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EDITOR.

A Micro-to-Macro Model of the Swedish Economy.

Papers on the Swedish Model from the Symposium on Micro Simulation Methods in Stockholm Sept. 19-22, 1977.

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THE INDUSTRIAL INSTITUTE FOR ECONOMIC AND SOCIAL RESEARCH, STOCKHOLM.

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A MICRO-TO-MACRO MODEL OF THE SWEDISH ECONOMY

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INTRODUCTION

This is the set of papers on the Swedish micro-to-macro model which were presented at the *IUI-IBM Sweden conference on micro simulation models*, September 19-22, 1977. To our knowledge this is the first international seminar ever devoted to micro based models of entire economic systems. Besides the Swedish model, papers were also presented on the Yale model (Orcutt et al.), on the University of Maryland model (Bergmann et al.) and on others. The conference program has been attached at the end.

The plan is to publish the complete proceedings in one volume pending editing and also to allow for separate publications of various items. The papers on the Swedish model have been ready for some time, and since we need the documentation we are now publishing them under separate cover. They will appear as they now stand in the full conference volume.

The Swedish micro-to-macro model is based on a modified Leontief-Keynesian 10 sector macro structure. Four of the sectors have been expanded to accomodate a large number of individual business firms (decision units) connected via explicit labor, product and credit markets at the micro level. The individual firm model contains several novel features. Emphasis is on the importance of the market process, as we see it at the micro level, for macro behavior. This micro-to-macro link includes both how individual decisions interact to affect macro behavior and how the behavior of the total system impacts micro units. In that sense the performance and stability properties of a market based, industrialized economy are the prime concerns of the study. The performance aspect very much centers around the allocation of total resources in the long run and how that process is affected by decision making and market behavior. More specifically, the interaction of inflation, expectations and growth is the topic that carries through the project work and also this set of papers.

In the first paper (Eliasson) the full model is presented. In the two following papers (Klevmarken) and (Eliasson-Olavi) estimation problems in the context of micro based models are discussed. However, the *IUI-IBM Sweden* joint project to build a micro-to-macro model was defined as a theoretical inquiry and an exploratory venture into a new methodological field in economics. It was never intended to be a turnkey forecasting tool. That would require a second stage with more sophisticated and much larger data base work than we have mustered so far. Hence, at this stage we prefer to refer to the model as representing a *Swedish-like* economy. The orientation of model work since autumn 1977 has been, however, strongly empirical and aims at eventually encasing the model in a high quality micro and macro data base. For this reason we distinguish between the *theory* as such, outlined in the beginning model presentation (Eliasson) and the complete *model code*, sometimes referred to as MOSES (Model for Simulating the Economy of Sweden).

In the applications section one paper is devoted to the growth response to exogenously induced inflation (Eliasson) and how a disturbed price signalling system affects business decision-making at the micro level. We think we have been able to cast some new light on the current inflation phenomenon.

A paper on the impact of technical change on employment, growth, profits and prices (Carlsson-Olavi) follows. Another paper (Albrecht) investigates how exogenously modified expectations affect a closed US-like economy and an open Swedish-like economy; in particular, whether exogenously generated inflationary expectations could produce a general run-away inflation and/or whether optimistic expectations among firms can generate a higher growth rate. The set of papers on the Swedish model concludes with a description of the data base that has been used (Ahlström) and a complete model code on an early and simplified version of the model (Eliasson-Heiman-Olavi).

Stockholm, April 1978

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PRESENTATION OF THE SWEDISH MICRO-TO-MACRO MODEL

A MICRO SIMULATION MODEL OF A NATIONAL ECONOMY

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This micro based macro model has been built with the primary intent to use it as a tool to investigate two problems in particular, namely

(1) the micro basis for inflation - assuming that this is a relevant and interesting area of inquiry and
(2) the interaction over time between inflation, profitability and economic growth.

As we will soon find out below a byproduct of this ambition will be a skeleton theory of an economic system in total disequilibrium at the micro (market) level being bounded upwards each time by an exogenous technology constraint. We will find (and especially so in the later application papers) that we are particularly interested in the stability properties of the total system that also define the lower limits of the activity domain of the entire system.

The model is of the microsimulation kind in the sense of Bergman (1974), Orcutt (1960, 1976) etc. The major difference is that we study business decision units (= firms) in an explicit market environment, rather than subindustry aggregates or households, and perhaps that we have allowed very little detail to enter the model.

The philosophy behind the model is that we need more knowledge of the interaction between micro agents (firms, households, etc.) in markets to understand important aspects of macro behaviour. This is thought to be particularly so when it comes to studying the mutual influence over time between changes in the general price level and aggregate economic activity levels.

The two purposes overlap and general experience is that the second purpose requires a micro approach to be meaningful. The first question requires a complete model covering all relevant sectors of the economy, however, with limited detail in specification. As long as we abstain from asking for numerical estimates or forecasts the empirical requirements on specification are reasonable.

They are, however, much higher if we want to deal with the second problem: "inflation, profits and growth" in a relevant way, although, this time, demands on economywide coverage are not so large. Emphasis is on the business sector. We may reformulate this second problem somewhat as an analysis of the interaction between long-term growth and the business cycle.

Of course, if we have built a model that can handle the above problems to our satisfaction it should be capable of handling several others as well. In fact, one ambition of ours is to catch as much as possible of the true market based economic system at work through being as explicit as possible in modelling the market process at the micro level and how market price information is interpreted by firms. In order not to take on an overwhelming task we have struck a convenient compromise in specification that, however, does not - I believe - reduce the explanatory potential of the model or subject us to extreme empirical hardships. For the time being we have constructed a conventional, and in no way complex, macro model within which a micro (firm) specified industry sector operates. This approach allows us to keep our special feature, namely a micro specification of the behaviour of two types of markets: The labour market and the product market and to some extent also the money market.

We have to keep in mind that the prime ambition with this modelling project is to have a richly specified model structure capable of responding to a spectrum of interesting what if questions. The purpose is analysis, not forecasting. The idea, however, is not to model every possible circumstance of some interest or to forecast minute details. The potential of this model is that it can capture essential dynamic features of a fully specified market process, never in equilibrium, and to study what this core-mechanics of a market based industrial economy means for macro behaviour.

This paper will contain a non-formal overview of the model.[1)] There will also be an account of the estimation or calibrating principles involved and a few words on the empirical philosophy of the method: does it differ from conventional econometric method? A partial mathematical specification concludes the paper.

This paper is self-contained for those who are only interested in what the model is all about, without understanding exactly how it behaves at the macro level.

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1) A full description of the model as it stood in November 1976 is found in Eliasson (1976 b). Since then a full public sector with a tax system and a money sector have been entered together with a number of improvements and revisions. This overview covers these extensions and a full report is in preparation. See also Eliasson-Heiman-Olavi: Technical Specifications, supplement to this conference volume.

2. MODEL OVERVIEW

Table 1 sums up the main blocks of the model and its connection with the outer world.

It should be noted that besides policy parameters there are three important sets of exogenous variables; foreign (export) prices, the interest rate and the rate of change in productivity of new investment.[1)]

The model operates by quarter on a set of future quarterly values on the exogenous input variables. The model will generate a future of any length, by quarter, on the national accounts format, excluding certain sectors like agriculture, shipping, construction, etc. that we have lumped together as an exogenous dummy sector, that interacts with the model as a cell in an input output matrix only (see below).

The choice of period in the model is stepwise and involves gradual bindings. In the long run firms are seen as planning their investments for a five year period[2)]. This leads to

---

1) There are several, additional exogenous variables that are not important for the kind of problems we have chosen for analysis. They are left for the technical description under preparation. The rates of entry into and exit out of the labour force and Government employment, for instance, are exogenous.

2) This investment (long term) planning sequence is not yet in the model program. It has, however, been presented in much detail in Eliasson (1976 b, chapter 3). It should also be mentioned that the overall periodization choice for the model very much adheres to practice at the Corporate Headquarters level as described in Eliasson (1976 a). Further breakdown of periods than by quarter generally do not correspond to centrally coordinated decisions but are delegated down and sideways, and are generally buffered centrally, to allow some stability in the realization of top authorized decisions. This suggest that "undated tatonnement" within the quarter should be a fair representation (see below).

final decisions for long-term borrowing. Profit targets and expectations are semi-hardened for the annual budget period but adjusted partially for outside unexpected influences by quarter - the period for which production decisions cannot be changed.

This may seem too long a period for some activities to be fixed, like buffered supplies out of inventories and short-term market pricing. Such further gradations of the finalization of decisions can be entered if we so wish. In order to keep the model structure and computing time within manageable dimensions we have, however, abstained from further detail here, for the time being. This means that finalization of decisions into action takes place through an undated and elaborate "tâtonnement" process within the shortest time period (the quarter) made explicit in the model.

For all practical purposes the problems we have in mind mean that the time horizon should be around five years or one full business cycle. We will come back to the horizon problem later. However, even if our attention is restricted to a 5 year time span, much of the calibration work that we will perform, requires that we check model behaviour over a much longer period (see section 3 below).

The best way to proceed from here is to go through the central model blocks one by one.

a) Total system

One way of describing the total model would be to associate it with a so called Leontief-Keynesian (L-K) model, which is a fairly well known class of models. Let us begin from the L-K model by:

(1) reducing the Leontief structure to 7 sectors (see Table 1 and Figure 1).

(2) Adding a Stone-type linear expenditure system on the Keynesian side together with all the conventional national accounts identities.

From this:

(3) Add saving and some non-linear features to the consumption system.

(4) Define all manufacturing industry sectors in micro terms as populated by individual firms.

(5) Make individual firm export ratios (coefficients) endogenous and responding to relative foreign-domestic price changes.

(6) Ditto for import side but at macro-sector (market) level.

(7) Introduce non linear production structure for each firm that makes labour coefficients in I/O matrix variable and endogenous.

(8) Ditto on investment side.

(9) Add buffer stocks of input and output goods for each firm in each sector.

(10) Make business expectations forming, profit targeting and production and sales planning explicit for each firm.

(11) Merge real - price - and money parts of model with:

   (a) micro based labour market where wages are determined on the basis of the action taken by all agents in all sectors

   (b) Semi-micro, product market where product prices are determined, and

   (c) Macro-money sector that allocates financial flows and determines domestic interest rate.

(12) See to it that (in the process defined by (11)) business profits are determined endogenously and fed into each firm's investment function.

One could also say that the model has been built around a theory of firm behaviour, partly developed already in Eliasson (1976a), aggregated to the macro level through individualized labour, product and credit markets, the whole thing finally being encased in a Leontief-Keynesian macro structure.

The industry sector is conceived as the primary generator of material wealth in an industrial economy. Since an explanation of growth is a primary ambition of this project a relatively heavy emphasis has been placed on the industry sector. This also goes for the micro specification.

The real production and delivery structure of the model is pictured on a macro format in Figure 1. In the middle the four sectors that contain micro units (firms) are seen;

(1) RAW materials production

(2) IMED, intermediate goods production

(3) INV estment and durable consumption goods producing sectors

(4) CON sumer goods (non durable) producing sectors.

Each firm relates backwards, (leftwards) in this structure with its own set of input-output coefficients, some of which vary because of "non-proportional" stock formation.

There is an exogenous production sector (agriculture, housebuilding, etc.) that interacts with the other sectors only in the capacity of being a dummy cell in the I/O matrix.

The service and government sectors are denoted Z and G respectively in the input output matrix.

Left and vertically a vector of imports feeds into each production sector that includes finished goods for each sector (competitive products, endogenous I/O coefficients) and primary commodities as imports that are not produced in model economy.

Down and horizontally total product in each sector emerges. Part of each sector output is exported, the export ratio being endogenously determined. Summing X horizontally and IMP vertically and taking the difference gives the trade balance to the left. Correcting total supplies for the trade balance gives GNP to the right.

In the upper horizontal vector total labour input in each production sector is shown. Combined with wages determined endogenously they give total disposable household income before all taxes, including the payroll tax (DISP top right).

After subtraction of taxes that feed into public sector, the rest is disposable to households and feed back as demand to producing sectors through product and service markets. Part of it is saved and deposited in money sector.[1)]

Figure 1 gives the static, national accounts structure of the total model together with the Leontiefan delivery structure. The dynamic elements enter through the micro specified business sector and its interaction with all other sectors. One typical feature of the entire model, and the business sector in particular, is that its dynamic properties depend fundamentally on volume responses (within and between periods) to ex ante and transitory price signals. Hence, the core of the model is typically classical, shaped in an ex ante expectations framework. The entire model is a true general disequilibrium system although not based on marginalistic decision criteria. There exists no long run ex ante or ex post equilibrium position independent of the evolution of the system to the total model or parts of the model, except by chance. The position point in space towards which the system tends each point in time moves with the solution (actual position) of the system each time. Experiments carried out so far, however, suggest a strong tendency with the entire system to stabilize around a long run steady growth rate if the exogenous input variables are defined as constant growth rates. When aggregation is made across and over some time a typical Keynesian system can be shown to emerge.

b) Business sector - short-run production planning of one firm

Figure 2 gives a flow-chart overview of the short-term decision system of one firm. For the time being this is the only micro(firm) section of the model. Figure 3 gives

1) I have not managed to picture firm investment demand and the ex post savings investment accounting equality in Fig 1.

some detail of the production system. Each production sector holds a number of such individual firm (planning) models.

In Figure 2 an experimental run begins at the left hand side from a vector (P, W, M, S) of historic (5 year annual) Price, Wage, Profit margin and Sales data respectively. These data are transformed into expectations in the EXP module. Here we use conventional smoothing formulae.[1)]

The profit margin variable is translated into a profit target in the TARG block. Here we also use a conventional smoothing formula. The length of historic time considered is longer than in EXP sector.

Growth expectations feed into the investment module to generate long-term plans as explained below. Long-term expectations are also modified to apply to the next year and are fed into the production system.

Each period (quarter) each firm is identified by a production possibility frontier (QFR(L)) defined as a function of labour input as in Figure 3 and a location within that curve. The distance between A and B measures the increase in output Q that the firm can achieve during the current period with no extra labour input than indicated by the L coordinate in A. In practice a vertical move between A and B cannot be costless. For the time being we will have to abstract from this. Suffice it to note that in those experimental runs, where we have investigated this aspect, there seems to be a general tendency among firms to be operating in the A to B range, which is constantly shifted outwards by investment.[2)]

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1) Applied to the quadratic feed-back learning EXP-function developed in Eliasson (1974,pp.79ff.). See further section 4.

2) This obviously is an instance of what Leibenstein (1966) has called X-inefficiency or a form of slack. Note here Carlsson's (1972) measurement of the presence of such slack in Swedish manufacturing, especially as regards the degree of capital utilization or (A-B)+(C-D) in Figure 3.

The distance CD measures (for the same period) the extra increase that the firm is capable of, with the application of extra labour, but staying within a commercially viable operating range. Approximate data on A, B, C and D were collected in the annual planning survey for 1976 and 1977 by the Federation of Swedish Industries.[1)]

The production function QFR(L) in Figure 3 is of the putty-clay type. New investment, characterized by a higher labour productivity than investment from the period before is completely "embodied" with the average technical performance rates of the period before through a change in the coefficients of QFR(L).

The first sales growth expectation from the EXP module (see Figure 2) now starts up a trial move from A in the direction indicated by EXP (S). After each step, price and wage expectations are entered and checks against profit margin targets are made. As soon as the individual firm M-target is satisfied, search stops and the necessary change in the labour force is calculated. If it is a decrease, people are laid off. There are various checks to prevent a too fast shrinking of the labor force (see pp.68-75).If it is an increase, the firm enters the labor market to search for new people (see below). After this search has been terminated the firm can calculate its output for the period. The wage level has also been determined and feeds back to update the historic vector (dotted lines in Figure 2).

The firm now checks up against finished goods stocks to determine how much to supply in the market. A certain fraction, determined by the last period's relative domestic and foreign price differential is shipped abroad.

The final distribution between sales and inventories for each market and the price level is determined in a confrontation with imports and household demand (middle right

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1) See Virin (1976) and Albrecht (1978).

end of Figure 2 and lower end of Figure 3) to be described later. Final price, profit and sales data are now determined and also feed back into the historic vector (dotted lines).

How rationally are these firms behaving in view of the fact that they deliberately abstain from moving on to the location where profits (in expected value terms, margins or rates of return) are at their highest in each period. (For details see section 4.5 on pp. 68-73.)

The answer is that corporate headquarter management of each firm in reality does not know even if the model specification would say so. Firm management knows, however, that (if necessary) better solutions can be found but not exactly how and where. Such better solutions require an extra management effort and support from below, which is only forthcoming when the profit performance situation is deteriorating sufficiently rapidly, and more rapidly than the firm adjusts its own targets. Such behaviour is quite well supported by empirical evidence (Eliasson 1976a). If one so wishes, one may say that profit maximizing behaviour is approximated in some long run dimension or under limited information, which lends an air of rationality to the use of simplified decision rules.

Part of this limited information consists in awareness of the fact (being an important property of the model) that if firms start departing from routine planning solutions en masse they will soon find that their expectations are much more unreliable than before. Search routines in production planning are geared so that the model firm strives to find solutions that allow it to maintain past output levels, when subjected to profit target pressure. However, if we force firms to raise their profit margin targets[1)] they will have difficulties finding a satisfactory solution without cutting out unprofitable production lines (reducing output). The same thing happens when profit margin targets stay put but price and wage cost development generate an expected profit squeeze.

1) by raising ε or TARGX(M) in (1b) in section 4.

On the other hand, if we want firms with high profit margins to produce and sell more to earn more profits they have to get more people. If many firms start searching the labour market for additional people they very easily push up wages so that, on the whole and after a while, profits, investment and growth come down. This is the same as to say that for some numerical specifications of the model there exists no profit maximizing solution to the model at one point (quarter) in time. And the idea of the model is that this is a relevant aspect of real life and that it is slightly irrelevant to be concerned about the problem.

Some might argue that firms should maximize sales under a profit constraint. First, this is not meaningful in the short run. Second, there is no good evidence that firms really are that concerned about their sales. Third, in the long run it is also a rather empty proposition but the outcome might yet be very similar to what can also be derived from a profit maximizing or profit satisfying objective. In fact it is almost impossible to make a meaningful distinction between profit maximization, profit satisfaction or sales maximization under a profit constraint over a longer time period since the rate of return of a firm, as demonstrated by the targeting formula (1a) in section 4 below, relates directly to the value growth of the firm. If firms want to raise their value to the stockholder they should raise their rates of return and invest the proceeds at those higher rates of return. Since that will normally mean to grow faster also in output or sales, profit maximization, satisfaction or sales maximization under a profit constraint are hypotheses that normally cannot be discriminated between in empirical tests. As matters stand, satisfying behavioral rules of the kind modelled here match actual corporate practice much better than the other, above mentioned alternatives. Since these behavioral rules are furthermore much easier to model and since they also give rise to somewhat different and more realistic behavioral forecasts in the <u>short run</u> we have used them.

c) Labour market

The labour market process is represented in micro in considerable detail. At this level, however, the requirements on relevant specification are still higher. Hence, the version now to be described should be considered a provisional one. Experiments conducted so far have taught us that model behaviour is too sensitive to variations in the random search sequences (in combination with a small number of firms) to be reasonable.

All labour is homogeneous in the present version of the model.

The first step each period is an adjustment of "natural" decreases in the labour force of each sector and each firm unit through retirement etc. This adjustment is applied proportionally throughout. Then the unemployment pool is filled with new entrants to the labour market. After that the service and Government sectors enter the labour market in that order. They offer last period's average wage increase in the manufacturing sector and get whatever is available from the pool of unemployed. This sounds a little bit arbitrary and it is. We have had to enter this erroneous specification provisionally to allow for the fact that wage and salary levels differ a lot between sectors despite the fact that labour is homogeneous. The assumption that industry is the wage leading sector is quite conventional in macro modelling. It is probably not quite true at the micro level. With no explicit separation of wage levels (because of skills etc.) and little knowledge as to how the Government, service and industry sectors interact in the labour market this macro simplification should do for the time being.

After the service and Government sectors, firms enter one by one in the order by which they desire to increase their labour force. They scan all other firms inclusive of the pool of unemployed. The probability of hitting a particular location of labour is proportional to its size (labour force compared to total labour in industry and the number of unemployed). The probability of search leading to the pool of unemployed can been set higher than the fraction of the total labour force being unemployed. In fact, this probability can be interpreted as a measure of the allocative properties of the labour market. The institution of an employment agency should tend to increase that probability and the more so the more efficient this institution is. With no unemployment and/or no efficient search tool for the firms to find the unemployed the labour market consists only of people employed in other firms. We have found that macro model behavior is sensitive to specifications here and we will pay considerable attention to this in our analysis.

The firm offers a fraction of the expected wage increase. From the pool of unemployed people are forthcoming at the wage offered if a firm is searching that pool.

If the firm meets a firm with a wage level that is sufficiently below its own, it gets the people it wants up to a maximum fraction of the other firm's labour force. The other firm then adjusts its wage level upwards with a fraction of the difference observed.

If a firm raids another firm with a higher wage level it does not get any people, but upgrades its offering wage for the next trial. After the search is over, firms with relatively low wages, that have learned about the market wage levels around them, have had to upgrade their own wage level by a fraction of the differences observed. This is the way labour market arbitrage operates in the model.

Firms can be given any predetermined number of trials. Obviously the size of wage adjustment coefficients and the number of trials (= intensity of search) each period determines the degree of wage differentiation that can be maintained in the labour market under the homogeneity assumption. We have experimented with various impediments to this adjustment process. We have learned that overall macro behaviour of the model is very sensitive to the numerical specifications entered here.

d) Business system: Investment Financing (micro)

As the model now operates the investment financing[1)] section is quite simple.

The frame of the investment decision in each firm is the investment budget.[2)] Firms, defined as financial units, are typical plow-backers. After subtraction from profits of interest payments and dividends (that enter household income) and taxes part of the residual is set aside for mandatory financing demands from current asset (inventories, trade credits, etc.) accumulation associated with growth. What remains is what is internally available for spending on capital account. This financial "frame" is increased by borrowing. The rate of increase in outstanding debt depends on the difference between current nominal returns to investment and the nominal (endogenously determined) interest rate.[3)] There is, however, one constraint that prevents this rate of

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1) In Eliasson (1976b, pp.75-103) a complete long term planning and financing model has been specified in outline. Since this sector has not yet been made ready and programmed we only present the provisional investment module currenty in use.

2) The specification rests very much on the capital budgeting theory of investment planning developed in Eliasson (1969). This formulation in turn incorporates several features from the Meyer & Kuh (1957) "residual funds" theory of investment. It should be added that despite all good fits of the neoclassical investment function reported on over the last 10 to 15 years evidence strongly suggests that the above, financially based sequence of decisions best pictures the investment decision process at the firm level.

3) This is how the rate of borrowing function looks:
DBW = F(RR+DP-RI), F' > 0 (see p. 66).
DBW = rate of change in outstanding debt
RR = real rate of return on total assets
DP = rate of change in investment goods prices
RI = nominal borrowing rate.
Since both RR and DP figure importantly behind the current profit inflow, the profit and cashflow (plow back) hypotheses are merged into one, as they should of course be.

Table 1 MODEL BLOCKS

1. Business system (firm model) - four markets (sectors).
   (A) Operations planning (short term)
       Production system
       Inventory system
       Expectations
       Targeting
       (Cash management)

   (B) Investment-Financing (long term)
       Investment plan
       Long term borrowing*

2. Household sector (macro)
       Buying
       Saving

3. Service sector (macro)

4. Public sector (macro)
       Employment - exogenous
       Tax-system (value added, payroll and income taxes + transfers)
       Economic policy - fiscal & monetary parameters.

5. Other production sectors - exogenous

6. Foreign connections
       Foreign prices - exogenous
       (Exchange rate)
       Interest rate { foreign - exogenous / domestic - endogenous }
       Export volume
       Import volume

7. Markets
       Labour market
       Product market
       Money market

8. Exogenous variables (summary)
   (a) Foreign prices: one for each of the four markets
   (b) Interest rate: foreign
   (c) Technology: The rate of change in labour productivity of new investment, i.e. between vintages.
   (d) Government policy parameters, labour force, etc.

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*Conceived, but not yet programmed. See pp. 75-103 in Eliasson (1976b).

