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No. 103

THE SWEDISH MICRO-TO-MACRO MODEL

- IDEA, DESIGN AND APPLICATION

by

Gunnar Eliasson

Paper presented to the GMD conference on Micro Analytic Simulation Models for Improving Social and Financial Policy. June 21-23, 1983 in Bonn.
Revised 1983-10-03.

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ABSTRACT

This modeling project, codenamed MOSES (for **MO**del of the **S**wedish **E**conomic **S**ystem), began in 1975. It has three main ambitions:

(1) To conceptualize a dynamic economic process in terms of economic agents operating in markets (Theory).
(2) To serve as a means of quantification and, eventually, forecasting (Model).
(3) To serve as a consistent (theoretical) design for building a systematic micro-to-macro statistical base (Database).

The theoretical base is a Schumpeterian type economic process with individual - real - firms, that combines with the Wicksellian idea of a cumulative process, that feeds on a capital market disequilibrium. Each firm forms its own decisions as to price, production, hiring of labor, wages, investment and how fast to grow in an explicit market framework. The result is an endogenized growth cycle.

The MOSES system belongs to the class of microsimulation models pioneered by Orcutt (1960 etc.). Model development has temporarily been halted to allow estimation, analysis and database work to catch up. The current version of the model has manufacturing industry divided into four sectors inhabited by 150 decision units, 110 of which are real firms. The rest of the economy is a macro 10 sector Keynesian-Leontief model. Product, labor and credit markets are endogenized. The entire model runs on a small bundle of exogenous assumptions. The most important are labor supply, government hiring, four foreign price indexes (one for each sector), a foreign interest rate. The marginal investment/output ratio and labor productivity is exogenously assigned to new capital goods items invested by an endogenized decision mechanism in each firm.

Model work since 1979 has been concentrated to estimating the micro parts of the model and to building an integrated micro-(firm)-to-macro(national accounts) database.

Besides analytical, numerical work aimed at studying the properties of the entire model system, the micro-to-macro model has been used provisionally to support quantitative analysis in several areas, for instance, the macroeconomic effects of technical change, of foreign price shocks, and of industrial subsidies, as well as the effects of changing from one tax system to another, etc. [see bibliography at the end].

This paper gives a very condensed description of the computerized version of the model that we currently use. A more detailed presentation of an older version is found in Eliasson (1978a). A complete documentation of the current version, including also a description of the long-term investment decision, the monetary sector of the model and the database work will soon be available (Eliasson 1983b). Part of the data-base work is accounted for in Albrecht-Lindberg (1982) and in Bergholm (1982).

1. The idea of the MOSES Economy*

In contrast to many traditional, large scale models, this model economy 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 expansion is very openended and dependent upon the

* This large scale modeling project would not have been possible to realize without the contributions of many people. During its first few years the project was generously supported by IBM Sweden. I want to mention Thomas Lindberg, Ingemar Hedenklint, Lars Arosenius and Ulf Berg in particular. Mats Heiman and Gösta Olavi, then at IBM Sweden, were very helpful in programming the model and solving many mathematical problems. In turning this model into an empirically useful analytical tool a number of people at the IUI and the Federation of Swedish Industries have been instrumental. In particular I want to mention Jim Albrecht (Columbia University), Louise Ahlström, Fredrik Bergholm, Thomas Lindberg and Ola Virin.

market investment allocation process. The model treats most of the demand side in a more traditional, macro fashion.

The model economy may appear unfamiliar to begin with. It is fashioned much more in the mode of thinking developed by Joseph Schumpeter than it is on 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 a noncooperative game situation. A Wicksellian monetary disequilibrium is a normal working characteristic of the micro-to-macro model and the old Stockholm School ideas of a dynamic economic process should be quite visible on the pages to come.

The <u>first</u> difference is that we are dealing with a large number of firms (models) responding individually to their market environment within the constraints of a macro system.

The <u>second</u> difference is that MOSES is <u>not</u> an <u>equilibrium</u> model but (in mathematical terms) a <u>process</u> model. We have chosen not to restrict our analysis to an ad hoc theory that makes it possible to use simple mathematical optimization techniques or easily available data. Firms do not jump in phase from one equilibrium turf 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.

The model (<u>third</u>) incorporates a theory of both quantity and price adjustment. Firms are not price takers except in a momentary (next quarter) ex ante sense. They currently interprete the price and quantity signals generated by the economic process and form their individual decisions as to which prices (wages and prices) to offer in the markets, and how to adjust output and factor inputs [labour, investment, utilization rates, etc.].

<u>Fourth</u>, firms are in principle behaving rationally, but occa-

sionally they make inconsistent decisions, and they do not optimize in the short term. They search for improved, profit positions (hill climbing) given what they know. This process recognizes search time and is normally terminated before a perceived hill is reached. Firms can to some extent change their decision rules if they consistently lead to deteriorating profit performance (error learning by doing). We call this a rules of behavior approach to modeling.

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

A particular aspect (sixth) of this slack is that firm management is assumed not to know more than 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), as we have assumed. These assumptions correspond to known and well established facts (Eliasson 1976a).

A much larger part (seventh) of the empirical information of the model than what is normal for a macro model is embedded in the hiearchical ordering of the decision process within and between the firms and in the initial state variables.

These and other features require a somewhat unfamiliar mathematical representation of the model that, to begin with, may be difficult to think in terms of.

Any large, "nation wide" model has to exhibit a fair degree of complexity. The MOSES economy, however, is quite simple in fact and transparent in principle. Each behavioral module can be understood independently. Complexity develops because of multiplication of such principally identical and simple but, numerically different, behavioral decision units. The "matter" that aggregates the decison units is the dynamic market process and endogenous prices.

The main reason for our micro approach is to improve the measurement base for macroeconomic analysis. At the output level we are not attempting to study more fine detail than will conventional macro model builders, even though this is technically possible.

[Few people venture behind the walls of Central Bureaus of Statistics to see how the numbers they run regressions on are cranked out. 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 awkward market assumptions to obtain, and to interpret, aggregate behavior.

We will try to ease the familiarizing 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 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 accounts identities always hold at the macro level ex post].

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 modeled labor, product and credit markets, all being (3) constrained within the state of technical knowledge vested in capital installations of the past and in currently produced capital goods and the imposed consistency of a macro accounting system.

