[()*\Psi-\rho]} \qquad \text{(III:7)}$$

where: $() = DK1-DP(DUR)+\rho$

Proof:

Define gross business saving as:

$$SAV = \Pi-RI*BW-DIV$$

The savings ratio then becomes

$$\Psi = \frac{SAV}{INV} = \frac{\Pi - RI*BW - DIV}{CHK1 - CHP(DUR)*\bar{K}1 + \rho*K1}$$

This expression can be rewritten as[30]

$$\Psi = \frac{RRNW}{\beta*(1+\phi)*()} + \frac{\rho}{()} - \frac{\Theta}{\beta*(1+\phi)*(\ )}$$

where $() = (DK1 - DP(DUR) + \rho)$

This expression can easily be solved for the leverage factor ϕ.

Q.E.D.

Theorem 1 E

The current profit contribution $M*\alpha$ to RRN in Theorem 1 is a weighted average of the profit contribution of each constituent production activity, the current asset endowment A_i serving as weight. Hence

$$\alpha \bullet M = \frac{1}{A} * \sum M_i * \alpha_i * A_i \qquad \text{(III:8)}$$

Proof:

$$M \bullet \alpha = \frac{\Pi}{S} \bullet \frac{S}{A} = \frac{\Sigma \Pi_i}{A} = \frac{\Sigma \frac{\Pi_i}{S_i} \bullet \frac{S_i}{A_i} \bullet A_i}{A} = \frac{1}{A} \bullet \Sigma M_i \bullet \alpha_i$$

Q.E.D.

Theorem 2: (Profit margins and labor productivity)

At whatever level of aggregation that we choose below the CHQ level we can define a profit margin Mi. Mi can then always be decomposed into:

$$M = 1 - \frac{W}{P} * \frac{1}{Q/L} \qquad \text{(III:9)}$$

where W is the wage cost level, P the output (value added) price level and Q/L labor productivity of the production activity considered.

Proof:

$$M = \frac{P*Q - W*L}{P*Q} \qquad \text{(definition).}$$

The above then follows immediately. **Q.E.D.**

(There is a more complicated equation that relates the rate of return to total factor productivity growth. We will return to this equation in Chapter V on allocation and economic growth.)

The problem of making something meaningful out of these theorems really has got less to do with their internal (accounting) logic than with the problem of establishing a useful measurement system to associate with the symbols.

The most tricky problem - which we leave for the end - is to measure value growth or net worth. To transform net worth into something else, like consumption by a share owner, we have to impose an intermediate "valuation man", ("a market") if the transaction is to be real. At this point we are only concerned with accounting prices, not market prices. Thus P and W in Theorem 2 could be the accounting price in a planned economy or a market notation in a western economy. If a large business organization chooses to divisionalize into units, some of which engage only in internal firm deliveries, the P would also have to be an accounting (transfer) price. The important thing, however, is that Theorem 2 provides a direct link from the physical concept labor productivity to the goal variable. At some low enough level within the firm - the "machine" level - Q/L can be identified as a physical concept like "number of screws divided by number of hours of work of some well defined quality". The problem is that at this level the concept of capital has ceased to be a measurable quantity. This is well recognized in the corporate world and explains why capital as a physical quantity never enters the important, internal accounts of a business organization. It is not stable, intelligible and interpretable enough a measure to serve an operational purpose. This is why Theorems 1 A, 1 B, 1 C and 2 will be the backbone for the "theory of the firm" that enters the MOSES micro-to-macro model. The key to the endogenous growth machinery of the model, however, is how the market valuation of NW and the interest rate continue to force a rate of return requirement on the investment decision at the firm level.

Theorems 1 C and 2 "control" decisions related to short term production planning of Chapter II. Theorems 1 A and 1 B control the long-term investment-financing decision that we will develop in this chapter. As soon as we enter this stage (decision making) we will have to be much more explicit and all variables used will have to be well defined by reference to a measurement method.

c) How does a Firm do It - a Case Description

Before we go on with specifying what a MOSES firm does, we will briefly describe how a live firm does it in terms of the rules of behavior idea.

This firm (see case description p.xxx in E1976a) consists of several large divisions, each of which produces for a different type of market. The firm has designed a financial model of itself built up around its divisions in a fashion quite similar to the divisionalized firm modelled in Supplement 1. The overriding rate of return target is of the type (III:1).

In the first round of the long-term planning process, planners (a staff function) go with the top executives - a sub-committe of the Board - to some remote, undisturbed location. The purpose is to set the overall rate of return ambition (target) for the medium term future (in this case 5-10 years) and to agree on the assumptions on the exogenous environment of the firm. In our terms this means making long-term expectations on the interest rate and quantifying EXP(p), EXP(w), EXP(S). This takes place early in the year and the task of the planners is to translate top executive talk and discussion into quantified terms compatible with the corporate allocation model and with the corporate planning and budgetary process. As a rule there are no explicit technological assumptions made. They are embedded as trends out of the past in the "production functions" of the model and in the parallel planning procedure of the company (see below). Whatever is thought to be known at lower, division levels is incorporated in the figures put together there.

This being done a new, but smaller, corporate executive group meets with the planners to finalize the assumptions for the plan. For each division there now exists a set of price assumptions EXP(DS,DP,DW,RIS), - where RIS is the short-term borrowing rate - an assumed, financial frame for investments of the entire corporation and an individual profit margin target calculated by MIP from past performance, but adjusted to a separate calculation compatible with (II:1).

Those data are now sent around to division heads. Divisions are asked to come up with their long-term plans on the basis of these assumptions.

Parallel to that the same assumptions are fed into the allocation model. Being a fairly simple device most features having linear or loglinear specification, the results can be quite easily foreseen. Without restrictions regulating the rate of contraction of physical activities, the model would allocate all investment resources to the high rate of return performance end of corporate activities.

The point of this whole procedure is not to obtain a numerical plan but to come up with a consistent, provocative offering bid in the negotiations that take place when division heads present their plan proposals. They do that together in a large meeting in early autumn. The described analytical procedure forces consistency on the first stages of division planning and exercises a sobering influence in the sense that it reveals clearly to all participants in the planning game their relative performance. Exorbitant demands for large investment resources from loss operations have to be well argued or they are argued down at the round table by other division heads that also want their fair share or more of the investment pool.

This procedure divulges a lot of information to top CHQ executives that also participate in the meeting and allow them to move the discussion and negotiations towards feasible and reasonable but tough performance standards on each division. It is more difficult for a division head, after an open negotiation like this to solicit a generous or "soft" profitability standard on the basis of his superior knowledge of his own division. This was the whole point of the analytical procedure. The plan and the budget is always a negotiated compromise between the division proposals and the synthetic plan cranked out of the computer. These negotiated results are what matter. They are what reasonable and responsible division heads have committed themselves to do. They are, hence, taken seriously, and all reporting on actual performance is set against this negotiated result.

We cannot of course model the negotiations into a MOSES firm, so we have had to rely on implementing decision rules that approximate the top down bottom up management confrontation that makes up the planning process, and results in a bottom up commitment to perform in terms of the corporate objective function (III:1). This case illustration should at least demonstrate that the negotiated plan stops short of the feasible maximum and that the interior parts of a large business organization are always run with considerable slack. Slack is known to exist, but those who want to see it gone do not know where it is. Hence, the key notion to improved top down leverage on interior corporate decisions and performance is improved information through trial and error learning over time. We have tried to recognize that in the MOSES firm model and we do not believe in models that do not!

d) The MIP-Principle Extended

The separable additive targeting device (III:1) provides an organizational format to divide up the business functions that contribute to overall profitability in an additive fashion. It can also be described as a central Corporate Headquarter (CHQ) grid through which an overall corporate rate of return target can be imposed systematically through a decomposition of the entire organization into lower level performance criteria in a fashion illustrated in the above case description. This is current practice in several large business firms, and it is predominantly done in short-term budgeting and production planning through the

$$(A) = M^*\alpha$$

part in (III:1), much in the same fashion as we have modelled it in Chapter II. For a given (α, β) this profit margin criterion can be said to correspond to an adjusted real rate of return standard on production decisions that implies a particular choice of profit deflator (see Theorem 1 B and next section).

The extended targeting formula that applies to the long-term investment financing decision has to take all the other components of (III:1) into account as well - inflation, economic depreciation rates, borrowing and the decision to distribute dividends.

e) Inflation, Capital Gains, the Real Return to Assets and the Dividend Decision

So far we have deliberately avoided the problem of real versus nominal decision criteria. These are almost as tricky as the problem of measuring aggregate capital stocks. These problems serve as a second rationale for firms to stick with M in their internal guidance system. The profit margin in fact approximates an index of the real rate of return on total assets and it appears to be a fairly robust measure when it comes to choosing the appropriate deflator [E 1976a].

The nice thing about the MIP principle as it is stated above is that it is expressed in nominal terms and whatever the rate of general inflation the firm will want to keep each of its components as high as possible. The problem with real versus nominal profit criteria appears when there are strong relative price movements and the firm has to choose between expanding through external finance and/or distributing profits rather than plowing them back into the company.

The MIP principle suggests both that the profit margin criterion should apply to all ongoing production, and that the firm should be concerned with exploiting capital gains and inexpensive external finance.

Share-owners are, however, concerned with preserving the real value of the money they have invested in the company while the financial managers of the company may take a more narrow look, and be primarily concerned with the refinancing of existing assets. Relative prices may develop very differently making the capital gains component an important part in overall profit performance.

The origin of capital gains in each company is clear. They appear through the inflationary component (C) in (III:1). This price may develop very differently compared to the prices that share-owners are personally concerned with. As to the choice of proper deflators economic theory does not give a clear answer. The traditional, Anglo-Saxon assumption is that share-owners are potential consumers that consume from the same basket as the average consumer. Hence, they will respond to differences in price movements in company assets, in consumer goods and in other assets that the share-owner may be investing in. If low capital gains within the firm are not compensated by large production profits or shrewd financial maneuvering they may opt for higher dividends. This being the case, we could introduce the consumer price index as deflator for the nominal rate of return on net worth, and impose that the real rate of return criteria be:

$$\bar{\mathbf{G}} = \text{RRNW-DCPI}. \qquad \text{(III:10)}$$

In this simplified setting we could pick either G = RRNW or $\bar{\mathbf{G}}$ as the variable to compare with alternative rate of return measures to determine dividend policies. The separable, additive targeting formula would have to be somewhat reformulated as to the evaluation of capital gains in the portfolio choice decision (see further Chapter V). This could have an effect on the borrowing decision and the determination of the opportunity cost of investment. We will come to that. Besides, there would be no difference to criteria used in the short-term decision machinery. This is the way we have chosen to handle dividends in a MOSES firm for the time being.

There will, however, be a problem if share-owners in a firm abide by a different deflator. This is in fact a plausible assumption to adopt for the very large share-owner capitalist for whom future consumption is not the main criterion for wealth creation. He may take a very long-run view arguing that, even if inflation favors a different portfolio choice right now, the very long-run prospects for a particular company may nevertheless be very good. And if he wants to be in control and "run" the business, he has to keep his shares. Alternatively, he might argue that this company has a higher than average production performance even though it cannot reap immediate capital gains. The choice of rate of return standard to use in a firm is the same thing as the time preference of the majority of owners. For some large share-owners the relevant rate of return to compare with other alternatives could well be (see III:1):

$$\hat{\mathbf{G}} = RRN = A + B = M^{*}\alpha - \rho^{*}\beta.$$

$\hat{\mathbf{G}}$ is a frequently used "hybrid" real rate of return measure on total assets that can be rewritten as follows:

$$RR = \frac{\Pi - \rho^{*}Kl}{A}$$

and that differs from $\mathbf{G}$ above in that it does not include a relative price factor.[31]

3. The Investment Financing Decision of the Firm - First Approximation to What Goes on in the Firm Model

So far we have mostly been concerned with ideas and how the investment-financing decisions should be modelled. We now proceed to take a look at what is actually going on in the model. The exact procedure for determining the investment plan and for realizing investment spending in a MOSES firm is described in all necessary detail in Supplement II to this chapter.[32] This is a less technical approximation told in terms of Figures III:1 and III:2.

Step one (setting **targets** and **expectations**) begins when CHQ forecasters form their long-term expectations about sales (S), product prices (p), investment goods prices (P(DUR)) and wages (w) for the next five years. The operator is called EXPL( ) and incorporates a smoothing function with error learning correction and adjustment for variations in historical experience, much along the same principal lines as in short-term expectations formation. The exact formula is found in Supplement II, Section 1.

In a similar fashion other CHQ staff people work out a long-term profit target from the real rate of return target on equity passed down from the Board in terms of (DNW,Θ) in formula (III:1). The MIP principle applies. We can calculate a target on M much in the same fashion again as in the short-term planning procedure. The code in Supplement II gives this derivation with company taxes included (Section 3).

$$TARGL(G) = TARGL(DNW+\Theta) = MAX(GHIST,X) \qquad (III:11)$$

$GHIST = \lambda * GHIST + (1-\lambda)G.$

X = Exogenous.

Long-term targeting goes on at the upper part of Figure III:1. It constitutes the first planning round in the earlier case description and it applies to all divisions, even though we won't present the divisionalized firm (not yet in program) until Supplement I.

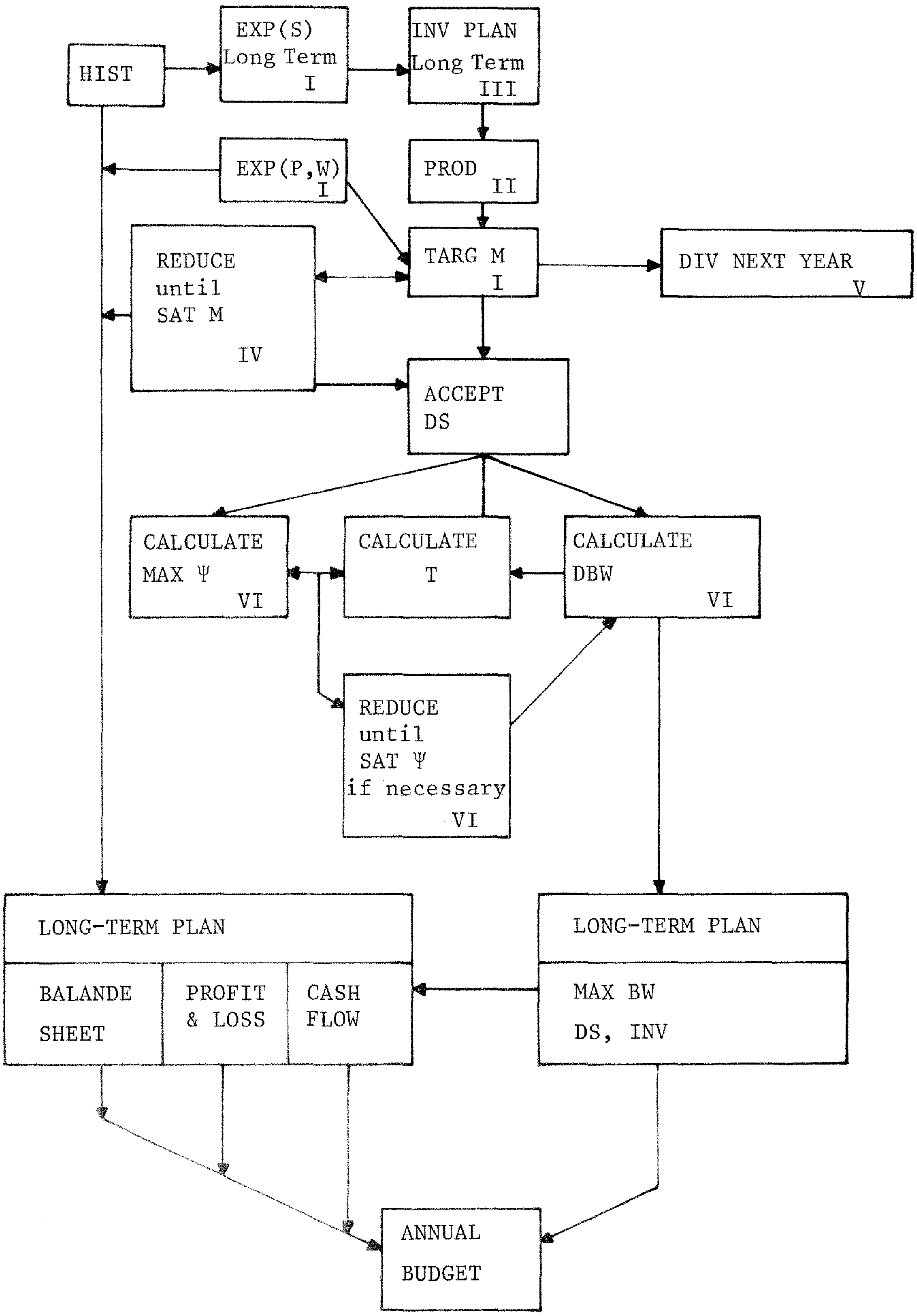
This targeting round enters the investment decision. Even in the one division firm the targeted rate of return has to reflect other opportunities available than expanding production. The firm we conceive of consists of one or more production divisions with their individual rate of return capabilities. There is the option to invest in property that yields both a current income and a capital gain, in shares in other firms, in Government bonds or in bank deposits. Taxes furthermore affect the real rate of return to the owners of the company. The choice procedure will eventually be endogenized. For the time being we have simply entered X in (III:11) to indicate that if expected returns on current corporate production based on past performance is not regarded as the proper target you can plug in any outside target that you wish, and wait and see what happens to the firm.

Whatever the final choice may be, apply:

$$TARGL(G(AT)) := MAX[TARGL(G(AT)), (1-t)RI, \ldots] \qquad (III:12)$$

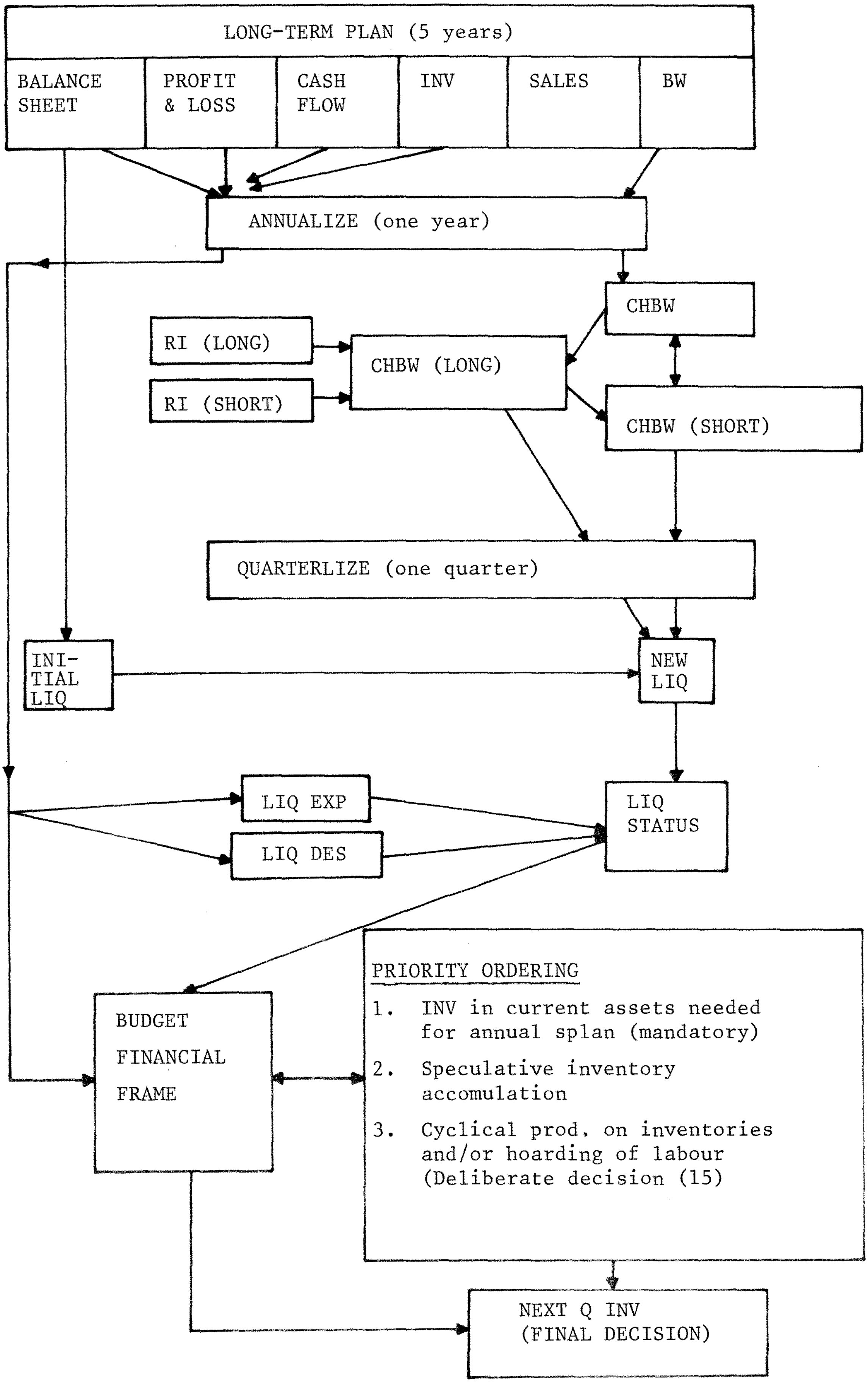
Figure III:1. Long-term plan

(Modified version of Figure 3 in E 1976b)



Step I: : Targets & Expectations
Step II: Production system
Step III: Investment plan
Step IV: Profit check
Step V: Dividend decision
Step VI: Borrowing check

Figure III:2. The investment and borrowing decisions
(Modified version of Figure 4 in E 1976b)



(where AT or (1-t) stands for after tax), enter an assumption on the leverage function D in the targeting formula (III:1) and expectations as to P(DUR) and solve for M to obtain

TARGLM

Step two is to apply this set of expectations and targets to data on the **production system.** The theoretically most appealing way would be to make technical assumptions as to new investments, and to calculate the optimal capacity accumulation path up to some chosen horizon. (The possibility of making special productivity assumptions on MTEC and INVEFF and entering them (INVEFF = $\frac{\alpha}{\beta}*\frac{P(DUR)}{P}$, MTEC = $\frac{Q}{L}$) in III:1 to evaluate their rate of return consequences on the margin is discussed in the supplement to Chapter V.) That is, however, not the way investment planning is carried out at CHQ levels in real firms (E 1976a). Long-term planning at that level rather aims at establishing a preliminary financial frame for investment and growth within which the fine details can be fitted later, at levels below CHQ. Since the plan is revised at least every year, and by no means is a "holy" number, rough approximations are used. We have approximated actual, observed procedures in the MOSES model.

To calculate the total asset (A) accumulation needed we apply two fixed proportions; The ratios between total assets and value added ($1/\alpha$ in the separable, additive targeting function (III:1)) and between production assets and total assets β in (III:1), are assumed constant throughout the planning period. They do, however, change endogenously over time.

Excepting periods of large relative price adjustments this appears to be reasonable enough an assumption. Firms use it in their own calculations.[33] (See Section 1 in Supplement II.)

Investment needed for any chosen activity path can now be calculated from the definition:

$$INV/K1 \equiv DK1 - DP(DUR) + \rho \qquad (III:13)$$

Third, an assumption on the normal rate of capacity utilization $\left(1\text{-Average}(A21+A22)=NU\right)$ is made and the approximate investment plan is entered to shift the production frontier QFR(L) according to:

$$CHQTOP = \frac{INV*INVEFF}{P(DUR)} \qquad (III:14A)$$

$$D\left(NU*OFR(L)\right) = DQTOP1 + \frac{L*\exp(-\gamma*L)CH\gamma}{1-\exp(-\gamma*L)} \qquad (III:14B)$$

vertically along a given L. (III:14A) is in effect the definition of INVEFF, which measures the additional value added feasible for an extra unit of investment at a given labor input. In terms of the targeting formula (III:1) it can be said to be a "marginal" α in (III:1) corrected for relative changes in the price on products and investment goods.

In practice we estimate the initial value of INVEFF by dividing potential value added Q/(1-A21) in Figure II:3 by K1 from the replacement valued balance sheet that we use. From then on INVEFF is an exogenous factor like DMTEC. For various reasons we have assumed it to be constant signifying a current professional strand that technical change is predominantly of the labor saving type.[34]

The assumption implied in (III:14A) hence is that the average level of technology expands at the same rate as

QTOP i.e.
DTEC = DQTOP

and that capital depreciation takes place at the assumed rate $CH\gamma$. If $CH\gamma$ is assumed to be zero for simplicity, the second part of the right hand expression in (III:14B) vanishes.

The fourth (**profit check**) step (Section 7 in code) now is to make certain that this growth plan tallies with the profit targets.

Apply expectational (P,W) variables to (III:9) and check whether

$$M > TARGL(M). \qquad (III:15A)$$

If not, keep reducing sales along QFR(L) on horizon reducing also L per unit of Q until profit margin check on new investment is satisfied. Recalculate INV needs, assuming α also for new investment and that INVEFF remains unchanged.[35] This is the first loop in the upper end of Figure III:1.

The fifth decision determines the **dividends**. Again this could be viewed as an entirely exogenous decision. We do, however, expect the dividend payout rate (Θ in III:1) to depend on the rate of return of the business operation. Hence, using the symbols of (III:1) and (III:6) and ignoring taxes for the time being

$$\Theta = \Theta\left(TARGL(G)-RI\right) \qquad (III:15B)$$

$\Theta' < 0$.

We assume the rate of dividend payout of net worth (NW) to decrease with increasing targeted profitability as defined in (III:11). For (1) a 100 percent production company that (2) is 100 percent self financing its investment and (3) manages to realize a constant RRNW forever this means that the present value of all future cash dividends will increase in direct proportion to realized performance in terms of RRNW. This is an operational way of using the standard dividend assumption, that firms distribute dividends in proportion to the difference between its discount rate and its rate of return.[36]

The sixth (**borrowing check**) implies a complete overhaul of the decisions reached so far.

Each firm is assumed to have its own borrowing rate in the bank that deviates from the market deposit interest rate by a fraction, the size of which depends on the financial position of the firm.

$$RI_i = f(RI, \phi_i) \qquad \text{(III:16A)}$$

$\partial f / \partial \phi_i > 0$.

The checking procedure so far has been organized to secure minimum revisions under normal circumstances. As long as the long-term profit check has been flagged with a margin, only an unusually bad debt position would signal a revision at this point.

The firm is willing to expand debt (CHBW>0) as long as this contributes to overall target fulfillment. This holds as long as from (III:11):

$$TARGL(G)>RI_i$$

which is the same as:

$$RRNW>RRN>RI_i \qquad (III:16B)$$

The maximum debt-equity ratio ϕ is reached when an extra \$ of investment spending increases ϕ in such a fashion that RI_i pushes above RRN on new INV (cf. Supplement II, Section 11.1).

The normal procedure in firm planning is not to maximize G with regard to investment, but rather to establish an acceptable minimum ϕ ratio that applies traditionally over long stretches of time. Although many factors enter the determination of maximum ϕ, some simple approximation will be empirically superior to maximizing G in (III:5) by increasing investment (this in fact is the classical way of determining the investment-financing decision in literature).

We adopt the following procedure.

The cash flow balance (III:2) is used to calculate borrowing needed to finance the INV plan just established above.

This borrowing estimate allows us to establish both debt (BW) and the leverage ($\phi=\frac{BW}{NW}$) on the horizon (say 5 years from now).

Enter ϕ_i in (III:16A) and calculate RI_i. Check back on TARGL(G) so that (III:16B) is satisfied.

If not, cut back on BW, INV and Q until (III:16B) is satisfied or INV=0, whichever comes first. Then stop. We have arrived at the preliminary long term (budget) plan, with yearly entries, shown in the middle loop in Figure III:1.

4. Short-Term Budget

As mentioned already short-term financial decisions are determined as before (see earlier documentation). The change to a more sophisticated investment financing model primarily concerns the acquisition of long-term debt and the ability to carry out a desired long-term investment spending program.

The long-term plan from the earlier section contains the full accounts for the firm year by year up to the horizon. We think in terms of a 5 year horizon. We now pick the first year. We may want to apply some forecasting mode to the plan (see Section 8 in Supplement II) to obtain a cycle in the variables that are determined in this budgeting module. They are investment spending and the cash flow items. In all applications of the model so far the procedure has been to think about the long term (5 year) plan as a bundle of trends up to the horizon, and then simply to pick the first year for the annual budget. Normally this was the planning mode practiced in U.S. and European companies at least up to the "revival" of a strong business cycle in the early 70s [see E 1976a]. I.e. there was no real recognition of the business cycle in the formalized plan, except in some particular, "partial" instances. This situation changed rapidly during the middle of the 70s. The entering of business cycles in long-term plans, and an increased attention to the short-term budget procedure, soon became a standard corporate feature. Already by the end of the 70s, however, professional economic forecasters had fallen into disrepute both through their dismal performance and of their apparent diversity of opinion. In addition to this rapid and irregular inflation made economic calculation in companies difficult. My guess is that this has moved planning and forecasting in firms back to a more simple and less ambitious mode.

Annual investment determined in the budget is spread over quarters by some mechanical procedure that mimics actual budgeting practice (see E 1976a). This means entering one quarter of the annual investment for the first quarter. This completes the (annual) budget at the bottom line of Figure III:1 or upper line of Figure III:2.

a) Long-Term Borrowing Decision

Firm management at this stage takes a look at the credit market. The long-term plan suggests that the amount of external funds that will be needed over the next five years is Y:

$$Y = CHBW(PLAN) \qquad (III:17A)$$

The firm now decides to borrow long term next year up to:

$$CHBWL = Y*F(RIS_i, RIL, ...) \qquad (III:17B)$$

$$0 \leqslant F(\ ) \leqslant 1.$$

Depending upon the relationship between long- and short term interest rates the firm can decide this year to borrow nothing (long-term), or the whole "five year amount". If the long-term interest is low compared to the short-term rate the firms stocks up on liquidity to meet future needs for expansion. If the long-term rate is high, the firms waits with tidying up its balance sheet. Any funds needed up to the annual borrowing requirement are borrowed short term.

We expect the long-term interest rate to be the same for all firms. It is thus a question of obtaining long-term finance at all.

b) Liquidity Management

The next step in the planning procedure of the firm is to calculate its expected liquidity position by quarter (LIQE) over the next year, using the cash flow balance (III:2).

Then the firm establishes its desired liquidity (LIQD) by some chosen formula. Liquidity is needed to meet varying demands for payment. There are a large number of possible ways to arrange that at the lowest possible cost. We do not think that elaborations at this particular place will add much to our understanding of total firm behavior (an hypothesis that we do not test). We expect that payment demands on the average should be proportional to sales and we calculate them accordingly as:

$$LIQD = f(S) \qquad \text{(III:18)}$$

We hence disregard both economies of scale in cash management and the sensitivity of S to the interest rate. The argument that this assumption will not affect firm behavior is based on the observation [E 1976a] that liquidity management aiming at minimizing the cost of holding liquidity is a management routine separated from the comprehensive control function excercised at CHQ. The budgeted LIQD is calculated at CHQ very much as above. Separate liquidity forecasts are made up on a monthly, weekly or even daily basis and estimated temporary cash surpluses are invested in the short term and in over night markets. If liquidity management appears to be more important than we currently believe, (III:18) can be easily modified later when we have the empirical information needed.

A liquidity check is defined as:

$$CLIQ < \frac{LIQE-LIQD}{LIQD}$$

Whenever the above criterion is not satisfied the long-term investment spending plan is adjusted downwards in the following sequence.

a) Reduce investment until

$INV = \rho * K1$

if not sufficient to meet liquidity standards, then:

b) Dump

STO-MINSTO

in market at any price offered. If this does not clear CLIQ criterion by next quarter a crisis is looming ahead.

If the above remedial action is not sufficient to meet CLIQ target

c) Cover remainder in **short-term borrowing** and stop all new recruitment.

c) Crisis and Bankruptcy Proceedings

The "life" of a MOSES firm is controlled by three criteria.

First, whenever net worth (NW) as calculated on an economic replacement value basis[37] turns negative the whole operation closes down. The NW-value can be propped up e.g. by Government subsidies.[38] This instruction is dominant and overrides the other two.

Second, whenever no (Q,L) combination that meets profit margin targets can be found in short-term planning the plant is shut down. This procedure is described in passing in Chapter II and in all necessary detail in (E 1978a, p. 72).

This shut-down rule can be overridden by a short-term target modifier that aims at bridging a cyclical period of difficulties (see Section 15 in Supplement II). Production for inventories, hoarding of people over a recession or a countercyclical timing of investment are possible reasons for this. This profit target modifier brings the shut-down rule 2 closer to rule 1.

Third, if new recruitment and advance layoffs of people do not restore short-term liquidity after CRITER (a chosen number) quarters, declare bankruptcy if this has not happened before according to rules 1 or 2. Bankruptcy in the MOSES economy today is always followed by shut-down of operations, all labor is transferred to the status of being unemployed, all physical capital is scrapped at zero alternative value,[39] i.e.

$$Kl = 0.$$

If any net value remains afterwards; i.e. if

$$NW \equiv A - Kl - BW > 0$$

stocks of finished goods are sold off in market at next period's price. Net proceeds and all financial assets net are transferred to household savings deposits.

d) Taxes

The firm pays a corporate income tax on declared profits. There are ample opportunities in Swedish firms to carry over profits and losses from year to year by adjusting declared asset values on the balance sheet. We will enter this possibility and assume that firms only declare income for taxation in order to distribute dividends. This means that

$$\text{DECLARED INCOME} = DIV+TAX$$

Setting the tax rate to t we have

$$TAX = \frac{t*DIV}{1-t} \qquad (III:19)$$

and the DIV decision becomes the prime decision that also determines taxes.

Many observers would argue that this specification of the corporate income tax function is an empirically acceptable approximation. We used it in our earlier corporate income tax allocation experimently on MOSES [see Eliasson-Lindberg (1981)] and it appears to be an acceptable approximation to judge from the recent results in Södersten-Lindberg (1983).

e) The Final Decision (Quarter)

Funds available next year for investment (INVF) are now calculated as [40]

$$INVF: = M*S(PLAN) - \frac{(1-\beta)*CHS(PLAN)}{\alpha} + \left(\frac{DBW}{BW} + RAM\right)*BW - (RI+RAM)*BW - DIV - TAX - CHLIQD \qquad (III:20)$$

where RAM is the rate of pay back (amortization) of debt set exogenously. M is calculated as targeted:

M = TARG(M)

TAX comes from (III:19) and CHLIQD from (III:18).

Next quarter INVF is calculated by entering quarterly sales plan data from short-term production planning as well as finance needed for the next quarterly stock adjustment.

S(PLAN) = EXP(P)*(PLAN(Q)-OPTSTO+STO)

When ready, investments (=INV) for next quarter are obtained from the long-term plan (Section 9 in Supplement II) and **final investment** is determined as:

$$INV: = MIN(INV, INVF, REDINV)$$
$$INVF - REDINV \geqslant 0 \qquad \text{(III:21)}$$

is deposited in bank.