Figure 1 The INPUT-OUTPUT and MARKET STRUCTURE

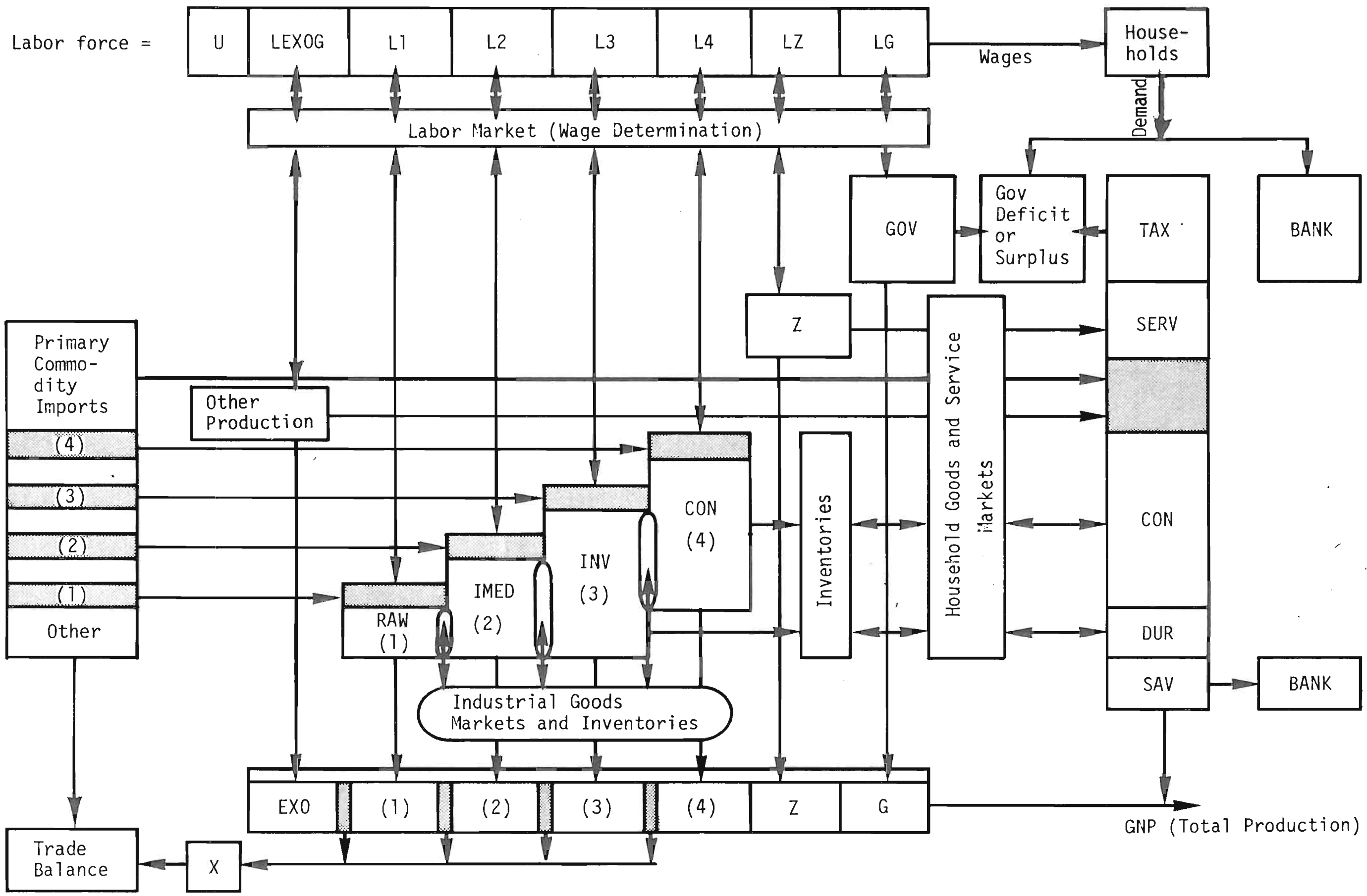


Figure 2 Business Decision System (One Firm)

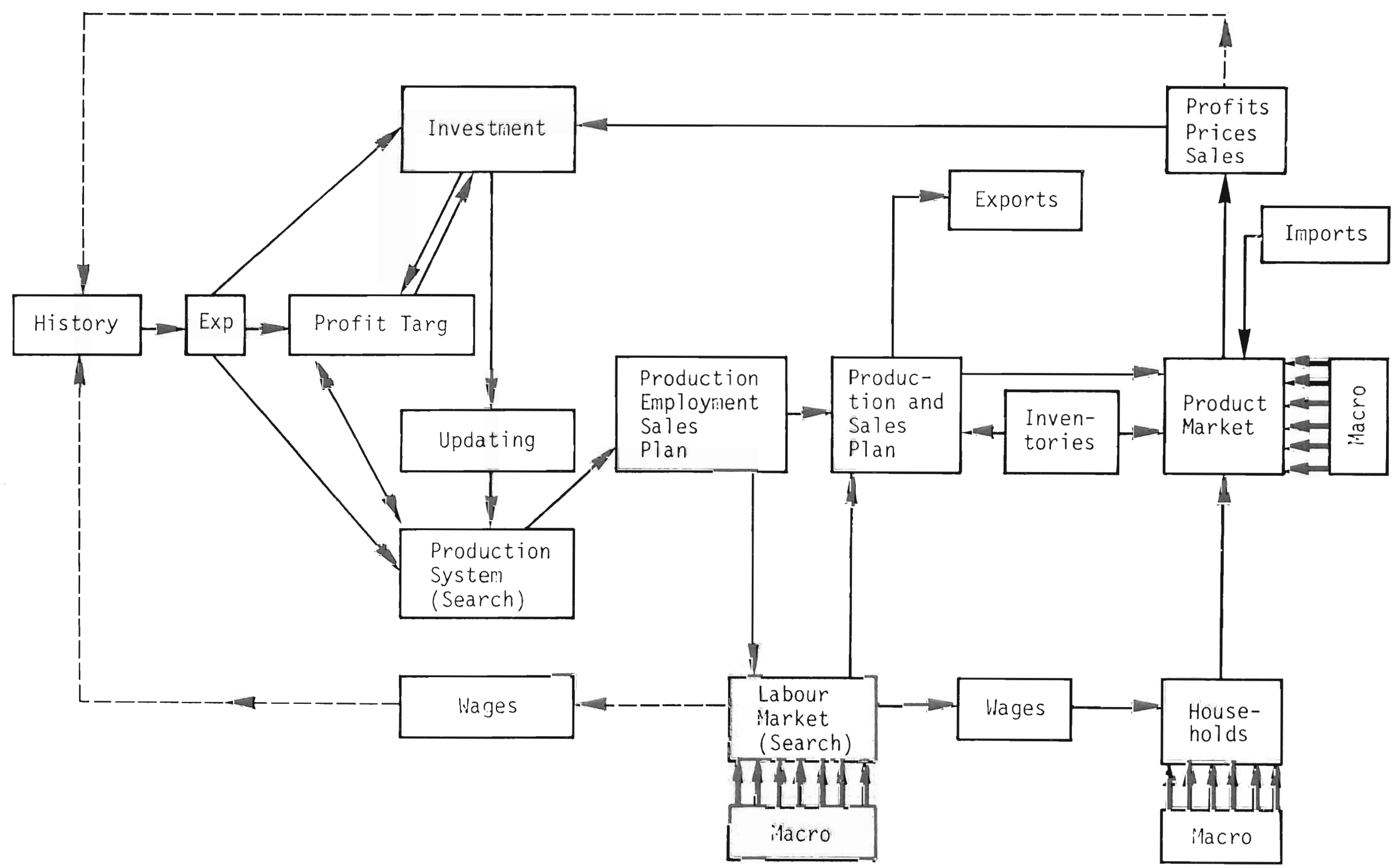
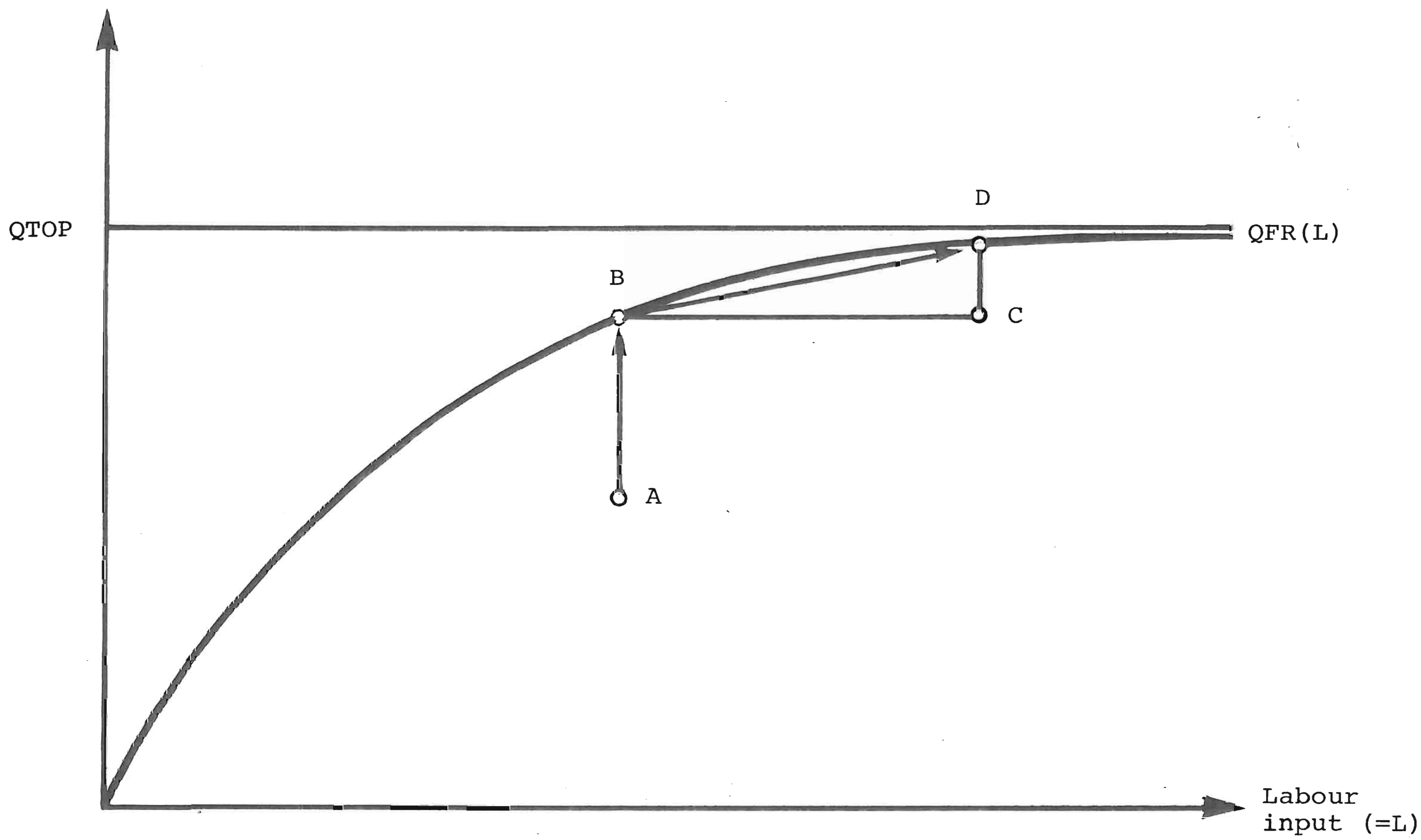
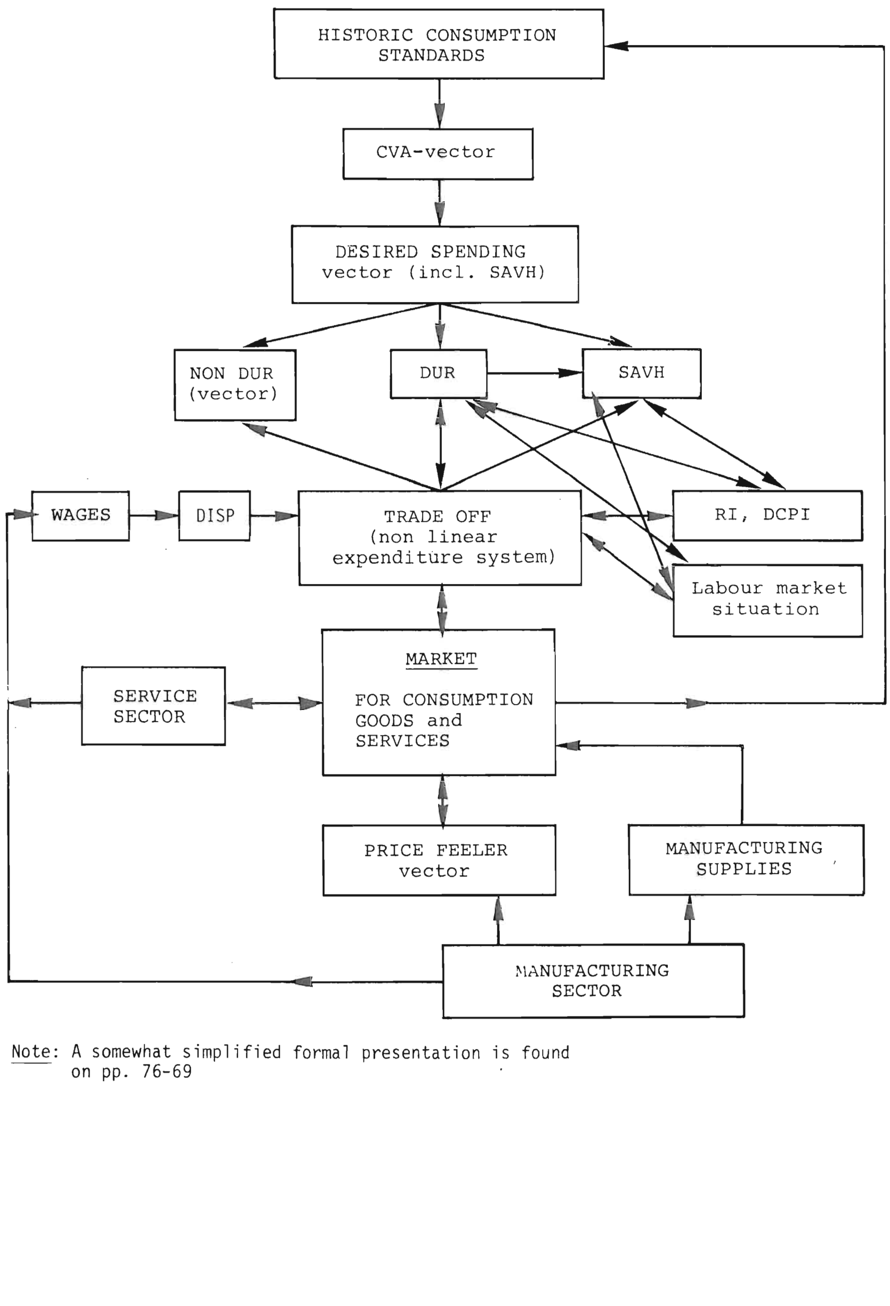


Figure 3 Production System



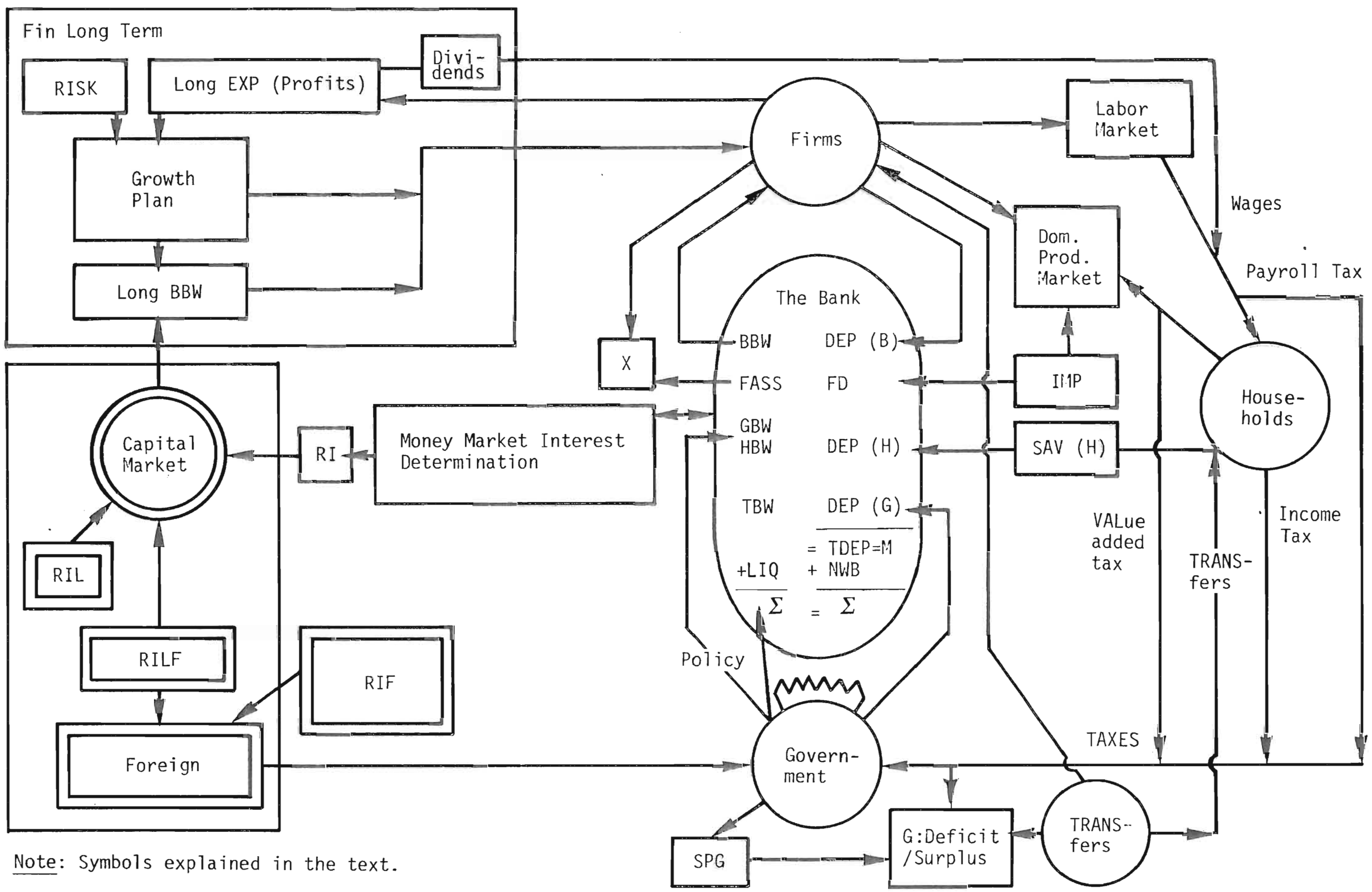
Note: Also see pp. 63 ff.

Figure 4 CONSUMPTION SYSTEM AND PROD-MARKETS



Note: A somewhat simplified formal presentation is found on pp. 76-69

Figure 5 The Money System



Note: Symbols explained in the text.

borrowing from materializing fully. The firm is checking back at its rate of capacity utilization. The total investment budget calculated as above is corrected for the rate of capacity utilization of equipment and the rate of borrowing is reduced accordingly. Hence if no borrowing takes place and surplus internal funds emerge firms deposit such funds in the bank (see Figure 5).

c) The household consumption system (macro)

The household sector today is only specified in macro. However, the module as such is prepared for an easy transfer into micro, in the sense that macro behaviour will be assumed to be formally identical for each micro unit (household), the only difference being the numbers we place on various parameters. The prime reason for staying at the macro level here is empirical. There are practically no empirical micro data for Sweden available on which to base empirical estimates. This is in marked contrast with the situation in the U.S., where most of the work in this area has been done on the household sector by Orcutt and others. Besides, the author himself does not have the same kind of background experience for the household sector as for the business sector.

The consumption function is a Stone type expenditure system with some non-linear features. One additional novelty is that saving is treated as a consumption (spending) category. There is also a direct interaction (swapping) between saving and spending on household durables, entered as the relation between the rate of interest (RI), inflation (DCPI) and unemployment changes. (See (8c) p. 79.)

The household spending decision process is described in Figure 4. For the time being we are concerned with macro, the entire economy. Each period a vector of historic consumption data is transformed into a vector (CVA) of "addicted" spending levels which in turn can be translated into "desired" spending. This is very simply done through linear transformations. Desired spending is decomposed into several kinds of nondurable (NON DUR) consumption (incl. services), durables (DUR) and "saving" (SAVH).

In another end of the model the manufacturing, service and Government sectors generate income that feeds into households as disposable income (DI).

There is a residual (positive or negative) between desired spending and disposable income. This residual is allocated on different spending categories by way of marginal elasticities that differ from those that divided up total desired spending.

The production sectors announce their supplies in each market and put out price feeler vectors.

Households tell what they will buy at these prices and there follows a predetermined number of confrontations. The last price feeler vector is then taken as the price for the period (quarter) and firms split their available goods between sales and inventories on the basis of this price. When firms decide on preliminary supply volumes to offer in the market they each check back at their finished goods inventory positions. The guiding principle is to maintain the price level that has entered the production planning-supply decision and to try to move inventories towards optimum levels within a predetermined min-max range.

f) The money-sector

The real and price determination (market) parts of the model described so far have recently been integrated with a money system.[1)]

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1) This block and the input-output system described before was not ready in the full description of the model reported on in Eliasson (1976b).

The money system is there to handle the interaction between quantities, prices and financial flows, notably the determination of the absolute price level and the rate of interest. We do not (as yet) aim at explanatory detail in the credit market.

Figure 5 gives an overview of the money system. Its core is called The Bank and is made up of all financial accounts (debit and credit) that other sectors hold with financial institutions. The Bank represents all financial institutions (commercial banks, savings banks etc.). Firms borrow (BBW) from and hold deposits (DEP(B))in the Bank as described earlier. The Government does the same (see below).

One important feature is export and import credits (FASS and FD respectively). For reasons of simplicity we do not explicitly allow individual firms to have their own financial ties with the rest of the world. An export transaction always gives rise to a temporary credit to the rest of the world. This asset on the part of a firm is always sold to the Bank for Swedish crowns and the bank holds an aggregate of not liquidated trade assets vis-à-vis abroad called FASS in Figure 5. The size of FASS (or rather net changes in it) depends strongly on the outflow of export deliveries (X) and (NB!) the difference between the domestic (RI) and the foreign (RIF) interest rate.

A similar relationship holds on the import side. Before imports have been paid for there is a temporary debt called FD vis-à-vis abroad. Also this debt is transferred to the Bank and the aggregate depends on the inflow of imports (IMP) and the foreign-domestic interest differential.

Households, finally, also deposit their savings (SAV(H)) in the bank as DEP(H) in Figure 5. Since the household sector has been treated in aggregate terms we do not here distinguish between gross depositing and household borrowing but rather treat saving net.

There is, however, one real fact of money life that we have to account for. Who is going to absorb the effects of a money constraint, if there is one, and if the Government chooses to carry out restrictive monetary policies? As to the size of the total effect on money supply we let the model decide through the total system. If the money constraint cannot be accomodated elsewhere in the system (by an interest rate increase or a reduction of liquidity in the banking system) households take the first impact, up to a limit. To accomodate this we have a household borrowing variable (HBW) that becomes negative when such things happen. Beyond a limit the impact spills over on firms through a reduction in their investments as definitly planned. This is treated as a flat rate reduction as the model now stands and any firm that then finds itself with liquidity "to spare" automatically deposits it in the Bank.

As is well known, and quite trivial, the public sector excercises a monetary policy impact through its spending and tax decisions that cannot be strictly separated from other monetary policy measures. We will return to this in the next section. Except for fiscal policy the Government can carry out monetary policies (in the model) in 4 ways.

(1) It can fix the interest rate and adjustments take place through liquidity flows throughout the money system.

(2) It can tighten up liquidity requirements (LIQ) of the Bank.

(3) It can borrow abroad (see Figure 5).

(4) It can (also) impose a trade margin requirement on the Bank.

The reader should note here that the Central Bank as a separate and semi independent policy agency has not been made explicit. For this to make economic sense we would have to have open market operations explicit in the model.

Since the whole capital market and long term borrowing is not in the model, open market operations do not figure, and the Government is the sole policy maker.

Suppose that the Government does not aim at directly controlling the interest rate (RI)[1] but rather uses the other monetary policy parameters mentioned.

Any change in the model then affects the economy in four ways.

The first impact is a liquidity effect. Under normal circumstances the Bank should be able to buffer it through its own liquidity reserves.

Next, these liquidity effects work themselves into the interest rate.