The growth engine of the model economy is a population of independently operating business firms. Their ways of behavior decide the future course of the economy. Note that the micro-to-macro model economy cannot easily 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 modeled 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 an expected convergence of prices onto that structure. Only to the extent he expects his firm to excercise some amount of monopoly power in the market 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 by some external force, his Board or 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].

He has to watch out for - in order of importance:

1) the value of the firm as assessed in the equity market that determines his debt capacity (not yet in program),
2) 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
3) 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.

There are three decision levels within the firm:

1) strategic decisions - Board level; informal.
2) investment/financing decisions - the budget and the long-term plan,
3) production management - the operating budget and production planning,

To the extent possible we have tried to incorporate the results from a series of interviews with firms (Eliasson 1976a) when modeling the interior firm decision structure.

Besides 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.

Besides Government policy parameters the most important exogenous variables are

1) foreign prices (one index for each market),
2) the foreign interest rates; one long and one short term
3) the rate of technical change (embodied) in new investment, and
4) total labor supply.

The model represents a general economic process that is moved forward in time by the exogenous prices within the bounds set by the profit-based investment decisions and technical change in new investment vintages. Markets are 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-à-vis a number of plausible, exogenous disturbances that will throw the model economy into an extended state of chaos (see Eliasson 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.

The model has an elaborately developed short-term and long-term supply side embodied in the individual firm planning process. Production decisions are taken by quarter. 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. There is another complete integration between a monetary sector and the real system.

Two observations should be made here. First, none of the exogenous variables 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 a great variation in long-term growth rates of the economy, depending upon how you set the market response parameters in (most importantly) the firms (see experiments reported in Eliasson 1983a).

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. 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, the structural adjustment may be very dramatic. We know from real life Swedish experience during the middle seventies that the government then intervened in various ways, e.g., by changing the exchange rate or disbursing industrial subsidies to prevent unemployment for increasing.[1] This also means that exogenous assumptions are subjected to some endogeneity in the sense that policy makers have to change them to prevent macroeconomic behavior from becoming unreasonably disruptive. [In the longer term, hence, even policy makers should be made endogenous. However, aircraft builders can design computer test flights in which wings collapse, and we can design experiments on the MOSES economy that subject individuals to extreme hardships, simply to learn about optimal macro policy designs.]

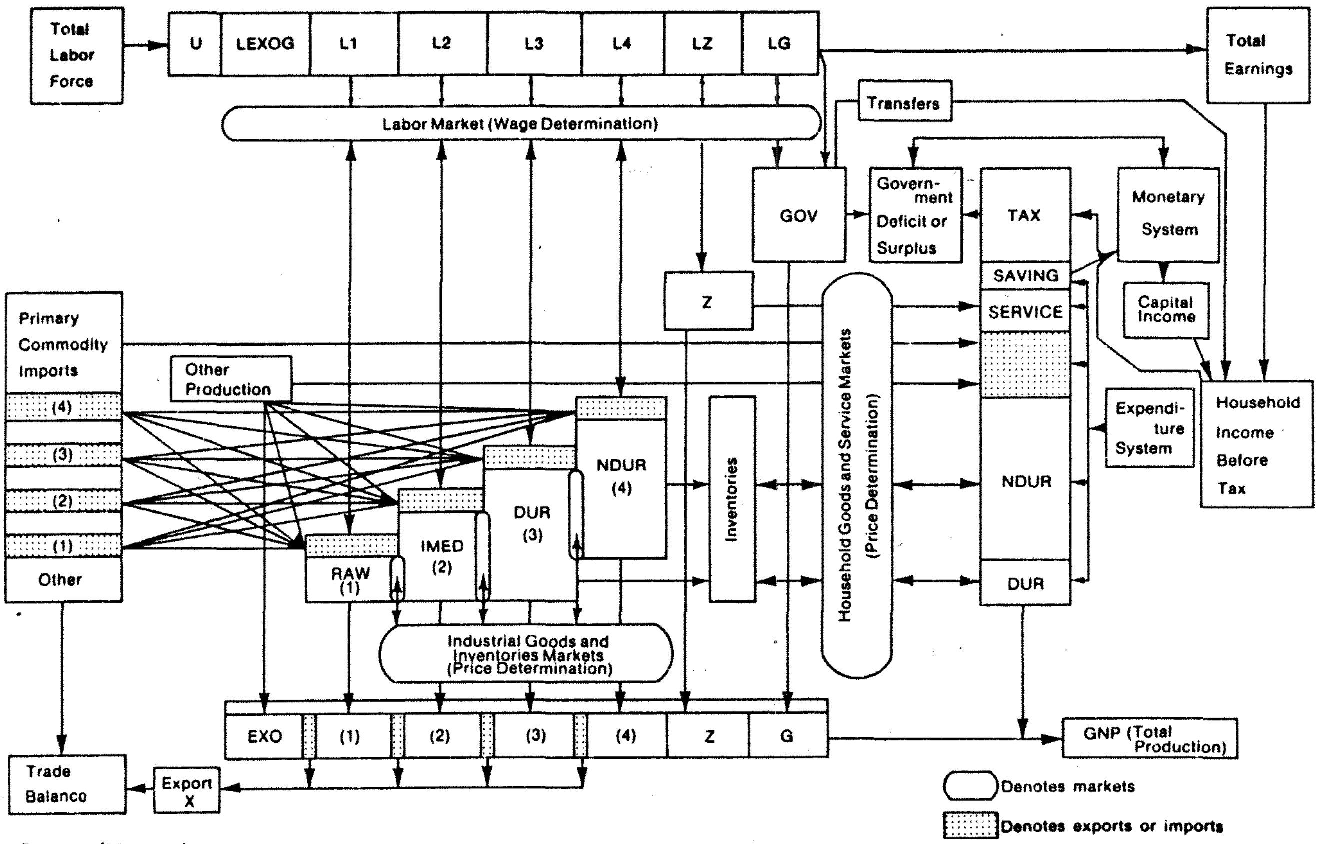
[In fact, statistical consistency at all aggregation levels is an important property of the model and the initial, statistical description of the economy requires great care. The model is fitted into the national accounts macro framework. The manufacturing sector is broken down into (a variable number,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

Parallel to model development, a time series micro firm database has been developed. To begin with all firms were "synthetic" in the sense of being chiseled out of the aggregates preserving a) across firm distributional characteristics to the extent they were known and b) the consistent macro accounts when aggregating across firms. As more real firm data have been accumulated they have been entered into the data base. The real firms of each sector have been reconsolidated and the 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 (Albrecht-Lindberg 1982, Bergholm 1982).]