REDINV is a fraction of INV that is determined after short-term capacity utilization has been checked. Whenever the current rate of capacity utilization is running below the normal utilization rate (NU) by a certain margin (x) the long-term investment plan is temporarily shelved in the following fashion:[41]

$$\text{If } \left(\frac{Q}{QTOP}\right)/NU < X \qquad \text{(III:20)}$$

$$\text{Then } \quad INV = REDINV = Y*\rho*K1$$
$$Y \geqslant 1$$

Suppose:
X = .6
NU = .8
Y = 1

This algorithm means that investment is taken down to replacement investments (ρ*K1) if current capacity utilization falls below 48 percent (0.8*0.6). This is below a level of 60 percent of the normal rate of utilization (48/80).[42]

5. Entry

Competition occurs in all markets; for products, for labor, and for funds. When firms cannot meet their profit standards for a long period and/or if they lose enough money to make their net worth negative, they go bankrupt and/or close down. In sufficently long experimental runs of the model (see E 1983b) the model economy - and some sectors in particular - tend to lose the majority of firms and a heavy tendency towards concentration manifests itself, despite continued demand growth. This is not realistic for the kind of dynamic economy we have in mind. The absence of entry in markets will lower competitive vitality and - in our model experiment - distort the "historic" simulations we believe (1) are necessary to understand the stability properties of the MOSES economy and (2) also are economically meaningful to help understanding economic growth processes in general. This problem is analysed in some detail in Chapter VI.

To correct for this deficiency we have tried to specify an entry mechanism to each product market to maintain long-run competition in a realistic fashion. (See E 1978a, p.52 ff.) The obstacle to keep the entry feature as a permanent device in fact happens to be lack of data on the specification of typical entrants in the manufacturing sector.

In the beginning we did not realize the importance of this entry feature for the long-run vitality of market competition. Hence, in most experiments so far this entry module has been switched off. For reasons to be expounded in Chapter VI the entry feature is planned to be modified and turned on in the future. It works as follows. Each market is characterized by a particular entry frequency with the appropriate size and performance distribution as they should be known. New firms establishing themselves in the market have no history of their own. They base their expectations on historic aggregate market data on (S,W,P,M) for the sector (market) they are entering. They hire labor in the market in the same fashion as, and together with, other firms. If the new firms are economically more efficient than the average for the market they will begin to capture increasing market shares and to grow faster than the average for the market, and vice versa. Even more important, exhibiting superior economic efficiency, the new firms may be able to weather foreign competition and bad times better than other firms in the market.

Already in the earlier, experimental runs with this device the entire model responded in the fashion expected. New entrants spurred competition and pushed prices down. Output increased because the less efficient firms (whether being new entrants or old firms) were forced to contract or shut down, forcing a reallocation of resources towards the relatively more efficient firms. One interesting property was that new entrants occasionally relieved bottlenecks that had forced a slump in the economy in earlier experiments, through local, sudden increases in prices on scarce resources (see E 1978a, pp. 52-55).

6. The Theory of a Firm

From the set of behavioral principles (theorems) based on the targeting formula in Section 2 of this chapter and presented throughout this paper we can piece together a theory of how the firm in a MOSES economy organizes itself as a financinal entity. It combines physical (real) activities in a decentralized way, under the constraint of financial objectives. In the process the growth rate of the "conglomerate" of activities, and its total size are determined. One conclusion from this discourse is that technical change as measured at the firm level is the result of a combination of entrepreneurial skills and technological advances in the interior of the firm entity. This technical change, or rather "business skill" variable - very much as Schumpeter argued - is hardly predictable or explainable at the firm level by any general theory.

a) The Concept of a Firm

We have introduced the concept of a firm as an investment bank that attracts or leaks resources according to how it performs in terms of the targeting formula (III:1) in Section 2. This performance in turn is based on the above mentioned entrepreneurial-technical skills. To complete our conceptualization of the firm we have to go beyond what is currently in the model program and formalize the CHQ investment bank function. This will be done below and in Supplement I through the introduction of a multidivisional firm. This conceptualization also provides the basis for a theory of the size of the firm, the size being determined by the interior (divisional) performance and the firm's ability to attract funds or to rein in funds. This entity will be placed in a financial resources (credit) market environment in Chapter IV. The nature of "entrepreneurial and technical ability" within the firm will be explored in Chapter V.

We can formulate a theory about a representative Marshallian firm that behaves in a predictable fashion in a stable market environment (stable relative prices). This firm can be modelled to grow progressively more and more skilled in organizing itself (internal organization and efficiency). Similarly, we can envisage an economy that gradually grows more efficient in its allocation of resources as long as the external and internal environments are stable and predictable. The harmony of one such representative firm can be preserved in the case of erratic changes in competitive conditions outside the economy, and among firms within the economy, as long as they are known in advance. The argument of Schumpeter was that none of these changes representing the enterpreneurial function and represented by future values on MTEC and INVEFF are at all predictable from a general theory at the firm level. Nor is the response of the firm itself in coping with the new situation.

b) The Entrepreneurial Function

The endogenous machinery of a MOSES firm as it operates (behaves) in the model is that of the representative firm. The behavioral principles behind this firm are very simple. These principles can be logically traced back to a set of objectives that guide a MOSES firm through time. Realism requires that we explain the entrepreneurial factor in a broad sense at the firm level (enforced as the investment decision plus DMTEC in a MOSES firm) by some general principles or that we follow the argument to its logical conclusion and declare it to be random (see e.g. Simon-Bonini (1958)). If business success distributions can be demonstrated to be compatible with a stochastic explanation this would be all we need to have for satisfactory predictive performance in a number of macro analyses. Sharefkin has argued recently (1983) that with a sufficiently large number of firms with different characteristics, and with a sufficiently complex internal and external search machinery of the individual firm the behavior of a MOSES firm will appear to be approximately random.

There are both advantages and disadvantages associated with viewing the entrepreneurial function at the firm level as the result of a random process. For one thing it is a testable proposition and the proposition has not been rejected by the evidence that we have seen (see E 1976a, p.241). Secondly, predictability or not at the firm level is of no consequence if we are concerned with macro behavior only, as we mostly are in MOSES analysis. Then we could view entrepreneurial skills as a randomly distributed skill, the frequency of which can be related to (explained by) economic, cultural and other environmental factors. This was a provisional argument adapted in E (1980b, p. 71 ff.).

c) The Firm as an Investment Bank

However, this is not a satisfactory theory until properly tested, and it is not consistent with the large number of large firm organizations that perform above average decade after decade. The argument we will return to in Chapter V is that there exists a firm (management) technology that can be formulated in general terms, that is capable of predicting entrepreneurial, innovative behavior at the firm level. The explanation relates both to the ways firms are organized and to the environment of the firm. We will devote Supplement I to modeling the investment banking or CHQ functions of the MOSES firm entity, assuming an exogenously given technology factor associated with new investment. We will return in Chapter VI to synergy effects associated with the investment banking function of the firm and the overall corporate objective in terms of (III:11), of conglomerate formation, joining existing firms under a corporate Headquarter financial hat. Since this is not yet in the model program we will work out the specification in the following Supplement I, and discuss it in a context that is not directly tied to the existing model program.

Supplement I to Chapter III

Long-Term Internal Resource Allocation at CHQ[43]

1. The Distributional Equation

A market makes decentralization of decision making among financial units (firms) possible. An ambition to decentralize decisions also prevails within any large organization and a critical question is when the non-market allocation mechanisms of the internal business organization cease to be superior to those of the market [Coase (1937)]. Superiority here has to be defined in terms of organizational ability to generate a return to funds compared to what can be earned elsewhere in the market. For us this profitability manifests itself in the ability of the firm to attract funds to and/or to keep funds within the business organization. One aspect of this problem is the availability of reliable measures of achievement for the non-market allocation within the organization (E 1976a).

So far we have only dealt formally with a one division firm. This is also what currently is a firm in the MOSES economy.

In this supplement we will extend the separable additive targeting formula (III:1) to obtain a multiple division firm categorization. Even though this extended firm concept does not yet reside in the MOSES economy we can currently use the idea developed below to handle investment decisions in multiple division firms manually. Several large Swedish firms are in fact represented in the model economy by more than one entity. A special "dialogue" facility for a real firm - MOSES firm interface along the lines of the sophisticated (investment-finance) planning system in Chapter III has in fact been developed. (See next Supplement II.) A simple formula that monitors the allocation of resources and outputs within a business organization which follows directly from the definition of RRN (for proof see Chapter VI) is:

$$\Sigma p^*Q \equiv \Sigma w^*L + \overset{j}{\Sigma}(RRN+\rho^*\beta)^*A \qquad \text{(III:23)}$$

This distributional equation belongs to the set of equations that make up the separable, additive targeting equation in (III:1). Summation is across profit centers j. In the case of no joint production within the firm (III:23) represents a one to one classification of inputs over outputs. Again we disregard all inputs but (L,A). This means that we disregard intermediate goods purchases for the time being. We will generalize our formulae later on. Identity is enforced through the definition of RRN, which makes all "residual" value created above wages and the explicit and/or the implicit rental of capital accrue to the equity owners. This is the neoclassical way of looking at the business accounts. It does not disturb us at the macro level, but it departs from our "micro" idea of an entepreneur (a management technology) that manages (A,L). The entrepreneur and the equity owner have so far been made identical. Whether they are, or not, we do not want to have the entrepreneurial function in a broad sense identified with A neither as an input nor as an output - except for a short while in this formal excercise.

Use (III:1) and (III:9) to rewrite (III:23) as:

$$\Sigma\varepsilon*A \equiv \Sigma[M*p*Q-(RI+\rho*\beta)*A] \qquad (III:24)$$

where:

ε = RRN-RI

ε_i hence is the difference between the realized rate of return at profit center i and the reference interest rate.

The ε is a critical variable in our dealings with the internal allocation process of the firm. In defining its long-term profitability target TARG(G) in the previous section (III:11) firm management has indirectly decided to demand an average ε of the organization. This decision was shown to affect the borrowing capacity of the firm. In a multidivision firm it could be modified and be made dependent on MAX(ε) within the organization.

The multidivisional firm can be departmentalized in several ways. The normal thing is that some assets are centrally managed and some assets managed by the divisions. The mix differs between firms and even though we will have the necessary empirical information it would be very awkward to model all aspects of portfolio management. We simply assume that all assets related to production and sales are managed by the divisions. The CHQ unit controls portfolio (financial) assets (Bank deposits, Bonds and Shares in other companies). It also controls equity (Net worth=NW) and all debt(=BW). Production assets (=K1), inventories (=K3) and trade credits (=K2) will be held by divisions. For technical reasons all foreign denominated trade credits will be discounted in the Commercial Bank (see Chapter IV) and replaced by bank deposits at CHQ.

Investments in property will be modelled as a separate division represented by an exogenous profitability factor, simply to establish an internal opportunity cost term.

Similarly, foreign subsidiary operations, which are important and sizable for most firms in the model, will be represented as separate divisions.

This means that we can use our algebra from the earlier part of this chapter when making the internal investment allocation process explicit.

2. Internal Investment Allocation

Each firm now consists of a bundle of smaller firms like the ones we have already dealt with, plus a CHQ investment bank that divides up the pool of financial resources available from the borrowing decision (III:17) above between

(a) INV in divisions
(b) investments in financial assets
(c) investments in property.

The financial portfolio part and property investments are not yet explicit in the model. Such investments, however, have to be implicitly handled and we do it in the following fashion.

If investments of type (b) or (c) yield a higher return than investments in (a) the highest return appears in the long-term targeting function (III:11) that controls the amount of INV (type (a)) as a discount rate. Note, that this means that returns higher than those expected on INV may in fact make the firm increase borrowing above what is needed for expansion of production.

Besides, the type (a) INV decision comes first and cash flow in excess of what is needed for INV and financing that comes with growth, are allocated to the financial portfolio. This is explained in Chapter V.

The total amount of INV decided on in the one division firm was explained above. In the multi-divisional firm we simply repeat the profit check (III:15A) on each division using the same target.

The borrowing check is replaced by an investment budget check. Maximum amount of finance available for INV has been decided as before in the borrowing check (III:17).

The internal allocation on INV in principle begins by taking the most profitable division, calculating INV on the basis of its long-term sales plan. If the profit check is passed the division gets what it wants and the same is repeated in a decreasing order of profitability until the investment budget is exhausted.

This "linear" procedure is not a fair representation of what goes on in a real firm. For one thing firms often invest in low profit operations now on the presumption that higher rates of return will be achieved in the longer term. This is almost impossible to model as long as we have no theory that predicts such outcomes from historic data, except a stochastic planning scheme. We do, however, need a set of decision rules that gives also low profit divisions some investment money since this is what we observe to happen.

Secondly, a budget squeeze is one way of forcing low profit divisions to become profitable by doing something with themselves. One such way is of course not to give them any investment money. However, there is a certain convexity in all performance frontiers in the model. The long-term plan proposal from the division (see case description earlier) is a simple minded projection into the future. If the profit check fails it can decrease Q and L along the production frontier, thus raising M and RRN.

These profit checks even out RRN among the divisions to some extent, but large differences usually remain. However, we know, and firm management knows, that the market situation may very well have turned around in a few years. Hence, they want to slow down the investment adjustment process towards what currently appears to be the optimal structure by setting a maximum allowed annual departure from a distribution of investment funds that is proportionate to installed assets.

This more or less transforms the proposed interdivisional allocation of investment money out of a total investment budget into a constrained, stepwise programming problem. We will formulate it mathematically below, after we have introduced the other types of assets as well.

3. The Foreign Investment Decision

Foreign subsidiary operations have to be treated differently for many reasons. Much of the activity in foreign establishments in reality belongs to the distribution and marketing side. Some late stages of production and the final distribution of goods and services from all domestic operations (divisions) are run through the foreign subsidiaries. The international marketing organization is an integrated part of domestic operations. We hence want to push beyond a simple input-output representation of the foreign unit. Its size should be an integrated part of the overall investment allocation process of the firm.

There is only one straightforward way of modeling this:

(a) by removing the price taking assumption from exports. Firms with foreign subsidiaries earn an extra return on their assets and pay a higher price than PFOR on deliveries from Swedish plants.

(b) by exploiting economies of scale in receiving, processing and distributing a larger volume of goods from Sweden.

(c) by exploiting economies of scale in domestic operations on fixed inputs that are not part of the production plant described so far. R&D spending would be one example.

To model this we would have to make both marketing and R&D investments explicit in the model.[46]

In addition, the foreign unit confers economies of scale back to the Swedish divisions by selling more of their goods, thus making them invest and grow. In so far as the Swedish production specification incorporates economies of scale they can now be activated.

The foreign subsidiary linked to our particular division can be seen as consisting of two parts

- one production establishment that purchases goods from the corresponding Swedish division, processes them and passes them on to the foreign market.
- one marketing agent that adds value to both finished goods for the Swedish division and the semi-manufactured goods that are processed further at the Swedish subsidiary.

Some firms have only a marketing subsidiary. Others have both production and marketing activities.

The value added achieved through the marketing investment can be formulated as an increase in the price over and above the exogenous foreign market price (PFOR).

This price difference could be made proportional to the size of the foreign marketing investment relative to the size of the production assets K1. Technically it should be entered as the corresponding increase in the profit margin on all deliveries out of Sweden.

The meaningfulness of adding this feature to the MOSES firm depends on the availability of data to estimate a submodel (division) in which the growth of foreign activities relative to Swedish activities is explained. Work along these lines is currently in progress in a separate project at the IUI for the 1983/84 Government long-term survey. Questions on the price elasticity of exports related to the 1982 devaluation have been asked to the model firms in the 1983 planning survey (see further in database section in Chapter VII).

c) Other Types of Investment

Other asset categories to consider are property, bonds and short-term bank deposits.

For the time being the MOSES firm does not invest in property[47] but simply responds to the profitability of property investments by placing stiffer profitability standards on regular investments.

Bonds and bank deposits enter in a similar capacity, although this time actual purchases or deposits are made and exercise a liquidity effect on the firm.

All this belongs to the money chapter, and is explained in some detail there.

d) The Inter Firm Capital Budgeting Problem

The capital budgeting problem of the 5 year plan can be formulated as a step-wise programming problem.

The preferred procedure would have been to allow for upward sloping supply curves for investment categories of individual firms, as we do for borrowing. This is not possible for two reasons. First, data are not available for empirical applications. Second, firms do not have this kind of information themselves. Even large firms go about this decision in a period to period search fashion, much as described in the case illustration above (see Section III:1 c).

Hence, the procedure is to decide whether at all to go for financial securities and/or property, or to concentrate on investment in production facilities. Higher expected returns across the investment spectrum decide the extent of borrowing and the total investment budget, and returns are taken as given and independent of the size of the investment.

The decision problem can now be narrowed down in the following way.

Step I

Pick MAX $[RIS_i, RIS, RIL, RIF, MAX[RRN_i], T_i, \tau]$

MAX( ) lists also foreign investments

T = rate of return on share investments in other firms

τ = nominal rate of return on property investments

RIL = Long-term bond rate

RIF = Foreign investment rate (exogenous)

RIS = Short-term domestic deposit rate

RIS_i = local borrowing rate

Step II

<u>If</u> $Max(RRN_i) \leq RI_i < \tau$

Then (see III:20)

$INV \leq INVF$, $CHBW = 0$

Borrow up to (see III:16);

$RI_i = \tau$

and invest all:

$INVF - INV$

in property (fictious investment item)

Step III

<u>If</u> $MAX(RRN_i) \geq \tau > RI_i$

<u>then</u> borrow (see III:16) up to:

$RI_i = \tau$

(Split INVF on INV and property investments)

Step IV

<u>If</u> $MAX(RRN_i) \geq RI_i > \tau$

<u>then</u> borrow up to

$RI_i = MAX(RRN_i)$

and distribute all INVF on INV_i by solving the following programming problem:

Maximize: $\Sigma RRN_i \cdot \beta_i \cdot A_i$

subject to: $\frac{INV_i}{INV} - \frac{A_i}{A} < \xi$

$\Sigma INV_i = INVF$

Supplement II

Firm Model Planning Dialogue

The sophisticated INVestment FINancing module forms the base for designing an interactive Firm Model Dialogue: The sophisticated INVestment FINancing model has a structure that is very similar to a normal long-term planning and short-term budgeting sequence as they are carried out in large corporations (see E 1976a).

The sophisticated INVestment FINancing model interacts with the entire model (through the markets) exactly as the more simple investment module currently in the standard program. Hence, by adding the dialogue interface a firm manager can interfere with the long-term decision machinery of the model as he does in a typical long-term planning sequence. He can set and revise his own coefficients, targets and assumptions as plans are being realized. (In principle the manager of a large business group can also bring his divisions together, and carry out the same administrative action on each of them.)

With this set-up we have designed a quite sophisticated business game. The firm manager can make up a 5 year plan and a budget every year and revise both; the plan every year and the budget every quarter as he watches his firm interact with its model market environment.

For the time being the program technically allows only one firm to interact with the model at a time. But in principle there is no limit (except the number of firms in the model and computer capacity) to have all firms being manipulated on line by their managers. Then the business game would be a true market game in the sense that everybody would be responding to an environment determined by everybody's individual actions.

If our firm manager interacts alone with the rest of the model, he may learn the model properties such that he eventually will be able to predict his environment, and also - if he is large enough - the effects on this environment of his own manipulations of his firm.

If a large number of "managers" are interfacing through their firms, and if these managers exhibit substantial irregularities in behavior, compared to the endogenous behavioral design of the model, environmental predictability will be more difficult.

However, the firm model has been designed to be realistic and the overall model is quite complex, which means that whichever alternative we choose, a firm manager participating with his firm in a game interface is liable to meet with surprises as he guides his firm through the model environment.

The main point with the model interface is not to use it for forecasts but rather to allow managers to practice (simulate) to cope with unexpected business events. A more detailed account of the Firm Model Dialogue is in progress (Lindberg).

The Firm Model Dialogue has been used in one particular instance, namely to calibrate a firm model. Staff planners from one large firm were inivited to "play" with the divisions of their firm and set their own assumptions. We plan to do more about that in the future.

Supplement III to Chapter III

Technical Specification of Investment-Financing Block[48]

(Sophisticated version. Not in standard code and program. The standard program has gradually been augmented with features from this sophisticated investment module (same symbols as in main text).)

References are made to New Code of current model version in the final part of this publication or in a separate volume.

Long-Term Growth Plan

[Note that we will use the algol notation := or make equal to, throughout this supplement.]

Section 1

Timing: Once a year in 4th quarter for 5 future years

1.1 EXPL(DS) := HIST(DS)+α *HIST(DEV)+β*$\sqrt{}$HIST(DEV2)
HIST(DS) := λ_1*HIST(DS)+(1-λ_2)*DS
HIST(DEV) := λ_2*HIST(DEV)+(1-λ_2)*[DS-EXPL(DS)]
HIST(DEV2) := λ_3*HIST(DEV2)+(1-λ_3)*[DS-EXPL(DS)]
when
$0 \leq \lambda_i \leq 1$, i = 1, 2, 3.
DEV := DS-EXPL(DS)
DEV2 := [DS-EXPL(DS)][49]
Note: We think in terms of a 5 year historic background to project the 5 year future. In the current initialization, starting 1976 only 3 years of experience are used the first year, namely1974, 1975 and 1976. The planning survey started in 1975 with data for 1974. See Albrecht - Lindberg (1982). When the simulation has run for 2 years the 5 year history has been generated and is put to use.

1.2 DA := DS

1.3 DK1 := DA
Note: These are assumptions for the long-term plan only. They do not have to be very realistically computed since they are to be used for a rough, ex ante calculation in a planning context.

In the future we may want the firm to plan for the future on the assumption of substantial changes in (MTEC, INVEFF) i.e. in α and

β in (III:1). See Supplement to Chapter V. Then we would not have simple proportionality in 1.2 and 1.3 but a more complex relationship.

1.4 Note: On any long-term planning occasion it is possible to impose DS exogenously for an individual firm or to impose a cycle in DS.

Section 2

2.1 INV/K1 = DK1-DP(DUR) + ρ
(Definition same as 10.3 in new code).

2.2 Endogenous determination of ρ
Optional ON and OFF routine (not yet in program).
Note: The problem with the present specification is that ρ is fixed and exogenous and that output of average, rather than lower end quality, is scrapped. We do not want to enter all the cumbersome algebra of a full vintage formulation but we want to keep the idea. Hence:

Assume:
a) INV/P(DUR) has been invested at a steady state rate. Keep that rate updated currently through cumulation. Hence, current capacity to produce (on QFR(L), A21=0), is spread over vintages of declining MTEC qualities according to a declining exponential curve.

b) MTEC qualities are allocated on these vintages according to a known DMTEC (exogenous) time profile. If INV/P(DUR) has in fact grown at a steady rate this formulation would be identical to a vintage formulation.

c) Calculate

$$\text{MIN MTEC} := \frac{\text{EXP(W)}}{\text{EXP(P)}} * \frac{1}{1-\text{TARG(M)}}$$

Each period, scrap all vintages below MIN MTEC[50]

Shift QTOP down accordingly
Pivot QFR(L) by recalculating TEC.

MIN MTEC means the labor productivity (Q/L) of a vintage when A21 = 0. Vintages are scrapped when they yield an expected M lower than TARGM.

(This has been done in a "backward" fashion, in (4.1.7) in the technical code. We cannot retain a truncated vintage series but have to mix what remains, and stir well.)

Next period (quarter) a whole new synthetic vintage constellation is calculated as above and the procedure begins all over again.

With this formulation we do no longer need ρ. ρ is in fact endogenously determined as CHQTOP due to scrapping in percent of QTOP.

Section 3

3.1 Calculate from 1.3
K1 year by year to horizon (= H = (say) 5 years from now)

3.2 Enter EXPL[DP(DUR)] from EXP block (1.1.1-3, same smoothing time as (1.1) above)
and ρ from block 2.2 (exogenous, or endogenous average of past 5 years)

3.3 Calculate INV year by year to H from (2.1)
Note: We choose to obtain the "trial" INV paths this way rather than feeding the preliminary EXP(DS) etc. into the production block to derive (indirectly) investment requirements.

3.3.2 Option: exogenous specification of INV. Same as 1.4.

3.4 Enter QFR(L) with last period L from (4.01) in old code. (E 1978a p. 183).
Enter NU = normal expected long-term capacity utilization rate = (1-Average SUM) = (1 - Average (A21+A22)) for last 5 years
or = Exogenous (optional)
Calculate NU*QFR(L)
Assume no change in L and that DTEC=DQTOP.

3.5 Enter INV from 3.3.
Quarterlize INV. Deflate by EXPL[DP(DUR)].
Enter in (4.1.3) in technical specifications, old code (E 1978a p. 184).
Calculate DQTOP1 each year to H.

3.6.1 $$D(NU*QFR(L)) := DQTOP1 + \frac{L*\exp(-\gamma*L) * CH\gamma}{1-\exp(-\gamma*L)}$$

3.6.2 Calculate
NU*QFR(L) on Horizon year (L same as now).

Profit Check

3.7.1 Calculate

TARGL(G(AT)):=λ*TARGL(G(AT)) + (1-λ)*GL(AT)

TARGL(G(AT)):=(1-R)*TARG[L(G(AT))]+R*TARGL[XG(AT)], R∈(0.1) using formula (E) in (3.7.3) below.

TARGL[XG(AT)] is an external reference, say G(AT) of the market leader, the best performer in the market, a long-term interest or some other reference that can be optionally imposed.

Put (A) and (B) in (3.7.3) into (C) and SOLVE for M = TARGL(M) with TARGL(G(AT)) in (E)
Note: This is needed to make TARGL(M) dependent upon changes in corporate income tax parameters.

3.7.2 On H (expansion of current operations)

M:= [(EXPLP*NU*QFR(L)) - (EXPLW*L)]/(EXPLP*NU*QFR(L))
(Same formula as (3) in Chapter II).

3.7.3 Calculate

RR = M*α - ρ*β (A)
(see p. 50 in E 1976b)
and
RRN = RR + DP(DUR) (B)
and

G(AT)=[(1-t)*(RRN+(RRN-RI)BW/NW)+t*(DP(DUR)+d-ρ)*K/NW]*NW/(NW-TC) (C)

d = fiscal rate of depreciation.
TC:= (NW - NW(BOOKED))*t each year (D)
AT signifies after tax.
To apply TARGL to G(AT) in (G) means that firms strive to maintain their after tax growth rate in nominal net worth. An even better formulation would be to formulate G(AT) in real terms after tax as in E (1976a, p. 292). This would mean replacing (C) with:

G(AT)=(same as before)-DCPI (E)

and to apply TARGL operator to G(AT).

TARGL[G(AT)] as defined in (E) stands for a long-run real, after tax rate of return requirement on net worth. It signifies a corporate head quarter (CHQ) objective and can easily - through (A) - (E) - be transformed into an M-requirement each period, that depends on inflation rates, tax rules etc. They in turn can be used as a criterion in long range planning.

3.7.4 Investment in bank deposits at RI deposit rate.
Enter from Money system period (quarter) before.
Never considered as an alternative to INV if
CHBW > 0 in (5.2) below
G(ATBDEP)=(1-t)*RI.

3.7.5 Other investment options

[EMPTY]

Note: If we decide later to split the firm into a set of production units held together by a financial CHQ function, this is the place to enter a rate of return screening across production units as discussed in Supplement I.

3.8.1 Choose
TARGL(G(AT)):= MAX(TARGL(G(AT)), RI*(1-t), ...)

3.8.2 Solve for
TARGL(M) using (3.7.3)

3.8.3 Check for SAT using (3.7.2)

3.9.1. If SAT go to Section 4

3.9.2. If not SAT lower EXPL(DS) with X percentage points and repeat from (1.2) until SAT.

3.9.3. Calculate new INV from 2.1.

Section 4

Borrowing and Leverage Check

4.1 EXP(RIL) := EXOGENOUS (Expected long-term RI)
EXP(RIS) := EXOGENOUS (Expected short-term RI)

4.2 Enter EXPL(DS) from (1.1) (or final value) from (3.9.2)
whichever is MIN.
EXPL[DP(DUR)] from (3.2) and M from (3.7)
in (4.3) below to obtain MAX ϕ.

4.3 Calculate

$$\text{MAX } \phi = \text{optimum gearing ratio} := \frac{\text{MAX}(\ ) - RI_i}{\gamma}$$

$$\text{where } \gamma = \frac{\partial RI_i}{\partial \phi} \text{ in } RI_i = F(RI, \phi)$$

This expression is derived in Chapter IV. See Equation (IV:21).

(Also see derivation in (E 1976b, pp. 102-103)

Section 5

5.1 Calculate CHDLIQ:=LIQD-LIQ from (13) below.

5.2 Calculate for next year
CHWB := $[$INV+CHS*(1-β)/α+RI*BW(LAG)-M*S+DIV+TAX+CHDLIQ$]$/(1-RI)

5.3 and then for following years making
CHDLIQ:=CHLIQ

5.4.1 DIV:=Θ*NW(LAG)
Θ:= EXOGENOUS or endogenously determined as below.
Note: that LAG refers to the previous year. DIV after tax adds to total income in household sector.

5.4.2 Alternative
Dividend policies cater for two interdependent purposes
a) to keep stockholders happy
b) to maintain a stable growth rate in the market value of NW. This last ambition is very much supported by success under a) and depends as well on the ability to keep θ constant in the long run at a steadily growing NW, after tax and net of inflation.

By entering θ as an exogenous constant we are fairly realistic. We should then, however, allow for the fact that successful companies often tend to have somewhat below average θ and vice versa.[51] Hence it would be good if θ could be made endogenous. Let us assume, that:

Θ=f$($G(AT) - RI$)$, f'<0

G(A) is the after tax and inflation determined profit objective of the firm as specified in (3.7.3). With this formulation a firm that expects a CHG(AT) > 0 for the long-term future could plan - at each RI - for a lower θ and vice versa. If the interest RI increases, on the other hand, everything else the same, firm management will have to up the pay out ratio to keep stockholders happy.

5.4.3 Stock market and capital gains taxation

[EMPTY]

Section 6

6.1 Calculate (from 5.2)
BW:= BW + CHBW
K1 from 2.1

$$K2 := K2 + \frac{1-\beta}{\alpha} * CHS$$

6.2 Hence
NW:= K1 + K2 + LIQD - BW

6.3 Calculate
ϕ = BW/NW

Section 7

7.1 CHECK for $\phi \leq$ MAX ϕ each year
(Alternative Check for (7.1) only year H).
IF SAT go to (10)
IF NON SAT take away as much net borrowing as needed (no more) to satisfy ϕ-target each year.

7.2 Add up reduction in CHBW each year 0 to H and divide by H to obtain annual average: = X.

7.3 Reduce EXPL(DS) with the help of formula:

Reduction (in percentage points) of planned long-term annual growth rate in S. :=Y:=X*(I-RI)*(S(LAG))

7.4 Reduce INV/K1 by:

Reduction in investment Value planned per year: :=Y*S(LAG)*β/α

7.5 CHBW: = CHBW - X for each year.

Note: CHBW so calculated for first year defines maximum borrowing allowed for next year (long and short term) under normal circumstances.

7.6 A formal rate of return check across production units (3.7.5) is very unusual. Such considerations are normally taken more intuitively. In a model like this with no explicit interface, if a firm is split into production units, (3.7.5) has to be there. However, at this point we could establish a direct interface. We have obtained total DBW on a 5 year basis for the entire firm. CHQ growth management usually means allocating investment money and no more. CHQ can now call in data from all operating units (operating as individual firms) and split DBW among them as they please. That fixes investment in money terms above what can be internally generated.

Section 8

Short-Term Budget

8 (Tentative). Enter business cycle in long terms S by applying the optional instruction.

EXOGENOUS CYCLE.
Calculate consequences for M in (3.7) and LIQ (see later) in H-year plan.

The rate of capacity utilization together with current cash flows will later be added as a determinant of quarter to quarter INV or rather to explain deviations from long-term INV in (8) above.

Section 9

9 We now have the long-term (H-year) plan + the annual budget by quarter:
INV from (7.4) and (2)
Kl ditto
DS from (7.3)
DA from (1.2)
DBW from (7.5) and so on.
Quarterlize INV as in (3.5) and whatever else that is needed by quarter.

Section 10

One Year, Long-Term Borrowing Decision (Final)

10 Add CHBW in (9) for all years 0 to H
ADD(H) CHBW: = Y (= total borrowing, new, long term)
Note: Y is expressed in expected current prices each year.

Section 11

11.1 CHBW(H) is total borrowing from (7.5) for entire planning period.

Calculate long-term borrowing for year immediately ahead as:

$$CHBWL := [1+\gamma * (RIS-RIL)/RIL] * (CHBW(H))/H$$

$$\gamma > 0$$

Note:

RIS = short-term interest rate
RIL = long-term interest rate
In some model versions the short-term interest rate RIS_i is firm-local, e.g.:

$RIS(i) = RIS + \Gamma(\phi)$

such that $\Gamma' > 0$, $\Gamma'' > 0$

(see (IV:17) in next chapter).

Alternatively we could be more conventional and assume that firms borrow, invest and grow up to the margin where:

$EXPL(RRN):=EXPL(M)*\alpha - \rho *\beta + EXPL(DP(DUR))$

$EXPL(RRN):= RI_i$ on the margin

Subject to $\phi \leqslant MAX\ \phi$ from (4.3)

Note: ε in (V:2B) in Chapter V would then be = 0 on the margin.

11.2 If CHBWL in (11.1) for first year is smaller than CHBW in (9) make up for difference by borrowing short term (CHBLS).

11.3 Same as (1.4).

Section 12

Liquidity Management

12 Add one quarter of CHBW (total) to cash position beginning of each quarter and calculate EXPQLIQ from the long-term plan.

Note: For the time being we use this simple device. The determination of EXPQLIQ per quarter is as follows:

EXPQLIQ:=QLIQ+M*S+CHBW-RI*BW-RAM*BW-DIV-TAX-CHSTO-CHK2-INV

All entries from (8) (above)
DIV from (5.4) and TAX from (3.7) (check).

Section 13

13 Calculate desired LIQ as:
LIQD = F(S, expected excess cash outflow)

Note: Excess cash outflow is defined as in the following Supplement B, but for next year only.

13.2 Same as (1.4).

Section 14

Liquidity Crisis and Bankruptcy Procedure

14 Calculate expected LIQE from (12)
Expected cash position:

Ω = (LIQE-LIQD)/LIQD

defines the firm's short-term (next year) liquidity status as seen from within the firm. Ω measures expected deviations from desired LIQ.

14.2 LIQ-crisis

Whenever

Ω < CRITLIQ
or (see below)

Ω actual = (LIQ-LIQD)/LIQD < CRITLIQ
CRITLIQ $\in$ (-1,0)
The long-term growth plan is abandoned. Then:

a) reduce INV until
Ω = CRITLIQ
b) if not sufficient
dump STO-MINSTO in market immediately until
$\Omega \geq$ CRITLIQ
c) if not sufficient
cover the rest as short-term loan in bank.

Enter 5 percent of labor force in AMAN.
All new recruitment is stopped.
d) Repeat c) every quarter for a maximum of CRITER quarters. Whenever Ω requirement satisfied return to normal.

Bankruptcy occurs as follows:

1) Dominant. Whenever net worth has been negative or

2) if Ω actual < CRITLIQ
after CRITER periods declare Bancrupt.

When bankruptcy occurs:

The one plant firm shuts down.
All L to LU (unemployment).
Scrap all capital (K1).
Make K1:=0
and cancel all debt.

Note: One possible modification would be, only to scrap unprofitable capital. The procedure would then be to find the point on QFR(L) (see Figure II:3), where

M corresponds to RRN = RIS (see Formula III:1)

and then reduce L correspondingly.

Financial reconstruction of the firm would then imply that QTOP is run through a new point. Some x percent (say 5 percent) vertically above and QFR(L) is recalculated and a new firm entity with no debt is established.