Total deposits in the Bank by definition makes up the money stock (= M). Together with bank liquidity it defines total money supply. Total demand for money is made up of total borrowing requirements on the Bank, and the domestic interest moves in response to the change in total supply and demand for money (middle of Figure 5). In effect the entire model operates on the Bank vis-à-vis the in- and outgoing accounts that make up the supply and demand for money.

There are three important, and unsteady, components, that allow the rest of the world to affect domestic interest determination.

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1) Our model will not allow us to analyze whether this is possible or not and to what extent. We can only study the consequences of a given, below market rate of interest. This we have to do in our historic runs, since the Central Bank actually managed to keep the official interest rate substantially below the market rate well into the 60ies (see Eliasson (1969)). The sad thing is that the current version of the model will not be able to catch the market rate of interest very well since we have not entered a "grey" inter firm credit market.

The first and most immediate impact comes through the net trade credit position (FASS-FD=FNASS). FNASS reacts directly on the foreign-domestic interest differential.

Second comes business borrowing that responds to rates of return in individual firms and the domestic interest rate. The rate of return - in turn - depends on foreign and domestic prices and productivity and wage change (unit wage cost change) in individual firms.

Third comes household saving that depends on the cyclical growth and inflationary situation of the entire economy that in turn, in a very complex way, falls back on past profit and investment performance in industry.

In fact the model will allow us to study the Keynesian - Monetarist controversy on e.g. the origin of inflation in much detail. Is there a difference? To what extent can the policy authorities determine (policy) money stock, and, if they can, do we have to run our analysis or our explanation in money terms rather than using a mirror terminology of Keynes?

The reader should finally note that money is now in the model but not financial behaviour, except in a quite crude way. Long term expectations on the part of firms, long term borrowing and financial risk aversion, in particular caused by negative short term experiences are not yet there. The missing sector called long term planning and financing, including the capital market, has been indicated by two rectangles to the left in Figure 5.[1)]

g) The Public sector - policy making

The public sector (local and central) figures in a rather simple, aggregate way. The public employment decision is

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1) Part of it has been conceived and specified in Eliasson (1976b, Chapter 3).

treated exogenously as a policy variable together with the financing decision; three tax rates (payroll, value added (VAL) and income taxes) and total transfer payments (TRANS) to households or firms. We are explicitly modelling the possibility for the Government to hand out tax money free, or partly free, to individual (one or several) firms, for instance those who are experiencing profitability problems.

The tax and transfer flows are also shown to the right in Figure 5.

At the bottom of the same diagram, just below the Bank, the public deficit or surplus is determined. The exogenous public employment decision combines with endogenous, market determined public wages and public purchasing[1)] into a total spending (SPG) variable. If more or less than tax income it has to be cleared through Government borrowing (GBW) or depositing in (DEP(G)) the Bank or through borrowing abroad (bottom left in Figure 5). Quite naturally the Government deficit or surplus should be expected to be the most powerful monetary policy factor on the money side of the model.

h) Summing up

The entire model has been built on a module system. As long as one sticks to the organization of these modules, the possibilities of modifying the model are virtually unlimited. For several modules more or less complex alternative versions are ready or planned and can be combined in a way that fits both computer capacity and research budget. Before the model is finally estimated, or calibrated, as we prefer to call it (see next section), there are three (earlier) stages of completion. First, conceiving

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1) A fixed coefficient to employment in real terms, then spread to our seven sectors according to the Swedish input output matrix and then transformed into money terms through endogenously determined prices.

the "economics" of the model module. Second, to get it systematically coded in a way consistent internally and with the rest of the model. Three, to program the code (with us in APL) and to test the program. For the time being one simple version of the model (called the 96 model version) has been ready for more than half a year. This model does not include intermediate goods and stocks. There are no Government or monetary sectors and no exogenous (dummy) production sectors. This model has been described in full in Eliasson (1976b); including a complete technical code. This version of the model has been run on an internal IBM Computer in the U.K. and is now installed in the IBM Computing Center in Stockholm. We have also, recently, managed to get a slightly slimmed version of the 96 version operational in the IBM 5100 desk computer (the largest version with 64K). The disadvantage is that a simulation run takes a very long time, about an hour for a year. An extended version (called the 350 series) with the full input-output structure is ready and installed in the IBM Computing Center in Stockholm. So is also a further extended version (the 500 version) with a full Government sector. Finally the money sector is ready but not yet programmed (September 1977).

3. ESTIMATION METHOD

Even though based on a micro foundation this model addresses itself to typical macro economic problems, related to inflation and the determinants of economic growth. The advantages of this approach are many. We can move specification down to typical decision units (the firms) instead of having to deal with relationships between statistical artifacts at a more aggregate level, when it comes to observation and measurement. As always, it is imperative to get the assumptions correctly specified. Here the assumptions are defined at the level of micro behavioral units even though most of our analytical attention will be paid to the behaviour of macro aggregates and cross sectional correlation patterns in simulations. To get at the micro assumptions we can draw upon the wealth of relatively high quality statistical information that exists at the firm level on the business sector. We introduce measurable concepts that are well known and easily understood among others by business decision makers, and, above all, we construct a consistent "measuring grid" by which known micro information is organized within the framework of the national accounts.[1)] This in itself is worth the modelling effort, and for such statistical organizing purposes the model is already useful.

If we entertain the higher ambition, as we do, to use the model eventually for empirical analysis of the Swedish economy, the approach presents us with one large obstacle. Realism in micro specification in combination with explicit modelling of market processes necessitates that we give up well known, standardized econometric estimation techniques, as far as several sections of the model go. In a way this is no unusual thing today. Practically all large scale macro modelling projects in existence have been forced by formidable statistical problems to break text-book rules of clean procedure much in the same way as we do, and rely

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1) This is the idea of the synthetic data base method. See below.

on extraneous information and intuition to get out of what would otherwise have been an insoluble task. The problem is that we may be able to generate time series data by the model that fit macro time series data of the Swedish economy to our satisfaction. But the way by which we have reached the parameter specification that generated these results makes it difficult for us to describe the stochastic properties of our parameter estimates and hence to give conventional rules for generalizations. This is in no way unique to us. Most large macro models have the same problem of generalization. However, we cannot avoid facing it directly by virtue of the very method we use.[1)]

Our model addresses itself to macro problems. This means that their solution should meet the same requirements as those of conventional macro models. This in turn means that requirements on realism in micro specification are less demanding than what would have been the case if our attention had been focussed on some particular micro problem. We do not have the ambition to explain individual firm behaviour over time, only cross sectional patterns. Neither do we aspire to explain actual movements over time in all variables that the model can be told to generate. We can nevertheless argue that our model is general enough so that we can assume, a priori, that it is likely to contain the correct macro hypotheses, albeit together with a whole lot of incorrect numerical specifications or irrelevant features. At least we should be able to reach agreement for some particular decision problem what risk we are running of not having the correct specification within our general model system, or that the model does not contain an acceptable approximation to the correct specification. Our first and fundamental empirical postulate, hence, is that as we confront the model with new empirical information we discard irrelevant (incorrect) alternatives only, at a predetermined acceptable risk of throwing out the correct alternative.

1) Also see paper by Olavi and myself in this conference volume.

Alternatively, we could also say that we have a very general theory with many alternative "structures". We are interested in one of them. The more diverse the range of observation or experiments (the more sample variation) the faster we should be able to narrow down the parameter domain (read: the more narrow the "confidence intervals"). This is the precision aspect of our estimation procedure and it emphasizes the usefulness of "shock experiments" like the "Korean boom" and the more "recent oil crisis" experience to get the parameters right. With an infinite number of observations (an infinite sample) we are certain to get a consistent estimate, i.e. to come out with the correct one under the maintained hypothesis.

Theoretically consistency can only be obtained if the infinite sample is there at one point in time. In practice, however, the modelling effort will have to be seen as a never ending (sequential) process that is hopefully continually improved - or abandoned - as it is confronted with new test information. By this simple reformulation we manage to make a virtue out of the difficulties we faced initially.

Although also a theoretical problem (inflation might be due fundamentally to a micro phenomenon that we have simply forgotten to specify) in practice we have to deal with a numerical (estimation) problem. Which (numerical) parameter combination, among many possible ones that satisfy our requirements of fit, is the correct one? This is no uncommon problem in econometrics although the least squares method provides a procedure to choose, namely the parameter combination that gives the best fit in terms of minimizing the sum of squared deviations. In theory we can use that principle of choice also,[1] although it is rather arbitrary if we happen to have a cloud of parameter combinations of equal power in the close neighbourhood of the combination that happens to be picked.

This means that our estimation problem might be even more crudely empirical, namely to choose, without conventional rules of thumb, from a very large number of well defined combinations between which we cannot discriminate easily. Fortunately, our experience so far has not been of that kind. We have rather found it difficult to find one good alternative that meet our standards of goodness of fit.

Hence, we have to turn our problem formulation around again. For those specifications that we are, so to speak, satisfied with in terms of their ability to trace economic development according to our criteria, we have to devise techniques to check carefully that we have not happened to come upon a specification that is incorrect. The economic turmoil of the last few years has turned out very useful in screening parameter sets. This is of course exactly what should have been expected since ours is a true disequilibrium model. While we find profound disequilibrium situations explained within the model this should not be expected from conventional model structures. If we happen to find several specification alternatives among which we are unable to discriminate, we simply need more empirical knowl-

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1) Search techniques to fit simulation models automatically have been developed for simple cases, see e.g. Powell (1964 & 1965). A similar estimation procedure is being prepared for a restricted set of parameters of this model. See paper by Eliasson & Olavi in this conference volume. The flair of objectivity that such a procedure would lend to the project is, however, largely illusive. The question is whether the computer is more efficient than we are in tracing down the parameter set(s) that generates acceptable model behaviour over history. It is my firm conviction that the micro simulation method will have a low survival value, if we leave too much of the thinking to the computer.

edge, that we don't have, in order to choose. In science, as in decision making, it is often more important to see clearly what one doesn't know than being able to account for one's knowledge. This is the way we go about estimating the parameters of the model.

There is one final problem that has to be dealt with here before we go on. Our model is very rich in specification. There is now way of ensuring that all endogenous variables trace history in an exemplary manner. The choice of problems we set about to study will define what sort of irregularities we will accept. We will return to this in more detail in its proper context of application. Suffice it to note here that even though we concentrate on a limited set of national macro variables to ensure historic tracking, similar although less stringent conditions will apply to sector behaviour and at the micro level we will see to it that known and stable cross-sectional correlation patterns remain through simulations. For the time being we would like to say that the model has been loaded with numbers that makes it behave like a Swedish like economy.

a) Problem (objectives)

This model has been designed to deal with two problems that are not well handled by conventional approaches.

These problems are:

To formulate a micro explanation for inflation

and to

study the relationships between inflation, profits, investment and growth.

The two problems obviously overlap to some extent. The first is a typical macro problem and constitutes the core of current economic debate against the backdrop of more than half a decade of experience of much above normal inflation on a global scale. The second problem requires a micro approach to be tractable for analysis in a meaningful way.

Once ready to handle these two problems, as mentioned earlier, the model will also be capable of handling other problems, that we will leave out here to simplify the exposition.[1)]

The inflation task requires that we identify the channels through which foreign price impulses are transmitted through the Swedish economy and the micro parameters that are important for the speed and magnitude of that transmission. We also have to identify domestic sources and how they create inflation. The way in which expectations are formed is thought to be especially important here. We also have to identify how various inflationary processes may affect macro behaviour in real terms, like employment. The labour market is of particular interest. Finally, we want to identify the strings that can be pulled by policy makers to affect the process. We have included the conventional fiscal and monetary weaponry in the model. More importantly, the model will offer a unique possibility to experiment with e.g. the structural parameters of the labour market. Some trial experiments of that nature have already been made although the model is not yet complete. There will also be a possibility to introduce rough schemes of wage, profit and price controls and to study their impact within the domain of the entire model.

There are two levels of ambition involved here.

We may be satisfied with getting a feel for the magnitudes and direction of effects involved. We might also want to trace time profiles of various effects more precisely. The two dimensions normally cannot be kept apart as is commonly

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1) See e.g. the labour market experiment described in Eliasson (1977a).

assumed in comparative static analysis. We have found through experimentation, however, that some sets of parameters have a unique influence on long-run trends, others on cyclical behaviour around these trends and others again operate both in the long and the short run. We have used this experience to devise a two stage "estimation" procedure for our two problems.

The first step is to calibrate the model so that it traces a chosen set of long-term trends of the Swedish economy well, disregarding altogether the cyclical aspect. The test variables are chosen in order of importance. When the first variable satisfies trend requirements we move on to the next trend variable requiring that the earlier trend fits be maintained within a narrow range. Table 2 gives the reference trends and tracing performance of some early experimental runs. To exemplify the procedure between RUNS 67 and 96 in Table 2 trend fitting started with total industrial production (Q) as test variables. Experimentation aimed at getting it close to actual 1950-1974 growth performance with no upward or downward long-run drift in profit margins and capacity utilization rates. The next step aimed at getting the long-run drift in price levels (industrial prices (P), wages (W) and CPI) in line with 1950-1974 experience, while approximately preserving the trend fit of Q obtained earlier. As can be seen from Table 2 a number of test variables fell into the observed growth spectrum together by November 1976. The only apparent deviation is the rate of unemployment.[1)]

The second stage involves tracing the cyclical behaviour of the same variables satisfactorily, changing the parameter

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1) We are not overly concerned about that. The labour market contains enough parameters to allow separate fine tuning. Since an extended version (with intermediate goods, public sector and a money system) was to be incorporated in the model during 1977 we have found little reason to waste time on fine tuning the unemployment variable since we expected new specifications to disturb part of the calibration obtained by November 1976.

set so that the result on trend fits is roughly maintained. Again we will proceede from test variable to test variable in order of importance, requiring that earlier results (fits) be maintained.[1)]

The precision requirements at this second stage are probably quite small, since most of the cyclical features of inflation seem to originate outside Sweden, by way of our exogenous variables. The second stage becomes important if we want to include other problems in the formulation of our model as well. This is only tentative within the present project, so we leave it out for the time being.

This delimitation of the level of ambition is even more appropriate for the second problem, the relationships between inflation, profit, investment and growth. Here the medium-term development becomes more central together with micro specifications. It is a well recognized experience that these relationships cannot be identified in macro approaches. Lags between cause and effect are usually long, involving, as a rule, an intricate feed back machinery between experience, expectations, planning and technical delays. This means that macro aggregates are a blend of firms in different stages of development that erase the relevant relationships while a momentary cross-section picture does not identify the time dimension.

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1) Two comments are in order here. First, if we so wish, the test (or estimation) procedure described can be given a clear mathematical formulation to use as an automatic trend and sum of squared deviations stepwise minimization algoritm in a computer to search for a parameter specification that gives the best fit. Computer time requirements would, however, be enormous. We are currently investigating the feasibility of such an application. See the paper by Eliasson & Olavi on "stepwise parameter estimation of a micro simulation model" in this conference volume.

Second, the priority orderings imposed a priori of course implies the risk that search would lead away from the "best fit". However, we will certainly notice if search leads us nowhere. This is where our experience and intuition comes into play in an important way.

Since the model imitates the whole machinery we can bring out the desired time and cross-sectional features as we wish. In a way the analysis will consist in describing what happens to a cluster of variously composed firms when the economy is subjected to various macro happenings, occasioned exogenously, by policy making or by inconsistent, joint behaviour by the firms themselves. We are especially interested in identifying the role of profits for macro behaviour (growth) in an economy (model) populated by individual firms joined together by an explicit market process.

Again, the first calibration stage, mentioned above, (satisfactory trend tracing) is all we need to reach in order to handle our second problem.

b) A priori assumptions

Let us now deal with the a priori inclusion of knowledge in our model. Empirical information enters model in seven ways:

(1) The causal or hierarchical ordering of model modules. What depends on what and in what order (see e.g. Figure 1).

(2) Structural parameters, e.g. defining the relation between maximum possible inventories and sales or trade credit extensions associated with a given value of sales.

(3) Time response parameters, e.g. how exactly are historic observations transformed into expectations.

(4) Start-up positional data (like capacity utilization rates).

(5) Start-up historic input vector (e.g. on which to apply time reaction coefficients to generate expectations in EXP sector).

(6) Macro parameters and accounts identities[1] (e.g. in consumption function).

(7) Exogenous inputs (like foreign prices).

The hierarchical ordering is the first step from a completely empty formal structure to saying something about the world. All theory in economics has to have something of type (1) in it to be called economic theory. Without the use of operational, meaningful or measurable variables not much empirical knowledge is brought in. Consumer preference schemes and the marginal productivity of capital are concepts or variables that are close to being empty since we have no good measuring instrument or senses to touch them. We refer to the concept of a Keynesian model and immediately bells start to ring. Keynesian models represent a general class of causal orderings of economic variables that all correspond to a measurement system (the national accounts) that we are familiar with.

The great advantage of our model is that we bring the hierarchical ordering very close to two excellent measurement systems. At the micro firm level we are dealing only in terms of the firm's own accounting systems and at the macro level we are truly Keynesian. It is not necessary to be a professional economist to assess and understand most of the structural micro parameters of type (2) and to provide the start-up historical and positional data (4) and (5). This is definitely an advantage that outweighs the loss of econometric testing potential. This information is brought in as a priori assumption. We take it for given (true) in the causal specification.

Most evidence brought in here is based solidly on internal planning and information routines within firms as described by Eliasson (1976a). The specification there-

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1) To the extent possible we use outside information from econometric studies here.

Table 2 Trend comparison (MACRO - INDUSTRY), 20 year simulations (average annual change in percent)

	Sweden 1950-74 (24years)	RUN 67 (July76)	RUN 88 (Oct76)	RUN 96 (Nov76)
1) Production (Q)	4.6	2.7	3.5	5.0
2) Hours of labour 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 x 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)

Constraints

Profit Margins (M)
Capacity utilization rate (SUM) } Horizontal trend

Note: This table has been inserted for illustration only. It makes very little sense for an outside reader until a full description of the experimental set up has been presented.

In the bottom row of table the simulated rates of change have been correlated with the real ones for the period 1950-74.

fore appears to be as close as one can get to the buttoms that are actually being pushed in the decision process.

The causal ordering (1) is essential for the properties at the macro level. Such orderings between periods replace many time reaction coefficients in macro models.

Structural parameters (2), positional data (4) and historic input data (5) either have to be fetched from a micro data base (see below) or refer to the macro part of the model, like the household expenditure system. We are either taking our parameters directly from the individual decision units or we are using conventional econometric techniques.

Under this model specification scheme the estimation problem that is unique to this model is in practice isolated to the time response parameters under (3). Here we have practically no outside knowledge to draw on except trying out various sets of combinations and to check so that the total model behaves as an economy of our choice. Were it not for these time reaction parameters we could have said that our whole model exercise consisted in analysing the macro implications of a set of "known" or "measured" micro assumptions. Confrontation with macro data would then have been a second check that the numerical information had been realistically put together in the model. As we see it now the macro information will have to be made use of to "estimate" the time reaction parameters, until we have found a way to get also that information directly from the firms. Before we discuss this calibration phase we will introduce the micro data bases on which the model operates.

c) Data base

Two sets of data are needed; one set to operate the model and another set to assess performance (test variables).

The second set of test variables is partly macro statistics from the Swedish national accounts that will uncritically be said to represent Sweden and partly micro data on real Swedish firms from various sources.

The first set is more specific to our model. We need a micro firm data base of at least 5 years (annual data) and a set of positional data for the last year to get the model started. And we need a forecast or an assumption (or historic data if we trace history) for the exogenous data for the simulation period. We would also like to be able to start simulation at a date of our choice, which means that the micro data base should, preferably, stretch far back in time. In practice this means that except for the last few years, we will not have all the data we need.

Model building, model calibration and data collection must take place simultaneously. Thus much of the data we need for model testing will not be available until most of the calibration work has been done. This is how we solve this dilemma.

d) The synthetic micro data base

Through 1976 and spring of 1977 we experimented with the model on historic, five year input vectors for the years 1970-74 for each firm. Fortunately, 1974 was the peak of an inflationary profit boom in the business sector. The simulation run then begins under conditions that are very similar to those prevailing during the year when our historic national accounts test data begin, namely 1950 (the Korean boom).

To get a micro data set at an early time we had to be satisfied with synthetic data. Until spring 1977 macro subindustry data for 1970-74 (four subindustries) have simply been chopped up into 50 firms, applying a random technique that preserves the averages of each subindustry and introduces known cross sectional correlation patterns. On the basis of this start-up information we have performed a series of preliminary calibration experiments according to a procedure to be described below. Occasionally we have included one or several real firms in a simulation run to see what happens to them.

The next step, that began this spring, was to prolong the micro data base back in time, using essentially the same synthesizing technique, to introduce a new type of firm that only operates in inter industry markets and to enter a purchasing and input inventory function. We have also made it possible to enlarge the number of firms. There are two reasons for this. We have to check stability properties of the model when we vary start-up data by moving back and forth over historic time. In addition we need better and more precise test (historic) data to evaluate model macro performance. The change-over to this data base took place at a time when the new, extended version[1)] of the model described here was ready. Several parameters of the system have had to be recalibrated after this changeover and when this is being written the model has not yet found its way back to a good trend tracing performance of the quality already achieved with the more primitive, earlier version. The reason partly lies in inconsistencies between the various official statistical data sources used to put together a macro data bank on the industrial classification scheme used for the model. For instance, the national accounts based break down of total industry on sub-sectors does not seem to match the input-output matrix well. The model responds immediately by adjusting the size of the sectors in a way that creates turbulence for several years.

The final stage is to feed the model with a set of real firms and to apply the same synthetizing technique on the residual that remains between the subindustry total and the aggregate of the real firms in each market. We are thinking in terms of eventually having the 200 largest Swedish firms in the model. When and whether we will reach that ambition, or higher, depends not only on the amount of work associated with arranging a proper data base but also on the exact nature of internal memory limitations on the computer side. For various reasons this stage will be reached very late in the project. We are now experi-

1) As compared with the simpler version described in full detail in Eliasson (1976b).

menting with a sample of 30 to 100 firms. We have run a few test experiments on 350 firms. Besides making it possible to organize model work efficiently the idea of a synthetic data base in fact has a much greater appeal. Future builders of models like this will certainly find that much real information that they want is missing. Furthermore, the idea of micro-macro interaction, in our model at least, is not to feed the model with exactly the right micro measurements. The model operates from micro to macro on realistic cross sectional variations. Exactly identified firms are not needed. If we make all firms in each sector equal, markets disappear by definition and the model collapses into a more conventional, ten sector Leontief-Keynesian macro model. The maintained hypothesis is that if the synthetic sample of firms can be seen as a sample from a population of real firms with roughly the same variational properties, then the model should exhibit the same macro behaviour when fed with both sets. Both these presumptions; (a) that the synthetic sample is representative and (b) that the model behaves as described, will be subjected to tests in due course. But we are of course taking the risk of an unpleasant surprise when we reach this stage. However, a research venture of any meaning is risky by definition.

e) Calibration

We are here concerned with "estimating" the time reaction parameters (3) under paragraph (b) above - altogether about 20 for each individual firm. So far we have assumed that they be equal for all firms. All other parameters enter as a priori maintained hypotheses. We now need a set of criteria for a good "statistical fit" at the macro level to guide our calibration. These criteria, of course, relate back to the precision requirements we have in dealing with the problems we have selected, described already above. In econometrics this corresponds to choosing the level of significance and to some extent the estimation method.

We need a procedure of selection that guides us towards a specification alternative that satisfies our criteria and (NB) that is not a spurious one. These two steps are summarized in Tables 3 and 4.

Table 3 MASTER CRITERIA FOR FIT

A. Certain macro industry trends approximately right (within ± 1/2 percent) over 20 year period (see trend chart Table 2). This criterion is essential.

B. Same inter-industry-trends. Same criteria for 5 year period.

C. Micro. No misbehaviour of obvious and substantial kind, if it can be identified empirically as misbehavior.[1] Maintain known and stable cross-sectional patterns over simulation.

D. Identify (time reaction) parameters that work uniquely (or roughly so) on cyclical behaviour around trends. (This criterion is not essential to handle the two chosen problems.)

---

1) Since the model has not been designed to exhibit such behavioral features there is no other way to detect them, if they are there, than by carefully analysing each experiment. There is no use giving a "suspicion list" and then limit attention to that list.