3. Overall Macro Structure of the MOSES Economy

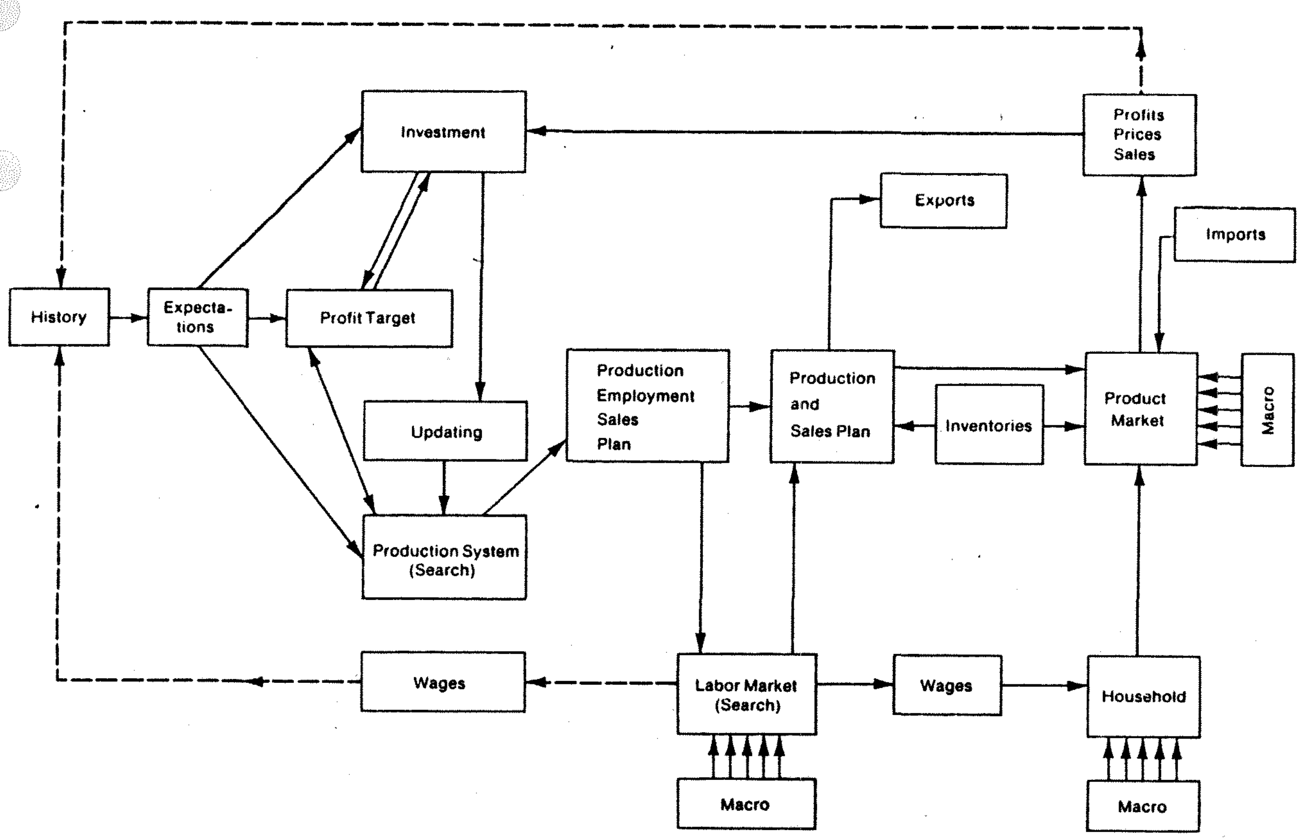
Another way to familiarize oneself with the MOSES micro economy is to look at its macro mapping in Figure 1. The macro layout is that of a typical 10-sector Leontief input-output model combined with a Keynesian demand feedback, or more particularly, a Stone type non-linear expenditure system. The endogenous supply mechanisms, that will be our prime concern in this presentation, reside at the micro level and disappear at the level of aggregation in Figure 1. The novelties of the micro-to-macro approach are most easily visualized by seeing four manufacturing cells in the input-output system (shaded) as

Figure 1 Macro delivery and income determination structure of the 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.

Figure 2 Business decision system (one firm)



replaced by market cells inhabited by individual firms. They are RAW, IMED, DUR and NDUR markets, respectively, in Figure 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[2].

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

Third, each firm is linked to all other firms and to the rest of the macro economy by explicitly represented market processes. The labor market process will be briefly described below. It has been described in detail in Eliasson (1978a). The money market process is only indicated.

4. Technical Change at the Firm Level

Technical change enters the individual firm (plant) through new investment. Labor productivity (MTEC) and new investment expenditure needed to obtain one extra unit of output (INVEFF), both at full capacity utilization, are entered exogenously through new investment 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 to technical change, or productivity growth, at the industry level. The importance of this allocation machinery in "real life" 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 (see Eliasson 1979 and Carlsson 1980).

To explain exactly how "technical change" enters the firm, a brief overview of the firm financing, investment and production system is needed.

5. The Firm and the MIP Principle

The entire business decision unit is centrally controlled by a rate of return targeting formula that links contributions to overall profitability from different units in an additive fashion. It can be demonstrated that:

The Nominal Rate of Return to Net Worth (=RRNW) (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 these components have an organizational counterpart. Each exerts a controlling influence on various in- and outgoing cash flows.[3]

The rate of return requirement is directly imposed in the investment decision, which will be described in section 10. Short-term profit requirements are imposed through profit margin targets under (a). As in earlier model presentations, also this overview will be predominantly occupied with the short term (quarterly) production decision exercised through short term profit margin targeting. (For a full presentation of the long-term capacity augmentation decision, see Eliasson, 1983b). The argument is that Corporate Headquarter Managers impose top-down profit margin targets on divisions that are based on past profit margin performance, gradually upgraded from below under the constraint that ex ante profits in monetary terms are not allowed to decrease. We call this the Maintain or Improve Profit (MIP) principle (see Eliasson 1976a, p.291 f.).