This firm could be defined as a new firm or merge with another firm as one likes.

The above modification is technically easy to enter, but it would not change model behavior more than marginally. This procedure could be used to handle say, the addition or separation of parts manufacturing to or from an integrated production system (= division).

The preferred procedure would, however, be to use a multiple division firm within which entire divisions can be added or subtracted. In fact most real, large firms in the MOSES system are currently represented as several entities.

The multiple division firm is not yet coded. A preliminary conceptual presentation is found in Supplement I.

Section 15

Short-Term Profit Target Modifier (Exogenous)

15.1 $$\Omega = \frac{LIQE - LIQR}{LIQD}$$

and/or

$$\Omega \text{ (actual)} = \frac{LIQ - LIQD}{LIQD} \quad \text{(per quarter)}$$

determines the extent to which short-term operations M-targets can be temporarily modified downwards because of unexpected or excessively strong profit influences that are not believed to be permanent.

Such modifications also relate to specific decisions:

(a) production for inventories
(b) hoarding of people and overtime
(c) contracyclical timing of investment.

This short-term modifier is to be operated exogenously on a chosen number of firms, or endogenously (not yet specified). One way to do it would be to instruct the machine to stop and print out necessary information whenever current INV, L and Q are down more than five (say) percent below the long-term plan. Then the operator (the chief executive) can decide what he wants to do.

15.2 Production for inventories

When a preliminary Q-plan has been determined after TARG(M) check (see 3.7.1), override further TARG considerations this quarter and raise the preliminary (Q,L) plan so that an exogenously set optimum final goods stock (OPTSTO, see code), can be realized during the same quarter. The only factor that can now prevent the corresponding Q level from being realized is non-availability of needed labor in the labor market at the offering wage (determined as before).

15.3 Hoarding of people and overtime
(Not yet in program)

Whenever there is a choice to get rid of people or an immediate need for more hours of work the firm consults its long-term plan to decide whether it expects any need for the people in the long run.

Calculate L = RFQ(Q) [see (4.02) in code] for H = 2 (years) at NU operations. The result is L(2).
Let go from AMAN

If L(2) ⩾ L + AMAN content
keep redundant labor in AMAN as before.

Overtime

if A21 = 0 and
CHL > 0 in (5.4.1.0 in code).

THEN contemplate overtime
if

$$EXP(P)* \frac{dQFR}{dL} \geqslant (1+OVER)*EXP(W)$$

but make CHL = 0
if (in addition)

$(L(2)-L)/L < FRAC.$

If overtime needed to fulfil Q-plan, pay

(1+OVER)*W

for all work above initial L that quarter.

Note: These devices are inserted to handle real life mechanisms. Firm management:

(I) may want to behave rationally in the long run but dares not because of a perilous LIQ position.

(II) may find it economically rational to take drastic action, but social and other considerations suggest otherwise. Hence, we have to make a distinction between firms that deviate upwards and downwards from a normal or average M-trend. I consider this device empirically important when the model is used to analyze short-term economic behavior.

15.4 Countercyclical timing of investment (exogenous)

Section 16

16. Calculate from (14) and (15) the maximum contribution from LIQ next quarter as:
CHLIQP: = LIQE - LIQD

Note: CHLIQP may be negative.

Section 17

Investment Decision (if not already aborted in 14.2)

17.1. Investment finance allocated next quarter (final decision):

INVF:=M*PLAN(S)-PLAN(CHS)*(1-β)/α-(RI+RAM)*BW-DIV-TAX-CHLIQD

or (more easily recognized)

INVF:=M*PLAN(S)-CHK2-CHK3-(RI+RAM)*BW-DIV-TAX-CHLIQD

Quarterlize INVF to QINVF.

17.2 PLAN(S) is obtained from (4.3.10) in PROD planning block as:
PLAN(S):=EXPP*(PLANQ-OPTSTO+STO)

(17.3.1. Calculate planned intermediary inventory build up over and above next quarter planned use. Call this CHTESS).

17.4 Check for capacity utilization

If

(1-Q/QTOP)/NU < CAP.

Then

RED(INV):=RED*ρ*K1
RED $\geq$ 1.

17.5 Enter INV from (9) in

INV:=(INV,INVF-CHTESS,RED(INV)).

Deposit (INVF-INV+CHTESS) in firm bank account.

Section 18

[18.1 (Tentative). Split QINV into various types of INV, depending upon whether they affect QTOP or TEC in production block].

18.2 SPLIT INV into construction and machinery investments. SPLIT factor is exogenous coefficient. INV construction goes to dummy I/O production sector. INV machinery enters as before as demand in INV-sector.

Section 19

19 QINV from (17.4) enters as final money demand in capital goods markets (next period).
Market DP(DUR) determines volume QINV that updates production system.

Section 20

20.1 Residual LIQ invested currently (each quarter) at (RIS - ξ) in The Bank.
ξ: = Exogenous (difference between short-term borrowing and deposit rate and equal to profit margin in banking system. See Chapter IV).

Notes to Chapter III

[21] This chapter is a substantially rewritten and enlarged version of Chapter 3 in Eliasson (1976b). Since then I have worked out a technical specifications paper (a preliminary code) in various stages to serve as a code for the programming of the INVestment-FINancing module. This paper is based directly on a version of that code written down in a paper dated June 1978.

The entire paper has been written to serve two purposes; first to introduce the ideas of the MOSES firm model and second to tell how it works. This dichotomy in purpose becomes troublesome in this particular chapter since some important aspects of MOSES firm life, albeit worked out, have not yet been programmed into the model. We have chosen to present the full MOSES firm design in the first part of the chapter, and to indicate which important features that still remain outside the programmed model. In the technical specifications supplement these departures are exactly noted. In the model code only the programmed part of the model is shown.

[22] See the dialogue interface facility in Supplement II to this chapter.

[23] Maintain or Improve Performance=MIP. See Eliasson (1976a, p. 236 ff.).

[24] Such demands can be introduced exactly as described in the model. The results usually are that the firm finds no solution that yields the required performance, and shuts down.

[25] The full targeting formula that incorporates the MIP idea as it appears in a MOSES firm has been derived in Eliasson (1976a, Supplement section). See also p. 293 ff. Eliasson - Lindberg (1981).

[28] Calculated on K2 that includes deposits in bank, earning RIS minus bank margin ξ and long-term bond rate RIL. See Chapter IV.

[29] In this formulation "assets" mean only capital goods that appreciate in value at the rate (DP-ρ). Inventories as well belong here, and financial assets if we had made them explicit - as we will do in Chapter IV.

[30] $\phi=(BW)/(NW)$, $\theta=(DIV)/(NW)$.

[31] See Eliasson (1976a, p.291).

[32] The complete code is found in Part II.

[33] One should observe that firms can make forecasts on those coefficients bringing in all the information available. They in practice update the coefficients whenever they believe they should (see Eliasson 1976a) and we could of course do the same if we know something about (α, β).

[34] See Bentzel (1978). Empirical research appears to suggest the assumption that technical change has only been labor augmenting. It is technically easy to allow for capital augmenting technical change by varying INVEFF, or entering a growth trend. Since we have no empirical information to go on, we have simply assumed INVEFF to be a constant. However, evidence collected in other IUI studies, especially those associated with electronics in industry (see e.g. E 1982b) suggests strongly that at least technical change in the future will be relatively more capital saving.

[35] No capital saving is possible as long as INVEFF is constant.

[36] Assume a constant discount factor i that is higher than the constant RRNW by a margin signifying the extra risk of investing in the company. Then θ is a constant and the present value of all future dividens (=Y) is

$$Y = \frac{\theta * NW_0}{(i-K)}$$

NW_0 is the initial value of NW. Hence $dY/dK > 0$.

This result can be naturally extended when allowing for external financing and assuming a forever constant interest rate i. See also expression (IV:23) in Chapter IV.

[37] As total assets at replacement values minus debt. See further Chapter IV. Also see specification in Lindberg (1981) and in Carlsson-Bergholm-Lindberg (1981).

[38] See Carlsson-Bergholm-Lindberg (1981).

[39] This specification relates to the present one firm - one plant specification in MOSES. With multiple plant operations as in Supplement II, shut-downs can be restricted to some of the plants.

[40] Or reformulated somewhat:

INVF:=M*S(PLAN)-CHK2-CHK3-(RI+RAM)*BW-DIV-TAX-CHLIQD.

Also note that the model contains what we have called a REServe slack component see E (1978a, pp. 66-68 and p. 188 ff.) that we have deleted in Chapter II to keep the algebra clean. In the full model specification hence QTOP really reads

QTOP*(1-RES)

[42] See further Supplement II where investment spending has been split into different categories.

[43] Not yet in program.

[46] This makes a lot of sense. The R&D budget in turn could also be made to affect DMTEC!

[47] Except as part of the general investment process. Total INV are split by a technical coefficient (see Bergholm 1982) into machinery to be purchased in the investment goods markets and buildings that are simply forthcoming upon demand in a truly Keynesian tradition. Again this constitutes a partial endogenization of the input-output matrix. It would be fairly easy to add a speculative property investment side as well.

[48] From a circulated early draft May 1981 (Revised from November 18 and December 1976 and June and July 1978 and February 1981) by Gunnar Eliasson.

[49] Irregularities in historic data lowers the productive power of our EXP-functions. This factor is supposed to make firm managers cautious. The larger the standard deviation the more inclined to underestimate prices and overestimate wages are firm managers ("risk aversion").

[50] This criterion for scrapping vintages is very similar to the one used by Bentzel (1978) on macro data.

[51] Our data suggest that Θ should be in the range 2 to 3 percent.

IV MONEY IN THE MOSES ECONOMY – the Determination of the Interest Rate

1. The Actors and their Accounts

The money side of the model connects all savings in the economy in the sector of origin (households, firms, government and abroad) with all demands for funds (households, firms and government). In the process the domestic interest rate is determined.

The credit market provides the link between the sources and uses of financial resources. This linkage can be modelled in a more or less complex manner. When consolidating all these links over the financial markets in the economy, a direct accounting relationship appears between the **real accounts** (demands and supplies of goods and services) and the **financial accounts**. An important part of monetary theory is concerned with the extent to which the organization of credit market processes affects the dynamics of the investment allocation processes and how this manifests itself in the entries of the real accounts. The main vehicle in this respect is the rate of return requirement imposed on all investment decisions through the interest rate. With this the determination of the interest rate becomes very important.

We have argued strongly earlier that micro specification in labor and product markets is essential to capture the dynamic market process, and to understand a real, "live" economy. We argue the same for the money markets. Money is a very special "good" to model, and to do it meaningfully at the micro level we have to enter a micro-specified household sector in MOSES as well. This is still some way off, mainly due to the lack of systematically collected data.[52]

This means that for the time being much of the intricate intermediation that goes on in the credit system of an industrialized economy has to be assumed away. We will concentrate on the determination of two domestic interest rates; a short-term rate (RIS) and a long-term rate (RIL). There are explicit links to the outside world, which means that the domestic interest rates are dependent on two foreign (exogenous) interest rates.

Part of the interest determination problem lies in the organisation of the credit market arbitrage process and how the rate of return requirements of household savers (their time preference) is brought to bear on the investment decision in the firm. Household rate of return requirements are determined by alternative investment opportunities available, e.g., in foreign markets or in real assets, where inflation plays a role. This arbitrage process can be more or less efficient, more or less affected by government intervention and regulation, more or less visible to the statistical eye etc.[53] One particular question concerns interest regulation. For how long can a low interest rate policy be supported through the tax system without destabilizing the economy? Another question concerns the extent to which such things as "quantity constraints" affect the price signals in the market.

One important feature of the financial system has to do with the absorption of risks on ownership entitlements associated with the supply of finance. Since the model contains a sophisticated, industrial firm submodel operating in both product, labor and credit markets at least a rudimentary equity market should have been entered,[53B] its main function being to transmit information and/or to impose rate of return requirements on firm management.

The money system in the MOSES economy currently consists of a model outline and a narrowed down version of the money model outline, that has been programmed into, and is operating (since 1980) in, the model economy.[54] It can be turned off for an exogenous determination of the domestic interest rate. When turned on all real and financial accounts are made dynamically interdependent and the domestic interest rate is determined in the process.

Simplifying, we can say that the whole MOSES economy revolves around an exogenous foreign interest rate assumption which affects the rate of return requirements in the domestic economy through the intermediation of the credit market. This is a key determinant in the dynamic allocation machinery of the micro-to-macro model economy. The government can affect the domestic interest through various monetary and fiscal actions. Somehow the MOSES economic structure has to adjust to these price assumptions, and the time structure of the price and quantity adjustment is an important part of the MOSES theory. Loosely speaking a price and interest parity mechanism describes the relationship between the model economy and the rest of the world. A good quality database guarantees that initial structural conditions are not out of line with rest of the world price assumptions based on recorded prices in the recent past. The domestic, expected rates of return at the micro (firm) level respond to these data through the investment decision. The domestic exogenous constraint on total economic growth is the productivity of new investment goods as it applies to investments of individual firms at one point in time (see Chapter VI).

We begin by describing the outline of the money model, which is based on a portofolio choice idea with firms and households, very much stimulated by the ideas of Tobin (1969). Different types of claims in the market signify different levels of risk, differentiated by different rates of return. We conclude by specifying the narrowed down version currently operating within the total model.

All real transactions in the MOSES economy are recorded in a set of financial accounts. Each firm has its set of accounts, and so do the household sector and the public sector. All financial transactions are cleared through The Commercial Bank that incorporates the banking system, and the Central Bank. This clearing constitutes the credit market in which the interest rate is determined. The accounts can be consolidated into a set of national accounts. To obtain a better overview, let us look at the balance sheets of all five categories in turn. They are shown in Tables I through IV.

FINANCIAL ACCOUNTS IN MOSES

Table I Balance sheet of ONE FIRM

ASSETS	DEBTS
(1) Production capital (=K1)**	(1) Borrowing (=BW)
(2) Liquid Assets (=K2=DEP(B))	-long term -short term
(3) Inventories (=K3)*	(2) Net worth (=NW)
(4) Trade credits net (=K4)	
(5) Bonds (=BO)	
(6) Shares (=SH)	
(7) Property (=PROP)**	
Total assets = A	Total debts = A

* A distinction is made between:
K3-IN = input materials inventories
K3-OUT = finished product inventories.

Inventories classified as K3 consist of goods produced in the model economy. We do not separate out goods in process from K3-IN. Such data are currently not collected. See further Chapter VII.

** K1 are hardware assets ("Machinery") produced in Sector 3 ("INV") in the model and invested in the business firms.

PROP are goods not produced in the model. We think in terms of a fixed endowment of land. We may later change our mind and cumulate all output in the macro input output-cell of the construction sector into a PROP volume measure.

Table II Households

ASSETS	DEBTS
(1) Stock of Durables	(1) Borrowing in commercial bank (=BW(H))**
a) property (=PROP(H))	
b) other durables(=STODUR)	
(2) Deposits in bank (=DEP(H))	(2) Future, perceived tax burden*
(3) Bonds (=BO)	(3) Net worth calculated as a residual (=NW(H))
(4) Shares (=NW(B)=SH)	
(5) Notes and coins (=N)	
Total wealth of households (=WH)	Total household debt (=WH)

* Barro (1974) type perceived debt that has to be paid back through higher taxes in the future.

** Note that in the current macro version of the household sector and flow specification of the money system DEP(H) = (-1) BWH. It does not make sense yet to keep both asset and debt accounts for "the household".

Table III The commercial bank

ASSETS	DEBTS
(1) Borrowing by firms (=BW(B))	(1) Deposits by firms (=DEP(B))
(2) Ditto Government (=BW(G))	(2) Ditto Government (=DEP(G))
(3) Ditto Households (=BW(H))	(3) Ditto Households (=DEP(H))
(4) Foreign assets discounted by firms (=FASS)	(4) Foreign debt by firms (=FD)
(5) Liquidity, domestic (=CBR=BLIQ)	(5) Central Bank Borrowing (=CBB)
	(6) Net worth of Bank (=NW(BANK))
Total assets	Total debts

Table IV The central bank

ASSETS	DEBTS
(1) (Government) securities (=BO(G))	(1) Notes and coins (=N)
(2) Borrowing by The Commercial Banks (=CBB)	(2) Commercial Bank Reserves (=CBR)
(3) Foreign liquidity(=LIQFOR) (Exchange reserves)	(3) Net worth (Residual)
Total assets	Total debts

Table V The government

ASSETS	DEBTS
(1) Real Assets (=K1(G))*	(1) Borrowing in the bank (=BW(G)=G)
(2) Deposits in bank (=DEP(G))	(2) Government Bonds (=BO(G))
	(3) Borrowing abroad (=GFOR)
	(4) Social commitments**
	(5) Net worth (=NWG)
Total assets	Total debts

* Cumulate INVG as INV in industry (firms).

** The extent of future "social" commitments should be entered as a future claim on real resources of the economy to be expropriated via the tax system. The calculated claim (see Barro (1974), and for Sweden Palmer (1981)) should be corrected for the political probability that future claims will be honored.

More generally, the rate of change in Government net worth, as suggested by Barro (1974) should enter households savings decisions under the presumption that a deteriorating public net worth position makes households more concerned about their own future, i.e. increases their savings propensity.

(4) is assumed to be zero in the current version of the model.

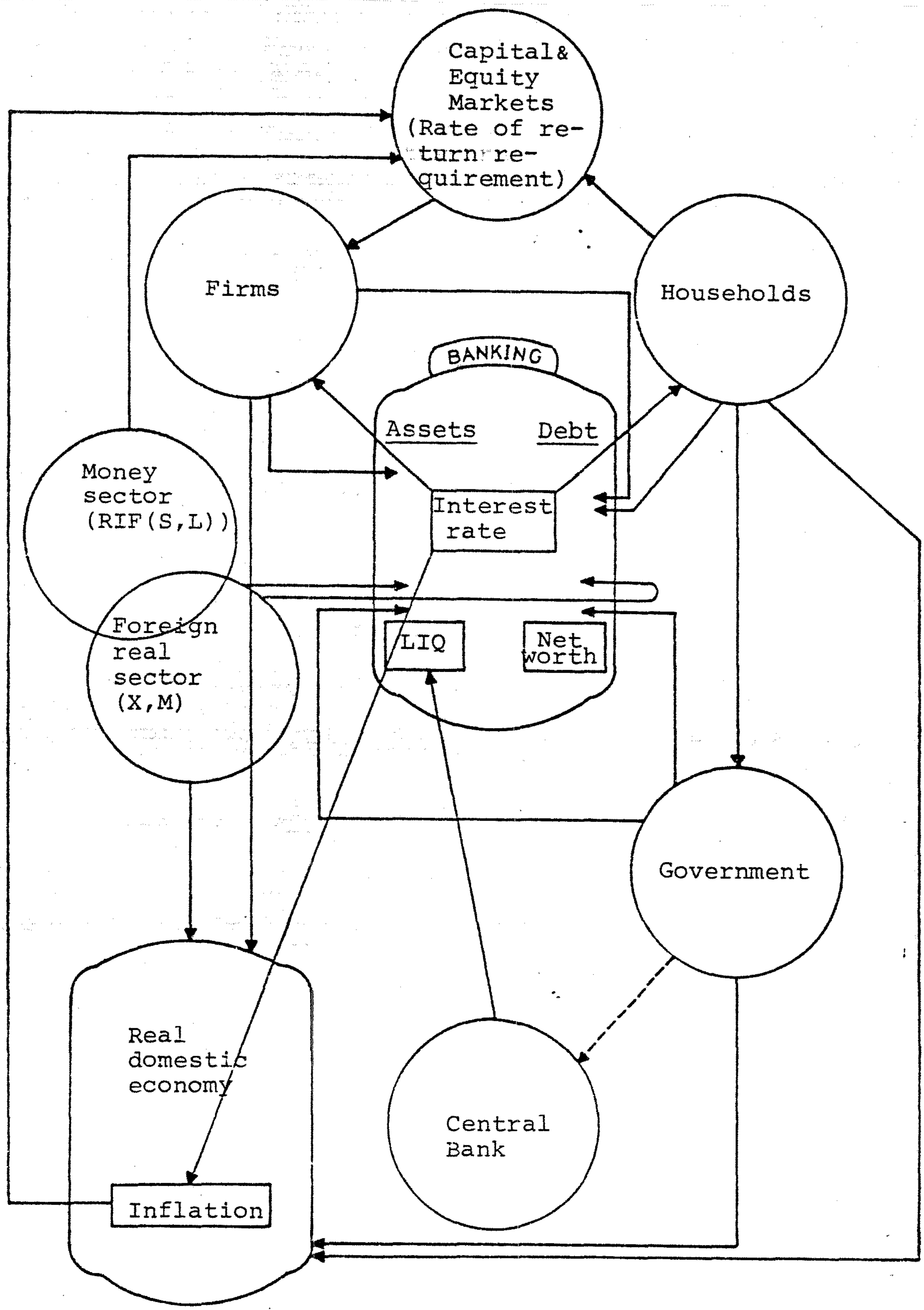
Table VI National (consolidated) asset position

ASSETS	DEBTS
(1) PROP(B+H)	(1) GFOR
(2) K(B+G)	(2) FD
(3) STODUR	(3) National Wealth (=NW(CB+G+H))
(4) FASS	
(5) LIQFOR	
Total assets (=WN)	Total debts

Note (1): The foreign net debt position is defined as: GFOR+FD-FASS-LIQFOR.

Note (2): This consolidation assumes:
(a) SH(B+H) = NW(B+Commercial Bank)
(b) BO(B+Central Bank+H)=BO(G).

Figure IV:1 The Monetary System



Through these accounts and in period to period interaction with the real accounts the interest rate is determined. What remains is to specify the market machinery that links the accounts together.

Figure IV:1 gives a simplified overview of the financial system of the model. At the center you find the Banking System made up of the accounts of the Bank, also exhibited in the balance sheet in Table III. All actors in the markets (firms, households and the Government) have their accounts in the Banking System. All foreign credit accounts are supposed to be carried by "the Bank".[55] They are sensitive to the short-term foreign interest rate (RIFS), as indicated (middle, left).

The Government interacts with the Banking System through its fiscal parameters, defining its debt asset structure vis a vis the Bank. A complete tax and transfer payment system links the Government together with all real agents in the economy.[56] The Government is assumed to excercise political authority over the Central Bank (indicated by dotted line, bottom, right).

The Central Bank excercises "monetary control" of the Banking System through liquidity requirements and as a lender of last resort. (The model system also recognizes the possibility of direct regulation of credit flows).

The ultimate monetary authority, however, is the Capital Market (top of figure) which interacts with the world capital market in which rate of return requirements are set, that influence (directly and indirectly) all real and financial decisions in the economy.

The short-term domestic interest rate in the Banking System is determined as the Bank adjusts:

(1) its supply of credit, to meet demand from all actors,
(2) to secure needed deposits,
(3) to meet Central Bank liquidity requirements in order to
(4) secure a required rate of return on its own net worth. The latter is dominant in the longer term and determined in the equity market, as are rate of return requirements of firms.

This describes the determination of the short-term interest rate (RIS).

This market process has been preceded by the capital market process determining rate of return requirements in the system, based on

(1) the short-term interest rate for the previous period,
(2) the foreign long-term interest rate,
(3) portfolio adjustments of firms and households based on initial data, beginning of period and
(4) alternative investment opportunities available.

The most important endogenous alternatives are property investments, entered exogenously simply as the rate of change in the capital goods price index. All this takes place in the upper part of the figure and the highest rate of return feeds back as an endogenous rate of return requirement in the firms and in the Bank.

2. The Aggregate Asset Structure

We will use the balance sheets shown in Tables I through IV to formulate a consistent portfolio choice system à la Tobin (1969). Some readers may already be familiar with this system. For them the aggregate specification to follow may be helpful as a frame and guide into the micro credit machinery to be described below. Readers who are not, may want to return to this summary overview after having seen the micro formulations. Asset categories are explained in the earlier balance sheets. They are all in nominal terms. This is a first and important departure from Tobin's formulation which allows capital gains to enter decisions related to the real economy, notably in profit targets of firms. Price variables are defined below.

I have symbolically entered the balance sheet of both the Government and "the Nation" to obtain a complete asset structure. Conventionally the latter is deleted and the former is replaced by a flow equation of the Government operating surplus or deficit. For future extensions of the model, including micro specification of the household sector (their saving, insurance and retirement schemes) it makes sense to introduce - already at this stage - a "slot" for Barro's (1974) idea that accumulated Government Commitments and liabilities is a debt and a negative income for future generations that will become manifest in the form of future taxes. Individuals and organizations take steps today to counter this negative possibility. Such counter moves affect the scope for action open to policy makers. In the extreme version, where economic processes through learning eventually become transparent to all actors ("rational expectations") Government policy-making based on debt financing of Government expenditures is made completely impotent. Hence, the direction of change in Government net worth, measured somehow, should feed back into households' savings decision. A simple such device has been entered already (see code).

The point of departure in Tobin's analysis was to assign (1) a rate of return to each asset and to (2) assume a net demand for each asset that depended on the same rate of return and other variables.

After introducing Tobin's overall general equilibrium scheme with our notations, we proceed to indicate where this monetary structure ties in with the MOSES non-monetary sectors, and then go on to detail the actual MOSES monetary process.

The reader should also know from the beginning that we will depart later from this simple set of equations in several significant ways.

The equations of the monetary system are the following (for explanation of variables see Tables I through VI):

Notes and coins (=N);	$F_1(RIF,RIN,RIS,RIL,RRN,\frac{Y}{WN}) = \frac{N}{WN}$	(IV:1)
Commercial Bank Deposits (=DEP);	$F_2(RIF,RIN,RIS,RIL,RRN,\frac{Y}{WN}) = \frac{DEP}{WN}$	(IV:2)
Bonds (=BO);	$F_3(RIF,RIN,RIS,RIL,RRN,\frac{Y}{WN}) = \frac{BO}{WN}$	(IV:3)
Industrial (firm) production assets (=SH=the market value of K in Table I)[57]	$F_4(RIF,RIN,RIS,RIL,RRN,\frac{Y}{WN}) = \frac{SH}{WN} = q^*\frac{A}{WN}$	(IV:4)
Foreign Assets (=FASS);	$F_5(RIF,RIS) = \frac{FASS}{WN}$	(IV:5)
Foreign Debt (=FD);	$F_6(RIF,RIS) = \frac{FD}{WN}$	(IV:6)
Bank Borrowing (=BW);	$F_7(RIF,RIS,\frac{Y}{WN}) = \frac{BW}{WN}$	(IV:7)

Total wealth is defined by:

$$WN \equiv N+DEP+BO+K-BW+FASS-FD \qquad \text{(IV:8)}$$

The left hand sides of F_1 and F_2 ($F_1+F_2=M^D$) is the demand function for money.

Note again that contrary to Tobin (1969), and most variations on his idea, we have all items expressed in nominal terms. This means that we have a problem in interpreting the time dimension of monetary adjustments, since monetary adjustments affect the real side (the quantities) in the MOSES economy, which in turn affect inflation. Hence, we have to face various kinds of money illusion in the model, because no actor in this game is able to see through all consequences of his actions and the actions of all other agents. This feed back we disregard in this didactic exercise which assumes no monetary feed back.

The price vector

(RIN,RIS,RIL,RRN,RIF(SαL))

represents rates of return on the holding of assets and debt

(N,DEP,BO,SH,FASS,FD,BW)

respectively.

Both Y (total income), and inflation are determined outside the money system in this excercise. This means that we can interpret (here) assets and rates of return as either nominal or real, as we prefer. RIF (the foreign interest rate) is exogenous. We have seven asset categories and four domestic prices as unknowns, and eight equations.

In imposing a market clearing condition (IV:8) - Walras' law - one price variable is made a function of all other price variables. Capital gains will then be restricted to the expected, calculable type, that responds to interest rate changes through an immediate adjustment of the base on which the interest is calculated. The asset pricing formula is of the console type, where the market value of all outstanding nominal "promises to pay \$ X every year to eternity" can be expressed by X/r•P. P is a general price index and r is the rate of interest that we choose. (Walras' law will not be imposed later on when we introduce unexpected capital gains.)

We now have 7 balance equations (one redundant). If a market clearing assumption is imposed the wealth definition (IV:8) applies exactly and there are 7 independent relations to determine 7 unknowns.

We have 7 asset categories and 5 rates of return variables, i.e., altogether 12 unknowns.

We assume RIN=0. The holding of notes and coins yields no interest.

RRN, or the nominal rate of return on industrial assets (reproduction value), is determined outside the system, as is inflation and total income Y.[58]

The foreign interest rate RIF is exogenous.

We recognize Government bond issues (=BO) and Notes and Coins (=N) as exogenous policy parameters.

Hence we have seven equations and seven unknowns (DEP, SH, FASS, FD, BW, RIS, RIL) and we can in principle solve the equation system for the unknowns.

F_5 and F_6 show that the <u>levels</u> of domestic interest rates depend on the foreign (exogenous) interest rate (RIF), a policy variable (BO) and an income variable (Y) determined in the real part of the MOSES economy.

Also note in passing that once you have RRN and SH also q is determined.

3 How does this tie in with MOSES?

We now have three sets of balance equations (IV:1+IV:2, IV:3+IV:4+IV:7 and IV:5+IV:6).

The first two equations define the demand for money (M=N+DEP). This is the well-known quantity relation:

$$v*M = P*Q = Y \qquad \text{(IV:9)}$$

where the velocity of circulation of money:

$$v = \frac{Y}{(F_1+F_2)*WN}$$

Notes and coins (N) in our version of an economy are only used by households (see balance sheet). The question is whether we really need N, since we are not modeling the payment process.

Deposits are held by households (for the time being formulated in macro), and Government. Already at this stage, hence, the simple macro formulation breaks apart. The income concept to use differs and the problem is whether individual firm deposit holdings should at all be related to income.

Equations (IV:3) (IV:4) and (IV:7) define a condensed, market valued asset and debt structure of a firm in which all foreign debt and assets have been discounted in the bank and transferred into Swedish currency.

In brief, the overall asset structure and relationships are conventional, when seen in macro, but the micro based parts of the MOSES system require considerable respecification, to which we will turn shortly.

The main new feature, however, is the interaction between the monetary system and the rest of the economy, which takes us back to the question: Why is money in MOSES at all interesting?

Table VII Balance Sheet of The Firm (market valuation)

Assets	Debt
K	BW
DEP	
BO	SH [= q•(A-BW)]
OTHER	
Total Assets = qA-(1-q)BW	Total Debt = qA-(1-q)BW

Look particularly at the rate of return (RRN) on the production value of industrial assets (A). Again the foreign interest rate is an important determining factor. RRN is a rate of return requirement determined in the financial system and imposed on the investment decision in firms. If realized immediately ex post on all A in the economy, A would be the market value of industrial capital as determined in the stock market and be identical to the replacement (reproduction) value of A that is dependent on the rate of return to new investments. It never is, and especially not at the micro level. This violation of Walras' law institutes the most important dynamic feature of the whole MOSES theoretical system. A constant Wicksell type disequilibrium in the capital market generated through unexpected technical (innovative) change and other factors at the micro level keeps investment and the growth process in motion (Chapters V and VI are devoted to this problem). Equilibrium in the capital market means economic "deep freeze" and an unstable, no growth, stationary equilibrium.

Chapter III should now tell us that the market rate of return requirement will rarely be realized in the production sector. Hence, F_4 will determine the market value of industrial assets. Let us call the market value of all industrial assets less debt SH, for "shares", as in the table above. As mentioned, SH will normally deviate from (A-BW). Hence there will be a difference between RRN and the return τ to investors in shares. Tobin (1969) called the ratio between the two $q = RRN/\tau = SH/(A-BW)$.

(In general the real money system that we envision, and that we will now begin to explain, is much more involved. Two things should be remembered.

(a) In what follows the market process will be made explicit at important points.

(b) Contrary to what has become traditional we regard monetary entities as expressed in nominal terms. This means in particular that capital gains enter in both stock and rate of return variables.)

4. Why is Money at all Interesting in the MOSES Economy?

With no notes and coins in the economy (and no bonds) there is no way to exercise a monetary policy on the MOSES economy, as it is generally understood, only fiscal policy. Public budget deficits (surpluses) are covered by variations in Government debt that simultaneously change private wealth. The supply of money is identical with Government debt. Monetary policy can be introduced by changing the composition of Government debt, i.e., by open market operations.

Why is there a difference in economic effects when the Government covers its deficit through the printing of money and when it borrows in the bank or issues securities?

Look at equation (IV:1). We have decided that the interest in notes and coins paid is institutionally set at zero while all the other rates of return vary depending upon demand and supply conditions in the market. These conditions are changed if the supply of any asset is changed, but differently if N is being printed or if Government securities are being issued. Hence, monetary policy in the conventional sense works through open market operations and their effect on the rate of return (interest) structure in the capital market. The only feature that distinguishes pure money in this respect from other assets is that its interest is institutionally fixed, so that variations in supply forces adjustment in the interest on other assets. Hence, the fixing (or regulating) of any interest rate would have similar implications. This is also exactly how we want to have monetary policy operating in the economy. It affects the real, non-monetary parts through policy induced interest rate variations.

5. The Value of Stocks

The valuation of stocks in the MOSES economy appears to be a problem in dealing with physical assets in firms (=K1), shares (=SH) and bonds (=BO). Most, or all, theorizing on this matter - originating in Tobin's (1969) portfolio formulation of the financial system of an economy - has been formulated within the static equilibrium framework where (unexpected) capital gains, or gains due to various forms of money illusion are simply assumed not to exist. We do not like such assumptions.

For one thing it is a very doubtful procedure, as is conventionally done to assign rates of return to assets. When markets are perfect, adjustments immediate and when you have consol type assets that never mature (no amortization) one could argue that the obligation to pay \$ 1 per year for ever, would capture a value in the market of \$:

$1/r \cdot P$

where r is the current interest rate and P is a general price index, set at 1 the year the nominal \$ commitment was made.

Even for such assets, this asset pricing formula does not hold up. The market may not be perfect or well informed, and the interest may not be the right one, whatever that means. We will return to the concept of a capital market equilibrium in Chapter VI.

Enter <u>ignorance</u> or <u>uncertainty</u> about future payments, and the formula does not hold.

Enter assets that depreciate, or "wear out", and things get really difficult. What does depreciation mean in a context like this? Let us take the most difficult case straight away, because this is the one that really concerns us; the valuation of business assets.

Tobin (1969) conveniently invents q to account for the fact that the actual market value of a firm departs from its "reproduction" value. In our notation (using Table I):

$$SH = q(A-BW)$$

If the firm[4] had no debt (BW=0) and only physical capital ($K=\Sigma K_i=A$) we would obtain Tobin's case when:

$$SH = q \cdot K$$

and

$$T = \bar{R} = \frac{RRN}{q}$$

T is the rate of return on shares and should be:

$$T = DSH + \bar{\Theta}$$

where $\bar{\Theta} = \frac{DIV}{SH}$ (of the separable additive targeting function III:1).

$\bar{R}$ is Keynes' "marginal efficiency of capital" applied to reproduction cost (i.e. K is measured at replacement values) or the "rate of return over cost", using Fisher's concept. In Tobin's model q is endogenously determined.

The marginal efficiency of capital is the $\bar{R}$ that satisfies:

$$P = \int_0^\infty e^{-\bar{R}t}\left(P(t)\,\frac{\partial Q}{\partial K} - \rho \cdot P(t)\right)dt \qquad \text{(IV:10A)}$$

P(t) is the price index for products or producers of Q. K is capital input and ρ is the depreciation factor.