Table 4 CALIBRATION PROCEDURE (TREND AND CYCLE FITTING)

1.		Find first reference case. Assess its qualities in terms of A above.
2	a)	Perform sensitivity analysis with a veiw to finding new specifications that improve performance in terms of A.
	b)	Ditto with a view to investigating the numerical properties of the model within a normal operating range (analysis). Check and correct if properties can be regarded as unrealistic.
	c)	For each new reference case, repeat the whole analysis of 2 b) systematically. The purpose is to ensure, each time, that the new reference case is really a better specification and not a statistical coincidence, and that the properties of the system revealed by the sensitivity analysis above, and judged to be desirable, are present in the new reference case. This step is important and is there to prevent us from moving away from a relevant specification achieved.
	d)	Subject model to strong shocks. Check for misbehaviour. (Especially fast, explosive or strong contractive tendencies that are generated from shocks that are obviously extreme but just outside the range that contains a real but rare possibility.)
3.		Define new and better reference case. Repeat from 2.

This is only another way of describing the estimation "program" presented earlier. There we gave the criteria to move from one reference case to another. Here we describe how to find another and better reference case in an intuitive way. In the absence of an automatic search-estimation program this trial and error procedure is the only alternative.

As emphasized several times, there are so many dimensions to consider in this model work that everything cannot be handled simultaneously. What is important depends on the problem choosen. Hence it is quite possible that the efficient handling of several problems demands that several versions (subsets) of the model be developed. Furthermore we will have to leave some check-ups for later consideration. Not until the macro trends (and cycles) are satisfactorily traced (A. in Table 3) will we look into industry trends (B. in Table 3). For some problems we can quite well live with bad tracking performance at the sub-industry level.

A final test will have to consider micro performance as well. Here the test will be consistent with the idea of the synthetic data bank. Even if we use a real firm data bank to run the model on we do not require that the model traces historic development of individual firms or predicts their future development. This would be unreasonable to require.[1] However, we should require that known cross-sectional patterns are preserved in model simulations. For instance, if we know that there is no or little correlation between initial profitability rankings and profitability rankings, say, twenty years later but that the distribution across firms remains stable, this knowledge should first be featured in the synthetic data bank[2]

---

1) If we want performance of this quality, we would have to build an expanded, tailor made model of the firm in question, but fitted, as all other firms to the total model. This is again an illustration of the fact that each problem choosen requires special model tooling.

2) And of course also in the real firm data bank if we have one.

used to run the model on. Second, the same patterns should be preserved in simulation runs over 20 year periods. In fact there exist a host of well known statistical methods to test if simulated cross sectional patterns differ significantly from real ones. The problems, as usual, lie in the availability of data.

f) Conclusions

We may say that the model we have designed is a combined medium-term growth and cyclical model although the two prime problems we have chosen only require that it imitates macro reality (Sweden) well over the medium-term, say five years, exhibiting a business cycle although not necessarily a typical Swedish business cycle. This is why we are talking about a Swedish-like economy.

Some may say that with these "empirical" requirements we have not moved far above a purely theoretical inquiry into problems of inflation and growth. However, we have done much more in so far as our numerical approach has allowed us to say something not only about the directions of change but also about the relative numerical magnitudes involved, based on data from the Swedish economy. Let us say that we want to study how disturbances are transmitted through an economy. The nature of this transmission must then be ascertained before one attempts to measure the effects involved. This task in itself requires a substantial amount of empirical specification. This is also how the ambition of the current project has been defined.

Towards the end of the project we also hope to be close to the following model performance; a specification that traces a chosen set of five year macro trends in Sweden according to A above quite well, irrespective of where in the period 1955-1970 we begin the simulations, (if we have the necessary start-up data), and that reproduces a typical business cycle in all the variables in A, if exogenous variables, including policy parameters and start-up data are correctly specified. For the model to be useful as a support instrument in a forecasting context achievement of this goal is a minimum requirement.

EXAMPLE OF MICRO EXPERIMENT - NEW FIRM ENTRANTS IN MARKET FOR INTERMEDIATE GOODS

Figures 6A-D have been inserted to illustrate the micro analytical possibilities of the model.

Figures 6A and 6C relate real rates of return (RR)[1)] of individual companies of our data base year 5 to RR in year 10 in a simulation run. If all dots had been on the 45^{o} line, rates of return would have been the same for each company in the two years. We see that the scatters exhibit the same kind of dispersing one observes in real life. This is a result that has been obtained without recourse to any randomization procedure within the model.

Figures 6B and 6D illustrate the correlation pattern between annual rates of growth in output (DQ) during a 5 year period and the average real rate of return during the same period. Again deviations from the 45^{o} line have to do with changes in capital structure within the firm, in financing patterns and dividend distribution practice and the timing of investment during the period. If these changes are normal, one should expect to find a fairly strong positive correlation between average rates of return and growth in output over a five year period (cf. pp. 58 ff. below).

Finally, the diagrams also illustrate a particular experimen on the model. During the first 5 years new firms have been entered in the intermediate goods market in sizes and at a rate typical of that industry[2)]. In figures 6A and B all new entrants have been given average performance characteristics of the industry, in figures 6C and D above average performan characteristics. Performance is here measured as labour productivity at full capacity operations on the QFR(L) curve at point B in Figure 3. New entrants are assumed to base their price, wage and sales growth expectations on average, past data for the industry. We can see that performance of the new entrants disperses somewhat during the simulation, but that the group as a whole still maintains its introductory quality (average or superior) towards the end.

One can also notice (at least on the original drawings) that the new entrants in the two cases (cf Figures A and C, and B and D) displace the other firms in the scatter somewhat differently, both within their own market (intermediate industrial goods) and in other markets.

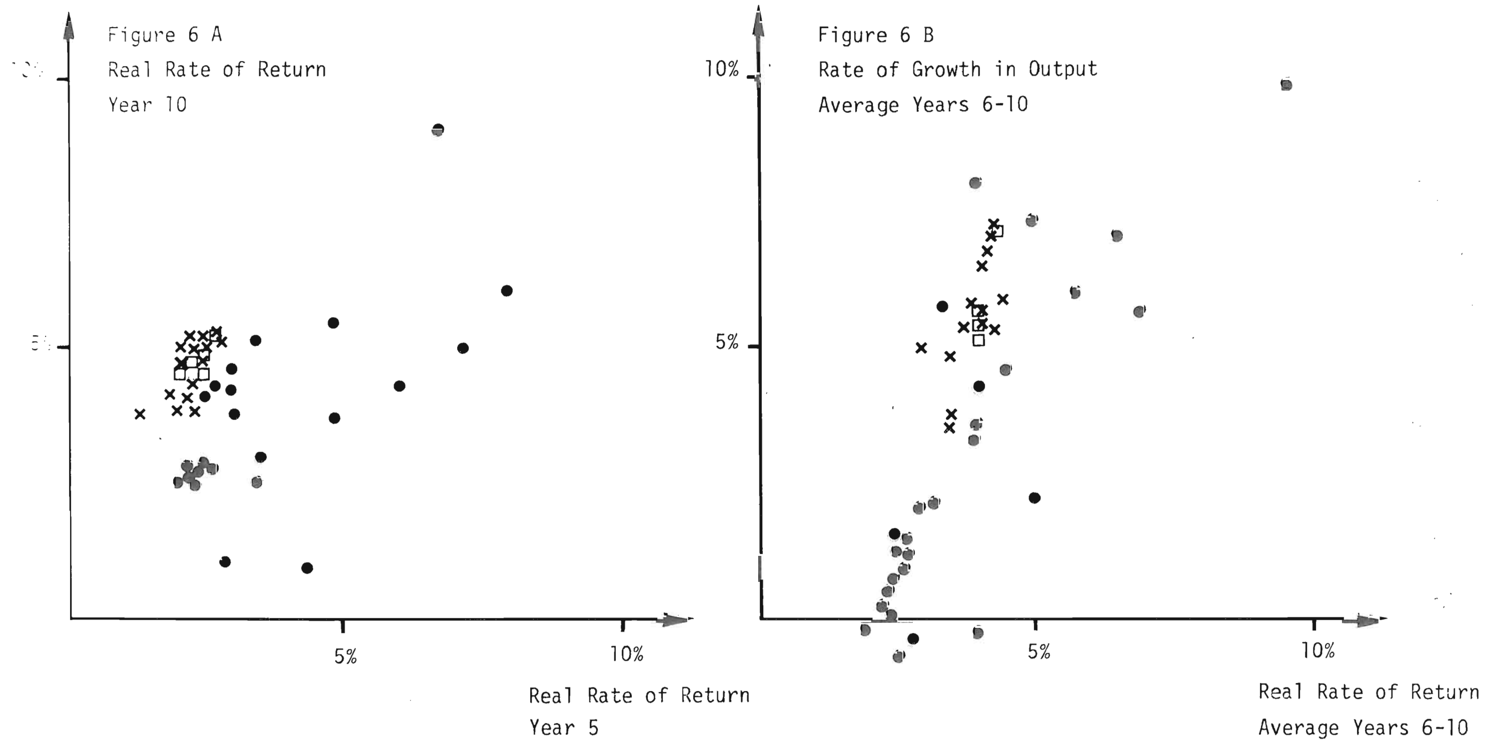
---

1) For a definition of RR see p. 80.

2) According to data from a forthcoming IUI study on new entrants in Swedish manufacturing.

Figure 6 A-B

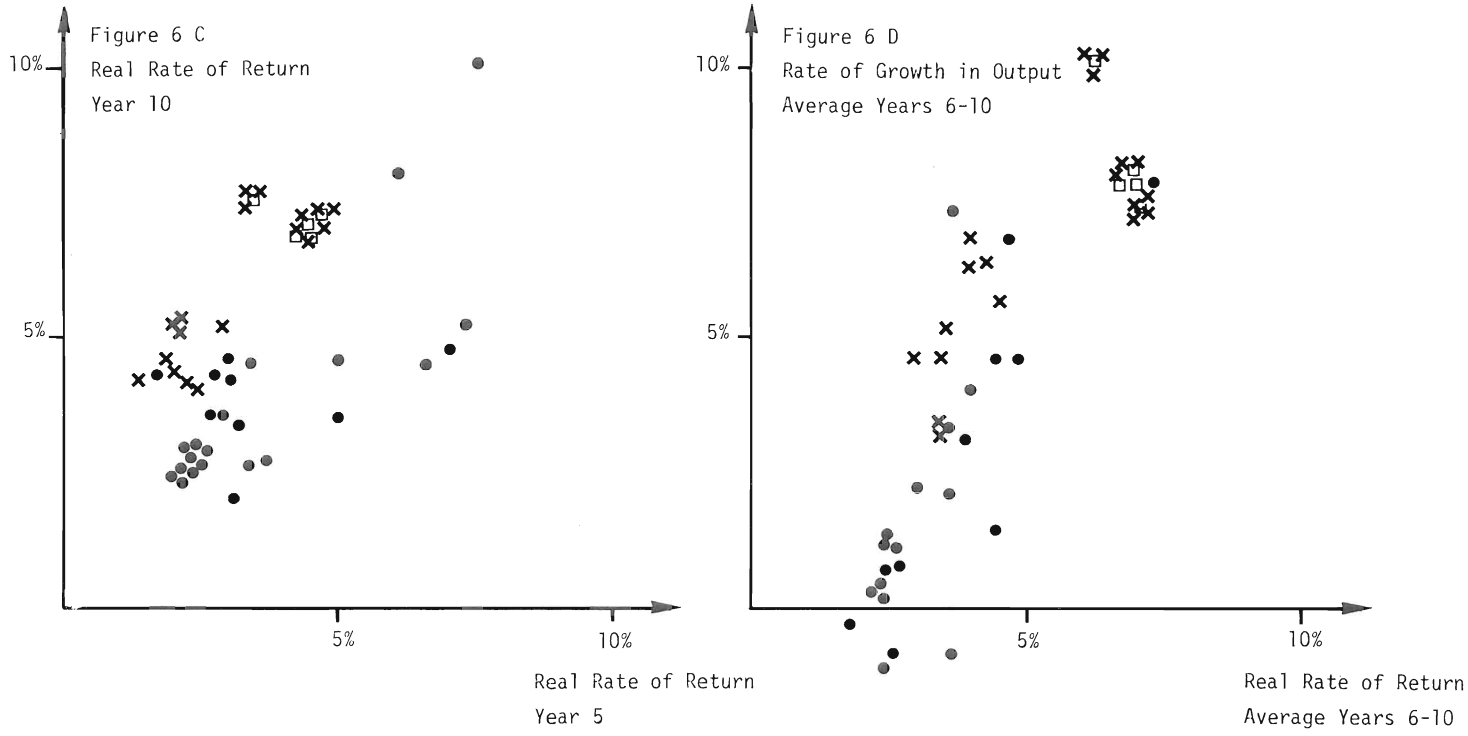
Entry of New "Average" Firms in Market for Intermediate Products



Legend: □ New "Average" Firms in Market for Intermediate Products
× Original Firms in Same Market
● Firms in Other Markets

Figure 6 C-D

Entry of New "Above-average" Firms in Market for Intermediate Products



Legend: □ New "Above-average" Firms in Market for Intermediate Products
× Original Firms in Same Market
● Firms in Other Markets

Figure 6 E

Output effects of new entrants

Index 100 = Reference Case

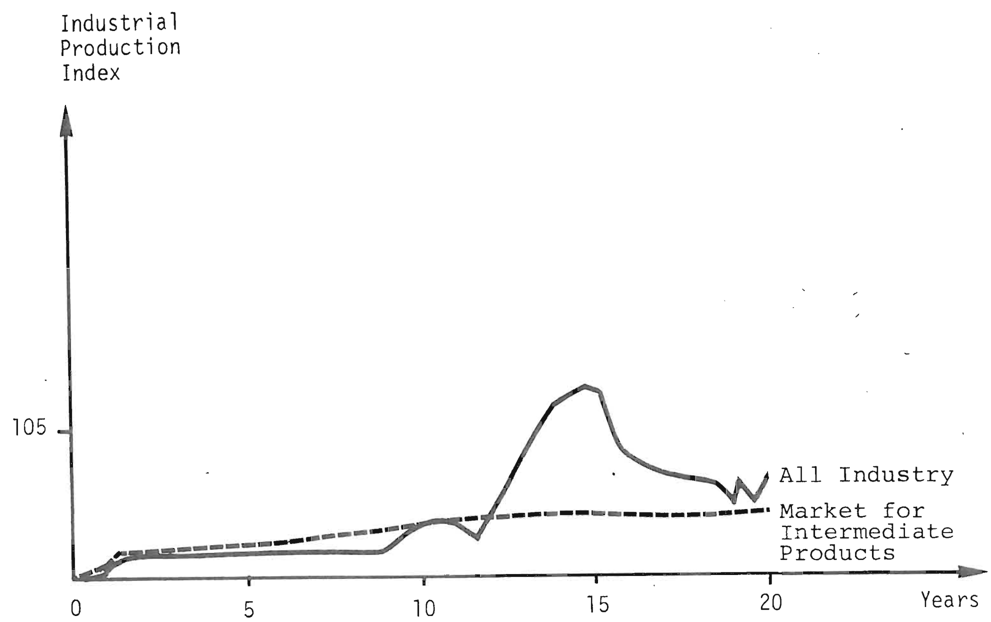


Figure 6E finally pictures the industrial production effect of the new (average, this case) entrants. Both output curves are compared on index form with a reference case. As one can see, the output effect is positive and slowly growing as expected. One interesting thing happens in year 13 when new capacity added for intermediate goods production suddenly releases a bottleneck, that allows a strong, temporary increase in total industrial output. Furthermore, when new, above average firms enter the market for intermediate products there is a slight lowering of the rate of increase of prices in the same market as below average performers are forced to slow down growth or to contract output. Average profit margins for the same market are left roughly unaffected.

4. A FORMAL REPRESENTATION OF THE MODEL

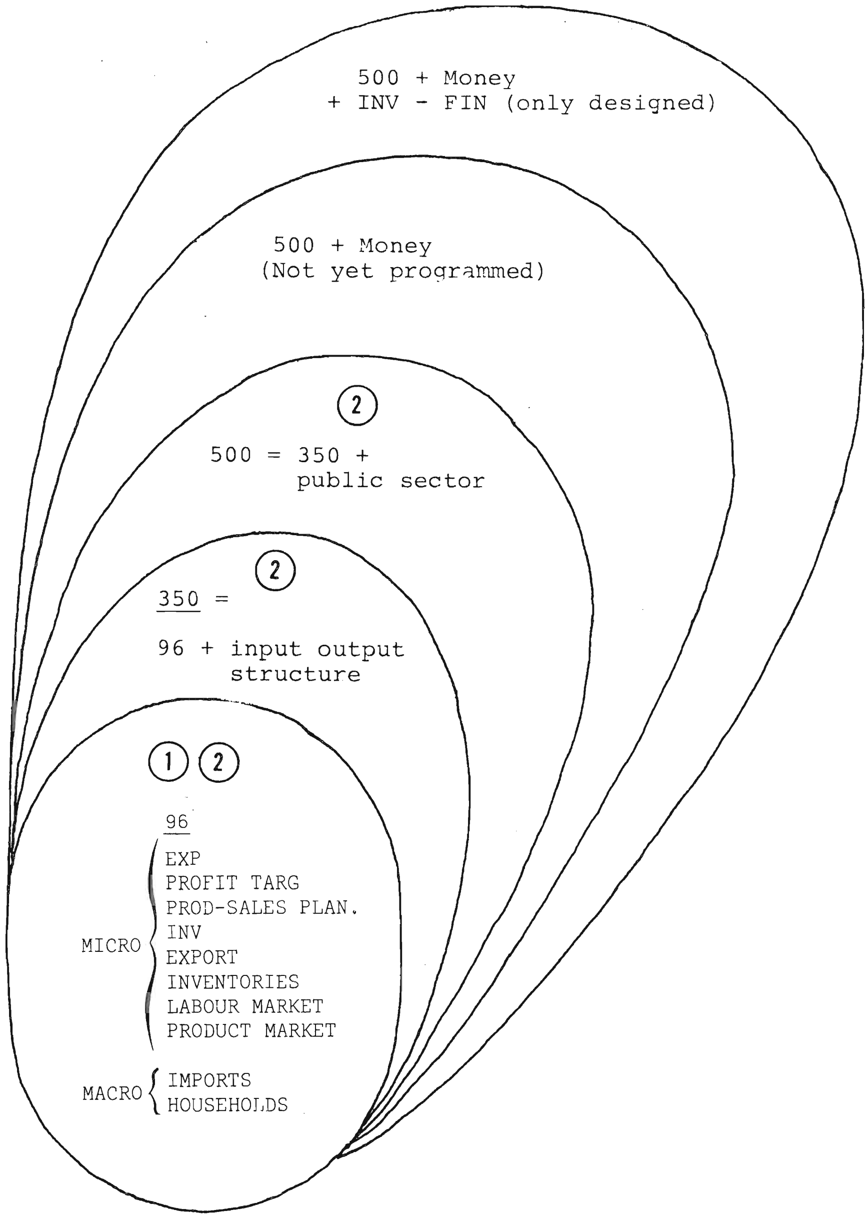
This section highlights some "analytical" features of the so called 96-version of the Swedish micro-to-macro model. A full and quite extensive presentation is found in Eliasson (1976 b, chapters 2 through 8). This presentation does not include more than the most important behavioral and market specifications that constitute the model. It serves as an introduction to the complete Technical Specification, put together by myself, Gösta Olavi and Mats Heiman (see separate supplement in this conference volume) that in turn relates one-to-one to the APL programme. We have found it useful to give a full presentation of the 96-version here since we have managed to fit it into the largest (64 K) version of the IBM 5100 desk computer, and someone might be interested in giving this version a try of his own. In this version of the model there is no input output structure (firms are producing value added only) and no public and money sectors.

Figure 7 tells how the 96-version relates to the various stages of the extended versions that have now been implemented.

4.1 Targeting sector

Central to the macro properties of the model system is the business objective function. At the corporate headquarter level, that we are modelling, and even more so at the macro level, we see no reason to vest other ambitions with corporate headquarter management than being an efficient profit making machine (see Eliasson 1976 a, p. 250). That is, however, by no means synonymous to being a profit maximizing entity. Profit maximization is practically without meaning at the "firm macro level" at which headquarter management operates. Since we are

Figure 7. Vintages of Swedish micro-to-macro model*



(1) Installed in the IBM 5100 Desk Computer

(2) Installed in IBM Computing Center, Stockholm

* As of April 1978 the complete model 2 with a fully integrated money system has been programmed and is being calibrated. The data base now holds 30 real firms and 30 synthetic firms. On a consolidated basis they add up to the corresponding sector totals in the Swedish national accounts system.

modelling their behaviour, so be it also here. And both the convenience of and reason for this approach becomes clear from this break-down of the value growth of an individual firm (proof follows at the end).[1)]

A separable, additive targeting function

$$DNW + \theta = \underbrace{M * \alpha}_{A} - \underbrace{\rho * \beta}_{B} + \underbrace{DP(DUR) * \beta}_{C} + \underbrace{(RRN - RI) * \Psi}_{D} \qquad (1a)$$

$$\text{Headquarter GOAL Variable} = DNW + \theta - DCPI \qquad (1b)$$

$$M = 1 - \frac{L}{Q} * \frac{W}{P} \qquad (1c)$$

The variables are defined verbally and in operational terms as follows:

DX will always mean the relative change in X (i.e. $\Delta X/X$) during a certain period of time.

CH will always represent the absolute change,

i.e. $\Delta X \approx \frac{dX}{dt} \cdot \Delta t$

A = total assets valued at replacement costs
BW = total outstanding debt
NW = Net worth defined as the difference between total assets (A) and debt (BW) i.e. NW = A-BW
θ = the rate of dividend (DIV) payout of NW = DIV/NW
α = S/A
S = sales expressed in current prices
β = Kl/A

---

1) See also Eliasson (1976 a, p. 291 ff.).

K1 = production equipment, valued at replacement cost

ρ = rate of depreciation of equipment[1] of type K1

W = wage cost index

P = product price index

CPI = consumer price index

M = gross profit margin in terms of sales (=S)

K2 ≡ A-K1 = other assets (inventories, given trade credits, cash etc)[2]

Ψ = BW/NW = the debt (BW) net worth (NW) or gearing ratio

RI = rate of interest

$$RRN = \frac{M*S - K1*(\rho - DP)}{A}$$ = nominal rate of return on total capital

$$RRNW = \frac{M*S - K1*(\rho - DP) - RI*BW}{NW}$$ = nominal rate of return on net worth

We assume here that all stock entities are valued at replacement costs. This means that firm net worth (NW) has been obtained by a consistent (residual) valuation method.[3] It is an entirely-empirical matter whether the decision criteria derived from such valuation principles are relevant, a circumstance that we will discuss later.

---

1) This requires that the following identity holds:

$$INV = \frac{dK1}{dt} \Delta t + \rho * K1 - \frac{K1}{P} * \frac{dP}{dt} \Delta t$$ where INV is gross investment.

2) Note that K2 is broken down into several components in the next chapter.

3) The balance sheet of the firm looks:

Assets	Debt
A	BW NW (Residual)
Total assets	Total debt

(1a) states that the relative change in firm net worth (DNW) plus the period's dividend payout in percent of the same net worth (θ) is the sum of four components:

(A) The profit margin (M) times the ratio between sales and total assets (α).

(B) Calculated economic depreciation (subtracted)

(C) Inflationary (capital) gains on assets[1)]

(D) The leverage contribution defined as the difference between the nominal return to total assets and the (average) interest rate on debt (BW) times the debt to net worth ratio ($BW/NW=\Psi$).

It is easily demonstrated that:

$$RRN = A + B + C \qquad (1d)$$

It can furthermore be proved that:

$$DNW+\theta=(\text{nominal return to NW}) = RRNW \qquad (1e)$$

One may say that (1a) corresponds well with a targeting-delegation scheme often found in large business organizations (Eliasson 1976 a). B, C and D represent typical corporate headquarter considerations that we will make use of when the long term investment financing decision has been modeled (Eliasson 1976 b, p. 52 ff). A refers directly to operational cost control matters and can be broken down consistently into a whole spectrum of profit margins and cost shares at the level of individual production lines to be used for targeting and control purposes.[2)] The value growth component A in (1a) is the one that we will be concerned with in what follows. It defines the prime targeting variable for short term operational planning which constitutes the core of the so called 96 model version.

---

1) There is a problem here. If realized inflationary gains are listed under (C) the costing principle used to obtain M has to be based on a replacement valuation of raw materials and intermediate products. This is a problem we have to face when the model is fed with real firm data.

2) Eliasson (1976a).