It is well recognized in any large business organization that the major top management task of a large firm is to apply well-calibrated profitability requirements on its constituent parts (divisions, profit centers). This is normally done without explicit knowledge of the underlying process of realizing these targets. The important rule is to pinpoint the performance band above what is normally feasible but below what is an unreasonably high target (Eliasson 1976a). This behavioral specification in essence makes productivity an important adjustment parameter for the firm even in the short term. 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 even though markets are very generous to the firm. Unreasonably ambitious profitability requirements push the firm 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 a fast value creation and a high rate of return on equity. Unstable market environments that are difficult to predict is one situation in which well calibrated targeting is difficult.

[The separation of decision making within corporate organizations that is embedded in the separable additive targeting formula and the MIP targeting principle are well established practices in firms (Eliasson 1976a). A MOSES firm is modeled as a set of adaptive decision rules on the basis of these principles. These rules recognize the basic environmental uncertainty that currently faces each firm. We also argue that this set of rules specifies an intelligent, albeit cautious, profit seeking entity that will generate a statistical performance flow that cannot be distinguished in econometric tests from those 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 specification is very simple. Top management in the firm does not know what is maximum technically possible to achieve!

Mathematically the interior trial and error process of a MOSES firm makes use of a graded search algorithm for 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 hill tops are rarely reached by micro agents and the hilltops move (endogenously) from quarter to quarter as a consequence of the interaction of all agents in the markets.

In the micro-to-macro model, hence, aggregation is not performed under the assumption of static equilibrium. Aggregation functions - if we want to construct such things - are not time stable. The central mathematical devices that hold the activities of the model economy together are the separable additive targeting formula, 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 that affects not only firm behavior strongly but also macroeconomic behavior, we will add some further detail from an extensive interview study that preceded this project (Eliasson 1976a). I do argue on the basis of these studies that anybody who wants to study, or model, the dynamics of an industrial economy with the ambition to understand what is going on has to 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 recognizes three facts of life in all large business organizations (Eliasson 1976a):

(1) It is very difficult for anybody, and especially for top CHQ managers to set targets for the interior of the organization that are close to what is maximum feasible. In short, management does not accurately know the production frontier of their own organization.

(2) It is extremely important for target credibility within the organization that reasonable targets be set. If 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 a substantially higher macro performance of the firm can normally be obtained if a good reason for the extra effort needed can be presented ("crisis situation") or if a different, technical investment solution is chosen (other firms are better), and time to adjust is allowed for. The scope of possible improvement and the time needed is always subject to different evaluations. The main point, however, is that operations management do not possess the information necessary to prescribe a better and workable solution and that there is no way to get the information. It is always in the interest of decision units within the firm, 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. Planning theory is all naive on this central point.

Hence, corporate management has to proceede by persuation, exhortation and coax.

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

[It can be demonstrated that the additive component (a) in the nominal rate of return to net worth (RRNW) above is:

$(a) = M^{*}\alpha$ (2a)

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

$$M = 1 - \frac{w}{P} * \frac{1}{Q/L} \qquad (2b)$$

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

Top management of the firm is "pinched" between two facts. The Board and the share owners are demanding a rate of return on their equity (=RRNW) expressed by the formula above. (2a) and (2b) demonstrate that RRNW can be translated into a M requirement. This was the first fact.

The other fact is that demands for compliance with this top down requirement has to be tempered by what is feasible and reasonable. If the difference is large in the negative direction there will be a "market" pressure brought on top management to impose pressure to improve onto lower levels.

If this improvment is too slow in coming resources tend to leave the firm organization to be invested elsewhere.

We will demonstrate in this chapter that one major vehicle for improvement is improved productivity, and this is especially so, if we adopt - which we will not do - the classical assumption of the firm as being price (p) and wage (w) takers. Then [see (2b) above] the only variable available to raise the profit margin is labor productivity (Q/L). As is revealed by practically all short term planning cases studied in Eliasson (1976a) this is also the variable that can , in fact, be improved (!) in the short term as well as in the long term.[4] There are two reasons for that:

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

Second, the (a) component in (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) cannot 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 higher productivity activities and/or higher margin yields because of better w/p ratios. Don't forget that average productivity depends on the weights.

[MIP targeting can now be represented fairly simply like:

$$MHIST := \lambda * MHIST + (1-\lambda) * M \tag{3a}$$

$$TARGM := (1-R) * MHIST * (1+\varepsilon) + R * TARGX \tag{3b}$$

$(\lambda, R) \in (0,1)$ $\varepsilon \geqslant 0$ but small.
:= is Algol for make equal to.
MHIST is a historic performance measure computed as in (3a).
TARGX is an exogenous target requirement (e.g., of the best competitor) that can be weighted in to the extent desired by $R \in (0,1)$.
ε is the improvement factor demanded.]

This is all we need to go on for 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 onto which reporting and control routines are, in turn, fixed.

6. 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 on 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 even though a very elaborate purchasing algorithm (a set of individual firm input-output coefficients) applies to each firm. This means that in our exposition, value added and sales volume differ only by variations in finished goods inventories.

Production planning is carried out individually by each firm. Within this 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. Figures 3 and 4 illustrates the principles.

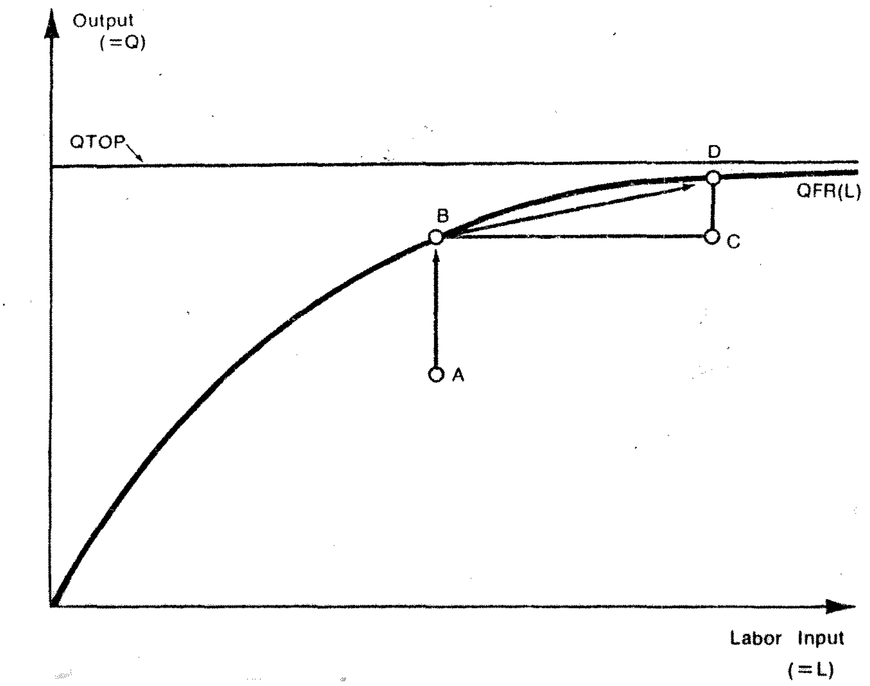
Each firm faces a set of feasible (Q,L) combinations (a short-run production possibilities set) each quarter that are defined by

$$QFR = QTOP*(1-\exp(-\gamma.L)). \tag{4}$$

This feasible set shown by the curve in both Figures 3 and 4 is determined by the firm's past investments as they are embodied in QTOP and γ. Investment between quarters pushes this set outward.[5] 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 the satisfying criterion. 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.