Assume that the marginal product of capital and ρ are constants and that prices grow exponentially at rate DP. Then we can solve (IV:10) as:

$$P = P_0 \cdot \left[\frac{\partial Q}{\partial K} - \rho\right] \int_0^\infty e^{-(\bar{R}-DP)t}dt \qquad \text{(IV:10B)}$$

or: $\bar{R} = \frac{\partial Q}{\partial K} - \rho + DP$

Since $\partial Q/\partial K$ is the marginal volume output of adding an extra amount of capital, holding all other factors constant, $\bar{R}$ is also the marginal, nominal rate of return. Keynes asserted (see Chapter 11 in General Theory) that firms would trade in capital goods until

$RIS = \bar{R}$.

This would then define some sort of capital market equilibrium where the rate of interest equals the marginal rate of efficiency of capital, which in turn means that

$$P \cdot \frac{\partial Q}{\partial K} = P \cdot (RIS + \rho - DP) \qquad \text{(IV:10C)}$$

or the marginal product value of capital equals the "price of capital service" (right hand expression), using a conventional formula.

In capital market equilibrium the marginal nominal return to investment equals the nominal interest rate.[58B] So far everything is fine. When Tobin's monetary system is in equilibrium, the market rate of interest will be equal to the marginal rate of return on new investment. Since the value of business assets installed may diverge from their reproduction costs (on the margin) by a factor q, we should adjust the return measured on these assets accordingly, and we have:

$$T = \bar{R}/q \qquad \text{(IV:10D)}$$

$$SH = qA$$

where K=A (under our temporary assumption of no debt and replacement valuation). So q (which is endogenous in the monetary system) essentially converts all installed capital stock to its market value, and makes the market return to corporate assets T equal to the interest rate, which in turn is equal to the nominal rate of return to assets at reproduction value, divided by q. For the marginal capacity augmentation invested at $\bar{R}$ = RIS, in equilibrium q should be = 1.

Arriving at this conclusion we immediately meet with another principal problem. ρ in (IV:10) is the depreciation rate that adjusts asset values, after price correction, to their reproduction values.

We now also have a second depreciation factor that is endogenously determined, namely the one that equates asset values measured from the cost (reproduction) side to their "right" value, as it is determined in the equity market.

The first depreciation principle is what we want to use to estimate capital stock in a "technical" production function analysis. The latter principle we apply to determine the value of the firm, or the growth of the value of the firm, for instance, in the targeting formula (III:1). But this one is also what matters in the investment decision (Chapter III) and in the scrapping decision (cf. discussion in 3.2.2 in Supplement II to Chapter III) and hence affects the amount of capital that can be used for productive purposes.

The market based depreciation principle may generate very erratic capital stock estimates depending upon the sentiments prevailing in the markets. And what about the rate of return? In the latter case, where values and depreciation rates are determined in the market, rates of return will always equal the interest rate (as in the console formula), and hence carry no useful additional information. In the former case, the rate of return will be heavily dependent on production costs for capital. A bad investment in the past will keep the shipyard unprofitable for a very long time, even if new investments on the margin are highly profitable: If you try to correct for that you obtain a capital valuation similar to the latter method.

6. The Portfolio Decision of Actors in the Markets

The demand for funds originates in all real sectors. Firms (at the micro level) may need external funds to invest and to finance the growth of current assets. Households both save and borrow at the micro level.[59]

The Government can cover its deficits through the printing of money. It can obtain external finance in the Commercial Bank, in the bond market or in foreign markets at the going interest rate. Government demand for external finance, as we see it, is interest inelastic.

The Commercial Bank itself, finally, may refinance itself in the Central Bank and/or exercise an internal demand on its own funds through own or imposed (policed) liquidity requirements.

6.1 The Firm

Chapter III presented the investment decision of a MOSES firm, where the real part of entrepreneurial activity combined with financial considerations, the rate of return requirement being the principal intermediator. This section completes the financial system of the firm by introducing its full balance sheet and its portfolio decision problem. We stick to the mode of discourse used throughout both modeling and presenting the MOSES idea. Decision making in organizations is a hierarchically layered process that is managed by different people in different parts of the company. The investment decision comes after the portfolio decision (to be discussed here), in which the rate of return requirement to use in the investment decision is determined.[60] In a sense then our presentation comes in the wrong order. The end decision on quarterly production, was discussed in Chapter II, the intermediate investment decision in Chapter III and the first and dominant decision is presented here.

The firms connect with the credit system in several steps.

The firm may decide to borrow long term to build up its liquidity in advance (see Section 4a) in Chapter III). This decision affects the supply of short-term funds in the same period.

The firm automatically accumulates trade assets and debts. This affects its decision to borrow the same period (see below).

Some of this trade asset/debt accumulation may be in foreign currencies. It is then immediately transferred to the commercial bank in exchange for domestic currency (see below).

What remains for the individual firm is the short-term borrowing decision taken each period after all real and monetary adjustments have been made in response to the interest rate the period before.

a) <u>Foreign Accounts of a Firm</u>

For every krona of exported goods (EXPORT) a corresponding asset on foreign account is created and added to foreign assets (FASS). FASS in turn is being amortized, at the rate:

F_5(RIS-RIF) (IV:11A)

$$\frac{\partial F_5}{\partial(\ )} > 0.$$

$1/F_5$ can then be said to approximate the foreign trade credit period, estimated to be 2 to 3 months on the average in the 60s.[61] Hence foreign trade assets accumulate as:

FASS := FASS+EXPORT-F_5*FASS+RIF*FASS (IV:11B)

This formula reads as follows. Foreign assets at the end of a period are equal to (:=in algol) initial foreign assets, plus new assets created through export deliveries during the period (EXPORT), minus what has been amortized during the period (F_5*FASS) plus interest receipts on FASS.

Similarly, every krona of imported goods (IMPORT) adds to the foreign debt of the country (FD) and this debt is currently being paid off at the rate[62]

F_6(RIS-RIF) (IV:12A)

$$\frac{\partial F_6}{\partial(\ )} < 0$$

Hence

$$FD: = FD+IMPORT-F_6*FD+RIF*FD. \qquad (IV:12B)$$

The net foreign credit position of the BANK then becomes:

$$FNASS = FASS-FD.$$

and

$$FNASS = EXPORTS-IMPORTS+(1+RIF)*[FASS(t-1)-FD(t-1)-F_5*FASS(t-1)+F_6*FD(t-1)] \qquad (IV:13)$$

Hence, end of period net foreign debt (=FNASS) is equal to initial net debt plus interest, minus amortization (net), plus new debt creation (negative or positive) through the trade deficit (surplus).

As we see it the rate of paying off these two stocks ("The international mobility of capital") is very sensitive to fluctuations in the foreign-domestic interest differentials through F_5 and F_6, and will strongly affect the supply of, and the demand for, funds in the domestic money market. In the aggregate representation in Section 2 above this influence works through Equations (IV:5) and (IV:6).

b) <u>The Portfolio Decision of a Firm</u>

The setting is very much as in the earlier version of the MOSES firm model. We begin with the current gross inflow of funds. It consists of a cash flow from current operations and new borrowing. New borrowing is determined as before by:

$$DBW=F_7(RRN-RIS,\Phi) \qquad (IV:14)$$
$$\Phi=\frac{BW}{SH}$$

Earlier RRN referred to the nominal return to manufacturing operations. We viewed the MOSES firm only as a production unit. This means imposing a restriction on the scope of activities that many large corporations have in fact lifted. A large firm could quite well consider increasing its leverage (borrow more) to extend its operations through investing in bonds or shares or through purchasing other firms. Then the rate of return variable (RRN in IV:14) used in the borrowing decision of the firm should be that of the most profitable activity open to the company. This is not necessarily a manufacturing activity. It is fairly easy to change the RRN specification used in Chapter III to cover the possibility of many internal firm activities (as in Supplement II in Chapter III) and external investment opportunities known to the firm. In doing so we have introduced the concept of an investment portfolio. Let us now assume that RRN refers to the (expected) most profitable activity which the firm entity envisions (see Supplement I to Chapter III).

The gross cash inflow or the investment budget of the firm for the period then consists of:

$$\Psi=\Pi+(\text{interest income})-RI*BW-T-DIV-CHK3-CHK4+CHBW \qquad (IV:15)$$

where T and DIV have been decided on as described in Chapter III (see also below). As before, all trade assets have been discounted in the Commercial Bank and are replaced by a bank deposit denominated in the domestic currency.

The firm now has the symbolic[62B] choice to invest this flow in:

- production assets (INV)
- shares (SH)
- property (PROP)
- long-term financial assets, yielding the long-term interest rate RIL. We call them bonds, or for short (BO)
- pay back of loans [BW(B)] at RIS
- and/or deposit the money in the bank (DEP(B)) at RIS(1-ξ)

ξ represents the profit margin of the bank, or the difference between the average lending rate (RI) and the deposit rate (RI(1-ξ)).

(The first item is taken care of by the going interest rate. A firm with a positive DBW should not consider depositing any of Ψ in the bank except for short-term liquidity reasons, an aspect that is not considered here.)

The total portfolio decision now recognizes a distinction between a full adjustment of the stock composition, on the one hand, and marginal flow adjustments on the other.

One way is to formulate this distinction in terms of differences in transactions cost, or a combination of Tobin's (1969) idea and Friedman's (1977) empirical application. More in keeping with our "rules of behavior" micro approach, however, we rather take several steps down to the level of decision makers themselves and use a three tier approach that relates to where and when in the overall decision process inside a corporation that this particular decision is taken. The steps signify the degree and length of commitment, the uncertainty involved etc. and so can be said to capture the transactions costs indirectly. When we aggregate over firms we will not obtain a typical Tobin equation like those in Section 1, but something compatible.

First, the firm can decide to cash in on financial and other assets (SH, BO, DEP and PROP) to finance a major expansion (INV) program. This is a stock adjustment decision that precedes the cash flow decision of fixing Ψ above. It occurs when long term expected RRN in own manufacturing operations significantly exceeds returns to investments in SH, BO, DEP and PROP. This has been dealt with already in Chapter III.

Second, the firm can decide to borrow a lot long term now to be well covered financially for a large INV expansion project. Also this decision precedes the determination of Ψ. The firm that has done so is well supplied with short-term bank deposits that are available, if needed, to break through the Ψ restriction. Also this decision has been dealt with already in Chapter III. It involves a decision as to the degree of risk ("leverage") to take on. We will return to this in the next section.

Third, the decision that remains from period to period is to allocate Ψ on INV, CHSH, CHBO, CHPROP and on deposits in the bank.

The investment choice procedure is in principle stepwise. The sign of the investment budget Ψ was marginally determined in (IV:14) by the rate of borrowing CHBW, which in turn depended on the marginally "best" internal rate of return over the going interest rate. In current model practice it is, however, only symbolic. Rates of return on investments in SH, BO and PROP raise rate of return requirements on INV. Investments of this kind, however, are not actually carried out. Excess liquidity created through a lowering of INV spending because of a higher rate of return requirement, because of higher rates of return on "outside" investment opportunities, is simply deposited in the bank.

If RRN in production activities, on the other hand, are higher than any competing investment activity, then the normal investment cash flow accelerator mechanism of Chapter III is engaged.

[The more general portfolio choice model compatible with the sophisticated MOSES Investment Financing decision of Chapter III that we eventually would like to see in the programmed version of MOSES is best described in terms of the firm balance sheet in Table I.

Step I. Determine maximum (optimum) leverage $\phi_i=(BW)/(NW)$,

of firm i conditional upon $MAX(RRN, RIS_i, RIL, T, \tau)$, to be elaborated in the next section. RIL is the domestic long-term borrowing rate. T is the return to investment in shares in other companies and τ is the return to investment in property (see below).

Note that each firm has its own leverage dependent, short-term loan rate (RIS_i). This leverage is, however, set by the lender at Φ=BW/SH. If shares are valued in the market at "reproduction costs" then $\phi=\Phi$ (see Section 5 above).

Step II. Calculate the optimum size of total assets A* compatible with ϕ.

Step III. Calculate the optimum portfolio mix (K*,DEP(B),BO,SH,PROP) the sum of which is conditional on a corresponding rate of return vector[63]

(RRN,RIS,RIL,Υ,τ)

This is described below in technical terms. As before RRN is the nominal rate of return on total assets (reproduction valued) engaged in the manufacturing operation (K*).[64] In the tax free world we are currently discussing, we could simply use:

$$\Upsilon_i = DSH_i + \bar{\theta}_i$$

as determined ex post for company i in the model. (Cf. separable Additive Targeting Formula (III:1) in Chapter III. Also see Section 6 below.)

Step IV. Calculate desired stock changes in money terms: CHK*=(K*-K), etc.

Step V. Check CHK* against INV and Ψ conditional on ϕ and MAX(RRN,RI,RIL,Υ). Adjust downward to INV position taken in Chapter III.

Step VI. Recalculate new $\hat{\Psi}$ available for investments in bank deposits, bonds and shares and recompute a new

[(DEP*-DEP),(BO*-BO),(SH*-SH)(PROP*-PROP)] portfolio change mix as in Chapter III above.

Note the hierarchical decision ordering assumed. Investments in current production activities come first. MAX(RRN,RI,RIL,T,τ), however, has already been used in Chapter III to scale the desired medium-term investment program. Second a leverage, or financial risk, calculation is performed to establish the total financing potential. Third, funds available for financial investments (size and mix) are determined residually. Note, however, that if such investments yield a higher return than investments in current production lines, this circumstance has already curbed planned INV spending in the first round. If other, financial investment opportunities happen to be extremely good (e.g. in property) this may in fact have suggested an increased leverage position in the second decision round.]

Is this a reasonable way to model the investment decision process of a firm?

For one thing decisions in large business organizations normally are ordered in a fashion like this. This process has already been elaborately modelled in Chapter III on the basis of a large number of interviews carried out in Eliasson (1976a). Let us present a brief illustration from real life.

c) Case

Practically all large firms have introduced budget control, production process control, etc. since several decades. These functions, portfolio management and financing are practically always organizationally separated. The typical arrangement in firms studied in Eliasson (1976a) was that large, long-term portfolio decisions were taken separately on their long-term profitability merits, and before they appeared in any way in the planning process. These decisions included departures from current production activity, going into financial investment business or entering new areas of production. Long-range planning and budgeting was normally restricted to the ex ante management of established operations.

Profitability prospects in new ventures coupled with estimated cash flows from current operations were then used in the financial department of the company to estimate total financing capacity or, more exactly, the Φ capacity available.

Thereafter a formal decision on funds available for expansion of current activity and funds available for new activities, etc., was taken.

This "decision" then fed into the preliminary stage of the budgeting process. Firm managers compare K_i^* with K_j^* as they appear in the long-term budgeting process in Chapter III. If the sum of all K_i^* proposed is too large then "the K_i^* are negotiated down", and set preliminarily at lower values.

Left is a residual of funds available for non-process "new" investment. As a rule there are no formal plans that break the portfolio mix down further. New venture decisions are normally taken spontaneously when a given opportunity appears. Essentially, however, when process innovations in existing activities have been filtered out the residual funds available are invested very much according to the expected relative profitability merits of investment objects.

One could perhaps argue that it would make little difference both at the firm and the macroeconomic level if a more simple, simultaneous decision process is modelled instead. Not necessarily. If our hierarchical procedure is a reasonable representation of what goes on, it is certainly richer in empirical content than any alternative, in which no ordering of decisions exists. A simultaneous decision process requires that the information contained in the ordering be replaced by estimated (average) parameters that will always contain less information. In our modeling context our chosen alternative would even be computationally simpler. Finally, I do hypothesize that the formulation we have suggested is both superior and yields different macroeconomic simulation results when the economy at large is moving through a period of unstable price experience. These are exactly the kind of situations we are interested in investigating (see Chapter VI). To decide on which specification to believe in, however, very careful simulation studies have to be carried out. Until then, we should stick with the more general formulation proposed here.

d) The Value, Risk Level and Proper Leverage of a Firm

The present value of a business entity can easily be calculated if we make some (simplifying) assumptions about the future. We assume that present rates of change in prices, sales etc. can be projected forever and that current performance and dividend ratios will last forever. Then (see for instance Lerner & Carleton (1966)) the present value of the firm will be the sum of all discounted future dividends:[65]

$$SH = \text{Market value of } NW = q^*NW =$$

$$\frac{DIV}{i-DDIV} = \frac{\Theta^*(\Pi-\rho K-RI_i{}^*BW)}{i-(1-\Theta)RRNW} \qquad \text{(IV:16)}$$

i is the appropriate discount factor. (Note that we use RI_i rather than RIS_i as above to signify an appropriate local borrowing rate.)

Such a calculation only makes sense in a particular and narrow context. Suppose firm management - as expounded in Chapter III - makes up plans up to the long-term horizon conditional on (RI,i,RRNW) being constants, and that stretching this assumption towards infinity would be an acceptable approximation.

Then the size of i that top management imposes would determine its dividend policy (next section) and the actuarial value of the firm. The corresponding i of the investors is determined in the market and indirectly determines the market valuation of the firm (=SH). In equilibrium competition in the capital market would presumably push the i's together as suggested in the previous section.

Borrowing is associated with an extra <u>risk</u> element, the probability of not being able to meet interest payment commitments. Creditors normally charge for that in the form of a higher interest on borrowing in proportion to the risk they believe they assume. The risk factor is traditionally assumed to be proportional to the debt/equity ratio and shows in the <u>individual firm borrowing rate</u>.

$$RI_i = f(RI, \Phi_i) \qquad \text{(IV:17)}$$

$$\Phi = BW/SH, \; (\partial RRI_i)/(\partial \Phi_i) > 0$$

and RI is some sort of going market rate for lower, or no, risk lending.

Our first problem is to define the discount rate of share owners (i) that appears in (IV:16) and refers to firm i. In the macro, general equilibrium setting in Section 2 we solve for this discount factor and it should - in a hypothetical equilibrium - equal the marginal efficiency of investment (see the end of Section 4). Within the complete MOSES economy framework we have to recognize that such equilibrium conditions do not prevail and that there are many individual discount rates. Under such circumstances we should introduce

MAX( )

as the discount factor in (IV:16) signifying the marginally best investment opportunity available to the firm. If opportunities to earn a return are equal and also equal to the "risk free" credit market interest rate RI, then only the amount of financial risk taken on differs. We temporarily adopt that assumption, make i=RI and derivate (IV:16) with respect to Φ. Make

$\frac{\partial SH}{\partial \Phi} = 0$ and solve for Φ. We obtain:

$$\Phi_i = \frac{RRN_i - RI_i}{\partial RI_i / \partial \Phi_i} \qquad \text{(IV:18)}$$

which is the Φ compatible with the highest steady state dividend pay out ratio. Somehow, it is very, very peculiar to carry out such a risk evaluation under the streamlined, steady state, full future visibility assumptions imposed on this exercise. But this is the state of the art. Firms use much cruder rules of thumb. These rules happen, however, to be more or less the same as the end result of the above exercise. We have carried it through. Let us now try to interpret it.

The market interest rate, free from the "local firm financial risk" is determined in the monetary system. If it goes up, it lowers (through (IV:16)) the market value SH of the firm. To support SH compared to NW (or q) dividends have to be increased. However, at each expected future steady state development of (RRN_i, RI_i) the firm can compute the optimal (steady state) leverage factor Φ = BW/SH compatible with the maximum present market value of the firm, which is identical to the maximum present value of all future dividends. The firm with a high expectation on RRN can raise its present value by borrowing more. It thereby takes on a higher financial risk - because the RRN expectation may be wrong - which is covered by the lender through the interest premium $(RI_i - RI)$. The higher RI_i the less money available to reinvest at RRN to produce future dividends and so on.

If (IV:17) in fact is:

$$RI_i = RI + \alpha^* \Phi_i \qquad \text{(IV:19)}$$

then (IV:18) becomes:

$$\Phi_i = \frac{RRN_i - RI_i}{\alpha} \qquad \text{(IV:20)}$$

This is an expression frequently met with in the theory of finance. It appears in the current version of the MOSES firm borrowing decision in the special case when $\phi = \Phi$, or when the reproduction value of net worth (=NW) equals the market value of net worth (=SH).[66]

However, once you depart from steady state assumptions all this will have to be reconsidered. Make the interest rate endogenous, or difficult to predict. If you expect a variable interest RI over the future you could always approximate numerically (IV:16) and (IV:18) in a more complicated fashion. But if your expectation of RI is associated with uncertainty then you would have to recompute your optimum Φ every time you change your expectations and there could be a wildly gyrating development of your Φ. If the lenders have a different expectation as to RI, then the problem gets so complicated that we have difficulties modeling it. We will simply assume that lenders evaluate the firm each moment through applying a steady state RI assumption in (IV:16) and then impose the corresponding RI_i through (IV:17). Firms respond by recalculating their optimal leverage and regulate their finances through the borrowing decision.

In the more general formulation where top management in a firm faces a whole range of investment opportunities we should use the best rate of return option MAX( ) rather than RRN_i and the optimum gearing ratio becomes:

$$\Phi_i = \frac{MAX(\quad)-RI_i}{\alpha}. \qquad (IV:21)$$

In determining MAX( ) we will introduce capital gains and inflation in the rate of return items, knowing full well that this traditional formula has been derived on the presumption of a steady state continuation of current inflation and no capital gains beyond what comes from that inflation. We know (E 1976a) that corporate routines in calculating ϕ estimates derive from such simple formulae, so that is the best we can do. To enter more sophisticated capital gains expectations would take us to a point where we have no way of empirical verification.

e) The Dividend Decision

The market way to treat the dividend decision would now be to assume that firm management on each long-term planning occasion has a steady state perception of its (RI,i,RRNW) vector; and that it wants to adjust its quantities accordingly in the long term. The (i,RRNW) relationship would then decide its dividend policy, assuming that firm management also wants to see the value of the firm maximized in the longer run.

The natural RRNW variable to choose would be the one used in the long-term plan. It is natural to choose a RRNW that firm management believes it can support in the longer term, so it may opt for a cautious estimate, somewhat lower than RRNW. Hence, cash reserves can be accumulated to bridge possible, unexpected deficit periods.

It is more difficult to choose the correct discount factor. In the typical, real situation of a MOSES simulation, market discount rates and the discount rates of management may differ. The market is usually more cautious due to less information and applies a higher rate. If the firm chooses its own time preference, and if this deviates from the time preference of the market, the market valutation of the firm will be affected and hence its debt capacity. So the firm should pick the market rate i, which may be higher than its own, and raise borrowing to pay dividends, if it believes strongly in a high, future RRNW.

From (IV:16) we have:

$$SH = \frac{\Theta * RNW * NW}{i-(1-\Theta)RNW}. \qquad (IV:22A)$$

This expression can be rewritten as:

$$i = RNW*\left(\frac{\Theta * NW}{SH} + (1-\Theta)\right). \qquad (IV:22B)$$

Derivate with regard to Θ and make $dSH/d\Theta=0$. Under the simplifying assumption that RNW is a time constant we obtain[66B]:

$$\Theta = \frac{i-RNW}{\frac{\partial i}{\partial \Theta}} > 0 \quad \text{since} \quad \frac{\partial i}{\partial \Theta} < 0, \quad i < RNW. \qquad (IV:23)$$

If $\partial i/\partial \Theta$ is a negative constant the firm should distribute dividends in proportion to the difference between its discount rate and its rate of return on equity. The dividend distribution function then looks as follows:

$$\Theta = A(RNW-i), \quad \text{A is a positive constant.} \qquad (IV:23B)$$

f) The Market for Equities

Rate of return requirements in firms that enter long-term targeting in Chapter III (Equation III:1) are set in the equity market. The equity market is the playground for share owners that scan the investment horizon for the best rate of return opportunities as they are manifested in the vector (RRN, RIS, RIL, T, τ).

In the model the share owner is a passive agent of the household sector whose only action is to add a particular stock to his portfolio, or to sell to invest in something else. This, however, is enough to make him influential. His action - especially if many, or all, share holders do the same thing - influences the valuation of the stock compared to its reproduction value. This means a number of things to firm management. The valuation of stock SH compared to its reproduction value A affects its financing potential through ϕ and the rate of interest (in IV:22). If $q = SH/A$ becomes too low it subjects the firm, and its managers, to the possibility of a hostile take-over, on the presumption that a firm that performs so badly on a current basis, in a market where other firms are doing all right, should be possible to capitalize upon through reorganization and removal of management.

In principle the rate of return requirement on firms is set through the determination of q in (IV:4) in Section IV:2.

Let us call the rate of return on a share investment T. It is then defined as:

$$T = DSH + \frac{DIV}{SH} \qquad \text{(IV:24A)}$$

which from (IV:10D) becomes:

$$T = Dq + DNW + \frac{\Theta}{q} \qquad \text{(IV:24B)}$$

Each shareowner looks at all the rates of return available to him or her, picks the highest and uses it as his or her discount rate (i) when making decisions as to where to invest. This affects the valuation of the firm in the market (see (IV:16)):

$$SH = \frac{\Theta \cdot RNW \cdot NW}{i - (1-\Theta) \cdot RNW} \qquad \text{or}$$

$$q = \frac{\Theta \cdot RNW}{i - (1-\Theta) RNW}$$

This valuation affects the ability of the firm to borrow, and/or to keep its financial resources, through its gearing ratio

$$\Phi = \frac{BW}{SH}$$

and its local interest rate

$$RIS_i = F(RIS, \Phi_i)$$

Obviously the firm can boost its SH through distributing more dividends (raising Θ) but this further reduces its cash flow. This is a rational policy only for a firm that plans to close down and pay back its net worth to share owners.

[If furthermore SH depends on the expected long-term growth in dividends, (in the numerator in

(IV:16)) rather than Θ, the market valuation may be negatively affected by raising Θ.]

The only positive way to support a sagging market valuation SH of firm net worth, and to be an attractive borrower, is to raise the rate of return to net worth (= RNW).

By how much must RNW be adjusted in a firm aiming for long-run steady value growth? Make τ in (IV:24) equal to the best investment opportunity in the market

$$\tau = i = MAX(\quad) \qquad (IV:25)$$

If MAX( ) has changed, it takes the same relative adjustment of RNW

$$DRNW = Di$$

to preserve the q value (CHq = 0) at a given dividend pay out rate.

(This will increase or decrease the net cash flow of the firm, depending upon the relative position of (RNW_i, RIS_i, ϕ, Θ).)

The required change in DRNW immediately translates into a changing rate of return requirement, through the targeting formula (III:1) in Chapter III;

$$G = DNW + \Theta = RNW$$

This in turn (see Chapters III and II) translates into a profit margin requirement that monitors supply decisions, wage offers, employment decisions and indirectly pricing decisions in firms. Hence rational decisions are taken with respect to prices in a competitive economy (cf. Arrow (1959, p. 45)[66c]).

At this time the alert, neoclassical dogmatist has already sprung into defense position. How come, that firms were not operating at maximum RNW to begin with?

Answer: They may have been, and then the increase in i does not affect RRN. It is as high as it can be for the time being. The increase in i only lowers the future credit capacity and investment propensity of the firms and its present market value.

But if there is a potential to reorganize the firm to increase its performance in terms of RRW and RNW, this is normally the way attempts to do that are pushed into action (see E 1976a), and we want to be openminded about that possibility in our approach.

g) Computation of the Portfolio Mix

This section in a way repeats parts of Supplement I to Chapter III. It treats the internal investment allocation of a firm (the choice of portfolio mix) as a rate of return dependent stock adjustment process which amounts to the same as a graded step in a programming algorithm that is taken each period. Next period new rates of return appear and a new step is taken.

This process can cover the whole portfolio or part of it (cf. Supplement I, to Chapter III, where our choice is described). Here we formulate the problem generally.

To make the portfolio mix decision of one firm compatible with the macro choice system (IV:1)-(IV:8) it can be formulated as a linear, homogenous selection model:

$$\frac{A_i}{A} = \sum^{k} \alpha_{ik} R_k + \Sigma \beta_i X_i + \gamma_i \qquad \text{(IV:26)}$$

The share of assets of type i in total assets A is a linear function of returns to all assets (R_i) and a number of other factors X.

We assume $\sum^{i} \alpha_{iK}=0$, $\sum^{i} \beta_{iK}=0$ and $\Sigma\gamma=1$. The homogeneity constraint assumes the portfolio mix to be invariant to growth in A at unchanged relative rates of return R_i.

(IV:26) allows us to compute desired stocks A_i^* for each (R_i) vector. A common behavioral assumption (Friedman 1977) is that each item (stock) will be adjusted in proportion to the gaps so computed:

$$CHA_i = \sum^{K} \Pi_{ik} (A_k^* - K_{k,t-1}) \qquad \text{(IV:27)}$$

where $\sum^{i} \Pi_{iK}=1$ and all $\Pi \in [0,1]$. The lower Π_{ik} the higher transactions costs associated with rapidly adjusting A to A*. (Note below and in Chapter III, Supplement III, that we have entered a sequential choice between production investment and other investments). One could apply sophisticated constrained programming models to compute the portfolio mix but this will do here. The main point is that <u>something holds back a complete reshuffling</u>

each period of all stocks in response to small relative rate of return changes.

There are two additional problems associated with this formulation of the portfolio selection:

First, we have the homogeneity assumption. Is the size of A really independent of the (R_i) vector? Should not $MAX(R_i)$ affect the leverage ϕ decision in the previous section? It should and it has already in the MOSES firm decision process. The portfolio choice in the MOSES firm comes after the total investment budget and after the INV budget decision has been taken.

Second, we have the problem of determining the (Π_{iK}) vector and how to treat capital gains in the rate of return calculations.

The reader should now note that one way of handling the time adjustment process is to split assets into two categories. Stocks of production assets (K) can only be changed very slowly in response to perceived long-term rates of return. We devoted Chapter III to that, and the maximum perceived alternative rate of return appeared in that decision as well as in the determination of the total investment budget in the previous section. It corresponds well with established business practice to have the investment decisions separated both organizationally and in time (E 1976a).

The next portfolio choice is to compute a new mix, excluding production capital. This time we have

(DEP(B),BO,SH,PROP)

corresponding to the rate of return vector

(RI, RIL, T, τ).

As mentioned we don't have this aspect of real life in the model yet. To include it we need a bond and a stock market. Firms would have to estimate the capital gains component of T and τ. We would have to device a matrix of Π coefficients that makes money flow very rapidly out of bank deposits in response to small rate of return differentials, but very slowly out of shares in order not to affect stock values and capital gains too heavily.

6.2 The Household

The household sector is normally a net supplier of funds in the aggregate. To support its long-term consumption levels it can occasionally turn a net dissaver. If, at some later point in time, a micro specification of the household is worked out we will have to distinguish between households as being both savers, investors and borrowers simultaneously.

Since a macro household sector with endogenous saving is already in the model, it is appropriate to enter here a brief sketch of how the micro specification of the sophisticated saver-investor-borrower might look. We will do this in terms of his household balance sheet in Table II above, and then go on to specify how he acts in the model. This time - not with the firm - we are simplifying heavily.

The MOSES household, as presented in the original (E 1976b, 1978) formulation was concerned with constantly upgrading, or maintaining its current consumption standard. Part of that consumption standard involved possessing a real wealth balance that insured the household from at least short-term shortfalls in the expected disposable income flow. The insurance premium was saving. We never worked through the utility mathematics of this but went right on to specify a non-linear "habit formation", expenditure system with saving as one ex ante expenditure category. In the long term saving was related to disposable income in a way that corresponds to the Friedman (1957) permanent income-consumption concept. In the short term it varied according to the real return to saving on a bank deposit for future consumption purposes, and a certain risk factor, (unemployment). Saving, hence, was more or less oriented towards maintaining a steadily increasing or reluctantly decreasing consumption pattern. The life cycle Modigliani and Brumberg (1955) consumption model was more or less the idea put to work.

Since we are discussing the money system in this chapter we have to tell more about what we have in mind for the household as a systematic saver-investor-borrower, to get the household supply of funds in the credit market properly specified.

In a few words then, the household in MOSES is accumulating wealth to support a long-term steady consumption growth. It is perfectly all right in our view to enter the real balance as a separate utility item of the household (E 1982). The purpose may be to pass on wealth to heirs or to enjoy extra wealth as extra financial security on a potential resource to put to use sometime in the future. Hence, also possession of wealth is habit forming, and enhances the demand for more wealth.

The real balance can be held in property or other durables. It can be invested in bank deposits, bonds or shares or simply be kept in non-interest bearing coins and bills. The composition of the household portfolio would change as relative returns to the various investment alternatives change. The gross size of the portfolio would depend on the returns to investments compared to the borrowing rate. Net worth (total assets less debt) would enter the household's utility function. In micro household terms, and with access to micro household data, this would make sense to model.[67] In the aggregate household approach implemented so far we have restricted the household's investment ambition to the traditional one of stabilizing expenditures on various consumption categories over time and its portfolio choice to deposit in a bank and the purchase of durable goods (called STODUR). Sophisticated portfolio accumulation to earn a high return by leveraging the balance sheet is thus no longer possible. However, the household does borrow to sustain or stabilize its consumption over time.[68]

Since the household, or households as a group, both deposit their savings and borrow at the prevailing short-term market interest rate, the net supply of saving in the market is easily modelled.

The household aims at a real long-term wealth balance that is proportional to its trend development in disposable income. There are short-term ex ante variations in this ambition that depend on the real (Fisher) interest rate on bank deposits. This ex ante savings ambition is instrumental in determining the household consumption budget for the next period (quarter). The distribution of budgeted expenditure over consumption categories is dependent on perceived prices, based on past prices, that will be finally determined every quarter when total supplies and demands in the market have met and sorted out a set of prices. Hence saving may deviate from plans. When purchases have been finally made and incomes earned "residual saving" is deposited in the bank, a new stock of wealth is calculated and enters next period's saving and consumption decision.

In the current version of the model, hence, household wealth appears as a stock supply in the credit market through the direct intermediation of the Commercial Bank only (see E 1978a, p. 79).

In the standard version now in use households <u>plan</u> to save more and buy relatively less durables if the real rate of return to saving (RIS-DCPI) increases, and if unemployment (RU, reflecting labor market uncertainty) increases. The specification is such that households plan to maintain a stock of wealth (WH) relative to disposable income (DI) that depends on (RIS-DCPI, RU). This means that if inflation lowers the real value of savings and/or if disposable income increases, households keep trying to increase wealth through saving to maintain the ratio. If they fail, the desired ratio gradually falls through a "habit formation" adjustment. Note that the tradeoff is only between durable goods purchases and saving. Non-durable goods and service consumption is not affected by this mechanism. This furthermore, is an ex ante plan.

It guides household spending plans as they are revealed to producers in the product markets. The final amount of consumption of households depend on the response of producers and final prices. Savings adjust as a residual.

What we should add are two wealth factors in the ex ante savings decision.

First, household wealth as measured by the ratio of wealth to disposable income (WH/DI) should have a habit forming effect in the sense that the higher the WH/DI ratio achieved the higher the WH/DI ratio desired.

$$\frac{WH}{DI} = F\left(RI\text{-}DCPI,\ RU,\ \frac{WH}{DI},\ \phi(GOV)\right)$$

$$\frac{\partial(\quad)}{\partial(RI\text{-}DCPI)} > 0$$

$$\frac{\partial(\quad)}{\partial RU} > 0$$

$$\frac{\partial(\quad)}{\partial(WH/DI)} > 0$$

Furthermore, following Barro's (1974) suggestion, we expect households to be worried about Government policies that generate a decreasing performance of the economy. Technically this can be handled by entering Government net wealth, or change in Government net wealth in Table V, or national wealth creation (to pick up the influence of foreign debt) in Table VI, in the household savings decision. The point is that a deteriorating macroeconomic performance makes households believe that their private resources will be taxed away in the future, hence they save more to maintain their future disposable income.

$$\frac{\partial(\quad)}{\partial\phi(GOV)} < 0$$

If, in addition, Government debt creates inflation, this stimulates even more saving since households want to preserve their real balances.