We believe to be well supported by empirical evidence, when assuming the following feed back targeting scheme for short term operational decision making:[1)]

$$MHIST := \lambda * MHIST + (1-\lambda) * M \quad (1.1a)$$

$$TARG(M) := (1-R) * MHIST * (1+\varepsilon) + R * TARGX(M) \quad (1.1b)$$ [2)]

$$0 \leq [\lambda, R] \leq 1, \; \varepsilon \geq 0 \text{ but small}$$

$$TARG(M) : = MAX[MHIST(1+\varepsilon), TARGX(M)] \quad (1.1c)$$

The profit margin history of a firm (MHIST) is currently updated by (1.1a). It is fed into current targets, perhaps upgraded by $(1+\varepsilon)$ according to "maintain or improve" (MIP) standards very often met with in firms[3)], after (perhaps) having been weighted together with some external reference target like profit performance in a competing firm. Targets are not always 100 percent enforced ex ante (see below). Ex post non satisfaction of targets can easily occur because of mistaken expectations. (Also see p. 69.)

---

1) Note the Algol notation (:=) "make equal to" that we use throughout to be able to delete indices of lagged variables.

2) TARGX(M) has not been programmed into the 96-version of the model that is fully described in the technical specifications supplement. Thus the used specification of the 96-version presumes R=O.

3) Eliasson (1976 a, p. 159).

4.2 Expectations sector

We use a general learning feed back expectations function developed partly and discussed in Eliasson (1974 pp.79-83).

$$HIST(\tau) := \lambda_1 * HIST(\tau) + (1-\lambda_1) * \tau \qquad (2a)$$

$$HIST(DEV) := \lambda_2 * HIST(DEV) + (1-\lambda_2) * [\tau - EXP(\tau)] \qquad (2b)$$

$$HIST(DEV2) := \lambda_3 * HIST(DEV2) + (1-\lambda_3) * [\tau - EXP(\tau)]^2 \qquad (2c)$$

$$EXPI(\tau) := HIST(\tau) + \alpha * HIST(DEV) + \beta * \sqrt{HIST(DEV2)} \qquad (2d)$$

$$EXP(\tau) := (1-R) * EXPI(\tau) + R * EXPX(\tau) \qquad (2e)$$

where $0 \leq \lambda_i, R \leq 1$

$DEV = [\tau - EXP(\tau)]$

$DEV2 = [\tau - EXP(\tau)]^2$

Internal expectations on τ are generated out of the firms' own experience as determined by the conventional smoothing formulae combined with a quadratic learning function as entered in (2a-d).

$\alpha * HIST(DEV)$; is a correction factor for systematic mistakes in the past. $\alpha \geq 0$.

$\beta * HIST(DEV2)$; defines the effect of variations in expectational hits whichever way they go. Even though HIST(DEV) may average out over time the very existence of variation is expected to make firms more cautious. Hence $\beta \leq 0$.

We do not believe that internal experience is enough to guide firms so we have made allowance for outside, external influences on expectations through (2e). A firm may watch a market price indicator or the CPI or forecasts by someone and form an outside EXPX(τ) to weigh together with its internal, interpreted τ-experience EXPI(τ) as in (2d).

These are what we call short-term expectations, that stretch from year to year. There is a quarterly updating function within the year as described in the Technical Code (3.1). These functions apply to firm prices (P), wage costs (W) and to sales (S), in the last case as a start up datum for production planning (see below). We plan to distinguish between long-term and short-term expectations by varying the time weights as described by λ in (2a-c). Long-term expectations are, however, not needed until the long-term investment financing sector is introduced. This has been described in Eliasson (1976 b, pp. 75-107). It is, however, not yet coded and programmed. Hence we do not discuss it here.

4.3 Production Sector

4.3.1 The Production Frontier

The production system consists mainly of the search algoritms aimed at finding a TARG satisfying solution somewhere within a feasible production frontier. This is too complex to describe in satisfactory detail here. A fairly complete description is found in Eliasson (1976 b, pp. 108-148) and an exhaustive description in the Technical Specifications supplement (see item (4.3)).

We begin here by defining the production possibility frontier. In order to make this presentation reasonably condensed we delete certain features like slack formation etc. We should note, however, that search leading to a TARG satisfactory output solution is a quite novel specification and gives the entire model system unique and quite realistic properties.[1)] The production possibility frontier is defined each moment in time for each firm by:

$$QFR(L) = QTOP*(1-e^{-\gamma L}) \qquad (3a)$$

L stands for labour input in production and QTOP is the maximum possible output at the application of an infinite amount of labour input (see diagram 3).

---

1) This is also one of the designs of the model that makes an analytical representation hopelessly entangled and hence numerical methods the only practicable approach.

Capital stock is not explicit. However, investment shifts the function QFR(L) outwards and depreciation (measured in terms of potential output) shifts it inward, so it enters indirectly (see below).

A firm is always located somewhere within its QFR(L). Determining next period's production plan means starting from the point A each quarter calculated from EXP(S) and searching outward along several alternative paths until TARG(M) is satisfied. Thereafter QFR(L) is solved for L and the firm begins to look for new labour in the market, or lays off people as the solution advices.

QFR(L) has certain convenient properties that we make use of. First, the planning survey of the Federation of Swedish Industries has been designed to allow a simple estimation of QFR (see Virin (1976), Albrecht (1978)). Once A and the L-coordinate of D has been obtained, QFR can be approximated (Albrecht (1978)). From a series of consecutive investment data we should then be able to determine how QFR shifts because of investment.

Second,

$$\frac{dQFR}{dL} = QTOP * \gamma * e^{-\gamma * L} \tag{3b}$$

clearly $\frac{d^2}{dL^2} < 0$

and $$\frac{dQFR(L=0)}{dL} = QTOP * \gamma = TEC \tag{3c}$$

If we define

$$TEC = \gamma * QTOP \tag{3d}$$

TEC determines labour productivity of the last piece of equipment to be closed down. Labour productivity is

$$OPTPROD = \frac{QTOP(1-e^{-\gamma L})}{L} \tag{3e}$$

OUTPROD signifies productivity when the firm is performing on the frontier QFR. It is furthermore, monotonously declining as more L is applied within each period (read: for each given QFR).

Actual labour productivity (=PROD) can, however, be increased by leaps and bounds when the firm reduces its redundant labour by moving vertically between A and B (see diagram 3) or horisontally to the frontier (leftwards) by laying off people. The first kind is what takes place predominantly in the early upswing phase of a business cycle, the second in the late stages of the recession.

4.3.2 The Technology Constraint

TEC is updated exogenously through DMTEC that defines the annual increase in feasible labour productivity on a piece of new equipment invested. Together with investment, that brings in new technology, the time development of DMTEC defines the technology constraint or the upper limit of feasible growth in industry.

New investment increases QTOP as described below. New MTEC is integrated with the production system of each firm and stirred well to produce a new TEC feature of the frontier as described by the harmonic average:[1)]

$$TEC: = \frac{QTOP + CHQTOP}{\frac{QTOP}{TEC} + \frac{CHQTOP}{MTEC}} \qquad (3f)$$

---

1) This can also be written:

$$\frac{QTOP + CHQTOP}{NEWTEC} = \frac{QTOP}{TEC} + \frac{CHQTOP}{MTEC}$$

The left hand side of this expression tells how much people that would have been needed to produce QTOP+CHQTOP if the production would have been a straight tangent to QFR in the origin after investment. The right hand side tells the same before the change (QTOP/TEC) plus the same value for the marginal addition to capacity (CHQTOP/MTEC). One could also say that investment creates a new, marginal production frontier [= $CHQTOP * (1 - \exp(-\frac{MTEC * L}{CHQTOP}))$] that via (3f) blends with (3a) into a new QFR(L).

4.4 Investment function

In the model now in operation investment decisions feed on the current profit inflow. This simple "plow back" or "capital budgeting" explanation of investment is adjusted in three ways:

a) build-ups of current assets associated with sales growth (RW*CHS) and interest payments (RI*BW) represent a mandatory claim on financial resources. RW is a coefficient.

b) residual funds available for investment after (a) are augmented or reduced by the current net borrowing rate. This depends on the current nominal rate of return of the individual firm and the nominal interest rate (RI);

$$DBW = \frac{CHBW}{BW} = \alpha + \beta * (RR + DP - RI)$$

c) this modified cash inflow marked for spending on capital account is in turn adjusted downwards for unused machinery capacity. If borrowing is negative this means that debt is being paid off.

Thus we come out with the following formulation of the investment function[1]:

$$INVMAX := MxS - RW*CHS - RI*BW + [\alpha + \beta(RR + DP - RI]BW \qquad (4a)$$

$$INV := A*KORR*INVMAX \qquad (4b)$$

KORR stands for the rate of capacity utilization[2] and A is a scale factor.

if $(1-A*KORR)*INVMAX < CHBW$

reduce CHBW to equality with left hand expression.

1) This formulation is very much based on a capital budgeting model of investment planning derived and estimated on macro data in Eliasson (1969).

2) Distance AB+CD in Figure 3 measures the amount of unused capacity.

<u>else</u> make CHBW:= 0

and distribute

$$(1-A*KORR)*INVMAX > 0$$

as dividends to households.[1)]

Note that the investment function (4a) is based more or less directly on the separable additive targeting function (1a). (4a) implies that the inclination of the firm to increase its rate of growth in total assets (and even more so in net worth by borrowing and investing) increases with the difference between the nominal return to total assets (RRN=RR+DP) and the rate of interest (RI).

Real capital stock in <u>volume</u> terms is not explicit in the model and we prefer to have it that way. The concept of capital, however, cannot be avoided for obvious reasons. It enters indirectly when investment shifts the production frontier QFR(L) every quarter.

<u>First</u>, the decision to spend on INV by a firm results in INV after a quarter. The additional delay between INV and the corresponding capacity increase can be varied between firms and subindustries. For the time being we are using a 2 quarter delay between spending on investment account and the resulting capacity increase, which is too short for many of the firms.

<u>Second</u>, depreciation is defined in terms of QTOP and takes place at a predetermined rate:

$$QTOP: = QTOP*(1-\rho) \qquad (4c)$$

where ρ is the exogenously given rate of depreciation.

---

1) In the 96-version as described in Eliasson-Heiman-Olavi in this volume (Technical Specifications) A*KORR: = 0.

Third, and simplifying somewhat (cf (4.1) in Technical Specifications section), QTOP shifts outwards according to:

$$CHQTOP: = \frac{INV*INVEFF}{P(DUR)} \qquad (4d)$$

P(DUR) is the endogenously determined investment goods price index.[1)]

INVEFF is a predetermined coefficient for each firm that relates one deflated unit of investment to QTOP. For the time being it is treated as a constant. We can, however, allow it to be updated endogenously via a current endogenous upvaluation of production capital in the balance sheet of the firm using P(DUR). This would mean bringing in the value of capital stock explicitly, and that value would also embody the extra value brought in by DMTEC in new investment. We can deflate that capital (stock) value by P(DUR). Whether a stable production function Q = f(L,K,...), with K so defined, exists at the firm or the industry level, or not, is a matter that does not concern us here. In fact, the total model would be an ideal instrument for probing deeper into that controversial issue, if one so wishes.

4.5 Production solution search

We will here give a very condensed specification of the production solution search process. A complete coding is found in the Technical Specifications supplement in this conference volume, section 4.3. A verbal and formal presentation in Eliasson (1976 b, pp. 123 ff) and partially also in Albrecht (1978, in this volume). QFR(L) and its inverse RFQ(Q) are used as described below. Four algorithms (START, SAT, CHECK, SOLVE) plus a predetermined set of SEARCH paths lead us to a production and recruitment PLAN:

---

1) Same as final price in sector 5 in the household chapter 4.8.

START

$$PLAN(Q): = \frac{EXP(S)}{EXP(P)} + \frac{OPTSTO-STO}{CLOSE} \quad (5a)$$

PLAN(L): = MAX [L; RFQ(PLAN(Q))]

OPTSTO = optimal finished goods inventory level

STO = actual

CLOSE = number of periods to close gap (OPTSTO-STO) by varying production level.

SAT

determines whether

$$1 - \frac{PLAN(L)*EXP(W)}{PLAN(Q)*EXP(P)} \geq TARG(M) \quad (5b)$$

is true or false for any trial combination of PLAN(Q) and PLAN(L).

CHECK (optional)
ascertains that no step in SEARCH leads to less expected profits in money terms than in position before. If decrease, step back to earlier position and EXIT with plan[1].

SOLVE

is a technical device used on certain sections of the SEARCH path to find where on the QFR(L) curve that TARG(M) is satisfied. A straight line represents the points when planned profit margins M equal TARG(M) and we look for its intersection with QFR(L). The resulting function is transcedental and we have to use an iterative solution procedure. We use the Newton-Raphson method. See further (4.3.12) in Technical Specifications Supplement.

First QFR(L) is updated by investment and the labour force of the individual firm is corrected for retirement etc.

[1] Not in 96-version of model as presented in Technical Specifications Supplement.

The firm is then positioned somewhere on the vertical line AB (Alternative I) in Figure 1 or at some point on QFR(L) above B but below D (Alternative II) via START, which calculates the first trial step in the production planning sequence. SAT checks whether the first step taken leads to a satisfactory profit performance ex ante. If not, SEARCH continues until SAT, occasionally leading to the origin in Figure 3 and a close down of operations.

How exactly firms scan their interior for satisfactory solutions is an entirely empirical problem. The alternatives are so numerous that we can easily guide the firm to all kinds of odd behaviour. For the time being firms switch between two alternative SEARCH paths;

Alternative I, which begins at a point somewhere on AB in Figure 3 and means that redundant labour is sufficient.

Alternative II, which begins at a point on QFR(L) above B but below D and requires more people than currently employed to realize Plan (Q).

We think the production search procedure now to be described provides a rough representation of what is going on in a real firm and we believe we should abstain from further detailing of the paths until we know more.

SEARCH[1)]

Start as described above.

If PLAN(Q) > Q(B) ⇒
PLAN(L) > L (more people needed for PLAN(Q)) then go to 5

If PLAN(Q) ≤ Q(B) ⇒ PLAN(L) = L go to 1.

1) Alternative I: (redundant labour sufficient)

If SAT at starting point A. Exit with PLAN(L)=L.

1) This is described in more detail and with further diagrammatical help in Technical Specifications (4.3.1-12).

Else

2) Raise PLAN(Q): = MIN(QFR(L), Q) such that MAXSTO is not exceeded.[1)] This happens at Q2.
Stop (and exit) if SAT is reached with PLAN(Q)∈ (Q(B),Q2).

Else

3) At Q2, computed above, reduce L down to RFQ(Q2).
Stop (and exit) if SAT is reached.

Else

4) Reduce PLAN(Q) further down along QFR(L) until original PLAN(Q), as determined in START(5a), is reached, or stop (and exit) if SAT is reached (using SOLVE). Else go down to 7 below, which is common for I and II alternatives.

5) This is alternative II: PLAN(Q) = QFR(L);
If SAT at starting point ⇒ PLAN(Q) > Q(B) ⇒ Exit.

Else

6) Reduce Q down along QFR(L) until Q(B) at point B or stop (and exit) if SAT is reached before (using SOLVE device).

Else

7) (Common for both I and II Alternatives)

Activate SLACK RESERVE

This device (described by (4.0.1), (4.1.3-4) and (4.3.7) in Technical Specifications) diagrammatically means pivoting QFR(L) slightly outward to a NEW QFR(L). The size of the pivot is endogenously determined in two steps by investment and by a short term limit within a long term limit defined by the scale of operations.
Move PLAN(L) down at given Q(B) stop and exit if SAT is reached.

Else

[1)] MAXSTO is defined as a fixed multiple of past sales. In (2) above MAXSTO - STO defines how much above Q(B) production can be raised.

8) Reduce Q down along NEW QFR(L) until zero.
Stop (and exit) if SAT is reached (using SOLVE device).

9) If the origin (0,0) is reached and the firm has not found a Q/L combination satisfying TARG(M), it is eliminated from the model, and its L is added to the pool of unemployed.

10) At any step 1-8 above, "exit" means that search is terminated, and that the current Q/L combination (giving target satisfaction) is fixed as the production/recruitment plan for the period in question.

In general one may say that search is geared towards the maintenance of long term rate of return requirements (cf. proof of targeting formula pp. 80 ff.). Firms strive to maintain past output levels, if compatible with targets and to make the best use of the existing labor force. Certain short term "floors", e.g. lay-off restrictions (see next footnote below) slow down contractions in firm size in the short run.

The pivoting of QFR(L) at (7) above has been entered to handle the case when difficulties to meet profit targets are encountered. A number of solutions are always available to raise productivity at the shopfloor level, although Corporate Headquarter management will not normally be aware of exactly how (see Eliasson 1976 a, p, 210 and pp. 234 ff). One well known solution that does not require new investment is to shut-down some low productive operations and allocate some labour to high productive areas. Another is simply to identify and eliminate some labour "functions" that do not affect output in the short run. There are always plenty of such "functions" in a large company.

One may ask why this was not done before the difficulties were encountered. And the answer is, there was no need since profit targets were satisfied. This may perhaps be called an instance of non-optimal behaviour. There is much evidence that it exists in a form specified in this model and described above (see e.g. Eliasson (1976 b), which can be seen as a preparatory study for this modelling project). We could of course save the concept of rational behaviour in terms of optimal behaviour by introducing very steep cost functions for new information or, fast adjustments and some of the model results might remain. This would mean changing our language and specification from something that is easy to understand for those who represent our decision makers in the model and our data, to something that is very unfamiliar.

It would mean unnecessary extra mathematical exercises and, possibly, quite erroneous properties of the model system at some places. Finally, behaviour in our model as specified is as rational as it can ever be. To take drastic action to ride through a crisis situation is a very unpleasant thing for employees and management alike, but normally accepted if the crisis is there. Not otherwise, however, and this is a very good reason for not doing the utmost at every point in time.

Summing up so far, production SEARCH steps lead to a desired reduction in the labour force or a planned expansion. If a reduction, let us assume here that all labour not needed is laid off.[1] If an expansion the firm enters the labour market with

PLAN(Q,L)

and the offering wage

QFFER(W): = W+IOTA*[EXP(W)-W]

PLAN(Q) $\geq$ 0

PLAN(Q,L) can only be realized to the extent that the firm gets all people needed or can keep the labour it has, after Labour market search.

4.6 Labour market search (wage determination)

The labour market process is characterised by firms in active search for passively waiting labour of homogeneous quality.

1) Eliasson (1977a) presents an experiment on what happens when the new Swedish advance notice requirements before lay-off are introduced into the model system.

Search follows a predetermined market sequence, firms being ordered by the degree of expansion exhibited in their plans.

The probability of one firm raiding another firm is proportional to the size (labour force) of the firm being raided.

The probability that search leads to the pool of unemployed is proportional to its size augmented by an exogenously determined factor SKREPA ≥ 1.

SEARCH is characterized by

(A) the intensity of search measured by the number of search loops allowed each firm (NITER) and

(B) the intensity of response. This intensity, represented by the $\{\xi\}$ factors (see below), is the core or the wage setting process. It can be formally represented as:

(C) FIRM I is raiding, wanting a quantity of labour determined in the production planning sequence (above) CHL(I) at an offering wage OFFER [W(I)]

This is the way labour market search is organized:

(1) SEARCH $\Rightarrow$ pool of unemployed $\Rightarrow$ [PLAN(L)-L] = realized employment increase at OFFER(W)

(2) else[1)]

$$\text{OFFER}[W(I)] \geq \text{OFFER}[W(II)] * (1+\gamma), \gamma \in [0,1]$$

$$\begin{cases} CHL(I) := \text{MIN}\,[\theta * L(II),\ CHL(I)],\ \theta \in [0,1] \\ W(II) := W(II) + \xi_1 * [W(I) - W(II)],\ \xi_1 \in [0,1] \end{cases}$$

(3) else

$$CHL(I) := 0$$

$$W(I) := W(I) + \xi_2 * [W(II)(1+\gamma) - W(I)],\ \xi_2 \in [0,1]$$

---

1) Note that firms immediately upgrade their wage level to the OFFER level once it has been determined. We thus delete the prefix OFFER in what follows.

This is all there is needed to describe the market principles at work here. For updating algoritms etc the reader is referred to the Technical Specifications supplement in this conference volume.

4.7 Foreign sector

Foreign connections of the economy are determined at the micro firm level on the export side and at the market level on the import side.

The export ratio (X) of the individual firm is determined as [(6) in Technical Specifications supplement]:

$$CHX = f\{\frac{PFOR-PDOM}{PFOR}\} \qquad (7a)$$

The import ratio (IMP) of the market is determined accordingly as [(7.3.1) in Technical Specifications]

$$CHIMP = f\{\frac{PDOM-PFOR}{PFOR}\} \qquad (7b)$$

The functions, as they are now specified in the program, are differentiable at all points except when PDOM=PFOR (see Technical Specifications). In principle a high or low price elasticity of foreign trade refers to the rate of change of the X and IMP ratios in response to the {PFOR-PDOM} differential. We are, however, not dealing with constant elasticity functions. Rather, a high elasticity means that goods are diverted to or from domestic markets very fast, causing a drop (or an increase) in volume supplies that forces the price to adjust (closes the (PFOR-PDOM) differential) through volume changes and hence curbs the volume adjustment just started. A low price elasticity on the other hand works more slowly on volumes (through X and IMP) and hence closes the gap (PFOR-PDOM) more slowly. This more complex machinery makes the use of the term elasticity give rise to somewhat misleading associations. Sometimes we use the term faster or slower, X-IMP times (TMX in (6.1.1) and TMIMP in (7.3.1) in Technical Specifications paper). TMX and TMIMP measure the number of years (roughly) it takes for X (or IMP) to change with as many percentage points as (PDOM-PFOR)/PFOR.

It would in fact be much more relevant to view the drift in export ratios over time as a result of the relative profitability of exports and domestic sales. This would at least be much more in keeping with the business manager's way of phrasing himself than using conventional demand functions. Since production costs (fixed and variable) can be said to be roughly the same irrespective of where the goods are sold the major discriminating variable (besides prices on imported input goods) are the relative prices on exports and domestic sales. Hence (7a) and (7b) can be said to approximate the alternative formulation that CHX and CHIMP depend on relative profit margins.[1)] As we will take clear note of in my applications paper below (How does inflation affect growth?) the X and IMP functions are the prime transmitters of foreign inflation to our model economy. We do think that these clean, profitability oriented export and import share function catch the decision machinery better at our quarter period specification than would the conventional approach to add a foreign demand component like GNP of the industrialized world. However, by abstaining from relying on proxies to impose the business cycle on the Swedish economy we are certainly making things more difficult for ourselves.

4.8 Household sector

Household demand is determined by a nonlinear expenditure system where all households are assumed to be identical. In practice this is a macro specification.

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1) For proof and further discussion, see Eliasson (1976b, pp. 150 ff.).

The novel features here are that:

(a) expenditure shares are determined in the long run by the growth in real income (β_3 in (8a)).[1)]

(b) durable consumption is out of a stock of durable goods, that varies with the household purchase decision, the price and the (fixed) rate of consumption (ρ) out of the stock.[2)]

(c) During iterations in product markets durable spending can be SWAPped for saving, and vice versa depending on the relative development of the interest rate (RI), CPI and the rate of unemployment (RU).

(d) Desired saving is aimed at maintaining a long run, stable relationship between household financial wealth and disposable income (8d) but

(e) this desire and SWAPPING only guides households in their spending decisions restricted by (8a). Final household saving is determined residually as (8g).

---

1) No growth in real income D(DI/CPI)=0 means that residual income is divided up in fixed proportions over time (β_{23} = constant for all i). In this case the marginal propensity to spend out of residual income is also β_{23}. If real income moves over time and if the consumer price index is not independent of nominal disposable income (which is reasonable) the analytical expression of the marginal propensity to spend becomes much more cumbersome.

2) According to the formula:

STO: = (1-ρ)*(SPE(DUR)+(1+DP)*STO)

STO stands for the stock of durable goods in the household sector.

Household spending function

$$SP(i) := \beta_1(i)*SPE(i) + \underbrace{[\beta_2(i) + \frac{\beta 3(i)}{DI/CPI}]}_{\beta_{23}} * [DI - \Sigma_i(\beta_1(i)*SPE(i)]$$

all β_j $i=1,2,3 \geq 0$ (8a)

$\overset{i}{\Sigma}\beta_2(i)=1$

$\Sigma\beta_3(i)=0$

Nondurable consumption (i=2,3,4)

$$SPE(i) := P(i)*[\alpha_1(i)+\alpha_2(i) \sum_{-T}^{-1}\omega * \frac{SP(i)}{P(i)}] \quad (8b)$$

when not otherwise indicated summation is always over historic time [-T, -1]

ω = weight for each year [-T, -1]

i = 4 is service consumption

Note the distinction between SPE ex ante, desired spending, before iterations are completed each period, and

SP = actual spending as in (8a).