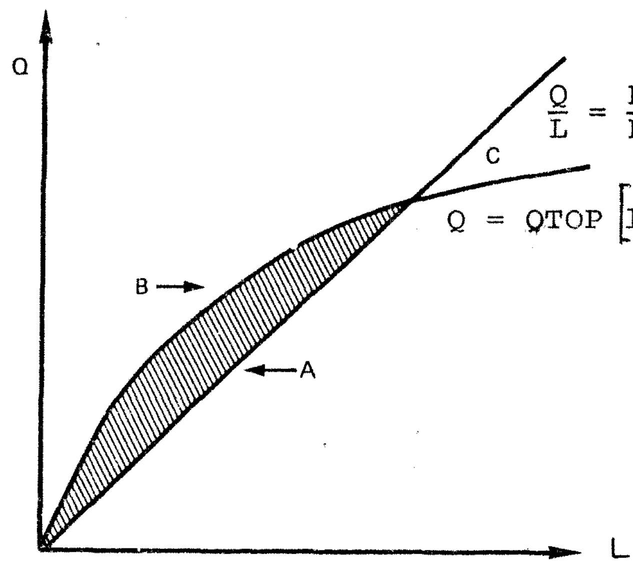
As shown above (see (1)), a profit margin target (TARGM) can be derived from the rate of return target. Bad profit experience can make the firm lower its target in the short term. This

Figure 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 4. Profit targeting (one firm)



$$\frac{Q}{L} = \frac{EXPW}{EXPP}\left[\frac{1}{1-TARGM}\right]$$

$$Q = QTOP\left[1-e^{-\gamma L}\right]$$

will normally affect long-term development negatively; 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 to meet short term profit targets are met by exploiting various forms of slack within the company, in a way that could be called <u>learning</u> or search for better solutions (see below and Eliasson 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:

$$TARGM \leq (EXP(P*Q) - EXP(W*L))/EXPP*Q \qquad (5)$$

(5) is shown by the line in Figure 4. If we combine (4) and (5) we obtain the shaded area in Figure 4, which contains (Q,L) combinations that meet profit standards and are also feasible. This can also be expressed as:

$$\frac{Q}{L} \geq \frac{EXPW}{EXPP} \cdot \frac{1}{1-TARGM} \qquad (6)$$

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 (3a). Risk considerations ("aversion") in expectations forming enter-through a standardized variance measure in the expectations variable. If variance increases in product prices, firm management tends to underestimate future prices, and vice versa for wages. This makes profit target satisfaction tougher and forces (Q,L) closer to the frontier and possibly down left along it (contraction). The expectations side of the model is discussed in great detail in (Eliasson 1978a, section 4.2).

The firm now chooses a point within the shaded area of Figure 4 that is both feasible and satisfactory. This is done by specifying an initial set of (Q,L) points and the rules to adjust these points, if they do not fall within the feasible and satisfactory lens area. Note that it is labor productivity that is adjusted.

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

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

$$Q \cdot EXP(P) - L \cdot EXP(W) \qquad (7)$$

do not decrease compared to an earlier, established position, including the initial one. If this 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[6] 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 in Figure 4 may, however, lead onto B, and down along it, to a premature collapse of operations. This may be incompatible with rational behavior in the sense that the firm deliberately chooses to lower its expected profits to find a quarterly (Q,L) combination within the shaded area. As mentionned, this is prevented by a supplementary rule that stops further search whenever expected profits begin to decrease.

For each L there is an interval of output plans that are (1) either both feasible and satisfactory in the lens in Figure 4, and/or (2) feasible but not satisfactory (Region B), or (3) neither feasible nor satisfactory (Region C).

Why do firms at all 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, that never calculates such things.

Remember that 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 a period. Target non-satisfaction may force it to speed up a bit, but improvements normally stop when production plans hit QFR(L). Where to stop is, however, endogenized within each period depending upon which way search goes and over time when QFR(L) shifts because of investment.

The state of slack across firms - the vertical distance to QFR in Figure 3 is measured every year in the Planning Survey of the Federation of Swedish Industries on which the model is based. Each year some firms are operating at full capacity, but most are not. We also know roughly from empirical studies (see for instance Eliasson 1976a) how firms adjust their output plans in a stepwise fashion. Production search has been tailored to mimic such procedures within firms.

When a feasible and satisfactory (Q,L) point in Figure 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, the firm adjusts by planning to lay off labor. 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) to the lens area, then the firm establishes a preliminary plan at the minimum feasible Q and L.[7].

[Production planning has now been completed. Expectational variables have influenced production plans in the following sequence. 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. (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. At the aggregate level, however, these plans may not be feasible. Firms must confront one another in the labor and product markets to sort out remaining inconsistencies.

7. Short Term - Labor Market Search

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

If CHL $\leq$ 0 the firm begins to lay off workers with the notification delays that are required by Swedish laws.

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

Ideally, labor market 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, it is empirically far more convincing for Sweden to make the firm the active search agent. Choosing labor as the sole search agent would mean uncritically applying theoretical specifications developed for the U.S. labor market to Sweden.

The number of searchers per period (=NITER) is a preset parameter calibrated by trying to fit macroeconomic model behavior to macro data.

Raiding of another firm for labor can be successfully carried out 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 partly contain its expectations during the first quarter of search as it learns about wages in other firms. This 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 facilitate understanding.[8]

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 demand for additional labor, i.e., 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. 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 (see Eliasson 1983b). 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.[9]

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 and the firm losing labor increases its wage offer by

CHWWj = ö4*(WWi-WWj).