6.3 The Government and the Central Bank

In the MOSES economy the Government figures as (1) a user and a redistributor of resources (financed through the tax system[69]) and as a (2) policy maker. The first function is modelled very crudely. There is only one aggregate Government production activity. Government employment is exogenously determined (a policy variable). Other resources are used in accordance with the Government input-output coefficients. The Government offers the average wage change determined endogenously in the manufacturing sector the quarter before. It enters the labor market next quarter - before the firms - and as long as there are unemployed people [70] in the market, it gets what it needs at the wage offered. Hence both Government employment and Government pay are in a sense endogenously determined.

With a given set of tax rates the economy yields an endogenous tax income. A net Government surplus or deficit follows and is deposited or financed in the Commercial Bank at the market rate, whatever its level[71].

The policy agenda is more varied. The Government or the Central Bank can:

(1) vary fiscal tax and transfer parameters that affect the size of the surplus (deficit)

(2) borrow abroad (GFOR)

(3) impose a LIQ constraint on the Commercial Bank

(4) Impose a trade margin (ξ) on the Commercial Bank

(5) impose an interest rate for Commercial Bank refinancing in the Central Bank (RP, see next section)

(6) impose interest rate controls (a ceiling on the domestic interest rate)

(7) vary the exchange rate (χ).

In this context all these options are important because they affect the supply of and demand for funds in the market.

In a more general context we could of course ask ourselves why the Government cares to vary these parameters. We have the traditional view, that the Government should be concerned with inflation, employment and growth and strive to obtain a mix compatible with what it perceives to be optimum national welfare. An alternative "welfare conception" of the Government would be to look at the national net asset position in Table V as a goal variable signifying the combined value of all resources accumulated in the economy. (At the end we will carry out a mental exercise comparing this "Hedonic" national welfare objective with the more socially oriented "Keynesian" inflation, employment growth and perhaps even equalitarian vector of national achievements. The interesting question is whether there is any real difference between these two national objectives. The reason for bringing this up here is that the whole structure of the MOSES model places asset values and returns to assets in the center of Government policy interests. Everything has to be run "through the markets", even Government policies. The MOSES model very easily computes the consequences for the balance sheet of the entire economy as shown in Table VI.)

7. Interest Determination - First Approximation

This section describes the simple credit system currently in the operating version of the model. Look at the balance sheet of the "Simple Commercial Bank" below.

Table VIII The Simple Commercial Bank

Assets	Debt
BW(B)	DEP(B)
BW(G)	DEP(H)
FASS	DEP(G)
BLIQ (non-interest	FD
bearing)	CBANK Borrowing(CBB)
	Net Worth of Bank (NW(BANK))

(BW(B),DEP(B),DEP(H)) are sensitive to the domestic interest rate.

(FASS,FD) are fictitious items in the Commercial Bank balance sheet. In reality they are moved by the firms that have generated them in response to the foreign-domestic interest differential. Hence, they are outside the control of the Bank, and the simple Bank makes decisions for the next period as if the past period's (FASS, FD) combination will hold.

The amount of Government borrowing (or depositing) is entirely interest inelastic. It comes straight out of the Government deficit (or surplus). Open market operations do, however, affect Government interest payments, and hence its deficit (surplus).

The Bank requires ex ante that its net worth increases at least in pace with its own lending rate. This means that the Bank's profitability requirement is:

$$RRN(BANK) = \frac{\Pi(BANK)}{NW(BANK)} \geq RI \qquad (IV:28)$$

or more specifically; Commercial Bank credit supply decisions in the credit market should be:

Step I

Calculate RRN(BANK) =

$$= \frac{RI*BW(B+G)+RIF*(FASS-FD)-RI*(1-\xi)*\big(DEP(B+H+G)\big)-RP*CBB}{NW(BANK)}$$

If RRN < RI, raise the domestic interest rate (RI) and Bank margin (ξ) by equal amounts until equality. ξ is the margin between the bank lending and deposit rates.

Step II

If the required (RI,ξ) steps are larger than 1 percentage point, make it 1 percentage point and wait until next quarter. Keep doing this until

- The bank RRN requirement is satisfied
- if RP>RI(1-ξ), reduce Central Bank debt in steps of up to 10 percent of initial amount of debt per period until CBB=0 (see below).

Step III (Alternative Mode=credit rationing)

The Government may have imposed a ceiling on the market interest rate RI.

- Then restrict parameter change to margin (ξ).

- Ration credit by some exogenously applied rule.

(The general case should be that for all firms for which CHBW>0, the same percentage reduction (10 percent each period) applies as long as the Commercial Bank cannot meet its RRN(BANK) standard.)

The interest rate charged to a firm (RIS_i) is local and accelerated with the leverage ($d/d\Phi > 0$, $d^2/d\Phi^2 > 0$). Firms are keen on earning a high return RIS_i on their lending, but they are also averse to risks associated (it is believed) with a high Φ. A firm with a bad profit performance and/or a high interest will gradually increase its Φ, either through a drain on NW (if Φ=BW/SH) or through a bad market valuation of NW (=q*NW=SH) because of the high risk that further raises RIS_i and so on. Hence in a perfect market setting credit rationing will take care of itself.

In a Government-imposed credit rationing situation the total amount of credit available (or allowed) would presumably be less than in a free market setting, but demand might be larger, if rent control (meaning a lower than market interest rate) is also applied.

First of all it should be natural for a MOSES reader by now to see that "higher or lower than the market" is almost impossible to determine after a quarter has expired, because of all the direct and indirect market adjustments to a regulation.

However, if there is a regulatory effect, meaning smaller total credit volume available and/or a lower interest rate in the market (that we preset) the bank could do one of two things:

(1) If "allowed", or possible, it can change its local mark-up for "Φ uncertainty" by applying (IV:28), inserting the controlled interest rate ($\overline{RIS}$) and distribute credit as before.

(2) If only the controlled interest rate $\overline{RIS}$ can be charged, it applies risk minimization and feed potential borrowers, as much as they want, beginning with the lowest Φ_i and continuing until it doesn't want to lend any more, or until the assigned, regulated credit supply is exhausted. The latter case would have consequences for the allocation of investments.

Step IV (next period initialization)

Borrowers and depositors adjust their balances in accordance with the new interest rates or rules.

Step V

FASS and FD adjust as described earlier.

Step VI

Calculate in- and outgoing cash flows. Add or subtract from non-interest bearing bank liquidity (BLIQ).

Step VII

Check BLIQ against the bank's own liquidity requirement BLIQ*. If deviation, regulate now by changing the spread ξ 1/2 percentage point in desired direction.

Step VIII

If BLIQ turns negative or falls below Central Bank minimum liquidity requirement (r=policy variable), refund in Central Bank at going (exogenous) offering rate RP.

Step IX

Recompute all accounts.

Step X

Start afresh from I.

8 The Long-Term Interest Rate

Four nominal interest rates have appeared in our previous discourse; a long- (RIL) and a short-term

(RIS) rate and of each there is a foreign and a domestic rate. The two foreign rates are exogenous. Together with the foreign market price assumption DPFOR, they can be redefined as Fisher (1907, 1930) type real interest rates.[72]

The short-term rate enters the MOSES economy through the short-term foreign asset and debt positions. These positions respond to foreign-domestic interest differentials as described above.

To determine the long-term domestic interest rate adjustment in response to foreign long-term interest movements we introduce a modified, simple purchasing power and interest parity mechanism. In passing, this allows us to introduce the exchange rate as a "policy" or a "pressure relief" parameter.

Why do we need a long-term interest rate in the model? The main reason is to introduce symmetry with the long-term investment-financing decision in Chapter III. The best thing would of course have been to have an elaborate credit model, with a multitude of credit institutions and a spectrum of interest rates pertaining to various time horizons and risk levels. Barring that the second best is to work with three "credit dimensions", the long and the short term, and the equity market.

The dual character of the nominal part of the credit system exercises a particular influence on the business sector. Whenever

RIS > RIL

expanding firms, planning to invest and grow (in Chapter III) on the basis of external finance, start gobbling up inexpensive long-term, external finance, to obtain balance sheets nicely structured for growth. What is not needed now, is temporarily deposited short term in banks.[73] This credit market activity, if it goes on, will of course eventually drive down the short-term interest rate as described in the previous section.

The long-term interest rate is a policy parameter that can be directly influenced by the Central Bank. In a financially closed economy this could be said to be almost true. Open market operations would do the trick, and regulation of access to long-term external finance, a typical Swedish policy feature up to the early 70s (E 1969) can be fairly effectively enacted.

The real problem arises when the economy cannot be assumed to be a financially closed one. This fact has been gradually accepted by Swedish policy authorities, since the late 60s.

The tricky modeling problem has to do with capturing a financial system that is partially - but to a diminishing extent - regulated, and which is, at the same time, integrated with the world financial markets. We use the distinction between the long and the short term to accomplish that integration in the model with the help of the simple purchasing parity and interest parity ideas.

The pure purchasing power and interest parity theories presume a more or less instantaneous and simultaneous real interest arbitrage across the world through speedy capital flows.

The purchasing power parity formulation reads:

$$DCPI = DPFOR + \otimes \qquad (IV:29)$$

$\otimes$ is the rate of change in the spot exchange rate (DSPOTR). The interest parity formulation reads:

$$RIL = RIL^{WORLD} - FP \qquad (IV:30)$$

where FP is the forward interest premium. In the pure versions of the two "theories", the forward interest premium equals the expected spot rate change. Then:

$$\otimes = -FP \qquad (IV:31)$$

Domestic and foreign real rates of interest are then assumed to be equal to each other. Hence:

$$RIL^{WORLD} - DPFOR = RIL - DCPI \qquad (IV:32)$$

To achieve such an equilibrium state, for one thing, a world with free and fast international capital flows has to be assumed and the market has to have correct expectations as to spot rate changes. These are necessary but not sufficient conditions.

While there is some empirical support for fast interest arbitrage, there is little support for the purchasing power parity theory in the instantaneous format commonly formulated (Genberg 1982) and market expectations do not predict future spot changes well[73B] (Oxelheim 1981, 1984). And this is exactly the way we want it to be in the micro-to-macro model. Foreign-domestic price transmission is a time consuming process that involves more or less the entire market adjustment machinery of the model (E 1978a, p. 105 ff.). There is empirical support for the kind of price transmission lag structure that operates within the MOSES economy (Genberg 1974, 1983). Hence (IV:29) should be rewritten:

$\otimes$ = DCPI - DPFOR + LAG (IV:29B)

and (IV:31) can then be rewritten as:

DCPI - DPFOR + LAG = -FP (IV:33)

Combining (IV:29) and (IV:33) we obtain:

$(RIL^{WORLD}-RIL)$ = DPFOR - DCPI - LAG (IV:34)

LAG is determined endogenously in the model and essentially involves the entire MOSES, real economic machinery. $\otimes$, or DSPOTR, is a policy variable.

LAG in (IV:29B) so to speak measures the exchange rate adjustment needed each period for purchasing power parity to hold each period. If, however, the MOSES currency continues to be over- or undervalued by that standard, endogenous mechanisms in the model economy keep working or adjusting LAG (rather than $\otimes$) "from within". Eventually this shows up in DCPI in (IV:29B). The correction process may, however, be socially very painful. Unemployment may rise. Hence, policy authorities often opt for adjusting the exchange rate $\otimes$ instead.

If we can assume (IV:31) - and we will do it for the sake of simplicity - then (IV:34) will also serve as an explanation of long-term interest rate movements in the MOSES economy. They will differ from world long-term interest rates by the expected rate of change in the spot rate[74] ⊗, which is assumed incorrectly to equal the actual change.

(Necessary and sufficient conditions for the pure purchasing and interest parity combination to hold each period then are that capital flows respond immediately to interest rate differentials and iron out LAG=0. If expectations as to inflation, exchange rates or policies are wrong as they were after 1973 and after 1979 LAG≠0. If adjustment times in capital markets and foreign domestic price transmission speeds differ, we also have a LAG≠0.

Whenever the foreign price level moves away from its earlier relationship with the domestic price level, this movement sets into motion a series of (time consuming) responses in the MOSES economy that gradually affect the supply and demand conditions throughout the system. In the longer term this process is self-regulating and a new relationship between domestic and foreign prices is established. During that process the trade balance (or current balance) is affected and supply and demand for MOSES currency in the world markets are affected. So if MOSES inflation is higher than world inflation and if this is not immediately countered by domestic real responses a LAG≠0 emerges <u>and</u> a deteriorating, or improving, current balance puts pressure on the spot rate, ⊗, such that it eventually has to be changed through external policy action.)

The complexity of the dynamics of the economic machinery suggests that LAG varies considerably in size over time. LAG can also be affected by domestic policies. RIL is often regarded as a policy parameter, as is the exchange rate. If one can assume that all capital flows in and out of Sweden - except trade credit flows - are effectively controlled, and that the Government is the only long-term borrower abroad, one can make the long-term domestic interest rate exogenous. A quick glance at (IV:29B and 34) however tells us, that this is not possible if the spot rate is not continuously adjusted. We will have to abandon (IV:31) if we believe that the long-term domestic interest rate can be effectively controlled.

Suppose firms have a free choice to borrow long term both at home and abroad. Then differences $(RIL^{WORLD}-RIL)$ will cause immediate adjustments in new, long-term financing. If (RIL^{WORLD}, RIL) is fixed and if DSPOTR=0 (by assumption) the model system cannot ensure that LAG adjusts to make (IV:34) hold if $\otimes = -FP$. Something will have to give.

With all these considerations in mind a natural way to handle the domestic long-term interest rate would be either to assume a freely floating exchange rate, adjusting for LAG≠0 and hence assuming (IV:34), LAG≠0 to hold, or breaking up (IV:31) by introducing an expected exchange rate change, dependent upon LAG to achieve an effect similar to moving $RIL^{DOMESTIC}$ together with RIL^{WORLD} or to assume that $RIL^{DOMESTIC}$ cannot be controlled or allowing for all three possibilities.

Our standard procedure will be to assume (IV:34) in effect making RIL equal to RIL^{WORLD}, except for spot rate adjustments.

This discussion introduces a very interesting property of an economic system that integrates theories of quantity adjustment, price adjustment, interest adjustment and exchange rate adjustment, as the MOSES economy does. We have learned by now that adjustment speeds are different in the four "markets". Quantities are the slowest to adjust, then come prices, including wages, then interest rates and finally exchange rates, if allowed to float freely. The slower all other variables adjust, the more of erratic behavior in the fast moving exchange market which has to absorb all inconsistencies in macroeconomic behavior. If exchange rates are fixed, the adjustments show up very much in interest rates. If interest rates are "controlled" trough monetary policies, adjustments take place in monetary flows and so on. We will return to this in the chapter on equilibrium and stability below.

Notes to Chapter IV

[52] Waiting for a micro household database, micro household modeling should be a relatively low priority in this context, considering the excellent micro firm database organized on the format of the MOSES system. However, if sufficient funding can be provided, a large scale household database, nicely structured for MOSES use will soon be available. See Eliasson-Klevmarken (1981) and Eliasson (1982a).

[53] See Eliasson (1969, Chapter X).

[53B] Only sketched in this chapter but not in Code on program.

[54] It should be mentioned that we still have several database consistency problems to solve before the money part of MOSES functions well.

[55] For instance, MOSES firms do not hold assets or acquire debt in foreign currencies but immediately transform any foreign currency account into Swedish kronor, thereby transferring the foreign currency entries to the bank as FASS or FD. This has been done for practical, simplifying reasons. For the time being individual firm capital losses and gains on foreign account all show up in the accounts of the Bank and cannot be studied as part of firm behavior. The addition of such a feature to the firm model requires that firms are also modelled to respond to changes in currency values vis a vis the Swedish krona. For the time being we do not plan any such extension of the firm model.

[56] See Eliasson (1980a).

[57] Note that this disregards debt in the business sector, cf. Table I.

[58] Since the system is nominal, total income Y includes an inflationary component.

[58B] In capital market equilibrium then $q=1$ and $\varepsilon=0$ (see V:2B in next chapter) for marginal investments.

[59] In our current macro version of the household sector, it appears only as a net supplier of funds.

60 In a company with only one activity, the manufacturing of one product, this is no problem. There are only two prices to compare; the rate of return on that activity and the going interest rate. If there are many divisions that manufacture many products, the problem is roughly analogous, as shown already in Chapter III (Supplement I). The portfolio problem appears, when there are many competing outside investment opportunities.

61 See Grassman (1970).

62 Estimated to be 2 months on the average in the 60s by Grassman (1970).

62B In the current version of the model only investments in production assets including working capital and in bank deposits actually take place. However, returns to the other investments enter the targeting formula and prevents the firm from investing in lower grade production activities. If cash flows are high surplus cash is nevertheless deposited in the bank at the rate $RI(1-\xi)$.

63 K* is seen as including inventories. We exclude (here and in what follows) the possibility to buy inventories in advance in expectation of future price increases.

64 In our earlier notation this would be K1+K2+K3+K4. Note, however, that bank deposits K2 have now been entered as a separate item in the portfolio.

65 This can also be written

$$i = \theta x RNW^* \frac{NW}{N} + (1-\theta)^* RNW$$

revealing immediately that i=RNW when the market value of the firm equals its "replacement value", "substance" or "reproduction value".

The proof of this formula runs as follows:

Make the value of the company (as seen by a stockholder that plans to keep his shares forever) equal to the discounted sum of all dividends ever.

$$SH_t = \int_t^{\infty} \theta^* R^{NW} {}^* NW^* e^{-i\xi} d\xi$$

i = discount factor.

Define $NW_t = NW_0 e^{R^{NW}(1-\theta)t}$.

R^{NW} is assumed to be a time constant.

$$\text{Then: } SH_t = \int_t^{\infty} \Theta \cdot R^{NW} * NW \cdot e^{R^{NW}(1-\Theta)\xi - i\xi} d\xi = \frac{\Theta \cdot R^{NW} * NW_t}{i-(1-\Theta) \cdot R^{NW}}$$

But $\Theta * R^{NW} * NW_t = DIV_t$

Hence $D(DIV) = \frac{dDIV/dt}{DIV} = R^{NW}*(1-\Theta)$ and $SH_t = \frac{DIV}{i-D(DIV)}$.

Q.E.D.

66 i.e. when q=1 note that this allows us to keep the simple borrowing investment function in the earlier model. The rate of change in borrowing now is:

$$DNW = a + b(RRN_i - RI - \alpha\Phi_i)$$

only the last term is new. See Eliasson (1978a, p. 66) and Eliasson-Lindberg (1981, p.399).

Note also that:

$$RRI_i = RRI*e^{\Phi_i}$$

yields no solution.

66B <u>Proof</u>:

$$SH = \frac{\Theta \cdot RNW_0 \cdot e^{RNW*(1-\Theta)t}}{i - (1-\Theta)*RNW}$$

Make $\frac{dSH}{d\Theta} = 0$ and:

$$RNW = i\left[\frac{\partial RNW}{\partial\Theta} * \frac{\Theta}{RNW} + 1\right] - \Theta\frac{\partial i}{\partial\Theta}$$

Assuming RNW to be a time constant one obtains:

$$RNW = i - \Theta\frac{\partial i}{\partial\Theta}$$

Q.E.D.

66C If rational is not taken to be synonymous with optimal decisions.

[67] Such data were not available by 1983 and the work effort needed for the rest of the model was sufficient to keep us busy at the time. Access to micro household data of the kind needed may, however, eventually be possible for the first time in Sweden because of the large household survey project initiated by IUI and professor Klevmarken at the University of Gothenburg. See Eliasson-Klevmarken (1980), Eliasson (1982a) and Klevmarken (1983).

[68] See for instance the quite amusing example of this discovered in a series of taxation experiments on the Model (Eliasson 1980a, p.64, footnote).

[69] In the current version of the model there is no bond market. Hence we do not discuss Government financing through the floating of bonds here. The tax system is presented in Eliasson (1980a).

[70] The pool of unemployed plus new entrants.

[71] In earlier versions of the model the Commercial Bank accepted unlimited deposits without regard for its own rate of return development, which was disastrous for the bank in some runs. This is one of the reasons why we have had the monetary sector disconnected in most runs. (In current versions the Commercial Bank receives deposits and lends only at rates that guarantee a long-run rate of return on its net worth compatible with the going market interest rate. See next section.)

[72] Note that we use the aggregate of DPFOR as a measure of the current price level change in the world. This is OK for the time being.

[73] or invested in other firms, property etc. (Not yet in program, but sketched. See above.)

[73B] Hence $FP + \otimes \neq 0$ due to mistaken market expectations.

[74] From this assumption follows the perhaps not so realistic conclusion that short-term interest rates may adjust much more slowly to foreign interest rate developments than the long-term rate.

PART III

THE ENDOGENOUS GROWTH CYCLE

"With both feet firmly on the ground, you are standing still".

V. GROWTH IN THE MOSES ECONOMY

1. Introduction

The earlier four chapters presented the principal design of what goes on in the MOSES economy. A mathematical summary of this design has been written to facilitate the analysis of the next two chapters (Supplement to Chapter VI. Not in this Working Paper version). A complete, consistent and formalized version of the standard program[73B] currently in use, The Code, follows in a separate volume. This technical presentation is probably difficult to understand for the general reader without first having been introduced to the MOSES economy by this publication.

The following two chapters represent two ambitions. The growth (Chapter V) and stability (Chapter VI) properties of the entire economic system are analyzed and discussed in principle. The earlier publications (E 1976b, 1978a) focused on the short-term side of labor and product market processes. In this volume the long-term finance-investment decision at the micro level comes together with the determination of rates of return to capital in industry, the interest rate (both macro phenomena) and productivity change. Productivity change is endogenous down to the new vintage of capital invested in one individual establishment. At that level we distinguished between labor productivity (Q/L in (III:9)) and capital productivity (as part of α in III:1) as it enters via new investment vintages. In Chapter III we found a very simple relationship between labor productivity and the profit margin (see Theorem 2). This chapter investigates the relationship between total factor productivity growth and the real rate of return on capital.

We have frequently referred to the MOSES economy as a formalized, Schumpeterian type economy which blends with the Wicksellian notion of a cumulative process, this time at the micro level, which feeds on a difference between the return to investment in firms and the market interest rate (E 1983b). This difference - a spread of temporary micro rents - defines the "disequilibrium conditions" in the capital market. The rent of the individual firm is endogenously determined from quarter to quarter (see next chapter) and the distribution of rents across the firm population is the key characteristic of the state of the growth cycle, in which both growth trends and business cycles are explained. Institutions act in the markets. Their response times to price signals ("inertia") affect the dynamic properties of the entire model economy. Hence the following two chapters also attempt to relate MOSES thinking to more traditional theory, including the classical - but static - Walrasian, general equilibrium model. I want to emphasize again that the economic principles at work in MOSES are the classical ones, with the difference that we deal with a non-tatonnement micro process and concentrate on the dynamic process per se, not its final destination.

The consequence of the two chapters appears to be that Walras fades away and Schumpeter comes to life to make a long-term, micro interpretation of the Wicksellian cumulative process possible. Even though Wicksell (1898) was concerned with the inflationary consequences of a positive gap between the nominal return to capital (the real rate of interest) and the money interest rate, this difference is just as naturally entered ex ante (as in Wicksell) in the investment function of one firm, and you have a growth model. Long-term capacity growth is open ended, except for the exogenous technical constraint associated with new investment vintages. As capacity growth evolves as a result of the investment process at the micro level the current rate of capacity utilization is determined in the short-term labor, product and credit market processes. The explanation of the Business Cycle and Economic Growth is merged within one formalized framework.

This chapter begins by bringing out the logics behind the economic growth explanation in MOSES. It continues to detail a micro-to-macro growth accounting system that is compatible with the fundamental profit targeting equation. Then follows a discussion about how spending on R&D account and technical change should be incorporated in this accounting framework. The main argument that concludes the chapter is that explaining economic growth within this micro-to-macro accounting system means making structural change between the observation units (through a reweighting of the aggregate quantity index) an explicit part of macro output growth. Relative prices are the weights and this opens the bridge to the next chapter by casting doubt on the relevance of macroeconomic production relationships when relative prices are shifty. The market price allocation mechanism is highlighted as the important vehicle behind total factor productivity growth. We find that it is necessary to understand dynamic disequilibrium market processes if one is to have any understanding of economic growth - the Schumpeter connection (next chapter).

2. The Growth Machinery in a MOSES Firm

Economic growth in the micro-to-macro economy is endogenized and bounded from above by an exogenous technology constraint associated with new investment in the individual firm. Differently structured market regimes allow for a wide variety of resource allocations and associated macroeconomic growth rates for each set of technical constraints. To understand this we should review the labor and product market processes, the investment financing decision in a firm and the credit market process simultaneously with the growth problem.

Think of the credit market as an arbitrage process in rate of return requirements in firms. There is no Walrasian auctioneer and contracting occurs all the time irrespective of whether the economy is in equilibrium or not. Markets never clear and a dispersion of interest rates - and prices as well - prevail at each point in time.

1. Hence the first market function in the growth process is the determination of the interest rate (RI), which is strongly influenced by (exogenous) interest rates abroad (see Chapter IV).

2. The second function in the growth machinery refers to the firm's market, cost and productivity performance, or the endogenous determination of labor productivity, wages and domestic prices as described in Chapter II. This process is by quar-

ter and assumes a given capacity. The production frontier (QFR(L)) is fixed for the quarter. Only labor (L) and output (Q) can be varied during the quarter. This short-term process is directly guided by the profit margin target of the budgeting process and hence "weakly" guided indirectly, by the rate of return requirement imposed by the credit market - because the profit margin target derives from a rate of return target (see Theorem 2 in Chapter III, expression (III:9)).

Foreign competition affects domestic market prices as described in Chapter II.

3. The choice of production frontier (in Chapter III) is more intricate. Expected rates of return, interest rates and productivity performance play the crucial rôles. However, expectations have to be formed on the basis of facts and perceptions of the future. Hence, the translators of the past into the future are very simple-minded. Uncertainty about the future and other complications like differences in talent, foresight and entrepreneurial competence at the micro level are introduced as a stochastic element.[74]

Theorems 1 and 2 in Chapter III now explain how the performance rates of one firm are translated into

(a) a rate of return variable and

(b) an internal cash flow variable.

4. The rate of return variable, when compared with the individual firm borrowing rate determines how much external finance to take on, the borrowing function.

5. External and internal cash inflows determine how much investment can be financed. The firm picks its new marginal production frontier as elaborated in Chapter III. This process is "strongly" guided by the rate of return requirement imposed in the credit market through the borrowing decision.

6. This much, or less, is invested in production capital. How much less depends upon capacity utilization (endogenous) and alternative investment opportunities.

7. Technical change. The investment decision in Chapter III signifies the choice of a new production frontier. New investment vintages are characterized by particular capital (INVEFF) and labor (MTEC) input-output characteristics.

8. Investment and technical change shift the allocation field of production frontiers that bounds feasible output from above.

This sequence at the firm level can be reformulated simply in mathematical terms. (Symbols have been explained in Chapters III and IV. Also see list at the end of Chapter VI.)

I. The additive targeting formula[75]

$$G = DNW + \theta = M*\alpha - \rho*\beta + DP(DUR)*\beta + (RRN-RI)*\phi$$

yields a minimum rate of return requirement through the application of some MIP-technique ((III:1) in Chapter III).

If the asset composition (β) and the use of assets per unit of output (α) are stable over time, growth in assets is a linear function of the gross operating margin and also equal to the rate of growth in output:

$$DA = DQ$$

We need this more simple formulation, stripped of financial items, when we discuss the interior production structure of a corporate entity.

II. The set of investment opportunities available to the firm i is described by the rate of return vector:

$$[RIS, RIS_i, MAX(\quad)]$$

III. The interest rate local to firm i is ((IV:17) in Chapter IV):

$$RIS_i = F[RIS, \phi_i]; \quad \frac{\partial RIS_i}{\partial \phi_i} > 0$$

IV. The current and potential profit margin is described by ((III:9) in Chapter III):

$$M = 1 - \frac{w}{p} * \frac{1}{Q/L}$$

V. Desired long-term investment INV on the basis of targeted long-term G in the additive targeting formula (I) above is "proposed" from the production level (bottom up):

$$INV = F[TARGL(G)]$$

to Corporate Headquarter people for approval.

Technical knowhow enters through Q/L which can take on any size within the feasibility production frontier:

$$Q/L \leqslant \frac{QFR(L)}{L}$$

Short-term (within quarter) market adjustments determine the position of Q/L underneath QFR(L)/L as well as labor recruitment, wages etc. The functional form of QFR(L) is defined below under paragraph VIII.

QFR(L) is moved from quarter to quarter through investment. ΔQFR is determined at the corporate level in three sequential steps §(VI) borrowing, §(VII) investment and §(VIII) QFR updating.

VI. The ex ante borrowing function (see (III:17) and (III:20))

$$DBW_i = F[MAX(\quad)_i - RIS_i]$$

is applied to a cash flow constraint.

A preliminary investment budget (INVF) is obtained:

$$INVF_i = F(RRN_i, RI_i, RI, DS_i, S_i)$$

VII. Actual INV is calculated after correction for desired INV (in §IV above) and the current state of capacity utilization:

$INV_i \leqslant MIN(INVF, INV, CAPINV)$

$CAPINV = f(\text{capacity utilization})$

Residual finance $INVF_i - INV_i \geqslant 0$ is deposited in bank.

VIII. Assume:

INVEFF exogenous[76]

MTEC exogenous

for the new capital vintage (INV). Calculate new QTOP by inserting QTOP and INV in:

$$INVEFF = \frac{CHQTOP * P(DUR)}{INV}$$

Calculate γ by inserting QTOP and MTEC in:

$$TEC = \gamma * QTOP$$

and a new, updated production frontier (see (II:5)) is obtained:[77]

$$QFR(L) = QTOP[1-e(-\gamma L)]$$

The rest of this chapter and the next chapter are concerned with the importance for macroeconomic growth of how INV is determined, distributed over, and used at the individual establishment level.

3. The Growth Accounting System

So much for one firm. Let us look at the entire economy through the following accounting identity:

$$\sum^{i} p^{*} \cdot Q \equiv \sum^{i} p^{x} \cdot X \qquad (V:1)$$

(V:1) states that the sum value of total factors expended as inputs equals the sum value of total output. Summation is over production units (i) or rather divisions, the firm being organized on a product (market) taxonomy. One aggregation scheme hence yields a set of firms or financial decision units (see Chapter III). Aggregation one step further yields the entire industry.

p* is the price on value added (Q), and p^x and X are the price and volume of factor inputs respectively. More precisely (V:1) can be spelled out as:

$$\underset{(1A)}{\Sigma p\bar{S}} \equiv \Sigma\big[\underset{(2)}{wL} + \underset{(3)}{(RR+Dp^{I}+\rho)K} + \underset{(1B)}{p^{x}X}\big] \qquad (V:2A)$$

p is the product price associated with the gross value produced by each firm. w is the level of wages (or rather wages and taxes on wages) paid for each unit of labor input (=L). RR is the real rate of return on capital inputs (K) and DP^I the capital gains component on K. ρ is an appropriately chosen depreciation factor. (p^x,X) represents a vector of other factor prices and input volumes. Some of them also appear as outputs in some firms.

(V:1) or (V:2A) is a mere accounting framework on the format of the macro mapping of the model in Figure II:1 in Chapter II. Beyond providing a consistent classification scheme for micro-to-macro accounting - like Figure II:1 - this identity tells nothing about economic behavior. However, (V:2) contains the important, endogenous micro variables in MOSES and gives an organizational breakdown of the accounts for a discussion of the dynamics of the growth machinery, both in the model and in the real life economy.

Components 1A and 1B in (V:2A) represent the final results of output decisions in firms each period (price and quantity), Component (2) is the labor market and (3) represents the financial markets, although in a way that requires some explanation.

The accounting breakdown (V:2) of the MOSES economy corresponds to the accounting breakdown of a firm in Chapter III (The Separable Additive Targeting Theorem and Theorem 2). Combining the three, one obtains a systematic aggregation formula from "in plant" productivity, via profitability to - as we shall see in this chapter - macroeconomic growth. For instance, K is not explicit in the MOSES firm, and is not traded directly in the financial markets. The critical thing is how RR_i, the real rate of return in production unit i, relates to the interest rate (RI) in the credit market. The determination of RR - ex post - was explained in Chapter II (the production model). The determination of RI in the credit market was explained in Chapter IV. The firm decided on its production frontier (the investment decision) on expectations as to RR and RI in Chapter III. Here these three steps combine to yield economic growth at the macroeconomic level.

$(RR+DP^I+\rho)$ is the standard definition of the cost of capital from the neoclassical theory of investment. In the MOSES economy it figures as the cost of capital only in a trivial sense, to be explained later.

Now, replace $(RR+DP^I)$ by some external cost component like the nominal market interest rate from

Chapter IV (call it the <u>discount factor</u>) and rewrite (V:2) as:

$$\Sigma p\bar{S} \equiv \Sigma[wL + (RI+\rho)K + p^{x}X] + \Sigma\varepsilon K \qquad \text{(V:2B)}$$

$$\varepsilon_i = RR_i + DP_i^I - RI.$$

In neoclassical theory standard conditions for producer equilibrium adjusts (L,K) to a given set of prices so as to maximize ΣK for the individual firm or a group of firms. When this holds at any level of aggregation the groups of firms are operating on their production function and total factor productivity growth can be measured as a shift in that production function. If prices on outputs and inputs are properly measured, Jorgensen-Griliches (1967, p. 249) argue that "the observed growth in total factor productivity is negligible". They recognize that there is a severe aggregation problem, that increasing returns to scale and externalities cause problems and that the existence of producer disequilibrium blurs the distinction between shifts in and movements along the production function. Brown & Greenberg (1983) argue outright that the users of traditional Divisia indexes of total factor productivity - claimed to be relatively free of aggregation errors - ignore the general equilibrium effects when prices and quantities are mutually interdependent. This is of course exactly our case of dynamic disequilibrium in which structural adjustment between quantities and prices in the market allocation is the source of economic expansion. We illustrate this by a formal exercise below.

We also ask the question (in the next chapter) what to mean by equilibrium. Non-zero $\varepsilon_i \neq 0$ at the micro level are perfectly compatible with the existence of producer equilibrium conditions. It appears that the Jorgenson-Griliches claim that the properly measured input and output prices that make total factor productivity change negligible, also make aggregate $\Sigma\varepsilon_i$ into a negligible magnitude, (see below). What does this imply for the nature and existence of a capital market equilibrium?

Make the interest rate equal to the marginal product of capital at all points. Then $RI=RRN_i$ is enforced on the margin everywhere. Excess or deficit profits are eliminated on the margin everywhere. Hence:

$$\text{Marginal } \varepsilon_i \equiv 0. \qquad i = 1,\ldots.,n.$$

This is of course what happens in perfect equity market arbitrage (Section 6.1 f in Chapter IV) where K is market evaluated and ρ consistently adjusted.