Durable consumption[1)] (i=5)

$$SPE = \frac{P* [\alpha_1 + \alpha_2 \Sigma\omega * \frac{SP}{P}]}{\rho} - (1+DP)*STO-DI*SWAP \quad (8c)$$

STO = stock of durables (current replacement value) that is consumed at the rate ρ per year.

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1) Since consumption and spending are different things in the case of durables, formulation (8c) is not entirely correct. We use it here for simplicity. For details see Eliasson-Heiman-Olavi: Technical Specifications (7.9.2) and (7.9.4) in this conference volume.

Household saving (i=6)

$$SAVH = SPE(i) = (WHRA*DI-WH)+DI*SWAP \tag{8d}$$

$$WHRA = \gamma *WHRA+(1-\gamma)*\frac{WH}{DI}, \qquad \gamma \in (0,1)$$

WH = household wealth

SWAP-function

$$SWAP = \alpha_3 *CH(RI-DCPI)+\alpha_4 *CHRU \tag{8e}$$

RI = nominal rate of interest
CPI = consumer price index
RU = unemployment rate

Adjustment mechanism

1) Firms $\{EXP[P(i)]\} \Rightarrow$ informs market
2) Households $\{SPE(i) \overset{cond.}{\Leftarrow} EXP[P(i)]\} \Rightarrow$ informs market
3) Firms $\{EXP[P(i)] \overset{cond.}{\Leftarrow} SP(i)\} \Rightarrow$ informs market

cond. stands for conditional upon.

Market process: If SP intentions above provisional supplies, firms supply out of their inventories down to min levels. If below, firms try to maintain prices at "expected" levels and reduce offering prices only gradually at a predetermined rate.

4) Repeat MARKETITER times (8f)
5) THEN $\{P(i) \Leftrightarrow SP(i)\}$, $i \neq 6$
   calculate:
6) $SP(6) = SAVH \equiv DI - \underset{}{\overset{(1,5)}{SUM}}[SP(i)]$ (8g)

Consumer price index

$$CPI = \frac{\Sigma\ SP(i)*P(i)}{\Sigma\ SP(i)} \qquad i = 1, \ldots 5 \tag{8h}$$

SUPPLEMENT: PROOF OF SEPARABLE ADDITIVE TARGETING FUNCTION

Assume no taxes.[1)]

Cash flow identity

$$\Pi - RI * BW - DIV + \frac{dBW}{dt} \equiv INV + \frac{dK_2}{dt} \qquad \text{(A}$$

Definition of gross investment spending:

$$INV \equiv \frac{dK_1}{dt} - \frac{dP}{dt} * \bar{K}_1 + \rho * K_1 \qquad \text{(B}$$

Π = Operating profits (gross), inclusive of depreciation
RI = Average rate of interest on net debt (=BW)

K_1 = Replacement value of production equipment on which the depreciation rate (ρ) is applied to obtain depreciation ($=\rho * K_1$)
$\bar{K}_1$ = The corresponding volume measure, obtained by deflating with the investment goods deflator P
K_2 = All other assets, same valuation
NW = Net worth residually determined from: $A \equiv K_1 + K_2 \equiv BW + NW$

Now reshuffle terms in (A) and insert in (B):

$$\Pi - \rho * K_1 - RI * BW + \frac{dP}{dt} * \bar{K}_1 \equiv DIV - \frac{dBW}{dt} + \underbrace{\frac{dK_1}{dt} + \frac{dK_2}{dt}}_{\frac{dA}{dt}}$$

From the definition of the nominal rate of return to net wor

$$RRNW = \frac{\Pi - \rho * K_1 - RI * BW + \frac{dP}{dt} * \bar{K}_1}{NW} = \underbrace{\frac{DIV}{NW}}_{\theta} + \frac{\frac{dNW}{dt}}{NW}$$

(θ is dividend pay out rate.)

Furthermore follows:

$$RRNW = \underbrace{\frac{\Pi - \rho * K_1 - \frac{\frac{dP}{dt}}{P} * K_2}{A}}_{RR} * \frac{A}{NW} - RI * \frac{BW}{NW} + \frac{\frac{dP}{dt}}{P} * \frac{P * \bar{K}_1}{NW} + \frac{\frac{dP}{dt}}{P} * \frac{K_2}{NW} = \theta + \frac{\frac{dNW}{dt}}{NW}$$

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1) For an extension of the separable, additive targeting formula (1) on p. 58 with taxes included see Eliasson: Business Economic Planning, (Wiley) 1976, pp. 293 ff. See also Eliasson: Two Papers on Planning and Efficiency, Economic Research Report B 13, Federation of Swedish Industries, Stockholm, October 1976, pp. 30-31.

and

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

since $\frac{A}{NW} = 1 + \frac{BW}{NW} = 1 + \psi$

(ψ = leverage factor)

Thus:

$$RRNW = \frac{\frac{dNW}{dt}}{NW} + \theta = RR + \underbrace{(RR + \frac{\frac{dP}{dt}}{P} - RI)}_{RRN} * \psi + \frac{\frac{dP}{dt}}{P}$$

But:

$$RR = \underbrace{\frac{\Pi}{S}}_{M} * \frac{S}{A} - \rho * \frac{K_1}{A} - \frac{\frac{dP}{dt}}{P} * \frac{K_2}{A}$$

$$\therefore \frac{\frac{dNW}{dt}}{NW} + \theta = M * \frac{S}{A} - \rho * \frac{K_1}{A} + \frac{\frac{dP}{dt}}{P} * \frac{K_1}{A} + (RRN-RI) * \psi$$

Q.E.D.

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ESTIMATION METHODS

ON ESTIMATION AND OTHER PROBLEMS OF STATISTICAL INFERENCE IN THE MICRO SIMULATION APPROACH

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The micro simulation approach to economic analysis is still in the beginning of its development. Although "numbers" are involved in the simulations much work is largely of a theoretical character one step away from empirical applications. This is so partly because of data shortage but also because there is a need to use the simulation approach to learn about the properties of ones theoretical constructs. The ultimate goal must, however, be to make an inference to the economy, whether on a macro or a micro level. To do this adequate micro data are needed as well as a basis for the inference.

The general principles of statistical inference apply to the micro simulation approach as well as to other research in econometrics. As a matter of fact, it is hard to find any useful alternative. This does not exclude, however, that there are methodological problems which are more or less specific to this approach. In the following I will first give a few comments on the analysis of micro data in general and then turn to some problems more specific to the micro simulation approach.

Analysis of micro data, some common problems

Micro data, and in particular longitudinal micro data, certainly offer new possibilities to obtain a better understanding of micro and macro behaviour, but nothing is for free. The use of micro data makes it necessary to solve problems we tend to neglect at the macro level.

1. There is usually a large individual variability in micro data which show up in low R^2:s. To explain this variability we will probably have to use models which involve more parameters than is typically the case at an aggregate level. For instance, an analysis of household consumption would not only involve household income and lagged consumption but also measures of household characteristics.

2. Partly because of the large range of variability micro relations are frequently non-linear which makes the statistical inference difficult.

3. Measurement errors become relatively important. Sometimes we will work with proxy or indicator variables which "suggest" models with latent structures, (c.f. Aigner & Goldberger (1977), Wold (1973, 1974, 1975)).

4. There are selectivity problems in micro data which may be difficult to handle. In panel data in particular self-selectivity may demand a separate treatment. One promising approach is to incorporate the selection mechanism into the basic model and estimate both at the same time, (c.f. Heckman (1976), Maddala (1977)).

5. Although micro data are expected to be a rich source of information there will most certainly remain unmeasurable individual characteristics. In panel data these have sometimes been taken care of by a variance-components approach.

6. The relationships between cross-section, cohort and time series data deserve more attention. We do not only need to know how macro activities influence micro units and how micro units should be aggregated to macro. Because the increasing demand for personal integrity will limit our possibilities to obtain micro data, and in particular panel data, we will often also have to investigate if cross-sectional data could be used for an inference about longitudinal behaviour.

We already have statistical methods which can be used to treat some of these problems, but the new emphasis on micro data will have to "generate" new methods. To indicate the nature of these methods I would like to give a few key words:

a) Although macro theory usually has a micro theoretical foundation it is not always good enough for empirical studies of micro behaviour. Our methods will thus have to be exploratory.

b) Because the sample size will be relatively large it is possible to emphasise consistency rather than efficiency. In traditional macro econometrics consistency is a completely uninteresting property because of the short time-series usually available. Frequently, however, we only know the asymptotic properties of our estimators. For this reason I agree with those who claim that one should not give much credence to confidence intervals computed in macro econometric models. On the other hand, from this does not follow that statistical inference is useless.

c) One should also emphasize robustness of methods. There is usually a conflict between our desire to have robust and efficient methods. With large samples of micro data, however, we will not have to be overly concerned about the loss in efficiency.

d) In traditional econometrics we concentrate on mean relationships, while with micro data the distributional aspects will be more emphasized. For this purpose we will probably have to develop better statistical methods than those available now.

e) There will be a need for methods which require neither linearity nor assumptions of particular non-linear forms, but rather admit data to determine the functional form of the relationships estimated.

Problems in the micro simulation approach

Next I would like to comment on a few problems which are more specific to the micro simulation method. The size of the models contributes to many of the practical difficulties. It is important to know the properties of an estimated model and the predictions produced by this model. It has been suggested that these properties could be explored by tracing out "reaction surfaces" by alternative assumptions about model structure and parameter values (sensitivity analysis). This is a good idea for small or medium sized models or for exploring particular features but cannot be used to evaluate a large micro simulation model. The sources of uncertainty in the predictions are the same as in most other econometric predictions. There will be genuine residual variation as well as measurement errors. Parameters will be unknown but estimated. Exogenous variables are not known but predicted. There will be specification errors, etc. The multiple of these errors cannot be explored in "reaction surfaces" because it would be unmanageable to analyse the large amount of computer printout required. With these large models it is not feasible to simulate all possible implications of a model and discover unrealistic features. Also, such an approach would not give the probability of the occurance of a simulated event. For these reasons it is very important that each detail (assumption) in the model be tested by statistical methods. It is also important to test the model carefully to balance what I would like to call the "size law", namely that the vested interest in our own model is proportional to its size.

Large size models also make simulations expensive. Methods have to be found which quickly trace out the distributions for strategic variables. Although the simulation methods will depend on the model structure there are general, efficient Monte Carlo methods and there are also powerful computer languages for simulations like for instance SIMULA. Experts on numerical methods and computer simulations could undoubtedly contribute to a more efficient use of the computer.

Another major problem in micro simulation studies is the lack of data. A typical feature of some micro analytic studies is that the objective function which is maximized (or minimized) to obtain estimates of the micro parameters is formulated in macro variables because micro data are not available. For instance, with respect to the micro parameters one might attempt to minimize some quadratic function of the residuals between observed and predicted GNP, consumption expenditures, investment expenditures, rate of unemployment, rate of increase in consumer prices etc. This procedure might easily lead into identification problems. To illustrate by a simple example, if we only know the sum of two variables each of which are linearly related to two other variables, it is not possible to identify the two intercepts. In a more complex model it might be difficult to see if the model is identified or not. If not, the search for a maximum (minimum) may go on for ever. Even if the model is formally identified there may be cases analogous to multicollinearity in ordinary linear models, i.e. the surface of the objective function in the neighbourhood of the extremum is flat. It might then be possible to change some parameter values with but a very small change in the value of the objective function.

Gunnar Eliasson in his paper "How does inflation affect growth - Experiments on the Swedish Model"[1) presented a slightly different data problem. He wanted to investigate if the "over shooting" response of his model to an external shock is a realistic feature. The problem is that so far we have not observed such an "over shooting" in the economy which makes it difficult to put this property of the model to a direct test.

First we would like to know if this particular property is the result of the general model structure or the particular parameter estimates obtained. Suppose we can write the model

$$M1: F(y, \theta) = 0; \theta \varepsilon S$$

where y is a vector of variables and θ a vector of unknown parameters which belong to the set S. These relations define our maintained hypothesis. If F has the over shooting property for every θ in S no sample would be able to reject this property, i.e. no test is possible. In this case there is no support for the property and one would like to consider a more general model which would include M1.

Even if there are θ:s in S which do not imply "over shooting" one might think of cases when this property is "almost" untestable. Suppose our data are generated by another (stochastic) model M2 which does not have the "over shooting" property and that the distribution of y is such that we with a probability close to 1 will obtain estimates of θ in M1 which give over shooting, then the probability to reject this

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1) See pp. 105 ff in this conference volume.

property will be close to 0. To obtain some protection against this possibility one would like to investigate if theoretically plausible models different from M1 with about the same fit would also give the over shooting property. If they do, some support for overshooting is obtained.

In general I can see no other way to solve the testing problem than to test each part of the model against micro data by statistical methods. If micro data are unavailable we will most certainly encounter difficulties in discriminating between model structures. Suppose our data are generated by M1 but there are many parameter vectors $\hat{\theta}$ which give almost the same fit to the observed (macro) data and some give "over shooting" while others do not. This result neither give support to the over shooting property, nor rejects it. Equivalently, if one estimate $\hat{\theta}$ implies overshooting but it is possible to find another $\hat{\theta}$ which gives almost the same fit but no overshooting, then there is no support.

Eliasson discovered the over shooting property of his model by deterministic simulation. But assigning the value zero to the random errors does not always give unbiased predictions, c.f. the case of log-normally distributed errors. Depending on the structure of the model it might also generate random shocks which would counteract the over shooting. If the random errors implicit in the behavioural relations are taken into account by stochastic simulations one might thus obtain different results vis à vis over shooting.

Finally I would like to comment on what is called "the dynamic approach" to estimation. Let us take the following simple example:

$$y_t = \alpha + \beta y_{t-1} + \varepsilon_t \; ; \; \varepsilon_t \text{ is NID}(0,\sigma^2_{\varepsilon})$$

Minimization of

$$\sum_1^T (y_t - \hat{y}|y_{t-1})^2 = \sum_1^T (y_t - \alpha - \beta y_{t-1})^2 ,$$

gives the Ordinary Least Squares estimates which are maximum likelihood estimates and they are consistent, asymptotically unbiased and asymptotically efficient. In the dynamic approach the following residual sum of squares is minimized

$$\sum_{1}^{T} (y_t - \hat{y}_t | \hat{y}_{t-1})^2 = \sum_{t=1}^{T} (y_t - \alpha \sum_{i=1}^{t} \beta^{i-2} - \beta^{t-1} y_1)^2 ,$$

where yl is the first y-observation. It remains to be shown that the estimates obtained have any desirable properties.

If the OLS estimates are used for "dynamic predictions", i.e. only the first y-observation is used to start the forecasting, and if all ε_t are set equal to zero, one would probably obtain a sequence of y-predictions which deviates from the observed series in a seemingly non-random way. Is this result an indication of a bad model? Not necessarily! In a mean-square sense the prediction was the best possible given that we only knew the first y-value. The random number generator which we call the economy will generate a y-series with all ε set equal to zero only with a probability close to zero. The probability that our random number generator would be able to generate the same series of ε values as generated by the economy is also almost zero. To simulate only one future y-path thus is almost useless. What is of interest is to simulate the whole distribution of y-paths. Our interest must then be concentrated on building models which yield distributions with small variances.

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STEPWISE PARAMETER ESTIMATION OF A MICRO SIMULATION MODEL

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An intuitive stepwise calibration method has been used so far on the Swedish Micro-Macro Model. This paper codifies this procedure described in the paper on the model already presented[1)] at this conference as a first step towards a more systematic, computer based estimation procedure.

Being recursively specified through-out, the model cannot be solved as simultaneous equations, but is forwarded in time via a simulation scheme. Since a complete set of real micro data has not yet been made ready, we apply fully dynamic simulations and calibrate all blocks simultaneously. It has not yet been possible to fit endogenously simulated micro data to its "correct" values, or to do the same thing partially block by block keeping all other blocks exogenous each time. Exogenization of blocks and partial block by block calibration in fact contradict the essential idea of the whole model. There is so much linkage across blocks, especially in the micro based market processes that exogenization of most blocks involves redesigning the model. Hence exogenization itself should be expected to affect macro behaviour in a not negligible way. Consequently it will not be very helpful in a calibration context.

Once we get a complete set of micro firm data we will <u>also</u> use simulated cross sectional patterns over time to calibrate the model further[2)]. We want to emphasize, however, that

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1) G Eliasson: A Micro Simulation model of a National Economy: The case of Sweden, pp 3ff.

2) Some such work can be said to have been done already. For instance, we know roughly the rate at which the correlation between past and current rates of return of individual firms decreases with time. We have checked that model simulations do not contradict this evidence. It should be noted here that there is no randomizing device in the model that sees to it that such results are obtained. In this context the model is deterministic.

the most important empirical test of the model has to do with getting the micro assumptions numerically right. (Cf the discussion on pp. 32-51.) Here we are concerned with "estimating" a very limited number of parameters indirectly where access to direct micro observation has not been possible. This estimation also serves as a complementary check at the macro level that this "other" numerical information, that has gone into the model, is consistent with reality.

It will be obvious from what follows, that this paper is concerned with one side of the estimation procedure only, namely with the practical problem of how to obtain the "best fit" within reasonable computer resource limits. We do not discuss here the important problem of the stochastical properties of the estimates we eventually reach.

The general idea is to first calibrate the model to produce trends for critical endogenous macro variables over the simulation period that are consistent with Swedish post-war development, and then to calibrate the year-to-year historical development. The approach in each of these two phases is to move a selected subset of model parameters within a predetermined range, to get successively better values of an objective function, measuring the closeness of fit. This two-step scheme is made possible by the fact, noted from initial experimentation with the model, that most model parameters can be classified into one of two groups; one largely operating on model trends and the other mostly on short term cyclical behavior.

For each of the two steps, the objective function has been chosen so as to

a) economize on computer time

b) allow the inclusion of as much a priori knowledge as possible

c) lead to an improved numerical specification from the chosen starting point.

The philosophy behind this two-step method is that the complexity of micro simulation models of the Swedish kind

(1) allows for a multitude of solutions that satisfy the goodness of fit criterion if scanning is unrestricted but

(2) that a priori considerations (knowledge) allow us to limit the number of choices considerably. We also believe

(3) that our own intuitive capabilities are superior to mechanical, unlimited scanning when it comes to avoiding non-global optima, but that the mechanical approach is superior when we reach the stage of fine tuning with little risk of going in the wrong direction.

First we define a set of goal variables G_i and find out by way of sensitivity analysis which parameters work on G mostly in the long run (Trend = GTR_i) and on short run cyclical variations (= GCL_i).

Then we define a goodness of fit criterion.

To make the presentation more concrete we introduce the chosen set of goal variables directly from the model version described in Eliasson-Heiman-Olavi (1976)[1]. There is no practical way whatsoever to perform this estimation on all macro variables and the variables thus have had to be chosen so as to minimize the risk that other variables stray off in undesired directions. We do not, however, explain this choice here.

Step one: TRENDS

Goal variables = GTR_i = Trends for the following macro entities:

Q	= (i = 1)	= industrial production
L (TOT)	= (i = 2)	= total employment
W	= (i = 3)	= wage costs in industry
P	= (i = 4)	= wholesale price index
CPI	= (i = 5)	= consumer price index
SAVH	= (i = 6)	= household saving

Trend criterion

(A) Minimize $\underset{i}{MAX} \left| GTR_i^{model} - GTR_i^{actual} \right.$

subject to:

(A1) M, RU, SUM $\in$ {low, high} through simulation

1) See Technical specifications of the Swedish micro-macro model version 96 at the end of this conference volume.

(A2) <u>by varying</u>

KSI	$\in \{0.1, 1.0\}$
NITER	$\in \{5, 15\}$ (integer)
IOTA	$\in \{0.5, 1\}$
ALFABW	≥ 0
BETABW	≥ 0
DMTEC	≥ 0.1
MARKET-ITER	≥ 1 (integer)
MAXDP	≥ 0
GAMMA	≥ 0
THETA	$\in \{0.1\}$

<u>Note</u> that we consider correct evolution of firms' profit margins (M), rate of unemployment (RU), and industrial capacity utilization (SUM) to be so important for calibrating the model, that we have chosen to enter them as restrictions rather than to include them in the objective function.

KSI — is a parameter that tells to what extent a firm, having performed an unsuccessful raid for new labour on another firm, closes the observed wage difference by increasing its own wage level [5.4.1.8][1]. Also see p.44 in this conference volume.

NITER — gives the number of interactions (searches) a firm is allowed in the labour market each period (quarter) [5.4.1.2].

IOTA — is the fraction of the expected wage increase that a firm chooses to offer directly when entering the labour market in search for people [5.4.1.0].

ALFABW and BETABW — the rate of increase in firm (net) borrowing is assumed to depend linearly on the difference between the nominal return to total assets and the borrowing rate. ALFABW is the intercept and BETABW the coefficient [10.6].

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1) Numbers refer to algorithms where this parameter appears in the supplement <u>Technical Specifications</u>. See previous footnote.

DMTEC	is the (exogenous) rate of increase in productivity of new equipment invested [4.1.1].
MARKET-ITER	tells the number of producer-household price-volume iterations in the product market [7.3.3].
MAXDP	maximum fraction by which one year's price increases can differ from expected values, as a consequence of excess supply or demand in the product market [7.6.1].
GAMMA	the relative wage improvement a worker demands to move to a new job [5.4.1.8].
THETA	maximum fraction of a firm's labour force that can be lost in <u>one</u> raid [5.4.1.9].

The optimum value of the objective function is of course zero; that is, it should be feasible to track the six trends exactly under the restrictions indicated. However, limited resources (time and money) for the calibration will force us to terminate the iterative process at some point which does not produce the optimum, but a closeness of fit which we have prespecified as satisfactory.

<u>Step two: CYCLES</u>

Use the same goal variables G_i as in step one. Let GCL_{ij} indicate the value of variable G_i in year j of the simulation.

The objective function to be minimized is now, (with an appropriate set (w_i) of weights):

(B) $$\sum_i w_i * \sum_j (GCL_{ij}^{model} - GCL_{ij}^{actual})^2$$

Restrictions are

(B1) M, RU, SUM as in (A1)

(B2) Don't let achieved trends suffer more than $\pm\, \varepsilon$ compared with step 1. Stipulate for each GTR_i that:

$$|GTR_i^{model} - GTR_i^{actual}|_{step\ 2} \leq |GTR_i^{model} - GTR_i^{actual}|_{step\ 1} + \varepsilon$$

In step 2, the following model parameters are varied:

SMS	$\in \{0,1\}$
SMP	$\in \{0,1\}$
SMW	$\in \{0,1\}$
SMT	$\in \{0,1\}$
FI	$\in \{0,1\}$
TMSTO	≥ 0
TMIMSTO	≥ 0
TMX	≥ 0
TMIMP	≥ 0
SKREPA	$\in \{1,50\}$

SMS,SMP,SMW,SMT	smoothing parameters, used by firms to make each year's trade-off between old and current experiences when forming expectations for sales, prices, wages, and profit targets, respectively [1.1.1, 1.2.1, 1.3.1 and 2.1].
FI	a smoothing parameter, used by firms to make quarterly adjustments of expectations [3.1.2].
TMSTO	a time reaction parameter, used by firms as the time planned for to adjust a deviation of their finished-goods inventories from their optimum level [4.2.2].
TMIMSTO	same as TMSTO, but applied to input-goods inventories.
TMX,TMIMP	time reaction parameters, controlling the rate of change of export/import ratios as a response to foreign-domestic price differentials [6.1.1 and 7.3.1].
SKREPA	a parameter regulating the probability that a recruiting firm will turn to the pool of unemployed (instead of trying to raid other firms), and thus affecting the time pattern of a net increase in total employment.

To be able to calibrate a year-to-year fit, we have been careful to choose, in this step, a parameter set that mainly affects the time response patterns of the model. Compare this with the trend-calibrating step, where we selected parameters that have a relatively stronger impact on the long-run profitability and growth development of simulated firms, and thus on the long-run behaviour of the entire model.

Further considerations

The above is a formalization of our ad-hoc intuitive procedure for estimating critical model parameters. We have also told why we prefer a user-model interaction scheme in a first phase, instead of applying an outright, automatic optimization procedure. In a later phase of the project, when calibrations like this have resulted in reasonable interval estimates of the parameters and the risk of approaching a non-global optimum is smaller, a computer-based algorithm should be appropriate. With any such algorithm, our own interactive scheme would be mechanized into an iterative search process, evaluating for each new step to be taken what changes in the parameter set as we judge them, give the fastest improvement in the closeness-of-fit objective function. However, instead of directly computing the derivatives by way of explicit formula, the algorithm will use trial model simulations at each point, requiring a well-defined algorithm/model interface.