If the attack is not sucessful, then the attacking firm increases its wage by setting

CHWWi = ö5*(WWj*(1+ö2) - WWi)

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

When all firms (which CHL > 0) have gone through this iteration a predetermined number of times the search process of the quarter has been completed and wage levels are set.]

We have learned from repeated numerical analyses of the entire 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.

8. Foreign Competition, Foreign Trade and the Exchange Rate

Export and import functions of the model are supply based.

Each firm 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 quarterly specification we do not need any additional explanatory variables. This formulation can be demonstrated to mean (roughly) that the ratio of deliveries to foreign markets and the domestic market slowly changes towards relatively more exports as long as a positive difference persists between profit margins on export and domestic sales for the producing firm (see Eliasson 1978a).

Two additional things should be noted here.

First, the main factor that keeps export ratios from generally 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 transmitter of 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 the sense that foreign markets absorb all that the firm can and want 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.

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 translates into Swedish crowns through the exchange rate μ.

9. Short Term - Product Market

The final quarterly, domestic market confrontation is between firms as suppliers on the one hand and households and firms as demanders on the other. This process 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 just 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 the product markets within the 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 the final product market outcomes only through the initial prices and quantities offered. Firms also indirectly affect the operation of the product markets through the wages they offer and the total amount of income that consumers thereby have available for expenditure.

A few clarifications of the product market process are needed at this stage. Firms have differing price levels on their products. The reason is differing export and domestic sales mixes and the foreign domestic price difference of each market and each firm's export ratio are endogenously determined in the model. Besides, however, the same domestic price is charged by all firms. The reason for this simplification is the practical unavailability of price data for individual firms. It does not make sense to model differing price 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 with production efficiency. Full price arbitrage is assumed within each market each quarter. In model terms this 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.

10. Long Term - Investment Decisions

We have presented the short-term quarterly production planning sequence of the micro-to-macro economy as it occurs within a given production feasibility frontier. The investment decision deals with the choice of future production frontiers. Technology enters in the long-term capacity augmentation phase (shifting of the production frontier). The micro-to-macro model has two alternative formulations of the individual firm investment decision, one sophisticated investment financing version, designed for individual firm "dialogue experiments" and one less elaborate version. In this overview we don't have to distinguish between them. The current operating version of the investment decision is presented in Eliasson-Lindberg (1981).

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

(1) - through the technical performance characteristics of a unit of new investment (called MTEC), which is exogenous. MTEC measures labor productivity.[10]

(2) - through the amount invested (endogenous.)

(3) - through the allocation of new investment over firms (endogenous.)

(4) - through the rate of utilization of installed investment (endogenous), and finally

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

This makes the model truly dynamic in the sense that growth is endogenously determined subject to an upper technology constraint. The micro-to-macro 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 1. The internal planning and decision process of one individual firm was pictured in Figure 2.

The model has been used quite extensively to investigate the nature of technical change in the growth process (see Carlsson-Olavi 1978, 1980, Eliasson 1979, 1983a).

11. Some Properties of the Model System

The distinction between theoretical and empirical analysis becomes very vague 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 before you have described initial (start-up) structures.

Until recently, most analytical work on the model has been concerned with sensitivity analysis aimed at ascertaining the properties of the entire economic system. Empirical verification has been concentrated to (1) enlarging and raising the quality of the firm database, (2) some micro estimation, especially on the production system, and (3) attempts to fit the model to macro national accounts data (see next section).

Analytical work so far has not been systematically organized, but has been of an explorative nature. The summary results reported on below hence should be considered as hypotheses, that are currently subjected to further testing (see Eliasson 1983a).

Only a few of the tests used have been properly designed to allow empirical or theoretical conclusions. We have found 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, that normally cause lasting damage in the form of lost growth.

(*b*) <u>that</u> the "domestic" price system of the model economy, 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 and that "price overshooting" appears to be a characteristic feature of the model economy (see Eliasson 1978c, 1983a and Genberg 1983),

(*c*) <u>that</u> 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) <u>that</u> the Le Chatelier-Brown principle is significantly at work in the micro-to-macro model economy. Reversal speeds depend importantly on the state as described by (a) and (b) and shocks of various kinds can "prematurely" trigger reversals. Positive experiences or policies normally generate expected positive short-term effects that are followed by reversals. More particularly, 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 to develop eventually a more shock-sensitive supply structure,

(e) that if you attempt to stabilize quantities (q), e.g., through countercyclical policies, that policy eventually destabilizes the prices (p) which distorts the labor and investment allocation process that affects (q). The reverse causal chain occurs if one tries to "fix", "regulate" or "stabilize" (p).

(f) that 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 of "Brownian motion" over time in the growth rates among firms,

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

(h) that it was 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 not negligible reduction of the growth rate. The reason seems to be the absence of sufficient micro "instability". The model features an endogenous exit of firms, but no entry. 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 (cf. Eliasson 1978a, pp. 52-55).

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

The micro-macro model - being a growth model - is especially well suited for studies on the dynamic efficiency in resource allocation. If market price signalling is erratic, biased or dramatically shifty, strong negative allocation effects occur. They combine negatively with supply structures characterized by "deficient diversity". For instance, if the tail of low performing firms is too short, almost all firms in a sector in the model can be forced to shut down causing large and sudden disruptions in supply and demand conditions that may be further aggravated by erratic relative price responses (through the allocation mechanisms) (see Eliasson 1978b). In the recently concluded study on the macroeconomic effects of the Swedish industrial subsidy program, these disruptive effects also appeared very strongly when subsidies to large, ailing basic material producers were withdrawn (see Carlsson-Bergholm-Lindberg 1983). This has helped to clarify the restrictive nature of traditional equilibrium assumptions.

One important part of all dynamic resource allocation experiments is the time dimension of supply responses. Short-term (quarterly) supply (the production decision) depends on the expected profitability of engaging people in production under an upper capacity constraint local to each firm. Long-term supply depends on the expected profitability of investing and adding to production capacity. 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, that various interferences with the price system may lower growth below what is technically feasible (Eliasson 1978c, 1983a, and Eliasson-Lindberg 1981), that technical change at the plant level only generates growth with a very long delay (Eliasson 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 transmission times of price disturbances through the model economy that upset the relative price structure and make it difficult for individual firms to interpret and predict price and wage signals in the markets (see Eliasson 1978c, pp.