By this criterion

$$\overset{i}{\Sigma}\varepsilon K$$

(using our reproduction cost valuation of K) could be said to represent a measure of the extent of "disequilibrium" in the economy. We can also talk about Schumpeterian, entrepreneurial or temporary (monopoly) rents. In the MOSES economy there will always be a distribution of quasi rents ε (positive or negative) across firms. The nature of "technical change" in the model is to create new $\varepsilon > 0$. Differentially distributed information and uncertainty are other reasons for the existence of ε. Monopolistic competition in all markets allow quasi monopoly rents to exhibit themselves as ε, as does of course a general "disequilibrium" in the capital market, if savers are not sufficiently interest sensitive. The nature of firm behavior in MOSES is to exploit such profit potentials. The nature of market processes in the model is to compete them away.

The nature of the actual distribution of ε across establishments is very important for macroeconomic behavior of the entire economic system. This distribution can be calculated at the micro level at each point in time in a MOSES simulation.

The credit market may be afflicted by imperfections. The RI_i represents a spread of interest rates over firms. A question that naturally comes to mind is what it means to assume that $RR_i=RI_i$ or $\varepsilon=0$ at all points in time. What should be meant by a general capital market equilibrium? We will return to this question in the next chapter on equilibrium and stability in MOSES.

Formalizing slightly, the central problem for the rest of this chapter concerns the relationship:

$$F(q,p,\varepsilon)=0$$
$$q=(\bar{S}_i,L_i,K_i,X_i)$$
$$p=(p_i,w_i,r_i,p_i^X)$$
$$\varepsilon=(\varepsilon_i)$$

Here the differences between the Walrasian system and the MOSES economy show up. The quasi rents ε_i represent a link over time. As long as $\varepsilon_i \neq 0$, or better, as long as there is no solution

$F(q,p,\varepsilon_i=0)=0$ sequences of temporary equilibria do not exist.[78]

4. R&D Investment and Technical Change

What is being discussed in this section is currently not in MOSES Code. It amounts to making DMTEC and INVEFF endogenous (currently they are exogenous for each vintage of investment) by making individual firm investments in marketing and in R&D partly endogenous, and applying a stochastic payoff in terms of faster or slower DMTEC and INVEFF rates. Negative effects on DMTEC and INVEFF would then signify "failures".

A growing share of spending on capital account in sophisticated manufacturing firms is not booked on capital account, but charged to current account. Quantified knowledge of spending on R&D and marketing investment is scarce or missing. Nevertheless these investment categories shift the production frontier QFR(L) outwards, either by reducing factor inputs per unit of output, or by increasing the end value of products for a given set of inputs. Several real firms in the MOSES economy spend more on R&D and marketing investments than on equipment purchases and construction. This alone is a good reason not to make hardware capital explicit in the production function while - at the same time - ignoring other forms of capital.

Entering R&D investment into a MOSES firm has to recognize the scant information existing for the investigator as well as for firm decision makers. We also recognize that much software investment really is of a routine nature (Eliasson-Granstrand

1982). Much of R&D spending concerns learning about, and adopting, technical change that takes place in competing firms or in research institutions. Consequences of routine R&D spending on product specifications are fairly predictable. The bulk of R&D spending in manufacturing seems to be aimed at product quality improvements (E 1982b). Hence, uncertainty associated with R&D investment lies to a large extent on the marketing (investment) side.

In principle we could treat software investments as any other investment category, adding an uncertainty factor to each category. This would generate distributions of business success that would be compatible with observed distributions, but it would deepen our understanding of macroeconomic behavior only if the stochastic hypothesis is a good representation of success and failure in business life. We are willing to consider such a simple explanation, but it does not seem to be compatible with the more well rounded theory of economic growth that we are trying to piece together. And, we are not prepared to impose the stochastic explanation as a prior in our analysis, even if it happens to generate well fitting time series and cross-sectional distributions.

The above, more general concept of the generation of technical change is what we have in mind (but not yet in the program) for application when data become available.[78B]

R&D spending affects technological development in the MOSES economy in two ways.

(1) Industrial R&D - directly in firms or elsewhere - raises the potential INVEFF and MTEC improvement embodied in new investment.

(2) The extent of R&D spending in one firm raises the MTEC and INVEFF levels of that firm compared to its previous level and the potential level as determined in (1) above. I would expect the effect to be non-linear in the sense that the closer the firm is to the potential frontier, the more additional R&D investment is needed to push one step ahead.

(1) and (2) differentiate DMTEC and INVEFF development between firms.

In the MOSES economy designed so far business risks consist only of profit consequences of mistaken market price expectations. We now propose to introduce a new type of business risk, namely:

(3) Technological risks associated with failed R&D programs.

Technological risks could be handled by a stochastic return factor associated with R&D spending in the individual firm. This would further differentiate (MTEC, INVEFF) development between firms. Mathematically such a device would be very similar to the stochastic creation of temporary innovative rents that Futia (1980) proposes as the cornerstone of what he calls Schumpeterian competition.

This respecification of the firm model would introduce a desired increase in macro diversity into the economy that can be further increased through relating similar characteristics to new entrants.

There is, however, one problem. By introducing such a crude technical change generator the possibility of "predicting" individual firm behavior has to be abandoned altogether. Only macro behavior and consequences for distributional characteristics can be meaningfully analyzed.

The database used for MOSES will soon make it possible to derive individual firm estimates of R&D, INVEFF and DMTEC. Hence, the average effect of extra R&D spending on the shifting and the shape of the production frontier intermediated through the investment decision can eventually be estimated.

How is the extent of R&D spending determined? We will have to enter this specification very simple-mindedly. Moving into high-tech, R&D intensive industries is a slow process, so the extent of R&D investment will be heavily dependent upon past R&D investments. It should also depend on rate of return performance. For the moment it would be fairly easy to generate R&D adaptation of a firm in the sense that past experience of R&D profitability (achieved MTEC and INVEFF shifting) affects the size of future R&D spending.

(In principle the same performance raising function should be attached to marketing investment.)

By treating R&D spending and marketing investments as just another, but somewhat different form of capital spending, we need to recognize truly innovative technical change. We can do that very simply, through new entry. New firms enter in the upper end of MTEC and do not have to mix with old technologies and old mixes of factors. We can assume that new firms enter according to a frequency distribution around MTEC and in "volumes" that correspond to the opportunities in the market, measured by upper end ε, and perhaps other, exogenous social factors.

5. Total Factor Productivity Growth and the Representation of Production and Technical Change in MOSES

a) The General Problem

Throughout the micro-to-macro modeling work we have represented information handling and decision making within the business organization according to the same principles as those upon which the measurement (accounting) systems of firms are organized. The rationale for this procedure of course is that we are modeling firm decisions, and that we are using actual data processed within real firms and used in their own planning and decision making. These data are generally of a much higher quality than data gathered according to some other imposed format of thinking. In particular, we are much closer to the source, and know the nature of errors that creep in. We think these two reasons are sufficient to warrant a few departures from received procedure. This rules of behavior approach to modeling recognizes two things; First that rules applied in the decision process have to rely on insufficient information (there is extensive fumbling in the darkness). Second, in choosing what information to use, well defined and accurately measured variables are to be preferred. This becomes a very obvious choice when one thinks of rate of return requirements.

Vague concepts in agreements simply cannot be enforced. Capital, for instance, does not appear explicitly in the internal accounts of a business organization as a quantified measure of a factor input (a "stock") in the production system. It cannot be measured properly. Rather, firms work in terms of estimates of potential output and rates of utilization of installed factors.

The closest one gets to the concept of a production function is the standard costing procedure and the use of standard cost functions, but these do not pretend to represent the physical side of capital use in production (E 1976a, p. 296 ff.).

We have approximated the same procedure by applying two productivity measures, one for labor (MTEC) and one for "capital" (INVEFF). They both refer to new vintages of investment. Hence, the concept of capital of course sneaks in through the back door. A production function can so to speak be derived from the accounts of the model. The point is that one first has to define the concept of capital one needs for estimating the production function by specifying a method of measurement. Then we can use the model to calculate a time series of capital stocks to our liking. The MOSES firm, however, does not depend upon any particular such method to make a decision, except the procedure to measure INVEFF.

Were it not for two things we could simply leave the problem at that. The two things that force us into a digression on capital theory are (1) curiosity and (2) the fact that we have argued strongly that some 50 percent, or more, of total factor productivity (TFP) growth in the Swedish economy between 1955 and 1975, as measured by traditional macro production function techniques, may in fact be accounted for by structural adjustments between plants and firms (E 1979 and 1980b and Carlsson, 1981). The all industry total factor productivity (TFP) measure necessarily rests on an aggregate production function estimate. A stable aggregate production function normally does not exist if the ε_i vary significantly over time. They always do in our model economy, and in any real life economy.

Introduce the concept of <u>total factor productivity</u> as:

$$TFP = \frac{Q}{X} \qquad (V{:}4A)$$

or as the ratio between the quantity of aggregate output and the quantity of aggregate input. Hence, relative change in TFP;

$$DTFP = DQ - DX = \Sigma wDQ - \Sigma vDX \qquad (V{:}4B)$$

where

$$w_i = P_i Q_i / \Sigma P_i Q_i$$

$$v_i = P_i^x X_i / \Sigma p_i^I X_i$$

are the appropriate (price) weights in the quantity index.

Impose the identity (V:1) and DTFP = DQ-DX. Growth in total factor productivity, can then be expressed by its dual

$$DQ\text{-}DX = DP\text{-}DP^X = \Sigma vDP\text{-}\Sigma wDX \qquad (V{:}5)$$

Imposing (V:1) means making $\varepsilon_i=0$ everywhere, and all RRN_i and RI_i equal throughout the economy. In such circumstances only, total factor productivity growth equals the difference in aggregate relative change in the output and input price indexes. Any consistent macro model with the actual return to investment properly measured would have to satisfy (V:5) ex post.

In MOSES $\varepsilon_i \neq 0$ almost everywhere and always. The analytical problem addressed in this chapter is how this "property" affects investment and growth in the model. It will be demonstrated that the existence of a "variable" distribution of quasi-monopoly rents, ε_i, that are temporary for the individual firm, such that $\Sigma\varepsilon K>0$ most of the time is a necessary, but not a sufficient condition for growth in the MOSES economy.

The next chapter addresses the question: What will happen to the macro economy when we try to establish a capital market equilibrium, i.e., to move all $\varepsilon_i \to 0$?

One could also say that the dynamics of the various market processes in the MOSES economy are in fact described by the time movements of weights:

$\{w_i\} = \frac{PQ}{\Sigma PQ}$; determined in the product market

$\{v_{Ii}\} = \frac{wL}{\Sigma wL}$; determined in the labor market

$\{v_{IIi}\} = \frac{(RI+\rho)K}{\Sigma(RI+\rho)K}$; determined in the credit market

$\{v_{IIIi}\} = \frac{\varepsilon_i K_i}{\sum_i \varepsilon_i K}$; determined in the equity market

This formulation takes us right into the fascination and mystique of capital theory and the explanation of the rate of interest. Let us try it with a modest degree of a ambition. The symbols used are those of (IV:5).

Using a Divisia (1928) quantity index we can express:

$$DTFP = DQ - DX = \Sigma w_{ij} DQ_{ij} - \Sigma v_{ij} DX_{ij} \qquad (V:6)$$

where

$w_{ij} = P_{ij}Q_{ij}/\Sigma P_{ij}Q_{ij}$

$v_{ij} = P^x_{ij}X_{ij} = \Sigma P^x_{ij}X_{ij}$

D( ) as before are relative change operators. Summation is across profit centers in firms (j) and across firms (i). From now on we discard indices whenever it is obvious from the context what symbols represent. We want to demonstrate two things:

1) How structural adjustment enacted trough the price system affects aggregate TFP in the MOSES economy.

2) How the production system of the MOSES firm relates to a traditional production function representation.

The first answer follows directly from (V:6). Aggregate quantities of outputs and inputs (Q and X) depend on the relative price vectors (P, P^x) used in the price deflators. These price vectors are all endogenously determined through the factor and product markets. Prices determine the corresponding allocation of quantities (Q,X) and so on.

DTFP as measured at industry levels through aggregate production function analysis has accounted for some 75 percent of aggregate output growth during the post-war period (Carlsson et al., 1979). Given the MOSES parameter specification that best explains long-term industrial growth during the post-war period, (see Chapter VII) more than half of that particular aggregate productivity growth can be technically accounted for by "reweighting" of the firm and plant composition (the w_{ij}) through the market allocation process. Change the market allocation parameters in some appropriate fashion and DTFP can be made to disappear almost altogether (in MOSES). To this we return with the long-run simulation experiments in Chapter VII.

This proposition leaves us with the task of explaining what change in aggregate TFP really means; A bias in the measurement technique,[79] a statistical error, or something real?

Attempting to answer this question essentially means making the relationship between DTFP and the rate of return explicit, or establishing the links between the production system and the profit targeting formula (III:1) in Chapter III.

Introduce (V:2B) and the assumption that $\varepsilon_i \neq 0$ for all i, implying that RI is used as the appropriate accounting rate of interest. Define again:

$$\Xi X = w \cdot L + (RI+\rho)K \qquad (V:7)$$

Note that RI is the nominal interest rate and Ξ the implicit price deflator for X. Assume - for simplicity - that all other X=0 and reweigh:

$$DTFP = DQ - [\xi_1 DL + \xi_2 D\bar{K}] \qquad (V:8)$$

where $\sum^{2} \xi_i = 1$

and $\xi_1 = \frac{w \cdot L}{\Xi X}$

$\xi_2 = \frac{(RI+\rho)K}{\Xi X}$

Aggregate output change can now be expressed as:

$$DQ = \Theta_1 DL + \Theta_2 DK + \Theta_3 D\varepsilon \qquad (V:9)$$

where $\sum^{3} \Theta_i = 1$

$\Theta_1 = \frac{wL}{pQ}$

$\Theta_2 = \frac{(RI+\rho)K}{pQ}$

$\Theta_3 = \frac{\varepsilon}{pQ}$

(ξ_i) and (Θ_i) are the weights in the implicit deflators (Ξ, P) with which we deflate total costs and value added respectively. It follows immediately that:

$\Theta_1 = \xi_1 * \frac{\Xi \cdot X}{p \cdot Q}$

$\Theta_2 = \xi_2 * \frac{\Xi \cdot X}{p \cdot Q}$

and

$$DTFP = DQ - DX = [1 - \frac{pQ}{\Xi X}] \cdot DQ + \Theta_3 \cdot \frac{pQ}{\Xi X} * D\varepsilon \qquad (V:10)$$

or[81]

$$DTFP = \left[1 - \frac{pQ}{\Xi X}\right] DQ + \frac{CH\varepsilon}{\Xi X}$$

The first term is negative if DQ>0 and $\varepsilon>0$, since then $pQ>\Xi X$, but rather small. The second term can be positive or negative depending on the sign of $CH\varepsilon$. There is no guarantee that DTFP>0.

In fact:

If $CH\varepsilon \to 0$

then $DTFP \to \frac{-\varepsilon}{\Xi X} * DQ$

since $p*Q - \Xi X = \varepsilon$.

For $\varepsilon=0$

or DQ=0

we have

DTFP = 0

and output can only be augmented through a larger physical input of one or many factors X.

All this has been derived in continuous time. When you measure total factor productivity change it takes place between two discrete points in time. So you can "manufacture" more or less total factor productivity growth through appropriate changes of weights in the price deflators. This is synonymous with the choice of production function into which to fit your measurements. To define production function specifications that produce TFP changes that are invariant to changes in structure between the two points of measurement seems close to impossible (Brown-Greenberg 1983, Caves-Christensen-Diewert 1982). Strictly speaking, by saying that X percent of total factor productvity change depends on structural change, hence, means to say X percent of something that may not exist. What we have done elsewhere (see E 1979, Carlsson 1981) is only to demonstrate that by entering a DMTEC of on the average 2.5 percent per annum 1955/75 (differing between sectors) and a D(INVEFF) = 0 we have been able to generate an expansion path of Q, INV and L in manufacturing that tracks actual historic data well (and a number of other historic (Q, INV, L) paths as well if we change market parameters), that records a Q/L development close to 7 percent per annum. Average labor productivity change at the micro level, hence, is less than half of macroeconomic Q/L change the same period. The rest has to do with reshuffling of (L, INV) between plants and firms in the economy to obtain a more efficient allocation of factors.

It is obvious from this discussion that total factor productivity change depends on the nature of the design of aggregate output (Q) and input (X) volume indexes, i.e., how the corresponding deflators have been designed. The shift in the aggregate production function really is a phenomenon related to relative price change, where the price of capital services (the interest, depreciation rates and the rate of return) plays the crucial rôle (cf. the duality theorem above). In saying so, the nature of capital market disequilibrium enters as the vehicle for total factor productivity change. DTFP$\neq$0 does not occur when ε_i=0 everywhere. This is exactly what we wanted to demonstrate.

When $\varepsilon_i = 0$ everywhere, it will be as profitable for each firm to deposit its cash flow in the bank as it will be to reinvest it in current operations.

We will now pass on three questions to the next chapter;

Question one:

Does the MOSES economy have an equilibrium in the sense that the whole economy stays at the state all $\varepsilon_i = 0$, once it has been placed there? The second question is very different, even though it may appear on the surface to be the same.

Question two:

If you increase capital market competition (which is the only way to manipulate ε in the model) to the extent that you compete all ε_i away at any point in time, will the above, possible equilibrium state be approached?

Question three:

If an equilibrium state with all $\varepsilon_i = 0$ exists, is this also a stationary state, with no growth in output?

b) Total Factor Productivity Change in One Production Unit

In this supplement we demonstrate how the individual production unit of the MOSES production system relates to the traditional production function. More specifically, we demonstrate how the parameters MTEC and INVEFF link back to the profit targets equation and forward to the coefficients in a production function.

Discard all outputs in (V:4) but one (i=1). We have <u>one</u> firm that produces <u>one</u> homogenuous output by applying labor ($p_1=w; X_1=L$) and capital ($p_2=(RI+\rho); X_2=\bar{K}$). As before RI is a suitable discount factor (interest rate) nominally denominated and determined outside the firm, perhaps in the credit market. ρ is the rate of economic depreciation of assets K. Hence (V:5) for this firm reads:

$$DTFP = DQ - \underbrace{\frac{(RI+\rho)K}{(RI+\rho)K+w*L} * D\bar{K}}_{a} - \underbrace{\frac{w*L}{(RI+\rho)K+w*L} \cdot DL}_{b} \qquad (V:11)$$

Three matters now have to be considered.

<u>First</u> this expression has no meaning in an economic context until we have related the symbols to a well defined measurement instrument, that generates data on all variables. This is especially important for the tricky triad (RI, ρ, K).

<u>Second</u>, if RI is replaced by a properly defined nominal rate of return on K (meaning $\varepsilon=0$) for this

particular firm, the whole expression collapses into an identity where DTFP≡0. For proof (see above).

<u>Third</u>, under certain conditions (V:11) can be integrated into an aggregate (for the firm) relationship:

$$Q = F(L,K,t) \qquad (V:12)$$

or a production function, that is stable, and perhaps is not an identity.

The first problem was to bring MTEC and INVEFF into (V:11). Let us begin by establishing a partial relationship (Q,t) in (V:7) to this firm that is the same for any RI.

As pointed out already by Wicksell (1901) a power production function,

$$Q = AK^{a}L^{b} \qquad (V:13)$$

can be derived from (V:11) if

$$a = \frac{(RI+\rho K)}{(RI+\rho)K+wL} \quad \text{and}$$

$$b = \frac{wL}{(RI+\rho)K+wL}$$

can be assumed to be time constants. A is an integration constant. In equilibrium, where all RRN_i equal the discount rate RI a and b are constants, but then the whole expression is an identity since

$$(RI+\rho)K + wL \equiv Q^{*}p$$

Then also $a=\xi_2$ and $b=\xi_1$ in (V:9)

We can of course assume that RI and ρ are constants and define K such that RRN=RI[84]. You then make an identity of (V:11), but there is nevertheless no guarantee that a and b in (V:11) are time constants, which they have to be to obtain a simple power type production function that is stable over time.

The rationale for a stable, aggregate production function of a simple power function type hence rests on approximate time stability of a and b in (V:6), and an aggregate $\Sigma\varepsilon \neq 0$, if there is to be any total factor productivity change.

If there is, shifts occur in the aggregate production function and all benefits from these shifts accrue to the capital owners,[85] since they are the recipients of all profits accruing from $\varepsilon > 0$.

This would traditionally be taken to signify a capital market disequilibrium situation (monopolistic conditions), generated through superior innovative behavior during an intermediary period, before being competed away by new innovators or imitators. In the meantime all $\varepsilon > 0$ have been reinvested somewhere and formed the basis for continued economic growth, the rate of which in turn depends on the rate of return on the new investments and so on.

In so far as this rent (ε) generating capacity is stable over time we <u>might</u> be able to <u>describe</u> the growth process by estimating a reduced form of the growth model, namely the production function of the firm. By the nature of the above discussion we should not expect to find such general stability over time at the firm level because of competition.

At higher levels of aggregation irregular micro motion in ε_i may aggregate into a stable aggregate monopoly rent that may be proportional to DTFP. But what explains economic growth is the process that generates the ε_i and then translates them into new investment. This is a true micro process.

It finally remains to relate (INVEFF, TEC) to the parameters in a production function of the above type and to the fundamental profit targeting equation (III:1) in Chapter III.

Recall from (III:14A) that (on continuous form):

$$\frac{\partial QTOP}{\partial \bar{K}1} = INVEFF$$

We can hence rewrite (II:5) as:

$$Q = QTOP(\bar{K}1) \cdot \left(1 - \exp(-\gamma \cdot L)\right)$$

Similarly, recall from (III:14) in Chapter III that

$$\frac{\partial Q}{\partial L} = QTOP \cdot \gamma \cdot \exp(-\gamma \cdot L)$$

and that $\frac{\partial Q}{\partial L} \rightarrow QTOP \cdot \gamma$
$L \rightarrow 0$

We afforded the marginally best piece of equipment (the last to exit when L = 0) the highest labor productivity

$TEC = QTOP \cdot \gamma$

Hence differentiating the "production function" above totally we obtain:

$$dQ = \frac{\partial Q}{\partial \bar{K}1} \cdot d\bar{K}1 + \frac{\partial Q}{\partial L} \cdot dL =$$

$$= \left(1-\exp(-\gamma L)\right) \cdot INVEFF \cdot d\bar{K}1 + TEC \cdot \exp(-\gamma L) \cdot dL \tag{V:14}$$

This production function (frontier) is not easy to integrate, but it can be estimated in its full differentiated form on existing statistical data.

Now finally recall from the fundamental, profit targeting equation (III:1) in Chapter III;

$$\alpha = \frac{p_{*}Q}{A}$$

$$\beta = \frac{K1}{A}$$

$$\frac{\alpha}{\beta} = \frac{p_{*}Q}{p(DUR) * \bar{K}1}$$

Hence: INVEFF on the margin $= \frac{\alpha}{\beta} \cdot \frac{P(DUR)}{P}$

(For a new entrant firm we introduce the INVEFF characteristics of new investment.)

TEC is labor productivity of the marginally best equipment installed, which is the equipment installed last.

(MTEC was the Q/L associated with new investment or the new entrant firm. Now look at (II:3) in Chapter II. For that last piece of investment,

$$M = 1 - \frac{w}{p \cdot Q/L} = 1 - \frac{w}{p \cdot MTEC} \cdot$$

Hence, for the marginal piece of investment, or the new entrant in the market, the fundamental profit targeting equation (III:1) looks like:

$$G = \left[1 - \frac{w}{p_* MTEC}\right] \cdot \frac{INVEFF_* p_* \beta}{p(DUR)} - \rho \cdot \beta + Dp(DUR)_* \beta + \varepsilon_* \phi \cdot$$

If we have data, or ideas, of the technical properties on new investment goods (plants) i.e. on (MTEC, INVEFF) we can plug them directly into the targeting function (III:1) together with expected prices and financing variables to evaluate profitability performance.

Notes to Chapter V

[73B] Which is a subset of the model design analysed in this book.

[74] See Eliasson (1976a, Chapter XI, Section 4). We have chosen to keep such exogenuous, random elements shut off in all experiments of the model so far.

[75] Same as (III:1) in Chapter III. Note for easy recollection that in the no external finance, no dividend, no inflation case this formula collapses into:

$G=DA=M*\alpha-\rho*\beta=RNN=RR$

Growth in total assets (A) equals the real (and nominal) rate of return.

[76] Note that INVEFF is the α, in (III:1), of the marginally added output capacity (=CHQTOP) through INV.

[77] The procedure is somewhat more complicated than this. Capital depreciation has to be entered, etc. See (III:13) & (III:14) in Chapter III.

[78] This appears to be exactly the point made by Brown-Greenberg (1983), namely that a divisia index of total factor productivity growth is a line integral. Its value depends on the path of integration, which of course in turn depends on the interaction of prices and quantities across firms and over time in our dynamic setting. B&G show that path independence only prevails when RIS = 0.

[78B] A survey on investments in R&D, production and marketing to the same group of firms as the planning survey sample used in MOSES simulations is currently being collected by IUI.

[79] Cf. Brown-Greenberg (1983). The problem of what to mean by productivity growth measured as the time derivative of the production function (Solow 1957) is neither trivial nor academic. Caves-Christensen-Diewert (1982) devote considerable effort to trying to find such general structures of production that arbitrariness in the productivity change measure is removed when the structures of production have been allowed to differ between the two points of measurement.

[81] Or:

$$DTFP = DQ - TFP*\frac{P}{\Xi}*\left[\frac{CH\varepsilon}{\Xi X} - DQ\right]$$

[84] or proportional. This is what Åberg (1969) and Berndt-Fuss (1982) more or less do.

[85] Note that this conclusion depends on the separability assumption associated with the shift.

CHAPTER VI EQUILIBRIUM AND STABILITY IN THE MOSES ECONOMY

1. Controllability

The MOSES economy has been equipped with a number of qualities that remove the nice conclusions from static, competitive equilibrium theory. We will argue in this chapter that in a true dynamic setting notions of equilibrium and stability, in order to be of economic interest, have to relate back to the welfare implications of a certain behavior of the economy.

Besides several theoretical questions which will be touched upon below, the equilibrium issue bears directly upon one important practical problem, namely the controllability of the national economy, as represented by the MOSES model. Does the economy, or the model need a (central) pilot to fly (to avoid crashing) or to stay within bounds? Is it a ship that goes to the wrong destination if not centrally guided, or is the economy selfregulating by an invisible hand that does better in terms of output than other guidance systems? What can a Government do to MOSES to improve economic performance over an indefinite time horizon, to pose a traditional question in economics?

For instance, are cyclical variations of varying amplitude a normal quality of a properly represented macro economic growth process? Does

Government interference reduce long-term economic growth as it goes about diminishing these fluctuations and/or does it simply build up a latent potential for an even larger swing at some later stage, as I have suggested elsewhere (E 1983a)? What sort of "equilibrium" are we thinking of if maximum sustainable economic growth requires a major economic depression now and then to remove tension in the system and to clear up mismatched structures? Should a dynamic model have ergodic properties in the sense that the system eventually converges onto the same growth path irrespective of starting point (initial conditions)? What social utility function - or rather, what kind of market regime - is best suited for an economy which is never in equilibrium and in general not predictable? What kind of role is left for Government?

(The M-M model we are discussing is populated by institutionally well defined firms that grow internally through an endogenized (with the firm) investment process. Decisions related to the future are taken on expectations generated through "intelligence" functions based on past price and quantity signals. hence the firms set both prices and quantities individually.

Endogenous investment, intelligence gathering of noisy price and quantity signals and individual price and quantity setting introduces very new properties in our macro economy.

The endogenous capacity augmentation phase effectively removes the situation of a pure exchange economy, an assumption which has been very helpful in introducing convergence towards a stable equilibrium through a non-tatônnement process, without (Smale 1975a,b) or with explicit (Friedman 1979, Clower-Friedman 1982) transaction costs or intermediate trade specialists.

It is the capacity augmentation mechanisms that matter for (probable) non-convergence in a static sense. When coupled with expectations functions that read off actual price and quantity signals in markets we meet with the phenomenon that "communication channels are interrupted or become 'noisy' when the system departs too far from its 'equilibrium' motion" (Clover, 1975). Once in disorder I see no generally acceptable restriction to impose that will take the system back to order or equilibrium even in time (E 1983a). I would like to reserve the term "dynamic" to economic models with these properties. Here equilibrium and stability conceptually merge and it becomes more interesting to talk about boundedness. Leijonhufvud (1973) discusses this as "corridor" phenomena.

As Clower (1975) notes the set of possible conjectures on this theme is effectively unbounded. We have a policy problem; how should the market regime be organized to keep the economy within a "corridor" defined by some welfare criteria (E 1983a)?

If general unpredictability is a natural state of the economy it becomes natural for market agents to develop elaborate information gathering systems. The expectations function in a MOSES firm represents these tasks. There is no explicit cost associated with information gathering in a MOSES firm, except that intelligence gathering and interpretation takes time and - in a disorderly economic state - generates more or less erroneous signals (forecasts). It is only to regret that we did not fully recognize the importance of information gathering sufficiently at an early stage of MOSES model work.

In a parallel study at the IUI (E 1984a) we observe that large business firms spend perhaps more than half of their resources on intelligence gathering about their interior life - which is well recognized in Chapters II and III - and about the external markets. Marketing efforts is of course the main activity in this respect, occupying some 25 percent of total costs in the 20 largest Swedish corporations.[85A]

This observation has two strong implications. First, the economic mechanisms usually associated with the market also become more or less a natural element of the informal information system of the firm, making the institution called a firm as such endogenous as to size and content of activities and demarcation lines vis a vis the market (see E 1984a).

The only way of keeping the traditional distinction between the firm and the market well defined is to introduce specialized traders in information, the actions of which we call the market.

Second, the ambition to monopolize or to control a market becomes natural to the firm, not in order to expropriate static monopoly gains, but to achieve some predictive order vis a vis the market (cf. Arrow, 1959). The welfare implications now become very different from those derived from static theory.

While the MOSES firm strives to achieve predictability for its external market environment through elaborate intelligence gathering mechanisms,[85B] the main competitive instrument of the MOSES firm is to create technological quasi rents (positive ε in Chapter V) that allow them improved market control, and that lowers market control for their competitors. Hence, information gathering and use is not only a dominant interior firm activity it is also the dominant generator of "technical" improvements in the firm being perhaps much more important to consider than what we generally mean when using the term technical change (see E 1984c).)

In introducing technical change Joseph Schumpeter began his discussion by assuming a Walrasian equilibrium as the initial state. This equilibrium was then disturbed by the entrepreneur, who created a temporary monopoly for himself by his innovations and thus started a growth process (see previous chapter). We have to accept that it may not be possible to establish a Walrasian type of equilibrium (or a steady state) at all in the MOSES economy to start from.

Kirzner (1973) on the other hand introduces the entrepreneur as a vehicle that stabilizes the economy, moves it towards "equilibrium" by exploiting the opportunities that reside in the business environment.

For any discourse of that kind to be meaningful we have to define what we mean by "an equilibrium". We have expressed scepticism about the usefulness of the concept as such already because it forces us to think or reason as if an equilibrium of the standard, static type exists. We reject that notion. We then, however, have to create an alternative concept. We introduced the capital market rent ε in the previous chapter, as the temporary profit consequence (rent) of the successful innovative activities that move the economy.

2. The Market Game Situation

In the MOSES economy agents are differently endowed with information about their environment and about themselves.

More information can be gathered, but gathering is time consuming and costly, and when some information has been acquired the market game situation has normally changed, since the new information changes every agent's behavior. Hence, intelligence gathering to improve the information base for a decision is not the typical decision procedure but rather search according to a set of rules that are currently updated, and a rapid realization of mistakes through scrapping.

Essential information is always missing in a typical business decision and for reasons to be given below, the situation can be described as one of pure <u>uncertainty</u>. It is inconsistent with the logics of the model design to restore a transitive choice situation of outcomes by equipping agents with the faculty of calculating subjective probabilities or certainty equivalents that come true on the average in the longer term. Rational <u>expectations</u> will hence be a misleading abstraction.

Mistaken decisions due to lack of, or erroneous, information generate a continued state of non-clearing market situations at the micro level, or a dispersion of partial or special monopolies. This in itself defines a state of "disequilibrium", and in such a state there is no reason to expect that there should be a single market price (Reder 1947, pp. 126-51), which is exactly the result exhibited in the labor market (with homogenous labor) in MOSES simulations.

One has to recognize that a model structure of the MOSES type with endogenous price and quantity adjustments may not have equilibrium properties, but may exhibit different evolutions that depend on initial structures. One also has to recognize the distinction between the consequences of taking action before marginal adjustments (ex ante) have been made and not taking action because it appears as if a better positioning can be reached. Whether the economy has long-run equilibrium characteristics or not it will take more or less time, or for ever, to learn how to hit the global optimum. There will be a trade off between decision rules that lead to fast action or to exactly the right action.

In this economy <u>rationality</u> is something much broader than optimal choice. Given what information the agent or the decision maker happens to have, he behaves rationally if he strives to improve his utility position through a continuous learning, and if he never takes steps that deliberately lower his ex ante perceived utility. All MOSES agents behave rationally in this sense of applying a gradient search rule with relatively weak information requirements of the kind that meets realistic decision settings.

Rationality also requires that decision rules are changed or adjusted when they consistently lead to mistaken action. (One can then - in a MOSES dynamic market setting - have the paradoxical situation that optimal decision rules derived from standard theory consistently lead to a deteriorating utility position and are changed for better rules.)

If agents are very differently endowed with information and if the workings of the economy is of such an order of complexity that even a very large number of experiments on the economy (or searches) does not make it possible for individual agents to learn and form rational expectations, then we have the typical market situation of a non-cooperative game. The equilibrium - if it exists - is a set of solutions rather than one point (see Johansen 1982).

3. Equilibrium

Time requirements are critical. This lends very special qualities to any equilibrium one desires to define.

Each period a set of prices can be computed that clears all markets. This set of prices can also be defined such that it leaves all agents with desired inventories, given the same prices.

In general, however, this set of prices is not compatible with

(1) efficient next period production (output), or

(2) the preservation - through investment - of existing capital installations. Neither is it compatible with

(3) the same production set the next period.

Hence, the next period supply of quantities in the market will generate a new set of clearing prices and so on, that moves production plans and investment plans ahead at different rates etc. The interacting of prices and quantities (p,q) over time is the concern of this chapter. Can the market perceive and peg a set of prices ($\bar{p}$) which makes quantities converge upon some stable set of growth trajectories ($\bar{q}$), such that we can talk about a "stable equilibrium quantity vector"? Or is there a dominant player with enough resources to trade at those prices until the whole economy caves in onto his set of prices?

The former is the traditional question and it is normally addressed as a mathematical optimization problem. If there is a solution, the "auctioneer" will certainly find it if enough time and market struggle is allowed for.

However, if there is no global optimum what kind of animal do we have? What will such an economy do to us if allowed to "move freely"? Is the solution set narrow enough to allow us to talk about "the equilibrium" as a bounded n-dimensional oscillation?

Are the bounds in the n-dimensional corridor path independent, or will the location of the corridor depend on where you begin or how the system "steps along"?

Should we even consider dramatic changes of corridor locations (collapses) now and then? Perhaps there is no corridor system at all, and no resemblance of an equilibrium situation, or "chaos", as it has also been called.[86B]

Within static economic theory, which so far defines the bulk of the so called general equilibrium theory, this question marks the end of inquiry. In the world of competitive equilibrium theory it is generally frowned upon if the model does not exhibit some sort of equilibrium where a disturbed economy can come to rest (stability) if it finds its way there. What can theory tell us otherwise?