Note that with a computer-based optimization algorithm, the problem formulations in the two steps above might have to be modified to suit the characteristics of the algorithm in question. Integer-restrictions, like NITER and MARKETITER, are awkward to all opimization schemes; and MINMAX formulations often make optimizations very time-consuming. The exact formulations will have to be worked out in concordance with the performance of the chosen algorithm.

Note also, that with the objective function and the restrictions on the allowed parameter combinations, as we have them, we cannot guarantee the convexity of either. This might give rise to problems of finding the correct (global) optimum. Usually this problem is accomodated by running several optimizations, selecting different starting points. That would probably be too resource-consuming in practice in our case. Instead we chose to base our confidence on having found a good starting point for search - from the beginning - namely the parameter set that gave the best fit in the initial, intuitive search procedure.

APPLICATIONS of the SWEDISH MODEL

HOW DOES INFLATION AFFECT GROWTH?
- experiments on the Swedish Micro-to-Macro Model

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INFLATION AND GROWTH

1. Introduction

The absolute price level can change for various reasons. We often tend to associate a higher growth rate with more inflation due to excess demand phenomena internal to the economy. There has been very little written or said on the characteristics of the reverse relationship. How does an exogenous change ("shock") in the general price level affect the rate of economic activity? This is a very relevant possibility for any economy engaged in extensive foreign trade. In fact it would be quite odd to assume a one to one correspondence between the rate of economic growth on the one hand and the rate of change in the general price level on the other, irrespective of the origin of growth and of inflation.

The same comment is in fact equally applicable to the relationship between price change and unemployment since so many and so different factors are at work on the two variables. The complexity of the originating and transmitting machinery certainly would generate an assymetrical price-volume response pattern.

We may say that this study is an essay on estimation. We have been through a series of frustrations when trying to load an extended version of the Swedish micro-macro model with numbers that resemble Swedish conditions. Some inconsistent pieces of empirical evidence still remain to sort out. The very fact that we can give an exact definition of what empirical information we do not possess in terms of the model should be interesting enough and conductive to further empirical research.

The model system operates on a market price signalling-interpretation-decision making mode among individual firms. At some critical inflation rate such a market based system tends to break down, if the inflation process is irregular enough and the interpretative learning mechanisms are not allowed time to adjust. Break down characteristics depend on certain market impulse time coefficients and (NB) the magnitude of the impulses being transmitted. We can study the behavior of the total system under alternative conditions and specifications and we can check some details although empirical evidence is distressingly scanty. The problem is that evidence on the speed of price transmission so far is not wholly consistent with a model specification that can withstand external price shocks of the same magnitude as those witnessed during the Korean boom and the recent oil crisis.

Preliminary experiments on an extended version suggest, however, that these instability properties will be satisfactorily reduced when we have introduced a full public sector and a complete taxation system. Sometimes an exogenous price increase in the foreign markets operates as a deflationary policy measure on the economy by reducing real incomes (as indeed the oil price hike did to the OECD countries); sometimes not, for instance the Korean boom where price hikes were concentrated to typical Swedish raw material exports. This series of experiments will however be structured so that we obtain the same aggregate price change on the import and export sides.

We have allowed some of the simulations to run for 20 years to study the convergence properties of the model system. For such a long time the ceteris paribus clause is of course utterly absurd and we expect the reader not to draw any empirical conclusions from this. The idea of this paper is to study the properties of the model economy of Sweden under somewhat refined and unrealistic conditions.

After we have formulated our problem more clearly we will first study how fast exogenous price changes are transmitted through the model economy described already in an earlier paper of mine to this seminar and in Eliasson (1976). We will then procede to investigate the secondary effects on economic activity levels caused by the market disequilibria occasioned by the price transmission process, and finally we will tell in more easy language what is in fact happening during the model simulations.

2. The problem

This paper combines three observations and asks one question.

First, never before in statistically registered time has such an intensive shock wave of endurable inflation encompassed so many countries and such a large total volume of economic activity as has been witnessed since 1968.

Second, we have found that one macro economic property of the Swedish micro-macro economic model is that exogenous step changes (shocks) in the economic environment of business firms, even if conventionally considered conductive to growth, if large enough in fact, are strongly detrimental to long run growth - if no counter-measures can be found.

One such exogenous step change that we have investigated at length is inflation in two forms;

a) a once and for all (sustained) change in the international market price of all Swedish export goods and

b) a temporary inflation pulse.

The results we are about to report on have been systematically maintained through several extensions of the model. If they can be shown to be reflections of real life phenomena and be substantiated by more empirical evidence, they have to mean a radical revision of our way of looking upon inflation and what it means for a market based industrial economy. Since we believe there is evidence to support the existence of the effects to be reported on but that their magnitude has as yet to be ascertained we should caution the reader to regard the results as theoretical for the time being and to be subject to further testing.[1] I should also add that the numerical results reported on in this paper are based on a model specification that we are gradually improving.

A price step impulse is transmitted through the model economy quite slowly and at different rates depending upon both the size of the initial step and the rate with which individual

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I am currently carrying out some of this testing work jointly with professor Hans Genberg, Institute of International Studies, Geneva.

export firms reallocate their supplies between foreign and domestic markets as a result of the new price differentials. The initial price impulse eventually overshoots in the sense that the ensuing consumer price increase becomes a multiple of the original step impulse, before a contractive process sets in. In those cases we have followed the process long enough - the consumer price effect tends to converge towards a price-price multiplier somewhere around unity in domestic markets for industrial goods (wholesale price index) and somewhere between zero and two in the consumer price end.

The overshooting mechanism feeds on the market price signalling system. When large, absolute and relative price changes are transmitted through the business sector interpretation-decision rules of individual firms become temporarily faulty and generate disorderly production, employment and investment decisions. Since market price arbitrage is faster than volume adjustments the net result is less growth in the long run if the price step is large enough and positive, negative or reversed back after a while; and the more so the more the economy swings off from a steady state growth path.

Very much so this paper is concerned with the stability properties of an open industrialized economy when the market pricing-interpretation-decision making system that holds it together is jolted by disturbances.

Third, the existence of a "price overshooting" property of our economy, in this case Sweden, is an hypothesis almost intractable to direct testing. If the overshooting lags are as long and as unstable as indicated in model simulations we do not have enough time series data to ascertain them properly. As the mechanics is a price-volume-price interaction, a conventional application of a stable lag to describe the price transmission with volumes kept constant will give biased results. We need a complete macro economic model. This we have, but to be relevant this model brings us far beyond the capabilities of conventional econometric techniques. We can, however, note the following. The overshooting property systematically remains after several extensions of the model. The model has also been quite successful in tracing the post-war growth patterns of Swedish industry.

Furthermore, the overshooting property means that a simple distributed lag regression of the consumer price change on the exogenous input change of foreign exogenous prices of an open economy like Sweden should display first positive and then negative time weights, the sum of the positive weights exceeding unity. Some support for such a lag profile was reported on in Genberg (1974). The lag length used by Genberg was, however, arbitrarily cut off at 2 1/2 years and the properties of a polynominal lag estimator are very sensitive to such a priori restrictions. Later experimentation with different and longer lags by Genberg and myself, however, preserve this property. Even though we cannot say that we have empirical control of the transmission rate time profile we believe that the overshooting property as such is empirically established.

The question to be posed finally is peripheral to the paper but central to the current economic debate in Sweden. If domestic prices and wages overshoot export firms can counter this only by cutting into profit margins and/or raising productivity. In the model productivity increases come by way of new investment reductions in output and employment and of slack. Depending upon the character of the disturbance firms respond differently. But the back side of the price overshooting mechanism normally is that firms are pricing themselves out of foreign markets in an economy subjected to international import and export competition, in a vain attempt to maintain profit targets. The more price- (or rather profit) sensitive foreign trade the faster exports and imports respond. Volumes shrink, profits plunge and the ensuing impact on investment spending brings the economy down onto a lower growth trend for a long time if everything else is the same. To many observers this seems to be exactly what has now been going on for some years in Sweden, beginning with the extreme profit boom of 1973/74 and threatening to break an almost uninterrupted 55 year steady state growth record of industrial production of close to 5 per cent. And we think that we can observe price overshooting going on around us.

The original export price steps associated with the 1973/74 profit boom (and with oil) have already been transmitted to the CPI index more than in full. The causal relationships in fact seem to have been turned upside down compared to what we were taught in the 60ies, when exogenous excess demand was thought to generate first more growth and then - as a consequence - more inflation.

Let us see what sort of evidence a sensitivity analysis[1] of the Swedish micro-macro model, described already in an earlier paper, can shed on this peculiar issue.

3. The rate of price transmission

Figures 1 picture the rate of transmission of an exogenous (a) step change in foreign prices and (b) a pulse wave through several production stages to the consumer price. All "price" diagrams shown in this paper exhibit the cumulative domestic (wholesale or CPI) inflation effect either in per cent of the original price step or on index form with the reference case with no price step as the base. All activity diagrams in the next section are of the second index type. Five things can immediately be observed.

First, the larger the step increase the larger (each period) the response in the consumer price index but the longer it takes for the full effect to work itself through.

Second, transmission is somewhat faster to the wholesale price index than to the consumer price index and also in markets with relatively high foreign trade that are immediately affected by the first transitory growth impulse from inflation (intermediate and investment goods (not shown)). The speed of transmission also depends positively on the speed by which export firms and importers adjust their supplies in foreign and Swedish markets in response to foreign domestic price differentials. This can be seen from a comparison of Figures 1A and 1B. We may say that the high price elasticity case of Figure 1A represents a more open economy than the low elasticity case of Figure 1B.[2]

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1) This experiment series has been run on what we call the 350 version of the model. It includes an elaborate interindustry market and inventory system but no tax and money systems. The government can only figure as an exogenously imposed surplus or deficit. See Figure 6 in my description of the Swedish model in this conference volume.

2) In the high elasticity case exports increase by half the quarterly foreign-domestic percentage price differential the next quarter and in the low elasticity case with 20 per cent. Part of the story is that the higher the elasticity the faster the price difference closes through volume responses. However, also see Albrecht's somewhat different way of distinguishing between an open and a closed economy in this same model in his paper for this conference volume.

Third, some overshooting displays itself throughout and is more persistent the slower supply responses by exporters and importers. Since this response time defines the openness of an economy we may perhaps say that the difference between Figures 1A and 1B picture the extent to which a foreign inflationary impulse can spin off a domestic inflationary spiral.

Fourth, in the longer run convergence is not towards a one to one correspondence between initial step and final change in the consumer price level as is often conventionally assumed. Some of the price effect may be absorbed or reinforced by profit margins. The equilibrium conditions (cyclical, etc.) characterizing the point in time when the price step hits the economy strongly affects the relative sizes of step inputs and whole sale and consumer price effects. The ensuing investment and relative sector growth effects may modify the transmission further.

Fifth, there is no necessary symmetry in time response patterns between step increases and decreases of equal magnitude. The reason is of course that firms do not respond symmetrically to plus and minus changes in their prices.

In Figure 1A the shaded area is the cumulated lag estimated on Swedish data by Genberg and myself using a polynominal lag, 12 years long assumed to add up to unity. It is one of a few trial estimates from a project initiated by the controversial findings of the model study reported on in this paper. The estimated lag represents the average lag response of all the ups and downs in the Swedish export price index since 1950. We will return to it in the next section, but we note in passing that if supportive at all it lends support to the faster supply reactions on the part of exporters and importers or for a more open economy. The econometric results furthermore are consistent with overshooting as well as the faster transmission to the wholesale price index.

Figure 1C finally pictures the transmission to the consumer price index of a 10 and 20 per cent step increase in the export price index respectively in year 2 that is reversed back to its beginning position in year 4 in the low elasticity case. We notice that the long run CPI effect is pracically zero.

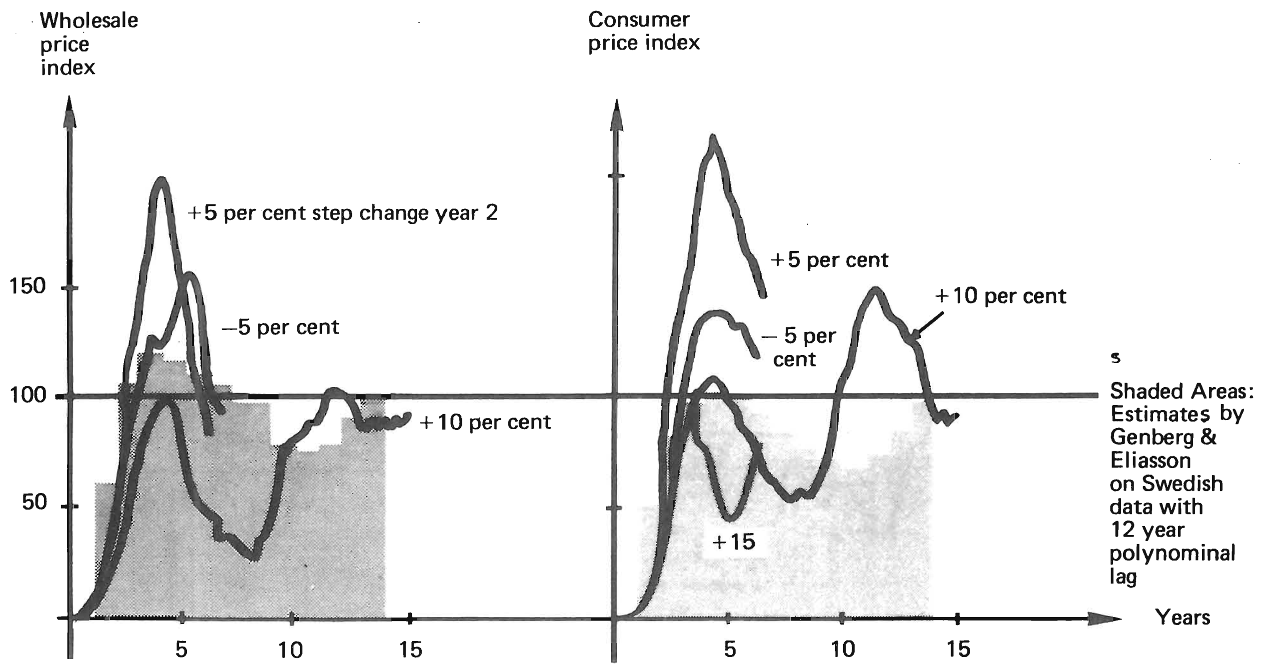
4. Asymmetric activity responses

Figures 3 picture the volume (output and employment) and Figure 2 the profit margin responses of a Swedish-like economy to the same series of step changes and pulses in the export price level the second year. Index 100 is the chosen reference case that traces the Swedish post war growth history quite well. We have allowed one simulation (the one with +10 per cent) to run for 30 years to ascertain the long run convergence of repercussions generated by the exogenous step change.

The initial profit margin effect of a foreign price increase is upward in all cases. However, over a 5 year period (whether up or down) the exogenous change spins off profit margin oscillations around a downward trend in the case with faster export and import volume reactions, seemingly supported by empirical evidence. After a few years the oscillation is replaced by a smoother development that eventually reverses into an upward tendency with the profit margin deviation converging towards zero in the 30 year run. However, for price step changes above +20 per cent market disorder gets out of hand and the economy shrinks substantially. This property was not there in the simpler, earlier versions of the model with no inter-industry markets and inventories. In this more extended version we have to slow down foreign trade price elasticities to make the economy stable enough to withstand extreme rates of export price change during the postwar period. In the low elasticity case the profit margin (Figure 2A) effect is first up from a positive price step, then down normally, until negative. Over the longer run total economy responses seem to cancel the profit effect altogether.

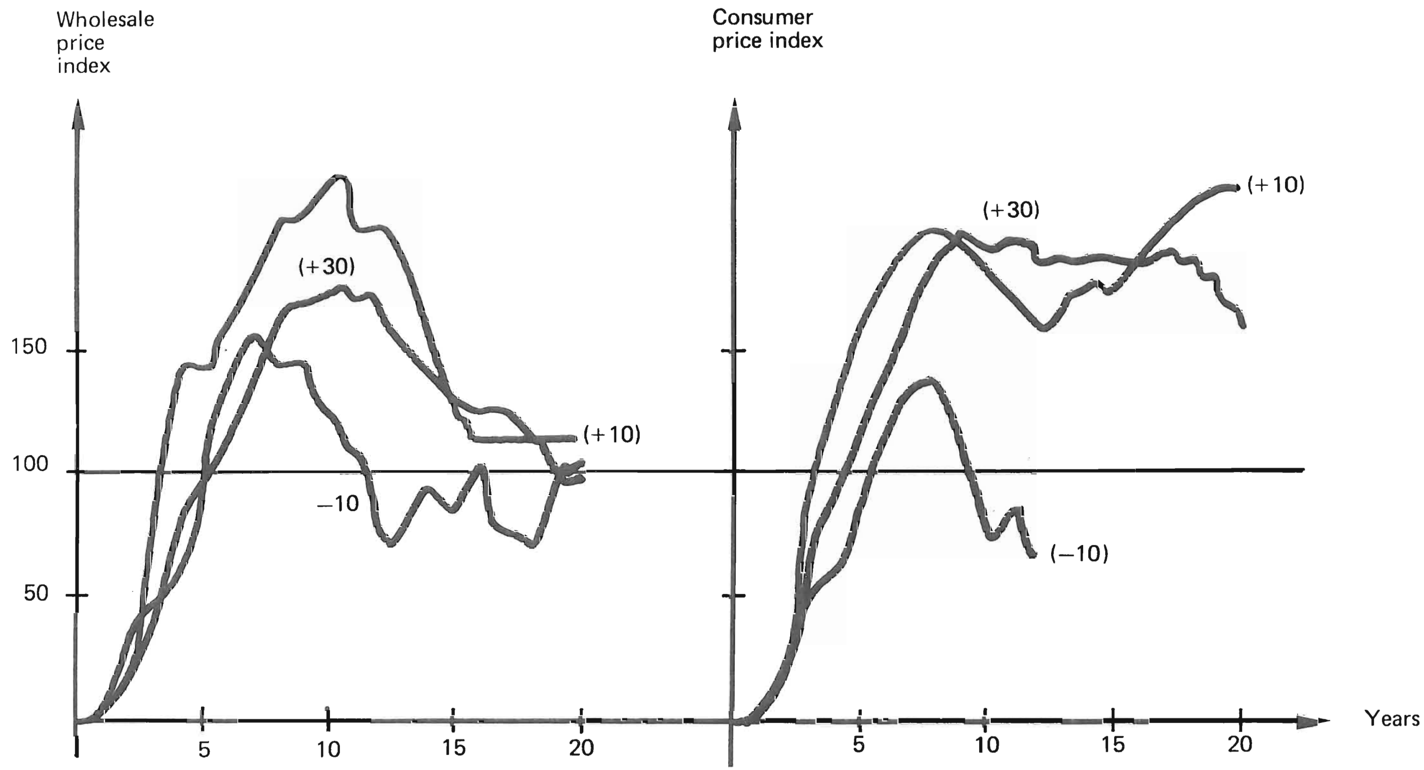
With lower foreign trade price elasticities the properties of the entire model economy changes. The positive activity (industrial growth) effect persists at least for some years even for large positive price steps in the case with smaller export and import price elasticities. On this point, when this paper is being written, we are at a loss exactly which case or which compromise to favour. Even though we need more evidence to decide, the high elasticity case seems to be the one to be preferred to allow a sufficiently fast transmission of foreign price impulses through the economy. However, we do not yet know

Figure 1A. Export-Domestic price transmission, with high foreign trade price elasticity



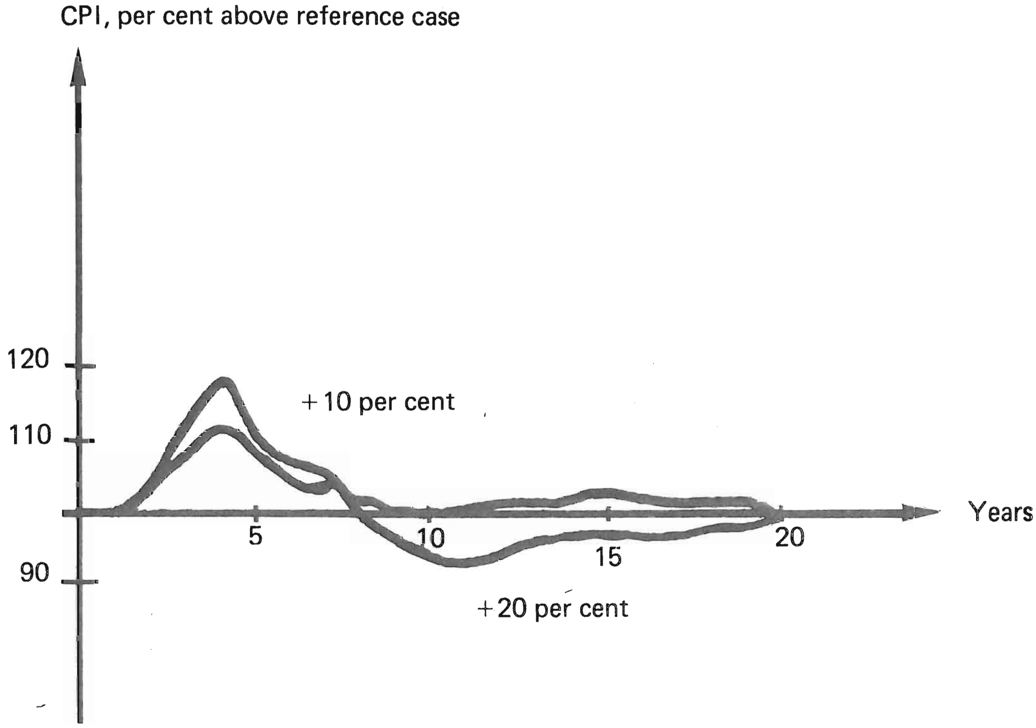
Note: Index = 100 means that an initial step change in the export price index year 2 of x per cent has resulted in an x per cent change in the whole sale price index or the CPI above a reference case with no such change in the export price.

Figure 1B, **Export-Domestic price transmission, with low foreign trade price elasticities**



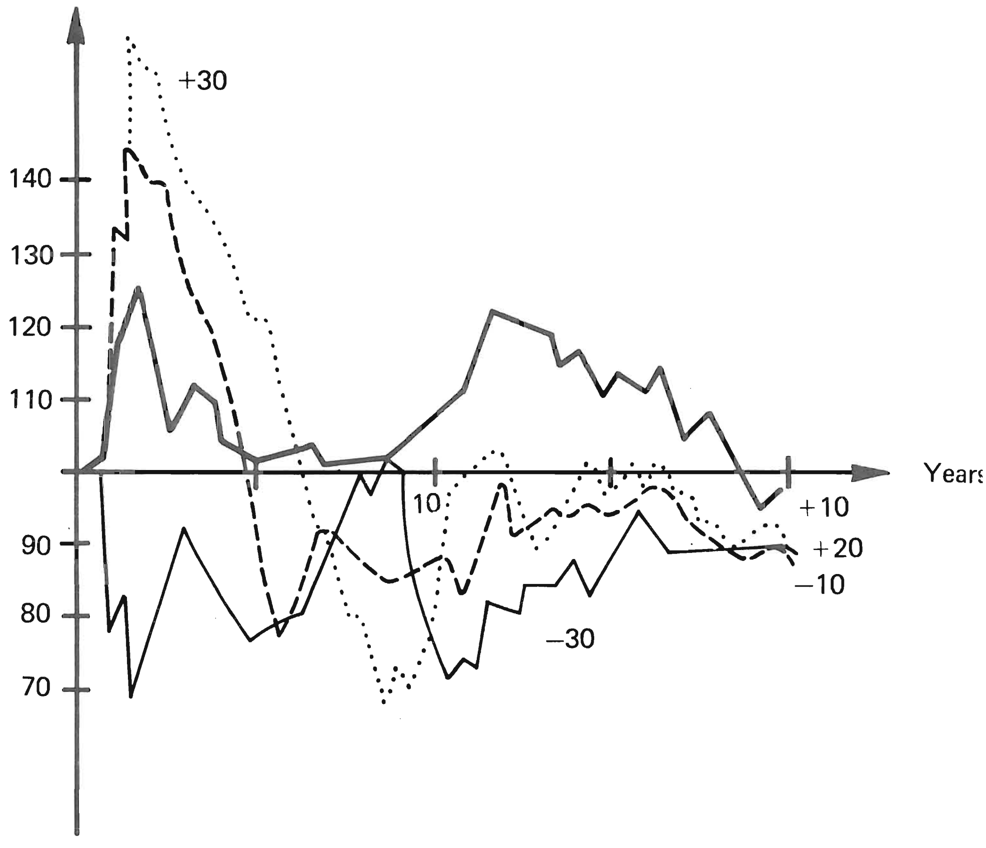
Note: Index = 100 means that an initial change of x per cent in the export price index has resulted in an x per cent change in the wholesale or consumer price index of the same sign.