105-126, and Genberg 1983). A brief period with high prices and profits easily changes into wage overshooting and a cost crisis that may take years to correct itself. If the initial disturbances are strong enough, investments are hurt and firms grow cautious as a consequence of serious expectational errors.

Some of the less palatable conclusions that have emerged from model analysis can be traced to the initial positioning (initial conditions) of the economy, emphasizing the importance of high-quality measurement 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 - create widely diverging macroeconomic effects depending upon the extent and distribution of slack (the cyclical state) of the economy when the policy is enacted.

Further applied work consists in ascertaining the empirical basis for the behavior of the entire model 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 to analyze the efficiency and stability properties of the Swedish economy.]

12. Empirical verification and application

Estimation problems

Good theory combined with facts improves the quality of information. In a micro simulation model of the MOSES type, theory or assumptions (facts) merge in a fashion that is often unfamiliar to the traditional econometrician. Ideally all micro relations should be individually estimated on panel data, under the constraint of some chosen macro data set. This ideal situation is, of course, impossible to achieve with the current, microeconometric techniques available (Orcutt, 1980, Brownstone, 1983, Klevmarken, 1978, 1983).

Three problems in particular should be mentioned in the context of estimating micro based macro models.

(1) Aggregation is explicit. A comparison of problems in estimating conventional macro models has to include a comparison of prior aggregation assumptions with behavioral specifications in the micro model. If such behavioral specification are well researched this 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 (exit, entry, etc.).

(3) While exogenous variables are decisive for predictive performance of macro models, this is not the situation in the MOSES case. Initial data base specifications dominate early macro behavior, rather than the relatively few exogenous variables.

Already the richness in specification in MOSES 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 resides in its specification, and the initial state (database) description of the model. This is matter of priors that enters the analysis. These priors (database measurement ("facts") and model specification) are generally introduced in MOSES on a format that can be subjected to empirical testing. But the fact that small variations in specification and small errors in initial data base measurement can mean a very different macro behavior of the model makes this perhaps a more important matter to consider than the traditional estimation problems.

These problems may be as important in macroeconometric modelling and application. Problems associated with measurement errors and internal consistency in initial data base specification are, however, as a rule completely neglected in the context of macro modelling.[11] We cannot do that in the MOSES model, a circumstance that makes it appropriate to discuss this problem 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 literature. There is, however, very little discussion to find on the importance of correct specification of initial, lagged endogenous variables. They are never discussed as a matter of routine. The lagged endogenous variables correspond to our initial data base. Can this be taken as indirect evidence that errors in measurement and consistency problems associated with the initial database "do not matter" in macro modelling, while exogenous, predetermined variables do?

We have the exact opposite experience from the analysis of the MOSES micro-to-macro model. Exogenous predetermined variables (they are quite few) mean relatively little, while initial database misspecification can generate a very different forecast compared to the one where known errors have been removed.

Some would argue that this is not a desired property of a model. A "good" model should be robust vi s a vis errors of measurement, especially related to the initial data base. It should be "ergodic". I am not so sure about this. I believe that we have seen too many articles and books published on models that have been intentionally or unintentionally misspecified so as to be relatively invariant vis a vis bad quality data.

This fact has also detracted attention in economics away from one of the most important facts of scientific progress, namely that theoretical improvement and the enhancement of knowledge has never progressed faster than the quality and precision of measurement instruments have improved.

A principal argument for the MOSES model has been that improved measurement at the micro level, using the data that decision makers themselves use, and formalizing their behavior in response to these data, should improve our understanding of macro behavior. Compared to entering arbitrary aggregation assumptions as priors in the statistical analysis - as in macro models - this must be considered recommended procedure (see Brownstone 1983, p. 82).

I would argue that good specification of models ("good and relevant theory") should be a prior concern in economics. Microeconometrics is generally much harder on bad theory than is macroeconometrics (Klevmarken 1983). Linearity assumptions furthermore, or close to linear models, or models that can be linearized by transformation are fairly insensitive to measurement errors. They are nice - but boring -to handle mathematically. (It is not difficult to explain why exponential growth models are so popular.) They are also fairly easy to estimate. But such priors imposed on your data may seriously bias your interpretation.

As you enter non linearities and qualitative choice you run into problems on all three scores. If, in addition, you start to disaggregate and increase the number of relationships, you multiply the same problems. This is the MOSES analytical situation. Strong non-linearities and switching behavior can create instabilities and/or explosive behavior in models. It is an open question whether models should be specified so that they are well behaved. Current experience from the 70's rather suggest that relevant models should be unstable at least in some operating domains and even under the benign influence of Government policy makers. Our experience with micro-to-macro modelling is that quality in initial database measurement becomes the overriding empirical concern when one is dealing with a well designed micro-to-macro model, which instead appears to be fairly robust vis a vis individual parameter estimates, and not extremely sensitive to exogenous variables.

In macro modelling one could argue that specification has been "adjusted" to make estimation possible. Even if the model so specified would theoretically be sensitive to the initial specification of lagged endogenous variables practically all data on which the model has been estimated are affected with the same quality deficiencies. Hence, parameter estimates are biased in the direction of compensating for systematic errors of measurement so as to achieve the desired "fits". This is the nature of the regression techniques used. This fact also - together with pure misspecifications - contributes to the wellknown need for reestimation of most models as soon as time has advanced by one year.

We have the opposite experience with MOSES work. As a rule stepwise expansion of the MOSES model (including addition of an input-output system and a monetary sector) has necessitated only minor adjustments of parameter estimates to achieve the same "fits". In addition to that, shifting the model from a very bad quality initial database constructed to mimic conditions in 1950 to a much improved initial database for 1968 - and an expanded model did not require more than minor parameter changes. Roughly the same parameters are used now for the new 1976 initial database, and macro economic fits have not deteriorated. However, the model gradually became more well behaved in response to shock treatments as we improved the initial database.

Finally, we should expect further disaggregation to enhance stability for two reasons. The law of large numbers should begin to influence model behavior, especially if "agents operating in the model" do that fairly independently of one another. If this is not the case - or in MOSES because of the macro monitoring excercised by market price adjustments - one should expect self regulatory market feed back to stabilize the economy. It appears to do in certain operating domains of the model (Eliasson 1983). But at the same time initial database measurement errors, if large enough, tend to move the entire model system into unstable operating domains.