This reasoning is of course scientifically unacceptable if there is any evidence to suggest the opposite. If the real economy has got no stable, static equilibrium - which is perfectly possible - then equilibrium theory may give entirely misleading predictions and especially when predictions are transferred to a real economy in a disorderly state. This means that we cannot accept as a working hypothesis that statics is a limiting case of dynamics and that "properties of a (comparative) statical system" give information of the dynamic system (Samuelsson (1947, p. 284) on the correspondence principle)[86BB].

Suppose there is an equilibrium where the economy will stay <u>if</u> it finds its way there. But suppose dynamic processes (search rules, the institutional specification) never, or rarely, takes the model there. The first question - conditions of equilibrium or rest - is the fundamental existence and stability problem of static, competitive analysis.

It has nothing to tell of <u>how</u> to get there in a dynamic environment. The latter is our problem, which I have not seen discussed much in literature.

Why are we at all interested in equilibrium and stability? Of course, because quantities that move erratically within widely defined boundaries are socially undesirable (E 1983a) and defy our sense of social economic order. If the free national economy is inherently unstable or unbounded then we want to impose restrictions (regimes) and policies that narrow down the boundaries to what is socially acceptable. This defines a national economic policy technique that can be more or less competent. As part of this general problem we have to accept the <u>possibility</u>

<u>that</u> a market economic system is inherently unstable in an equilibrium sense, and can be disturbed by policies;

<u>that</u> there are limits to the stability (boundedness) that policy makers can impose, beyond which the system is rather unstable, and

<u>that</u> a distinction has to be made between stability at different levels of aggregation.

This is again the general notion of controllability of an economic system. Any systems theory of an economy, like a Keynesian model or a general equilibrium model is characterized by the degree of which the system is self-regulative or needs policy guidance to move within a predetermined bounded domain. Controllability has to be addressed if we think we <u>need</u> a dynamic model like

MOSES to understand the real world; with prices and quantities being dependent upon one another over time.[86BC] In a dynamic model we can leave the world of the Walrasian auctioneer and ask the question, what happens if a dominant player - a monopolist like the Government, a large trade union or a large firm - simply keeps trading at a predetermined set of prices, which would not be an equilibrium set of prices, and which could never be, if we are confronted with a non-cooperative game. This is the general notion of "price regulation". It is exercised in planned economies. It was exercised partially through the Bretton Woods, fixed parity system in international trade. It is the rationale for the existence of monetary policy as something different from fiscal policy (see Section 4 in Chapter IV), and so on. Now suppose that "price regulation" so defined can be effectively imposed and/or that it cannot be countered through the creation of black, gray or unobserved markets (that is just an unrealistic, theoretical assumption). If the dominant player through financial resources, exhortation and/or political stamina can impose that price vector indefinitely the structure (quantities) of a dynamic, micro based economy, like the MOSES model, will eventually adjust to the imposed price vector.

It may not be possible to impose (theoretically still) any price vector, because a large set of price vectors may generate quantity oscillations that are socially unacceptable, but nevertheless, there may exist a set of price vectors that, if imposed, gives the entire economy a satisfactory quantity performance.

This is in essence the policy problem of a national economy. In the MOSES economy there exists some truly exogenous prices (foreign prices) that can be manipulated at the border through the exchange rate. Fiscal parameters can inflict "wedges" on the domestic price system. The domestic interest rate can (in principle incorrectly) be made exogenous. What are the options of controlling such an economy through policy manipulation in the sense of doing better than leaving the economy on its own, with a fixed regime specification? And what do we mean by doing better?

This is the way the equilibrium and stability problem should be formulated for a dynamic economic system. It concerns the relative performance of the invisible and the visible hands.

4. Equilibrium and Stability - a Policy Problem

If individuals would accept a wide margin of variability in an economy then the problem of equilibrium and stability would go away. Equilibrium and stability in economics carry no interest except in a welfare context. In fact these concepts have to be discussed in such a setting to be properly framed.

To make the welfare point let us discuss what happens to firms in the MOSES economy as if they were individuals. Can we use the traditional welfare criteria in the dynamic setting of the MOSES economy? (Hahn (1982) does that in the dynamic setting of the real U.K. economy in discussing Mrs. Thatcher's policies, see below.) We attach two meanings to a pareto optimum. The first relates to the concept as traditionally defined when extended in a dynamic time dimension with more than one generation. We begin with that. The second is a more commonsense notion. If the economy is not in pareto optimum, meaning that some can gain without hurting anoyone else then the regime will not be in long-run equilibrium. There will be economic forces at work to move the regime towards pareto standard. If the first (dynamic) notion is ignored, as in Hahn (1982), an entirely different conclusion is reached. This discussion is important to determine what the Government can, and should, do. In the process, however,:

(a) the economy may move through several depressions clearly making some individuals better off for some time at the expense of others.

(b) many, or all, of the initial population may die. Future bliss, if it at all exists will benefit future generations.

Even without the generational problem, to apply the pareto criterion one has to make the absurd assumption that each individual's time preference is known so that a "pareto optimal" time path up to bliss can be chosen.

With sequences of generations a pareto optimum must mean that a Government should only pursue policies that leave each individual in the next generation at least as well off as each of his predecessors. Besides being nonsensical, such policies may not be at all feasible in a dynamic economy. The normal situation in a dynamic economy probably is that some gain and some loose all the time for the economic process to stay alive at all. So, in a dynamic setting the whole set of traditional, static, ground rules associated with the welfare assessments ceases to be of much interest.

If attainment of pareto equilibrium conditions in the future can only be reached by breaking the same conditions over an indefinite time span, then forget about the whole idea. The complication of dynamics is elegantly sidetracked in Hahn's (1982) beautiful discussion of the pros and cons of the invisible hand as represented by Mrs. Thatcher's ideas, based on a strictly imposed pareto criterion and a zero time dimension.[86C] To begin with it is wrong to talk about an invisible hand in the static Arrow-Debreu model. The invisible hand cannot guide agents that do not form both price and quantity decisions (as pointed out by Arrow, 1959), only hold them in place when in equilibrium. Will the removal of the pareto obstacle give more leverage to the market or the Government intervention argument? This is a highly practical question, that can be illuminated in the MOSES context.

As far as can be learned from a very large number of simulation experiments on the model, continued economic growth at the macro level requires a constant transformation of micro structures. The origin of this Brownian motion at the micro level in turn can be traced to the prime mover of the economic system, namely constant innovative (or technical) change at the micro level. Innovative change is, however, only a necessary but not a sufficient condition. The institutional setting (we have called it "the market regime") has to be the right one. The market regime has to support change at the optimal rate. Too rapid change can disrupt the system; too slow change means low, or no, economic growth at the macro level. The MOSES economy always takes a long time in exploiting the technological frontiers introduced by the innovators (E 1979). However, as far as can be seen, the maximum, sustained macroeconomic growth for a given innovative input has to be supported by a sequence of overlapping long- and short-run cycles.

Macroeconomic growth can "temporarily" - for several decades - be speeded up by countercyclical policies that remove recessions and/or by a more rapid reallocation of resources - only to be followed by a "collapse-like" development (E 1983a).

The collapse can be avoided by constraining the allocation process at the cost of slower macroeconomic growth and a larger exposure to exogenous shocks - in an open economy - from foreign competitors that upgrade their competitiveness.

5 The Preservation of Structural Diversity

The preservation of structural diversity appears to be an important feature of a stable macro growth process (E 1983b) and the capital market process is the prime vehicle for controlling the system in that respect. Even with homogenous labor the productivity of labor depends on its allocation in space. If there is enough variation among firms there will normally be enough variation in wage paying capacity to generate wage dispersion. If wages are "regulated" and not much variation is allowed (E 1983b), the low performing firms are forced out of business and the high performers earn a hefty profit. For such an economy to preserve diversity there has to be a steady input of high performing activities, to allow the average level of wages to increase continuously, all the time killing off a tail of low performers.

If this does not occur, either wages have to spread again, or the distribution of ε (see previous chapter) flattens and the average ε diminishes. This is a sign of latent instability (E 1983b) that we also saw develop in the Swedish economy in the middle 70s. A small upward shift in the interest can suddenly make the "bulk" of ε negative causing contractions in production, investment and employment that eventually restores diversity through an adjustment of the overall price structure. During the adjustment process the macro economy suffers a collapse, a depression or a recession depending on its extent. Apparently flexibility of prices plays a rôle in avoiding severe quantity adjustments. However, it does not follow generally that the faster the price adjustment the better (E 1983a) because price adjustment can easily get disorderly, decreasing market predictability in the economy. Downward rigidity of nominal wages means that firms opt for curtailing production when profitability standards are not met. However, the key notion in the adjustment process ultimately is the rate of return standard imposed on the economy. In an open economy, like the Swedish one, where both product prices and the interest rate are imposed more or less from the outside the economy and wages have to stay in line as was elaborated already in Chapter II.

In a closed economy in the traditional sense we only have to ask what capital owners can do alternatively with their resources. It is very difficult to imagine a market economy in which the foreign interest rate or interest rates in other countries do not play a crucial role in setting a lower limit to rates of return. A rigid rate of return target "floor" in a badly performing economy either forces improved performance through productivity improvements and/or domestic price adjustments and/or a quantity collapse, as we have demonstrated. Even though the ownership function is only symbolically present in a MOSES firm, we discussed it at some length in Chapter III because contrary to the anonymous capital market the owner is a "trader" in Clower's sense between the business and the capital market that operates directly on the "productivity solution" helping supplying finance to profitable producers and removing it from bad performers.

Suppose there is no owner and a completely closed economy. We have not yet set up such an experiment, but we can do it by forcing imports and exports to be zero and by removing financial transactions across the border. The latter can technically be done by closing off the monetary sector and imposing a firm profit target of the pure feed-back type without any external inputs. Even this economy would not be safe for collapse prone developments, since there is always domestic competition for resources, notably labor. Firms with superior productivity performance bids labor away from bad domestic performers. Only when domestic competition is closed down, by removing incentives or possibilities for labor to move and by allocating intermediate goods by some other means will market generated quantity collapses disappear. Then - using the MOSES targeting system - firms will adapt individual targets. No reallocation gains will occur and economic growth will presumably dwindle away or turn negative.

Since there will normally be some competitive processes at work, even in a planned economy, economic growth will be associated with a cycle that reflects both sides of the allocation process, entry and expansion of new processes and exit. At the micro level this allocation process constantly changes the work environments of individuals. Individuals will lose their jobs. They may find better paying jobs, but once in the market they may have to accept a lower pay than before. The ability of the economy to avoid macroeconomic collapses may decrease if the downward rigidity of nominal wages of people employed is removed,[87] and so on. Taken together this means that the growth process will constantly violate the pareto criterion. A successful macro economy will require a population of gamblers or a very efficient compensation or insurance scheme.

(A perfect insurance or compensation scheme, with zero gambling involvement on the part of individuals would, however, require heavy restrictions on the systems specification.

Insurability requires that all uncertainty be calculable risks. This in turn requires that the market somehow can enumerate all possible outcomes over the indefinite future, apply an interest rate and compute and choose the best paths? If all the possible combinations of paths can be surveyed and players can form the necessary coalitions for everybody to be in a position that he will not be inclined to leave, we have by definition a Nash equilibrium.

How about that in MOSES? Take the first step the wrong way, and only a second best solution is open, and so on. The fact that action is taken before available knowledge has been analysed fully by the agent and by the system is enough to guarantee that errors will be made frequently. Hence, one cannot survey all possibilities and make such a choice.)

5 The Growth Cycle

The essence of the macroeconomic growth process can now be summarized by the following factors:

(1) The human capital productivity potential resulting from the combinatorial activities of "the entrepreneur" is extremely high. The distribution of this combinatorial competence is unknown and/or the outcome of such combinatorial activities is highly unpredictable.

(2) The socially and culturally defined market regime determines the extent and intensity of entrepreneurial search for new combinations (innovations) and hence the average outcome. The regime is extremely difficult to parameterize. It includes individual and political preferences, risk aversion, incentive systems and educational achievement levels of the economy etc.

(1) and (2) to some extent incorporate non-economic factors that supply a continuous, exogenous "feed in" of diversity. Innovations upgrade the quality of new investment exogenously. The investment decision of the individual firm is, however, endogenous.

(3) Rents (called ε) from successful innovative behavior arise temporarily in the economy. They first accrue to the "contract holder" of the innovation and benefit the rest of society indirectly through a higher and more efficient production, with the delays needed to develop (invest in) the round-about process. The contract holder in our simulations is the owner of the net worth of an individual firm.

(4) Competition in all markets limits the extent of temporary rents, forces inferior units to exit (creative destruction) and releases factors of production (notably labor) for more productive employment elsewhere.

(5) The investment decision in the firm is moved by the rent ε, and the firm decision makers are only partially aware of the origin of the rent.

(6) Price decisions in firms are taken on the basis of perceived prices as offered and charged by all other agents in the market, as computed by the firm under a profitability constraint. The complexity of the market game makes it impossible for each firm management to foresee the consequences of all possible activities of all other firms in the market.

Hence this game appears to be of the non-cooperative type and the distribution of rents is dependent upon how, and how fast, all participants in the game jostle into position in each market (competition).

(7) The market process generally pushes the economy towards increased static efficiency, conditional upon the future relative prices as viewed (expected) by agents in markets at each point in time.

(8) The adjustment of quantities towards static efficiency, can be too fast and generate gyrations in the price system of the economy that lowers predictability and takes the economy down below the growth trajectory on which it would have travelled without these gyrations. This new trajectory embarked upon each period changes all future trajectories open to the economy if, and when, the price system is stabilized. The new price system will in general be different from the one that would have persisted, were it not for the disturbance that initially sent the price system into gyrations. The long-term reason for this is the fact that the new trajectory implies a changed relative cost structure in the economy due to structural adjustment and a different allocation of investment.

The adjustment process can also be erroneously conceived. Expectations can be wrong or prices can be fixed temporarily in positions not supported in the longer term by the market process, by a dominant player like a price leader or a price controlling agency.

Attempts to fix prices in relative positions that are not supported in the longer term by the market process disrupt both quantities and prices after some time. Disruptions generally take a long time to correct and tend to lower price predictability in markets throughout the adjustment period. Disrupted relative prices are symptoms of increased uncertainty (lowered predictability) and are at first interpreted by agents with the old rules of thumb. Mistakes are made and agents scramble to relearn and adjust interpretation rules. In the process, caution prevails. Growth rates are down.

(9) The supreme arbitrator of the M-M economy is the rate of return requirement imposed through the Fundamental Equation (III:1) in Chapter III on each firm. It can be viewed as both internally generated (from past performance) and externally imposed by the capital market.

(10) The capital market is decisive for long-run economic systems performance in the M-M economy. Widespread and very large rents tend to generate waste (misallocation) in the investment process. Too small rents tend to shorten the gestation period - to use an old Austrian term.

There is a tradeoff between short-term allocative efficiency and the ability of the economy to maintain investment activities that take a very long time to generate profits. The optimal balance (the "interest problem") is a problem that has to be settled empirically. The short-term allocation aspect is the traditional, neoclassical, micro interpretation of the Wicksellian hypothesis. The other alternative has been emphasized in Dahmen

(1983). For instance, if rents are kept high in a low performing industrial economy through low interest rate policies or generous tax policies, the result is different from the case in which rents are high because of a superior commercial performance relative to, say, an international market interest rate (cf. Chen 1979).

One consequence of allowing the endogenously determined rents ε to affect individual firm investment is that cyclical behavior unavoidably enters as a natural factor in the growth process. Two factors can start the cycle; (1) an exogenous, unexpected change in market conditions for firms; or (2) a failure of the market system to establish a transparent, predictable price system and to adjust quantities to it, barring exogenous changes in the price system. The reason for the cycle is that it takes longer to create the new superior capacity to produce than it takes to scrap installed, inferior capacity. There is always an intermediate solution that is superior in stabilizing the price system and the economy on the best sustainable growth path.)

6 Managing the Growth Cycle

The conclusion appears to be that economic growth is a genuine disequilibrium process. The state of disequilibrium is reflected in the extent and dispersion of rents ε, or entrepreneurial remuneration, in the economic system. These rents cannot be removed without disturbing the economy or at least eliminating macroeconomic growth. An economic system with no rents or approximately so, meaning equally looking and equally performing firms, will be extremely unstable and exposed (E 1984b). We have not been able to derive any analytical conclusions on the properties of the MOSES economy with all ε_i competed away ($\varepsilon_i = 0$), but I venture the hypothesis that it will collapse, rather than approach a zero growth situation as all $\varepsilon_i \to 0$.

If this is true static, equilibrium theory gives misleading advice on policy options and static welfare economics is irrelevant as advice on policy choice.

(The Government can now enter this market scene in two ways. It can (1) act as the dominant player against all other agents in the system and force structures in line with its intentions. This is a power game and the likelihood is that any dominant player will loose in the end lacking the necessary power and - most important - lacking knowledge to know what it is doing. The second (2) approach is to play with the market and modify its institutions to smooth quantity adjustment. This more or less means a continuous upkeep and change of the value system as enacted through the institutions of the political process, legislation, welfare, unions, etc. with the purpose of helping economic growth along.)

The first departure from traditional policy doctrine will have to be to modify political notions of fairness and efficiency. A well functioning economy will mean unequal wealth distribution as generated in the production system.

A well functioning economy will mean different pay for the same labor input, depending upon the allocation of labor.

It will mean some degree of market control on the part of firms to obtain a balance between short-term efficiency and predictability on the one hand and long-term growth performance on the other. The temporary monopoly rent finances long-term, risky ventures, an idea voiced frequently by Schumpeter.

It will mean a constant change of work environments of individuals, and on ongoing scrapping of firms due to market failures.

The optimal policy regime would have to be concerned about maintaining a continuous state of inequality in wealth creation and work remuneration, but also a steady transformation of micro structures, meaning that both individuals and firms should normally change their relative positions over time.

No more conclusions can be drawn at this stage. The MOSES economy as it now stands has two open ends. The behavior of individuals - with the exception of labor mobility in response to wage change - is represented in macro.

There is no variation in work effort in response to changes in work remuneration. And there is no feed back from wealth creation, who benefits from wealth creation and the innovative process of the economy. This would require micro specification at the level of households and people as well. By giving this chapter on equilibrium and stability a social dimension this also appears to be a natural and an important, next step to take.

SUPPLEMENT

LIST OF SYMBOLS

CHX = ΔX (absolute change)

DX = ΔX/X (relative change)

EXP( ) = expectations operator. Generates expectations on ( ) on the basis of past observations of ( ), and external inputs.

TARG( )= ditto targeting operator. See IV.1.b.

: = make equal to (in Algol)

A = total assets (K1+K2=NW+BW)

α = P*Q/A

β = K1/A

BW = debt

DIV = dividends

G = firm probability targets (see I.1.a)

INV = investments

INVEFF = inverse of marginal (gross) capital output ratio in new investment vintages.

L = labor input

M = gross (operating) profit margin (operating profits/value added)

MTEC = labor productivity in new investment vintages

NW = net worth

K1 = production (depreciable) assets to which ρ applies

K2 = all other assets

$\bar{P}$ = value added price

P = product price

P(DUR) = price of investment goods

Q = production volume

$\bar{P}$*Q = value added

QFR(L) = production frontier, a function of L

ρ	= economic depreciation rate
SH	= market value of NW or the firm
ϕ	= BW/NW
Φ	= SH/NW
ψ	= opportunity vector (see I.1.b)
Ψ	= investment budget (see I.2.c)
Θ	= DIV/NW (dividend payout ratio)
R_{ij}	= real rate of return in division j in firm i
r	= market interest rate (in Chapter 3)
RI	= market interest rate (in Supplement)
RIS	= nominal, short-term market interest
RIS_i	= nominal rate, short-term local (i) interest rate
RIL	= nominal, long-term interest rate
RNW	= real return on net worth
RRN	= nominal rate of return
τ	= expected rate of return on property investments
T	= expected rate of return on investment in stock.
ε	= individual division "rent" = $RRN_{ij} - RI_i$ (see I.1a)
$\hat{\varepsilon}$	= individual firm target pressure factor ($\hat{\varepsilon} > 0$ but small. See IV.1b).
$\hat{\hat{\varepsilon}}$	= individual division "slack factor" = QFR(L) - Q ($\hat{\hat{\varepsilon}} > 0$ but small, as perceived by CHQ management).
RAM	= Rate of amortization of BW.
S	= sales value
SH	= market valuation of NW
ξ	= sales/value added ratio ($S/\bar{p}Q$). Hence ($\xi - 1$) is the ratio between external purchases of goods and services and value added.
TAX	= tax payments.

Notes

85[A] See E 1984b, Table 9B, p. 42.

85[B] Note that even though I write so, the corresponding model representation today only fractionally matches the real activity going on.

86[B] Note that chaos is perfectly consistent with the existence of an equilibrium point, but the economy is never there and does not even approach it. See Day (1982a&b).

86[BB] Competitive equilibrium theory, for instance, is only concerned with the existence and stability of equilibria, and not at all about how they are to be reached. Approach has to be guaranteed for the correspondence principle to apply.

86[BC] Endogenous and interactive price and quantity adjustment at the micro level, is exactly the specification that gives rise to all this trouble.

86[C] Of course the verdict comes out against Mrs Thatcher, which was probably the idea from the beginning.

87 Downward rigidity of nominal wages of people holding a job is currently a feature of the model.

PART IV THE MICROECONOMETRICS OF MOSES

CHAPTER VII ESTIMATION, DATABASES, TRACKING PERFORMANCE AND THE EMPIRICAL APPLICATION OF MOSES

1. Introduction

There are four kinds of empirical issues related to the MOSES econometric model. The first issue concerns the problems of estimating the behavioral relationships in the model. Since most economists are unfamiliar with these kinds of models, a comparison between the nature and quality of information carried in the MOSES system, and a more familiar macro model is warranted. Some results on the current empirical state of the model should be presented. It turns out that this to a large extent means accounting for the micro database upon which the model is run, and only secondarily has to do with statistical fits at the macro level. Finally, an empirical chapter should also report on the empirical analyses for which MOSES has so far been used.

2. Micro Estimation

The ideal econometric procedure would of course be to estimate every single relationship at the micro level under the constraint of a time series of real macro data that also the model can generate. Let us assume that we have a very simple micro econometric model consisting of n identical, but numerically different, linear equations.

Each micro agent posseses k different dependent variables (Y_{ij}) and there are l independent explanatory variables (X_{ij}).

All variables add up exactly to their corresponding macro (internal accounts) variables

$$Y_j = \sum_i Y_{ij}$$

$$X_j = \sum_i X_{ij} \qquad \text{(VII:1)}$$

The straightforward procedure would be to apply multiple regression techniques to a time series for each individual ij relation, or a simultaneous technique to a block of relations, explaining agent behavior under the constraint that, except for an error term, the model tracks macro (Y_j,X_j).

The other extreme would be to assume that all conditions for OLS on each individual relation are fulfilled. Bad macro tracking would be explained away by bad macro statistics - a good point in general, but not here.

Neither extreme approach is satisfactory. Since our main argument for the micro approach is the treasure of high quality micro information that we have, micro estimates should be given a fair chance. A general (Bayesian) approach to estimating the M-M model would be to weigh the sum of squared deviations at the micro and macro levels together, assign a relative weight to the macro deviation that signifies its relative importance in statistical quality, and then minimize the weighted sum of squared deviations.

Another approach would be to assume that each macro aggregate is associated with a stochastic error of measurement and assume that the errors average to zero in the sample for all Y_j. Given these conventional, stochastic a priori assumptions all micro parameter estimates can be given traditional stochastic interpretations. This is all right for the very simple model that we used as an example. For these simplistic micro models such estimation procedures have also been tried.

Difficulties show up when we take the first steps in the direction of MOSES realism.

Three problems in particular should be mentioned in the context of estimating micro based macro models.

(1) Aggregation is explicit. A comparison of problems of estimating conventional macro models has to include a comparison of prior aggregation assumptions in the macro model with behavioral specifications (priors) in the micro model. If these behavioral assumptions are well researched by micro inquiries such a comparison ought to come out in favor of the micro approach.

(2) Specification is immensely more complex and hence, presumably more realistic. Non-linearities are normal and many specifications involve qualitative choices like exits, entries to markets etc. (see Brownstone 1983).

(3) While exogenous variables are decisive for predictive performance of macro models, this is not the situation in a dynamic micro-to-macro model. Initial conditions dominate macro behavior rather

than the relatively few exogenous variables. Hence, the quality of initial database measurement becomes crucial. A related, and interesting problem is whether the MOSES model has and/or should have long-run "ergodic" properties in the sense that it converges in the long run on a state that is independent of the initial state. (Imposing ergodicity means entering a prior dynamic equilibrium property of the model - a theoretical requirement. Like the corresponding property of static models, dynamic equilibrium (ergodicity) is an untestable assumption. I have not made up my mind whether I want such an assumption in a dynamic model. By carry-over of conventional wisdom from static theorizing, one could plug it in without further contemplation, and it would probably be accepted by most economists. Contrary to the case in static theory, however, this assumption does not simplify the mechanics of our analysis. Neither does it sufficiently narrow down the set of possible predictions.)

These considerations have led me to conclude that good and well researched behavioral specification entered as priors, and high quality data are far more important to consider than the traditional estimation problems.

3. The Information Content of MOSES

The information content of the MOSES Econometric model system is another issue. Information is carried very differently in the MOSES model, compared to what we are used to in conventional macro models.

For one thing the model is dynamic. Agents are not resting in equilibrium positions at the end of each period and this is part of their behavioral specifications. Hence, it is theoretically incorrect to estimate parameters on single cross sections of data. Panel data on agent behavior are needed, and then initial conditions become important.

In a macro model the bulk of information about the economic structure is stored in the estimated coefficients. Since macro model specification is often of the linear, or slightly nonlinear, type the information in the linear specification is restricted to an enumeration of the variables.[87]

Using a linear format would distort information if linearity does not in fact hold.

In the MOSES process model the information that appears in the coefficients of the macro model resides in (1) the initial structural specification (the state variables), (2) the hierarchial (causal) ordering of the market processes that regulate the interrelationships between all decision units of the system, in (3) the estimated, and (4) the postulated coefficients of the behavioral relationship, and in (5) the specification (taxonomy) of the micro units.

a) Initial Conditions (database)

Problems associated with measurement errors and internal consistency in initial database specifications are as a rule (completely) neglected in the context of macro modeling. We cannot do that in the MOSES model, a circumstance that makes it appropriate to discuss the quality of the initial database here.

The predetermined variables in all models are exogenous variables and lagged endogenous variables. The importance for macro model forecasts of "correct" specification of ("forecasts of") the exogenous variables have been discussed at length in the literature. There is, however, very little discussion on the importance of correct specification of initial values of lagged endogenous variables. The lagged endogenous variables correspond to our initial database. Can this be taken as indirect evidence that errors in measurement and consistency problems associated with the initial database "do not matter" in macro modeling, while exogenous, predetermined variables do?

We have exactly the opposite experience from the analysis of the MOSES micro-to-macro model. Exogenous predetermined variables (they are very few) mean relatively little, while initial database misspecification can generate a very different forecast compared to one where known errors have been removed.

The bulk of the empirical information on the Swedish economy vested in a micro-to-macro model of the MOSES type resides in the measured, initial state variables (initial conditions). They are continuously (quarterly) updated by the model as the simulation experiment runs on, and we know from experience with the model that the nature and the quality (overall statistical consistency) of initial conditions very much determine the properties of the simulation. The estimation problem here is good statistical measurement (the database technique). Therefore, we have invested considerable effort in obtaining a consistent micro-to-macro database to start simulations from. (Albrecht-Lindberg 1982.) In macro models, systematic errors of measurement are picked up by the estimated coefficients and given economic interpretations.

In some sense this dependence on initial conditions is a handicap. The dynamic properties of the MOSES economy are not very robust vis a vis the initial state description. There are two types of variations in the initial state description that we have to consider; (1) actual variations in the "real" state that we measure and (2) errors of measurement, and internal database inconsistencies.

Concerning the first problem, it could be argued that models should be designed a priori so that long-run properties do not depend upon initial conditions. I disagree. In my opinion, no dynamic model should be so designed. If the responses of a policy parameter change are very different depending upon whether they are enacted at the bottom of, at the middle of or at the peak of the business cycle, initial specifications will be decisive (see E 1977).

This is an empirical question. It has to do with the quality of measurement. As mentioned, this is where most of the project effort is currently going. We want the model to be sensitive to systematic inconsistencies in the database. However, the robustness of the model to stochastic errors of measurement should be fairly good. Robustness could be tested by designing an experiment in which the initial state description is polluted by random noise (Brownstone 1983).

In macro model building very few initial conditions are in fact needed. Much of the information residing in the initial database is ironed out through the imposed aggregation assumptions meaning as a rule that all agents are almost identical and that they all rest in, or closely to, equilibrium each period.

(While the micro-to-macro approach uses good quality measurement on initial conditions, macro model builders enter only a priori, ad hoc assumptions, that would rarely pass even a generous statistical test (see Klevmarken 1983 and Brownstone 1983). Micro-to-macro modeling is clearly superior.)

b) Specification (causal ordering)

The causal ordering of the interaction between decision units has to be specified. This corresponds to specifying the functional forms of the equation system to be estimated in macro modeling. The MOSES empirical background studies (notably E 1976a) have been used to investigate certain "facts" about the ways decisions etc., are taken within firms. Moreover, the MOSES measurement domain is close to the direct (human) observation level. When we don't know from direct case studies etc., we can use intuition, casual observation and scattered empirical studies. More empirical work is of course needed here.

All prior research notwithstanding, the conclusions enter as priors in the results that we infer from model analysis. The prior assumptions - they are all explicit - that enter the MOSES model are more numerous than the explicit prior assumptions that enter all macro models I know of. One way to compare the importance of a priori assumptions in micro-to-macro models and in macro models would be (Brownstone 1983) to adopt a Bayesian view, seeing these assumptions as part of the prior distributions. The contribution of the prior distribution to the posterior distribution generated on the data by the model then measures their effect. In this perspective all macro models rest on a vast number of implicit assumptions - at least as many as in the micro based model - that are necessary e.g. to obtain structurally stable relationships and that are often simply wrong. The improved specification of micro based macro models where aggregation is explicit hence means improved intellectual control of the analysis, which is a clear scientific advantage.

c) Estimation

Macro models have a clear advantage on the parameter estimation side through simple specification. There are no intricate causal orderings and only rudimentary initial state descriptions. The information embedded in the initial database, the structural micro specification and the estimated and assumed micro parameters (see below) appear explicitly in MOSES, while it is packed into the parameter estimates in a macro model through aggregation assumptions. Simple estimation techniques on macro time series data now become feasible.

The richness in specification in MOSES on the other hand, with many non-linearities, dynamic feedbacks and frequent switching of behavior takes us far beyond the capacity of current simultaneous estimation techniques. Furthermore, much of the empirical knowledge that enters the model, as mentioned, resides in its specification, and in the initial state (database) description of the model. This is a matter of priors that enter the analysis. These priors (database measurement ("facts") and model specification) are, however, generally introduced in MOSES in a form that can be subjected to empirical testing. But the fact that small variations in specification can mean a very different macro behavior of the model makes this perhaps a more important matter to consider than the traditional estimation problems.

The micro unit decision models (the firms) are principally tractable for conventional estimation on micro time series. A simplified, and not very realistic version of the firm model could be represented by a nonlinear, simultaneous equation system. In principle each firm model could then be estimated individually and be plugged into the market process as a block.

If this were possible, if the initial state variables were measured with great precision, if the same could be said of the exogenous variables and (finally) if the causal ordering of the market processes were right by belief and entered uncritically as a maintained hypothesis, there would be no more to say. The simulations would be the best representation of reality. If aggregate national account statistics were not compatible with simulations, the statistics, not the model, should be changed.

Estimation problems are not that simple. The MOSES firm model cannot be estimated directly, partly due to lack of data, partly due to specification problems. A realistic specification of the decision process inside the firm breaks the firm down into a sequential process. Parts (like the production frontiers and the investment functions) can be estimated. Beyond that, however, a causal ordering like that between the firms also regulates the interior firm decision process. This, however, has been formulated on the basis of a large number of interviews on the budgetary planning and decision organisation about the firm, prior to modeling work.[88] Hence the micro parameters of the MOSES system are either estimated, based on variously assembled evidence, or simply assumed. In practice this will always have to be the case, although the estimated and researched specifications should increase in importance. Hence part of the estimation has had to be carried out in the form of trial and error experimentation with parameters to make the model fit national accounts aggregates for an historic period, and to generate micro firm performance scatters of actual firms (see below).

d) Taxonomy

The taxonomies, of course, clearly differ between MOSES and a macro model. The statistical grid of the macro model has to be based on a number of more or less artificial classification schemes (sectors, types of markets etc.). The MOSES system goes right down to the decision unit, a firm, or rather a division, and at some later stage in the development of the model perhaps also individuals and households. This is much more natural in many respects. Above all, behavior is modelled on the structure of actual information and decision systems used in firms, and data are taken directly from the firms on their own format, which gives a measurement (statistical) quality, that macro economists will never obtain. Another advantage for the micro-to-macro modeler, is that he models a behavior that he in fact can observe himself by visiting a firm or a household. Macro modelers have to observe the world through statistical intermediaries, which is like using consultants. They keep much of the information to themselves.

The ideal taxonomy should, of course, be composed of basic elements with stable physical and measurable characteristics. The division or the single product firm - our "elementary particle" - should take us as far as we can hope to go in this respect in social sciences.

A division or a firm also operates on a well defined, financially oriented measurement system, and as a rule, is guided by a fairly monolithic decision structure concerned singularly with long-term profitability. This is more or less right in principle and would be fine in practice if economic behavior were organized in such a way that exterior (surface) behavior of an economic unit could be explained for our purposes without disaggregating further into the interior processes of the decision unit. This may be possible in many respects, but not when it comes to explaining growth in size of the decision unit (see E 1980b). Growth in size of a firm, as we have carefully noted, is primarily explained by its ability to earn a return on invested assets (a typical interior problem) and secondarily how it divides up these earnings or cash flows into one stream that is reinvested in the company, and another that goes elsewhere. The second, less difficult, part can be captured by our financially designed division or firm by modeling how it "leaks" or attracts resources.

Even so, a division defined by its business or "product" is not a stable institution. The life histories of divisions and firms entered in 1976 in a MOSES simulation (see listing in Albrecht-Lindberg 1982) can now be followed from 1974 to 1982 as financially defined institutions. Their "definitions" have often changed significantly during that period. The firms may have reorganized themselves on a different organizational taxonomy (new divisions). The product definition may have changed or the production technology may have changed through acquisitions and divestments, rather than through internal reorganization. This means that establishment growth (change) in the MOSES database is not one hundred percent internal and regulated by the rate of return and the cash flow as the model presumes. This we have to accept and it won't help to disaggregate further down along production activities because then "institutional change" begins to increase again. A production line is normally very unstable in terms of structural or institutional definitions.

This means that our chosen observation units probably maximizes institutional or structural stability. They have as a rule been defined as organizational units by firm owners or managers on the same grounds. But firm managers do not need time series data to estimate models of their units to run them; they have access to the necessary information directly. The reader may have noticed that our modeling design to the extent possible uses the same technique, using similar sets of information as firm managers, minimizing their decision procedures and surveying their institutions once a year to update the database, thereby <u>reducing the needs for direct estimation of the firm model</u>.

e) Desired Properties

In all model building ventures one may, or should, have some prior views of the properties of the system. As long as these properties are defined within the sample periods, they are in principle testable. However, one may also want the model to perform "reasonably" in other domains. An "equilibrium" of some sort should perhaps exist. It should be stable etc. If one has very strong a priori views, one may want to reject the model, or the estimates, if some desired properties are missing. It has become conventional to require the existence of stable fix point equilibria in much competitive equilibrium theory, and to discard models that do not exhibit such properties in a broad sense, with words that make it appear as if an empirical test had in fact been made. One example of this is that dynamic models that do not converge onto steady state growth paths are not regarded as empirically sound. I have long been disturbed by such practices, and am happy to note that theorists who have earlier been concerned about ascertaining these traditional properties have recently begun to relax their views on these matters - in the wake of the experiences of the 70s, I presume. For instance, I hope that the analysis of Chapters V and VI has made it abundantly clear that growth models should not be constrained by a steady state equilibrium growth path onto which the economy eventually stumbles, whatever treatment it receives from its environment or itself.

Fortunately, the MOSES simulation model has offered some unique possibilities to extend the testing domain in these respects. Growth is endogenized in a realistic fashion and historic experiments (50 years or more) can be carried out without making the macro growth trajectories a priori determined by trend assumptions. Comparison can then be made with historical statistics gathered from different countries. It is comforting to know that MOSES generates various combinations of cycles and growth rates where market regimes rather than trends determine long-run growth rates, that vary as much as they have during the last 100 years between the industrialized countries. A real depression appears to be something that perhaps should occur now and then in that time perspective (E 1983a and b).

f) Analytic vs Numerical Analysis

The mathematical or anlytical economist by practice and tradition draws much more esteem from his colleague than his fellow number-cruncher economist. This higher esteem is always achieved through simplification of problem formulation to achieve mathematical tractability. However, there is no law of nature that guarantees that the important problems that we choose can all be handled analytically by the mathematical languages that we muster. Hence the esteem market in which economists operate appears to have a bias towards bad problem formulation. In this project we have to deal with a very particular instance of this problem. We may want to improve some long-run stability characteristics on the model a priori, or rather, we may want to know the asymptotic properties of the model. The properties can be studied by numerical experiments. Methods, especially graphics, are rapidly being developed to facilitate such analysis. The next section will include some illustrations. Numerical analysis, however, is necessarily discrete. (In practice, one cannot map and investigate all dimensions of the model), while the analysis of the properties of a model is an analytical problem. In this area the computer is coming to help. Symbolic analysis on the computer has been around since several years, and general solutions to fairly complex analytical optimization problems can already be achieved through computer analysis. Eventually this will put mathematical economics of today to rest as special cases of vastly more relevant problems. Thinking in economics, however, will change dramatically as these new methods develop. Simplicity and transparency will no longer be the virtues, but rather process understanding. For instance, it is normally not very interesting to understand how a car is driven along a road in a normal operating mode. The problem "how a car is driven" cannot even be defined. But if the car breaks down, or begins to swerve, understanding of the unexpected, abnormal operating mode is suddenly very important. To identify and evaluate the situation under which new, unexpected, difficult operating modes will occur in an economy, or a model of the economy, is an analytical problem that is conventionally handled by trial and error, occasionally through numerical simulation, e.g. in monitoring systems for nuclear power plants (cf. the discussion of the collapse of the North East power grid in E 1983a). General, analytic descriptions of the circumstances under which undesired events will occur in complex models will probably be an interesting domain for theoretical economists in the future.

4. MOSES Calibration in Practice

The actual estimation procedure of the MOSES model is more rough-hewn than the ideal ways discussed earlier. Three different aspects of what we have done have to be covered: (1) database work, (2) micro parameter estimation and (3) historic tracking performance.

a) Micro Database

To put the model project on an empirical footing a substantial database work has been required at the micro level. The regular planning survey of the Federation of Swedish Industries was originally designed on the format of the model to be used in model analysis. The model is currently loaded with data on divisions from the 40 largest Swedish companies and several medium sized firms, altogether some 150 real life decision units (divisions). The idea has been to design a measurement system around these decision units, and to use the high quality data at the firm level to improve understanding of macro economic behavior through the model. Such data are seldom used efficiently in support of macro analysis. This is one raison d'être of the model project. Direct observation of the units of measurement allows the use of simple and efficient estimation techniques at the micro level. Some of this econometric work has been done already and much is under way, but much more data work has yet to be undertaken before the model has been satisfactorily tested.

Part of the database work consists in building a consistent micro (firm) to macro (national accounts) database that can be currently updated and improved upon by adding new real firms (see Bergholm (1983a) and Albrecht-Lindberg (1982)). The national accounts statistics are taken as the best available statistical macro picture of the Swedish economy. Generally speaking micro firm data from our own sources are ready and final once our checking is done.

Macro national accounts data, however, tend to be revised substantially every now and then. We do not want to be dependent upon such revisions in the sense of being forced to reestimate the earlier model whenever a revised database is ready. Hence, we have designed the following procedure. Micro firm models are estimated independently on our own micro data (see next section). The core micro database is unaffected by revisions in macro national account statistics. To make accounts match at the macro level the model "initialization" procedure consolidates all real firms in the database, computes an aggregate entity and takes the difference up to the currently available macro sector accounts. The residual (the difference) is treated as one firm or synthetically split into several firms. They operate as firms in model simulations. The problem is that most statistical errors of measurement tend to appear in this residual. It is also heavily affected by each revision of national accounts data. When this occurs we simply reinitialize the model on the new macro database, if we wish to do so, leaving the core model machinery as before.

The Swedish national accounts (NA) statistics were not and are not yet ready on a consistent format in real (production) input-output, nominal and financial dimensions, with a consistent price deflator system. This is unfortunately a requirement of the model, since model behavior is very sensitive to inconsistent initial database specification. Hence a provisional statistical "integration" of national accounts data has been attempted within the modeling project, and internal, structural inconsistencies[89] have been cleaned out of the Swedish national accounts statistics.

For instance, when a model simulation begins on a spectrum of initial supply and demand conditions that are partially inconsistent at higher levels of aggregation, the first few quarters of the model simulation involve sudden relative price responses that force excessively strong adjustments in the supply and demand structure. These undesired properties disappeared when the new real firm database was ready in 1980 (see E 1983a).

The statistical dimensions integrated in our scheme are inter alia income statistics, production statistics, demand statistics, financial stock and flow statistics (the latter still not in good shape), delivery statistics in the form of a complete 11 sector input-output table, foreign trade statistics and a large number of price indices.

These "national account" statistics suffer from serious quality deficiencies and inconsistencies among sources. Important parts of economic activity are simply not observed. As a consequence, NA statistics are frequently revised substantially. As mentioned, to make modeling work dependent upon such "exogenous factors" would not be practical in the demanding context of a micro-to-macro statistical system. Hence we have taken the NA levels as recorded in 1976 (current initialization year used in experiments) as a given "bench mark" for the size of the Swedish economy. The substance of the observation technique, however, is the micro units that are observed and measured once and for all. In each category there is a "residual firm" between the NA level and the consolidated real firm accounts. This residual includes all small firms and in 1976 all crisis industries as well. It is treated as a firm, in the micro-to-macro model and has to absorb all the effects of errors in NA statistics. These errors are obviously large. They partly bias the residual firm strongly in the direction of being a low performer compared to average industry and partly exhibit unlikely combinations of data. Since all micro data on real firms are of high quality as to internal consistency and definitional differences fairly small, this suggests the existence of significant errors of measurement in the NA statistics. In fact, synthetic firms are so bad that they are among the first to close down (exit) in simulation experiments.

b) The Actual and Planned MOSES Micro Database

Besides aggregate statistics the MOSES micro database currently consists of two integrated sets of data;

- (1) the planning survey carried out annually and jointly with the Federation of Swedish Industries since 1975, was specially designed for the model. It covers more than 200 divisions or one-division firms and concentrates on the short-term operating characteristics (capacity utilization, output, employment, profit margins etc.). Data begin in 1974. The entire survey covers some 70 percent of value added in Swedish manufacturing and about two thirds of the firms are used in the model.

- (2) a firm financial database of balance sheets, profit and loss statements and cash flow balances since 1965 on some 40 large corporate groups of one or several division units under (1) above.

(1) provides data for the production system, especially for estimating and updating (through investment) of QFR(L) in Figure II:3 in Chapter II.

These micro databases have been made ready in steps. The first all synthetic firm database engineered from micro statistics was ready in 1976. Financial group data, with half synthetic data on the production system were gradually introduced between 1978 and 1980. The current, integrated database was (finally) ready in late fall 1980.

These data sources still only cover the domestic parts of Swedish companies, which is clearly a descriptive deficiency for an industry with some 30 percent of employment in foreign countries. The two micro databases above have very recently been integrated with

- (3) three huge sets of data on every single foreign operating establishment owned by a Swedish company, for the years 1965, 1970, 1974 and 1978. Data have been collected by the IUI during the last 10 years. These data cover internal and external trade flows (see Swedenborg 1973, 1979, 1982, Bergholm 1983b). This set of databases allows us to assign data on foreign production and marketing establishments to each division or firm in the MOSES system as well as to estimate certain parameters that regulate foreign-domestic investment, and trade relations.[89B] In addition to this

- (4) a separate survey to all establishments in the planning survey was carried out during 1983 with the purpose of obtaining data on interior resource disbursements on various activities, the categories being (a) marketing and distributing, (b) materials processing and (c) R&D activities.

In addition to this ongoing research at the IUI allows us to add to the MOSES database frequently. One very important instance of this was a joint IUI research project with the Swedish academy of engineering sciences in 1979 which added data on DMTEC in industry (see Chapter 6 in Carlsson et al. 1979, and Carlsson 1981).

Similarly the planning survey is normally extended with special questions to allow special studies. In this way we have obtained depreciation rate estimates, purchase value added ratios, short-term export price elasticity estimates etc. for individual divisions (see Albrecht 1984).

c) Micro and Macro Parameter Estimation

Estimation of the model has six dimensions.

1. Traditional econometric techniques are applied to behavioral relationships at the micro level and of course also to the macro relationships in the model.[90]

2. For a restricted number of large firms, real firm-model interfaces (interviews, model simulation meetings, etc.) to establish quantitative relationships have been and will be carried out.

3. Partial calibration. Isolated model parts are calibrated separately, with the rest of the model economy shut off.

4. Particular dynamic properties (time profiles) are simulated on the model on real exogenous data inputs and are compared with independent econometric results for the same period on Swedish data. (See for instance Genberg 1983.)

5. Tracking performance of the entire model system against historic data (macro aggregates and individual firm data) has been carried out.

6. Simulation experiments to establish the existence of certain properties, (long-run stability, etc.) of the system have been carried out.

All of this should of course be completed eventually. It will, however, take time because of the sheer amount of work involved. The work that has been done will be described after a brief discussion of the parameter estimation work done so far.

Our particular advantage in respect of the causal ordering of interior model processes has to do with the fine dimensions of measurement. Distributed lags between macro variables are replaced by quarter to quarter interaction between decision units and market processes. This requires proper classification of decision units and proper periodization of their decisions - an old idea from the Stockholm school economists that has now been empirically implemented.[91]

What is required is a periodization that corresponds to the production decision (roughly a quarter) and a micro unit that is a decision unit (a financial decision system).

Distributed lags do appear to some extent within the micro units, but here they have a well defined, operational meaning. For instance, the investment decision matures into a capacity increase with a delay that differs between sectors (and firms if we so wish). The time profile depends on the type of production. The important "time bridge", however, is that past activities are always updated in the form of new initial stocks the next period.

All six techniques of calibration have been applied to some extent simultaneously during project work. On the parameter estimation side simple micro estimation, individual firm interaction, and estimation of macro parameters have been carried out.

On the micro parameter estimation side most work has been done on the production system (see Albrecht 1978b and Albrect-Lindberg 1983), on technical change at the new investment level (see Carlsson-Olavi 1978), and to some extent on the firm financing and investment model (see Eliasson-Lindberg 1981 and Carlsson-Bergholm-Lindberg 1981). As for other micro relationships simple ratio-estimation techniques have been applied - the same technique as used in estimating input-output coefficients from flow observations for two periods.

So far only one direct model-to-firm interface has been attempted, but more are planned. This method may eventually make possible estimation of behavioral response patterns on relations for which statistical observations simply do not exist.

A second micro estimation problem has to do with certain micro parameters that enter as time dependent exogenous variables. These are the two technical change parameters associated with new investment which are then integrated in the firm production structure. On these variables considerable prior research has been carried out to the extent that a new research area at the IUI has been started up.

Within a joint project with the Swedish Academy of Engineering Sciences (IVA) a large group of scientists that had been associated with high level, technically oriented investment decisions in Swedish industry for many years were questioned on their experience with productivity development (or more precisely DMTEC) in new, best practice installations for a wide range of industrial activities over the period 1955-75. The results - reported on in Carlsson et al. (1979) and Carlsson (1981) - have been directly incorporated into the MOSES system.

The recent completion of panel data in three, of the above four, integrated databases will now make much more microeconometric work on MOSES possible. Current work goes on within several IUI projects and includes estimating industrial firm borrowing, dividend, interest, and export functions.

On the macro-side the main concern has been to estimate parameters in the non-linear consumption expenditure system and the input-output coefficients.

The private consumption sector draws heavily on results from Dahlman-Klevmarken (1971) and - for macro income tax parameters - on Jakobsson- Normann (1974). Since the consumption classification scheme is different from that in MOSES, the Dahlman-Klevmarken estimated price and income elasticities have been weighted together to the four consumption categories used in MOSES. A non-linear feature and a savings elasticity (see E 1978a, p. 79) have been added more or less by "informed" assumption.

Major statistical reclassification and adjustment work has been required on the input-output side first for the 1968 database, then for the 1976 initial year (Ahlström 1978 and 1983).

Partial calibration of parameters would appear to be a recommended procedure. For instance, we should attempt to ascertain the micro parameters by entering real data on individual firm exports and/or investments exogenously. Exports each period relate recursively to the firm and the economy. If we believe at all in the dynamic properties of the MOSES economy, however, this procedure is not acceptable from a scientific point of view. The quarterly adjustment of export supplies of individual firms in response to price developments in foreign markets (exogenously) and in domestic markets (endogenously) is the prime transmitter of foreign prices to the Swedish economy through domestic wage and quantity responses in all markets. Similarly individual firm investment behavior is regulated by individual firm profitability development and interest rate development which relates back dynamically to practically all variables in the economy. Partial calibration with exports and/or with investments at the firm level should result in different parameter estimates throughout the economy that in turn should differ[92] from the parameter estimates obtained through simultaneous dynamic calibration of the kind to be reported on in the next section. Partial estimation is, of course, not recommended procedure on a model of the MOSES kind.

5. Historical Tracking Performance of the MOSES Model

Observations are simply missing on a number of important model micro variables, most notably expectations variables. These variables enter behavioral relationships that require parameterization to be operational. Here we have provisionally assumed response patterns to be identical across firms, experimented with the model and compared historical tracking performance of the model at the macro level. This method which we call dynamic calibration is described in Eliasson-Olavi (1978). The statistical fits of the entire model system at various stages of completion will be described below. The problem here is that several parameter constellations, can often explain the same macro time series equally well.

The basic idea of the micro-to-macro model is that market linkages between decision units and over time bestow radically new properties on the entire model. Hence isolated block estimation (partial calibration) is against the idea of the micro-to-macro model. Practical circumstances, however, have made this method a necessary complement.

For one thing the model has been built in different stages of increasing complexity. The earlier stage has usually been a subset of the new stage or model vintage. The model has been calibrated against macro time series data at each stage. Considerable care has been taken to organize model work so that new model features would not radically alter total systems properties. But one could never be sure, and considerable risk taking has been involved in the sense that the results of calibration work at earlier stages would have to be thrown out. The various model vintages have, however, exhibited considerable robustness in this respect.

Direct isolated block estimation has also been tried by imposing exogenous investments and exports at the firm level, for instance in Carlsson-Olavi (1978) to estimate technical change and in Carlsson-Bergholm-Lindberg (1981) to obtain a realistic cyclical model behavior during the period 1976-80.

A more sophisticated indirect calibration method has been to estimate and analyze partial macro models to establish the existence of certain phenomena in real life that have been generated in model experiments. Certain price overshooting phenomena observed on the model in Eliasson (1978a) have been tested in Genberg (1983). His results confirm the overshooting hypothesis and in principle also the existence of asymmetric price transmission patterns, depending upon the size and sign of the initial price shock. However, the extent of asymmetries observed in model observations was not confirmed. (And indeed, on new and more realistic model versions, and improved initial databases exhibiting more structural diversity the strong instability properties generated by overshooting and asymmetric response patterns experienced on earlier model versions seem to have disappeared.)

Considerable recalibration of the official input-output system turned out to be necessary to get the entire model micro-to-macro database initially consistent in 1976.

The 1976 version of the model also features individual firm input-output coefficients. They have been obtained by using purchase/value added ratios from the 1976 planning survey and then distributing purchases, so calculated, for each firm according to the macro input-output table (see Bergholm 1983a). This means that the macro input-output coefficient table constantly changes in simulation experiments, because firms grow at different rates; the input-output structure is so to speak endogenized.

So far, most model experimental work has been performed with the monetary module, or rather with the endogenous interest determination, turned off. The reason has been problems with the monetary sector specifications and database. All data needed to fill in the accounts in the money Chapter IV have been put together for 1976. No estimation of financial macro parameters are yet ready. The final check of project capability will come when the monetary model is empirically ready and integrated.

(A pragmatic note, however, may be appropriate here. Large model systems will never be completely debugged of peculiar fringe properties. This is a defect that model builders in this field will have to live with. Many of the odd properties found may even turn out to be quite important features of real life, when we know better at some later stage. So, purists should stay with their small, clean problems if they cannot work with less than perfect tools. We have had several of these problems in the model all along. They have mostly appeared in the financial and monetary dimensions which are open ended in current experiments, as long as the interest feedback is shut off.)

Very few models of an entire economic system, perhaps none, have a complete monetary sector integrated with the real part of the economy as we have it organized within the MOSES system. Hence, monetary inconsistences will never be revealed or exhibited in most models. (With us they show on the printout for every simulation. This is of course a great, but disturbing, advantage.)

On the "macro tracking" record we can say the following. Long-term growth performance requires a long time series database for checking. We have not been able to initialize the model in the early 50s, even on a synthetic database. There simply were not enough data. However, on the presumption that the Korean shock in 1950/51 did similar things to the Swedish economy as the oil price shock in 1973, we have initialized the economy on all synthetic micro data in 1973 and compared 20 year forward simulations with development from 1950 to 1970. This time we have mostly been concerned with the transmission paths of inflation.

Similarly, we have initialized a partially real firm but incomplete database in 1968 and carried out a broad spectrum of 8 year simulations through 1976 on several model versions.

Finally we are just beginning to set the data for cyclical fine tuning of the model system and for comparing micro-distributional performance with the same real development in the database. This means that the long, the medium, the short term and the micro properties of the model for the time being have to be evaluated on somewhat different model versions and different data sets. Until more historical data are obtained, i.e., until the end of this decade, we cannot do anything about this.

On the track record we can say that:

- (1) price transmission patterns have been properly generated at the macro level from the beginning. Figure VII:1 illustrates this. It shows the wage and consumer price transmission paths generated by the 1950/51 "Korean" and 1973/74 oil price generated export price shocks. Model simulations are compared with real wage and consumer price developments. On the synthetic micro database, price and wage overshooting may have been too marked. More important is, however, that overshooting tended to generate quantity instabilities in the economy when the model was run on synthetic, or incomplete real data, because of too little across firm diversity (see discussion in Chapters II and VI).

- (2) medium- and long-term growth tracking improved as we moved up the model vintages and databases. Except for the shift from an industry model to a full economy model with a complete input-output system no major parameter revisions have been needed (see Table VII:1).

These nicely behaved results should not, however, detract attention from the fact that certain sections of the model may have generated odd results. The model simulates a complete and consistent national accounts statistical system by quarter in practically all dimensions and in fine detail. It would be surprising if a careful look did not reveal odd behavior here and there. It is possible to order the model to print out practically all intermediate or partial results that you want. This is of course extremely useful for the analyst, but we should also be reasonable in overscrutiny. Tools of analysis do not improve by aggregation that simply hides deficiencies. We have to do something if we discover these deficiencies and consider them to be important.

- (3) Cyclical tracking 1976-82. Not yet ready.

- (4) micro tracking 1976-82. Not yet ready.

- (5) long-term asymptotic properties of MOSES - historical experiments and theoretical evaluation (see Chapter VI and E 1983a,b).

Figure VII:1 Domestic price transmission, 1950-56 and 1972-76

1950–55 Korean cycle
1972–76 "Oil crisis" cycle
Index 1950 and 1972 = 100

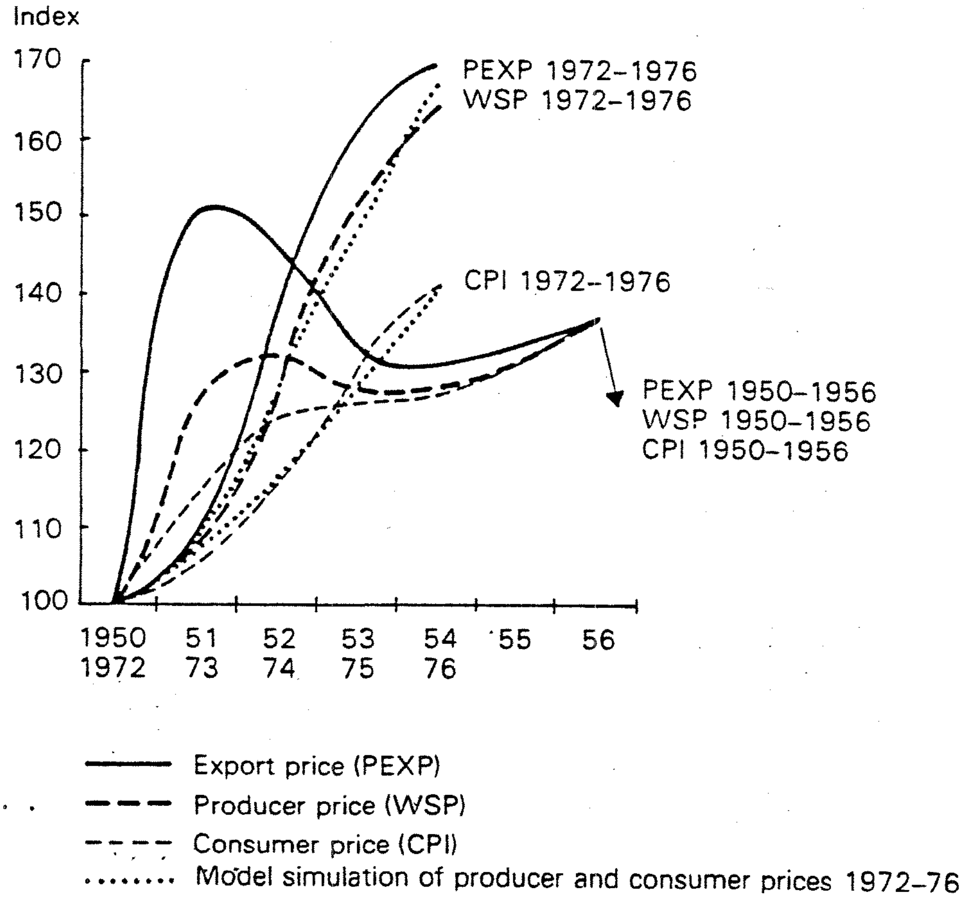


Table VII:1A Long-term (20 year) trend comparisons

Manufacturing (average annual change in percent)

		1950-74 (24 years)	RUN 67	RUN 88	RUN 96
1)	Production (Q)	4.6	2.7	3.5	5.0
2)	Hours of labor input (L)	-0.9	-3.9	-2.3	-2.4
3)	Productivity (PROD)	6.1	6.8	5.3	6.7
4)	Value productivity (PROD • P)	10.0	-	-	11.7
5)	Product price (P)	4.7	5.4	3.3	4.7
6)	Wage level (W)	9.7	13.6	9.4	11.9
7)	Investments, current prices (INV)	9.5	7.7	5.4	8.3
8)	Ditto, constant prices (INV/PDUR)	4.3	1.1	2.7	3.8
9)	Rate of unemployment (RU)	1.8	17.6	11.9	10.0
10)	Sales (S)	8.8	8.2	6.0	9.8
		-	(R=0.4)	(R=0.4)	(R=0.8)

<u>Constraints</u>

Profit Margins (M)	Horizontal trend
Capacity utilization rate (SUM)	

Note: (1) For explanation of symbols, see p. 335.
(2) In the bottom row of table the simulated rates of change have been correlated with the real ones for the period 1950-74. Simulations have been done in 1976 and 1977. The numbering of runs have the following meaning (see E 1978a, p. 57). Through 350 the model is basically micro and industrial, including manufacturing more or less as in all later model vintages and service production for final consumption. From run 350 a full input-output sector (10 sectors) is integrated with the model. From run 500 a crude Government sector has been added. Run 1,000 for the first time includes the first version of the Monetary sector and an endogenous domestic interest rate determination.

Table VII:1B Medium-term trend checks (1968-75, 8 years)

	REAL	630	647	701	712	800	801	821	822	831	832	900	1000	1001	1002	1003	1004	1020	1035
DQ	6.4	4.2	4.4	5.1	5.0	5.0	4.5			3.7		4.4	5.9	6.1	5.8	5.6	5.9	6.1	
DL	-1.3	-0.5	± 0	0.1	0.8	0.8	0.8			-0.2			0.8					-0.1	
DPROD	-	4.3	4.1	5.1	4.9	4.8	4.3			4.4			5.9					6.5	
DPDOM	6.1	7.5	7.3	7.0	7.1	7.0	7.0			5.8			7.0	6.8				6.6	
DW	12.7	15.1	14.2	14.8	14.1	13.0	12.9			2.8			14.0	12.4				13.1	
$\bar{M}$	31.5	32.4	36.1	37.5	39.4	40.9	40.3			47.4			40.8					39.6	
A21	7.8	1.9	2.3	3.5	3.6	4.4	4.1			8.6			4.1					4.5	
A22	6.4	13.2	12.1	13.4	14.0	14.1	15.0			15.0			14.5					15.5	
RU	-	6.8	4.1	5.2	6.2	6.3	6.1			8.9			5.9					3.5	
DPFOR	-	-																	
Priv.con.	2.7	4.7	4.5			-0.2												-0.2	
DGNP	3.1	4.5	4.5	5.0	3.8	3.7				2.2			4.6					4.0	
DCPI	6.4	7.1		6.7	6.7	6.7				6.0			6.5					6.5	
DDI	11.1	11.9		11.2	7.2	6.9				4.4			7.2					6.8	
SAVHR	3.0	4.1		4.1	3.4	3.3				2.0			5.0					4.4	
RI		-	-	-	-	-	-			-			2.6	2.9	3.3	3.3	2.9	3.1	
X	31.6	30.0			33.3	33.3							33.4					31.5	
IMP(1+2)	28.6	27.9			24.8	24.5							25.0					25.1	
INV(cur)	8750	5511	5831	7677	7757	7660	7374			6029			11519					8352	
DBW	13.5	10.8	11.5	14.1	14.4	14.4				11.2			19.1					18.8	
DNW										5.9									
DX(vol)	6.2			9.2	8.8					7.5			10.1						
DM(vol)				9.3	4.9					2.6			6.8						
DQ by subindustry																			
(1) RAW	6.5	5.9			6.5	6.4	6.2			5.4			7.3					7.6	
(2) IMED	3.2	4.6			5.4	5.5	5.2			4.7			6.6					6.6	
(3) INV	6.8	2.8			4.3	4.1	3.5			3.0			5.1					6.5	
(4) CON	2.5	4.7			4.6	4.6	4.0			2.9			5.5					4.7	

Note:

Table VII:1C GNP Break down 1968-75 (8 years)

Demand side

	Real D68/75	Volumes 1968, 1968 prices	Volumes 1968	RUN 1095=(RNW 1100) Rate of change 1968/75	Volumes in current prices 1975 Real	1095
Private C	2.7	79.2	75	4.6	150	166
Public C	4.5	29.5	37	6.2	72	119
INVTOT	?	33.3	29	5.4	60	58
- Manuf.						
- Governm.						
- BLD						
- External sectors						
Δ Inventory inv.	-	-	-0.2	-	9	0.7
EXPORTS	7.7	30.5	28	6.6	83	77
IMPORTS	7.6	-30.6	-28	8.2	-86	-87
GNP (purchasers price)	3.2	141.8	141	4.8	288	335

Supply side

	Real D68/75 (fixed prices)	1968 Volume 1968 price	Volumes 1968	Run 1095 (=1000) Rate of change 1968/75 (fixed prices)	1975 Volumes current prices Real	1095
RAW	6.5	4.5	4	4.6	10.5	13
IMED	3.2	6.5	6	3.6	15.8	13
INV/DUR	6.8	11.3	11	3.6	29.5	25
NDUR	2.8	9.5	11	4.6	18	32
Total Mnfs	6.4	31.8*	32	4.2	73.9***	82
A/F/F**	0.6	6.1	6.5	4.4	13.5	14.5
ORE**	3.6	1.3	1.3	5.0	2.6	2.3
BLD**	1.3			4.4		
EL**	6.8	2.9	3	4.3	6.2	5.4
SERVICE**	?			6.5		
Government**	4.8	20.2	25	3.6	52.7	81.5
Total non-manuf.	(2.8)****	105.7	99	(4.6)****	206.6	229
VATAX		15.8	10	-	29.3	26
SUBS		-0.6	-1	-	-3.0	-2.5
GNP(market price)	3.2	142	14	4.8	289	335

Notes:
* 35.7 billion in N1976:7.4
** From N1976:7.4
*** 83.1 in N1976:7.4
**** Exponential interpolation between end values.

Symbols used in tables

Q	= value added, constant prices
L	= labor input (effective labor time)
PROD	= Labor productivity
PDOM	= domestic price, industrial goods and services
W	= wage cost level
M	= profit margin
$\bar{M}$	= average profit margin
A21, A22	= capacity utilization measurement, A-B and C-D respectively (see Figure II:3)
RU	= open unemployment in percent of labor force
PFOR	= foreign price of industrial goods and services (exogenous for four sectors)
Priv.Cons.	= private consumption
DI	= household disposable income (current prices)
SAVHR	= household saving in percent of DI
RI	= interest rate
X	= exports in percent of sector sales
IMP	= ditto for imports
INV(cur)	= manufacturing investment in current prices
BW	= borrowing in manufacturing
NW	= net worth in manufacturing
X	= exports
M	= imports

6. Empirical Analysis

Good theory means good emipirical specification. There has been enough of the Swedish economy in the MOSES model from the beginning to make it interesting to ask "what if" questions to the model on the presumption that it would respond as the Swedish economy - and more so the more model specification and databases improved.

Hence the MOSES system has been used as an experimental tool in several studies at the institute.

We have studied the macroeconomic consequences of exchange rate variations (E 1977), different expectational models (Albrecht 1978a), the change of tax system (E 1980a), absolute price shocks (E 1978a), relative price and technical shocks (E 1978b), technical change (E 1979) etc.

As the current version of the model was prepared, and especially when the new 1976 database had been entered, the empirical ambition grew. In Eliasson-Lindberg (1981) we demonstrated the existence of not negligible negative allocation effects from price wedges introduced by corporate taxes. It was possible to demonstrate, in particular, that tax induced expansion in inefficient industries or industries operating in the wrong markets, reduced long-term output growth in efficient firms operating in expanding markets. The reason for this was, not surprisingly, that expansion in the wrong firms inflated factor prices compared to the case when such expansion was not stimulated by the tax system.

The ambition to quantify increased when we evaluated the macroeconomic effects of the Swedish industrial subsidy program (see Carlsson-Bergholm-Lindberg 1981, Carlsson 1982, 1983). The model has also been used for quantifying the pull effects on the Swedish economy of Swedish foreign investments (Eliasson 1984b, Bergholm 1984).

In all these studies the Swedish model economy has been positioned on an initial state described by the 1976 micro database. Results from varying certain parameters are, hence, dependent on that state, as they should be in a dynamic economy. One might argue that the initial state should rather be an equilibrium state and that comparisons should be made between that state and the equilibrium state on which the model economy eventually settles after the parameter change of the experiment. But any such equilibrium state is an imaginary state in a dynamic model and probably does not exist (see discussion in E 1983a). Comparisons of such states using static models (comparative static analysis) would then be wrong. Even though the MOSES economy would have dynamic equilibrium ("ergodic") properties, any attempt to force the model into such a "state" by distorting initial structures, if possible, would be an analytical exercise in deception. We have spent considerable time in attempting - unsuccessfully - to carry out such experiments. In retrospect we think the original ambition was futile.

The MOSES model economy should not be used as a forecasting model in the foreseeable future. A tremendous amount of additional estimation work is needed before such exercises become meaningful. The basic feature of a forecast, however, is that it starts from a true disequilibrium state - somewhere on a business cycle - and then follows a disequilibrium trajectory.

The main problem of all medium-term projections is how to deal with the business cycle. The common solution has been to use an equilibrium model and to correct all data from cyclical characteristics (unused capacity, unemployment etc.). Our argument has been that this is principally wrong. The initial state is imperative in determining the path the economy will follow, and the path is more economically interesting than the final destination - if there is any.

The MOSES model offers a solution to this problem. Today, the quality of parameter estimation does not allow us to simply start the model on its initial database description. However, the initial database description is of very high quality compared to all ad hoc adjustments that have been and can be carried out in order to use conventional macro or sector equilibrium models. These models, furthermore, have to be run on exogenous exports, notably labor productivity trends, that more or less impose the growth trends to be forecast by assumption. The MOSES model offers a much more sophisticated alternative. We can exogenize individual firm exports and/or investments, by assumption or by using the "plans" of the real firms. We can enter these individual firm plans into the dynamically calibrated model and start it from the high quality database description of any initial year that we choose. If we exogenize both exports and investments it would roughly correspond to the degree of exogenization traditionally applied in macroeconomic forecasting. But the forecast would be founded on the wealth of structural information residing in the initial micro database and the macro economy would be propelled into the future by the (model) micro dynamics of a Schumpeterian type growth cycle. Such an exercise, that we hope to carry out in a not too distant future, would very much capture the initial ideas of the MOSES modeling project.

Notes

[87] Of course, a macro model may use lagged variables which are part of the state variables in MOSES. Some coefficients may be=0, which means a structural deviation from a full linear system. And a simultaneous estimation procedure requires technical constraints that may be said to "impose" structural information.

[88] One example is direct model interfaces with real firms represented in the model. A group of people from a model firm has been asked to specify their own parameters and play around with their firm until they were satisfied with its behavior. To date only one such experiment has been carried out.

[89] See Ahlström (1978, 1983).

[89B] See Eliasson (1984b) and forthcoming study by Eliasson-Bergholm-Jagrén (1984).

[90] For instance, the household consumption and savings system.

[91] See for instance Lindahl (1939).

[92] We hope to be able to illustrate the importance of dynamic vs. partial calibration in the final version of Bergholm (1983a).

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7. A Micro Macro Interactive Simulation Model of the Swedish Economy.
Preliminary model specification
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15. Pay Differentials between Government and Private Sector Employees in Sweden
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25. On Unexplained Price Differences
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