Summarizing so far; If we are dealing with growth modelling the dynamics of market allocation has to be explicit in the model design. If this means that the model economy - and the real economy - has certain possible operating domains of instability and that exogenous shocks, or initial database misspecification, can push the whole system into these domains, these properties should not be removed by prior design.

It is altogether an empirical problem to make the model "behave". Until we know better from well designed empirical inquiries, properties of this kind should be kept.

The special problems we have mentioned also both indicate and restrict the choice of estimation methods. This is the path we have trodden.

(1) By far the largest work effort on the empirical side has been devoted to building a consistent micro-to-macro database. (The database currently used is initiated in 1976, and was ready to use late in 1982. See below.)

(2) Traditional econometric techniques have been, and will be, applied to estimate micro and macro parameters whenever practicable and possible.

(3) For a small number of firms, staff people have been, and will be, invited to experiment with their own firm model and to assign their own parameters.

(4) Partially specified simulation experiments are carried out and compared with approximate macroeconometric measurements (eg. Genberg, 1983).

(5) Isolated model sections are calibrated separately.

(6) Simulations of the entire model over historic time have been compared with macroeconomic variables. Results have been used as criteria in setting some parameters.

(7) Theoretical experiments have been carried out to study certain properties of the entire model system, notably related to its equilibrium and stability properties (Eliasson, 1983a).

Estimation

Estimation of individual firm parameters on panel data over the whole set of micro-and-macro parameters relationships would not be a satisfactory procedure, due to interdependencies across micro relationships and over time. The limited micro and macro estimation we have carried out should, however, pose no problems in this respect. At the micro level the most important work has been carried out in parameterizing the production frontiers (4) (Albrecht, 1978, Albrecht-Lindberg, 1982).

Work is in progress on estimating the micro export supply function in (8), the investment moved shift function for production frontiers (4) and the borrowing functions that enter investment functions.

A number of parameters, for instance the purchase coefficient of the individual firm, have been entered simply as ratio estimates from two flow observations in the database. This is of course also the case for the macro input-output coefficients that constrain the delivery system of the model (see Figure 1).

Household demand is specified as a micro, non-linear expenditure system, and the parameters have been borrowed from Dahlman-Klevmarken (1971) and been entered in somewhat modified form.

Database

The initial database defines the state of some 150 real firms and divisions of real firms end of 1976. It identifies their relative positions in the real and financial performance variables introduced earlier. It defines the information set available to decision makers in each firm (division). All data are consistently constrained within a similarly structured macro database.

In 1976 the macro database of the manufacturing sector is consistently merged with the national accounts of the Swedish economy. On this score, the MOSES team has had to merge also the financial, real and demand macro data sets into a consistent database, which was not expected to be necessary, and considerably delayed model work.

On the micro side the major source of information is the planning survey by the Federation of Swedish Industries that was originally designed on the format of this model and has been carried out annually since 1975. In this survey, production, capacity utilization, investment and other real data are collected. The other important source of micro data is a continuing external analysis of the financial accounts of the 40 largest Swedish corporations. These data are merged with the data from the planning survey (Albrecht-Lindberg 1982, Bergholm 1982).

Altogether this data set covers slightly more than 50 percent of employment in Swedish manufacturing.

An important part of calibration work lies in measuring and predicting certain exogenous factors, the most important such factor being the change in technical qualities of new investment. Work so far rests uncomfortably on the conventional and probably erroneous assumption that technical change is labor saving. (This can easily be modified when we think we know better.) Considerable work has been devoted to estimating the rate of change in labor productivity associated with best practice technologies (Carlsson-Olavi, 1978, Carlsson, 1980).

The importance of initial database quality is illustrated by current work on the model. Economic growth in the model is endogenous under an upper technology constraint associated with productivity in new investment. Depending upon how investment is allocated over firms and time, macro economic growth follows widely different growth trajectories.

Initial database specification also specifies the initial rate of return situation for each firm, which is important for their investment decisions.

When the new database for 1976 was initiated in the autumn of 1982, we observed that the industrial sector set off on a business upswing rather than continuing into the recession that took place in 1977/78. The rest of the eonomy (in traditional macro specification), tracked actual variables well through 1982. The overestimation in GNP volume was mostly due to indirect multiplier effects generated by the faster than real industry growth.

The reason for this perverse cyclical behavior was an overestimated value added and profit margin in the group of real firms in the initial micro database. The reason for the overestimation was that purchases of service inputs in production are not covered by the survey. (Questions on purchases of services have later been added to the survey). The higher profit margins obtained, because of the overestimated value added, gave a too high rate of return on capital that compared well with prices, wages and the interest rate.

Firms planned for fast expansion despite deteriorating external conditions. Only a model with endogenized growth decisions at the micro level would have problems like this with a systematic error in the initial database.

Macroeconomic tracking performance

Without going into detail here (see Eliasson, 1978a, 1983b) we can say that two versions of the model system have been demonstrated to exhibit acceptable macroeconomic and sector growth performance over 8 and 20 year historic periods, respectively. Parameters have only been marginally adjusted over several model vintages and changes of databases.

Price transmission patterns through the economy appear to check well with estimates from the real economy.

We have not yet been able to achieve acceptable cyclical macro performance of the model simultaneously with achieved long-term trend performance.

Micro tracking performance has not yet been studied. The means to do that, namely a panel of firm data on the format of the model are just now becoming available. [I had hoped to be able to present some results in the context of this paper, but progress on this side has not been as rapid as we thought, due to technical difficulties].

Notes

1 The MOSES Model has in fact been used to quantify the macro-economic effects of these subsidies. See Carlsson (1981).

2 See Ahlström (1978). The classification scheme corresponds to the OECD "end-use" classification system. Also see Albrecht--Lindberg (1982, p. 31).

3 (d) and the long-term growth decision will be presented in full in a forthcoming volume (Eliasson 1983b).

4 See also Grufman's (1982) study of the internal cost adjustment of a multinational company.

5 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 becomes "available" under certain, strained economic conditions.

6 Or rather sales volume.

7 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 in Figure 4 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 Eliasson (1983b).

[8] A full description can be found in Eliasson (1978a, pp.137-148 and 218-227).

[9] 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.

[10] There is also another exogeneous factor called INVEFF that takes care of capital productivity and compares with TEC which is the "marginal product" of labor in operating the old (pre-new-investment) facility near zero employment. It can be demonstrated that (in(4)) $TEC=\gamma *QTOP$. See Eliasson (1978a, p. 64).

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