Figure 1C. Export-Domestic price transmission with temporary price step



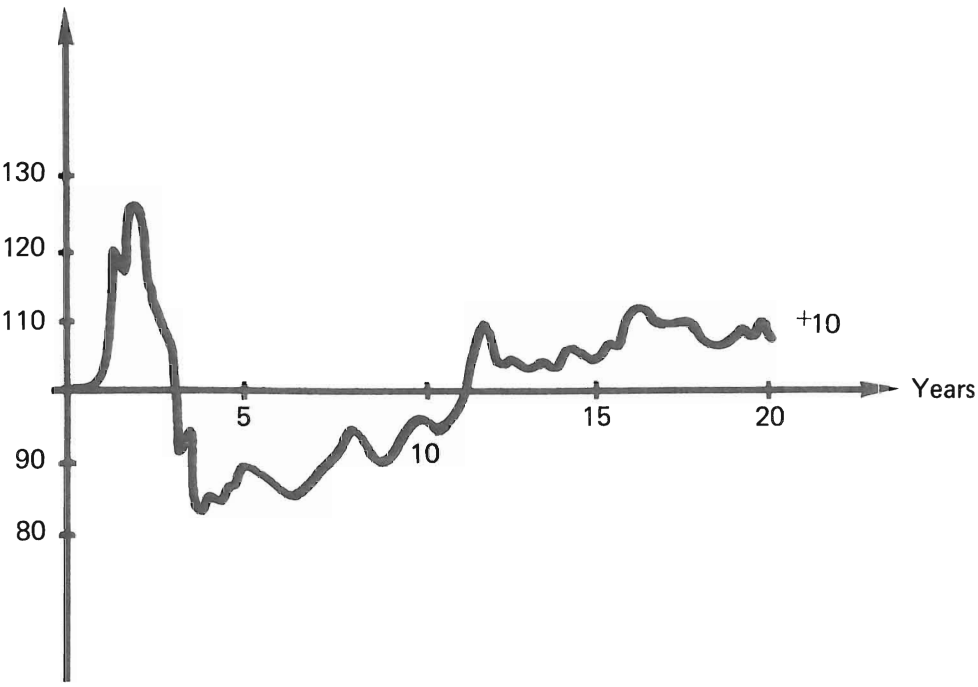
Note: *The export price rises with 10 and 20 per cent respectively the second year. In the fourth year it then drops back to its original time path in the reference case.*

Figure 2A. Effects on profit margins with low foreign trade price elasticity



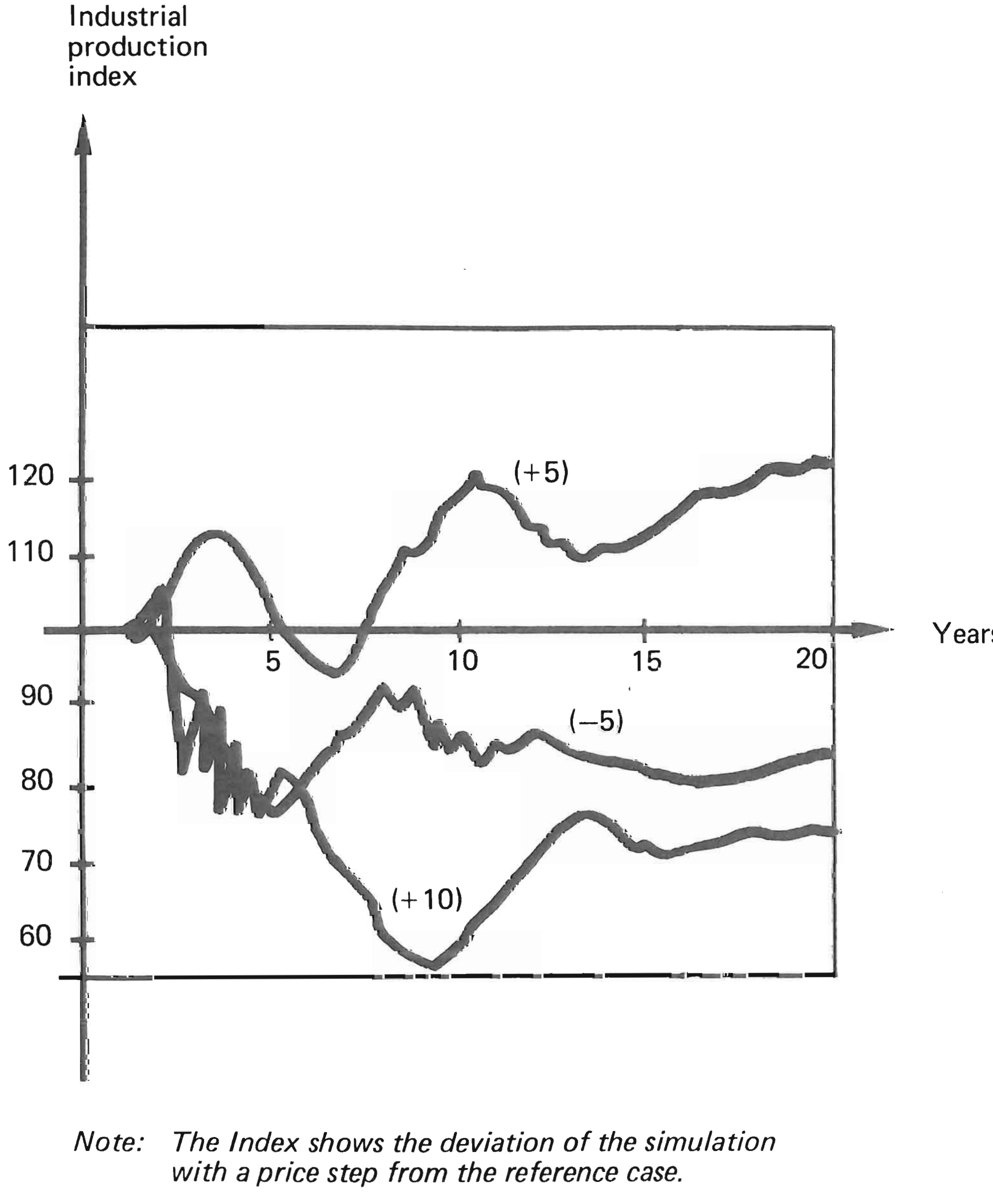
Note: Index 100 = profit margin in reference run.

Figure 2B. Effects on profit margins, temporary foreign price step between 2nd and 4th year



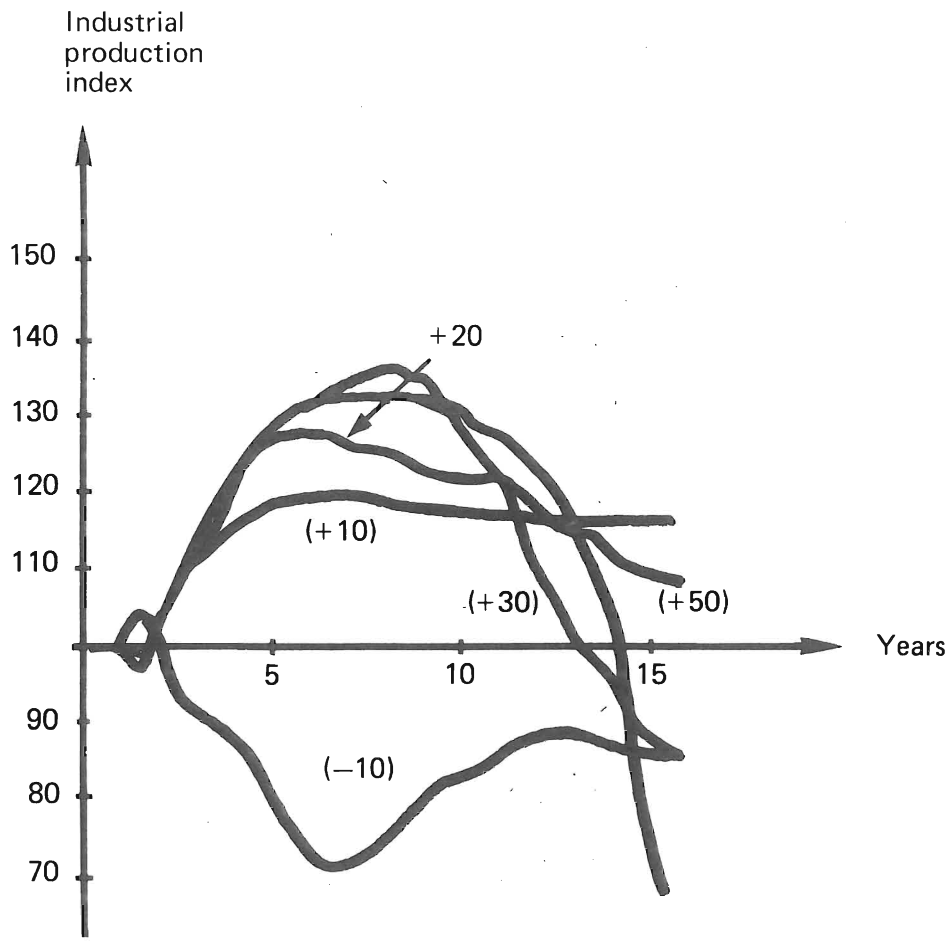
Note: Index 100 = profit margin in reference run.

Figure 3A. Effects on industrial production with high foreign trade price elasticity



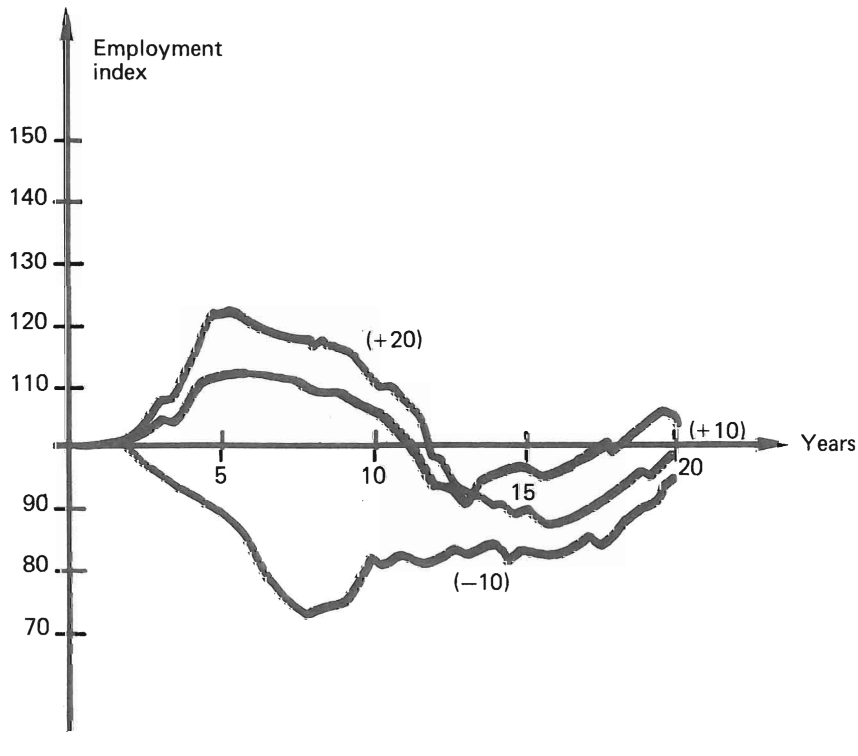
Note: The Index shows the deviation of the simulation with a price step from the reference case. Index 100 = Reference run

Figure 3B. Effects on industrial production with low foreign trade price elasticities



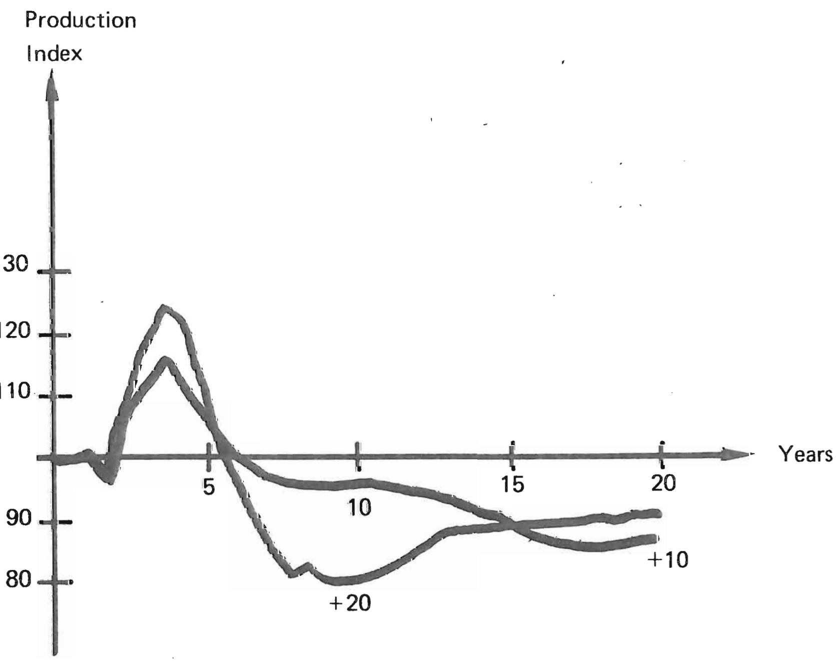
Note: Index Scaling, see Figure 3A.

Figure 3C. Effects on industrial employment, low foreign trade price elasticities



Note: Index scaling see Figure 3A.

Figure 3D. Effects on industrial production from temporary foreign price step between years 2 and 4



Note: Index scaling, see Figure 3A.

how exactly to adjust the market response parameters to obtain realistic stability of the entire economic system. Can domestic inflationary expectations of an overshooting nature alone generate such disorder? Not really if we consult Albrecht's simulation experiments on the Swedish model reported on later in this conference volume. To what extent can inflation of domestic origin, say of a wage cost-push nature, not caused by shocks external to the system retard economic growth? Is there a difference if the cost-push is of a steady state type or irregular? We know that a set of not particularly unrealistic, fast labour market - wage change - job change time parameters in combination with excessive expectations is capable of creating labour market disorder that affects growth negatively. Since fast price (wage) responses in the labour market favour short term allocative efficiency we have obviously identified an interesting conflict between short term efficiency and economic stability. This we will have to probe deeper into. If relevant as an empirical phenomenon a number of policy implications will follow. Similarly, such a conflict between efficiency and stability bears directly on the relevance on much steady state theorizing in growth economics.

Figure 3D, however, only partially supports the conclusion that the higher foreign trade elasticities are to be preferred. It pictures the activity effects of a temporary foreign price step in year 2 that is reverted back again in year 4. This assumption is more like the Korean price experience while the permanent price step is similar to what we believe will be the consequence of the present inflation experience. This simulation operates on the lower foreign trade price elasticity model. For year 1 through 3 the response is identical to that pictured in Figure 3C. As soon as the foreign price drops back again, however, bad experience is recorded. The output and employment effects are negative in the long run. So is also the profit experience of firms for more than 10 years after the first transitory two year period of exhilaration. The only comfort one can derive is that this temporary foreign inflation leaves no permanent domestic inflation effect (Figure 1C).

5. The micro process

This is what happens in the model:

The initial profit improvement from the positive price step spins off erroneous overexpansion in capacity and also output. Even though the overly optimistic expectations and initial expansion generate wage drift and more demand the final outcome proves detrimental when the domestic price level, after overshooting and reinforced by the reversal in foreign prices, begins to wind down again.

Firms respond by cutting back on output growth and investment to restore profit margins. Such measures increase productivity. However, labour is laid off, demand growth slackens and a backward multiplier gets going. In the long run industrial output growth seems to stabilize on a trend lower than that of the reference case even though the initial profit, investment and growth effects were positive.

We can compare these results with the effects of a permanent foreign price increase in Figure 3A (high elasticity case). In the +5 per cent case recovery is fast and strong. In the +10 per cent case the net impact of inflation is still negative but recovery is on its way after 30 years.

As it seems, however, the economy is in an even healthier condition after some 15 years after a moderate reflation than in the case with a somewhat larger inflationary shock <u>and</u> it is just about to move onto a faster growth path towards the end of the 20 year period.

In conclusion I would like to say that for smaller disturbances the model responds in a well behaved way. However, for larger disturbances it overreacts and much more so in the extended version that we are now experimenting with (with an elaborate interindustry delivery and inventory system) than in the earlier, simpler versions.

6. <u>Summary</u>

What can we learn from this? How reasonable are these results that are not forthcoming out of conventional Keynesian or neoclassical models?

The new properties of our (model) economic system originate in the misinterpretation of market signals by business firms in particular when they bounce outside well-known boundaries. The initial positive effects on business profits amplify this misinterpretation and spread the response pattern over a longer period.

In the tougher price decrease case firms are forced to do something about profits directly and the situation therefore improves sooner than in the more easygoing case with effortless price induced profit hikes that create problems in the longer run. The special, individual firm, feed back, profit targeting device that gears firms' future ambitions to past performance plays an important rôle here. We think this device is very realistic.

The high and low foreign trade elasticity alternatives may be said to picture the degree of openness of the economy. We have not been successful in "estimating" these elasticities but we have seen that the more closed the economy the stronger the tendency for the consumer price to run off on its own and higher than the initial foreign price impulse.[1)]

If the foreign price impulse is small enough this might even be conductive to growth. However, the results warn us that our market based economies may not be such stable systems as all of us no doubt thought during the steady state, non inflationary 50ies and the 60ies. For large foreign price shocks only the closed (low elasticity) model alternative responds with a stable future time path. I am very unhappy that we are not yet ready to allow the Government to enter the model together with business firms, also to misinterpret the situation and to policy the economy accordingly.

Perhaps we can also learn that the profession has more or less forgotten (or not observed) the experience from the inflationary Korean boom in the early 50ies. At that time the initial export price hike was even larger than during the "oil crisis" (+61 per cent 1951 in Sweden). After this price hike followed a prolonged period of relatively slow growth, in Sweden at least. The impact was not as hard as during the recent so-called oil crisis and the reason - in terms of the model - may be that the wage cost escalation from "overoptimistic" price expectations on the part of business firms was not as strong, probably due to a substantial rebound downward of export prices almost immediately after 1951.

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1) Also cf. Albrecht's experiments on the Swedish model and a parallel version loaded with US data reported on in this conference volume.

Perhaps the results also tell us something about the advisability of devaluating a currency to solve an immediate problem rather than stubbornly living on with a somewhat overvalued currency. It perhaps does if we are not overly concerned with the immediate employment effects.

LITERATURE

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TECHNICAL CHANGE AND LONGEVITY OF CAPITAL IN A SWEDISH SIMULATION MODEL

Bo Carlsson, IUI, and Gösta Olavi, IBM Sweden

The Model

The purpose of this paper is to explore the effects of varying assumptions on technical change and the longevity of capital on the performance of a microbased simulation model of the Swedish economy. This model has been described in several papers[1]. We shall be concerned here only with the block within the larger model where the output, employment and investment of firms are determined.

Like in all growth models, the assumptions regarding the way technological change enters in are crucial. In the particular model investigated here, the production function for each firm is of the form

$$Q(t) = QTOP(t) \cdot \left\{ 1 - e^{\frac{-TEC(t) \cdot L(t)}{QTOP(t)}} \right\} \qquad (1)$$

where Q(t) = potential output (value added)
QTOP(t) = the maximum level of output which is approached asymptotically when infinite amounts of labor are used, given a certain level of capital stock.
TEC(t) = state of technology
L(t) = firm employment and
t refers to the time period.

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1) E.g. Gunnar Eliasson in collaboration with Gösta Olavi and Mats Heiman; A Micro Macro Interactive Simulation Model of the Swedish Economy. Preliminary Model Specification. IUI, Working Paper No. 7, 1976.

The production function is illustrated in figure 1. The only factor of production which is explicit in this function is labor. However, the potential output, and hence the productivity of labor, is determined by the state of technology TEC(t). The state of technology at time t is determined by the previous period's state of technology and the amounts and level of productivity of new capital:

$$TEC(t) = \frac{TEC(t-1) \cdot QTOP(t-1) + MTEC(t) \cdot \Delta QTOP(t)}{QTOP(t-1) + \Delta QTOP(t)} \qquad (2)$$

where

$$MTEC(t) = MTEC(t-1) \cdot \{1 + DMTEC(j)\}; \qquad (3)$$

$$QTOP(t) = QTOP(t-1) \cdot \{1 - RHO(j)\} + \Delta QTOP(t); \qquad (4)$$

$$\Delta QTOP(t) = INV(t) \cdot INVEFF(t); \qquad (5)$$

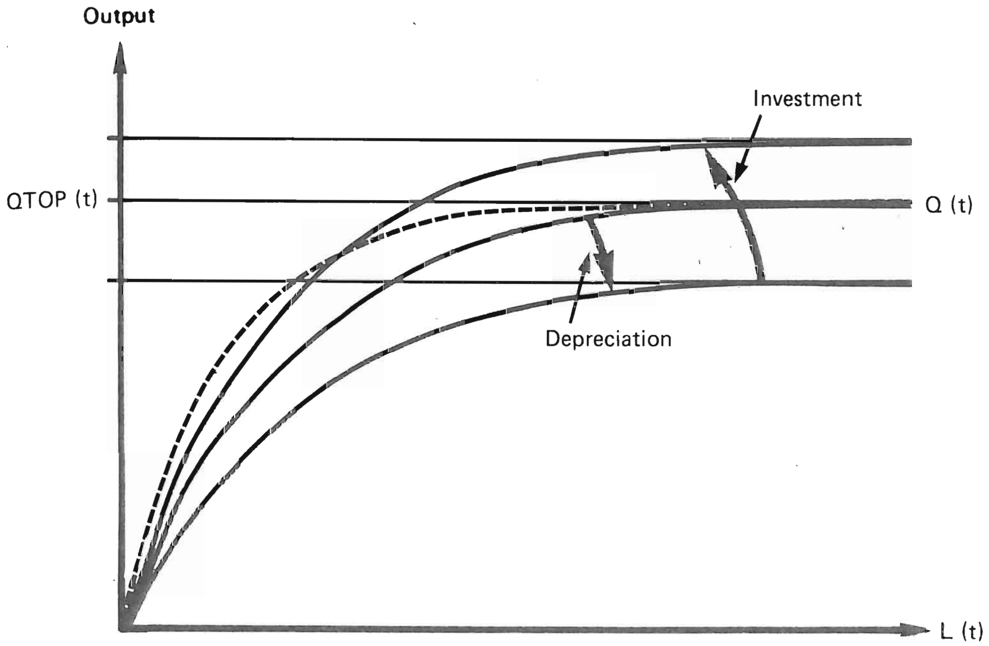
INV(t) = the level of investment in the firm in period t;
INVEFF(t) = the efficiency of newly installed capital (obtained from another part of the model and therefore treated here as exogenous);
MTEC(t) = the level of labor productivity associated with new capital;
DMTEC(j) = the rate of change of MTEC(t) in sector j; exogenous;

RHO(j) = the rate of capital depreciation in sector j, j=1,...,4

1 = raw material processing sector
2 = intermediate goods manufacturing sector
3 = investment goods manufacturing sector
4 = consumer goods manufacturing sector.

Hence, capital enters into the production function indirectly via its effects on labor productivity, and technological change can therefore be regarded as embodied in new capital. Note that QTOP(t), the maximum output attained asymptotically when infinite amounts of labor are used, is not affected by TEC(t). However, with a better state of technology, the curvature of the production function is increased so that the asymptote is approached more quickly (cf. broken curve in figure 1). QTOP(t) is lowered due to the depreciation of capital and raised due to gross investment.

Figure 1. Production Function.



Note: Figure from Eliasson; A Micro-Macro Interactive Simulation Model of the Swedish Economy, p. 133. IUI Working Paper No. 7, 1976.

It can be seen that there are three factors which are essential to the growth of potential output, namely the level of investment INV(t), the productivity of new capital MTEC(t), and the rate of depreciation of capital RHO(j). The level of investment is determined endogenously in another block of the model; however, in the present paper it is treated as an exogenous variable. We will be concerned, therefore, with only two "growth factors", the rate of change of labor productivity associated with new capital and the rate of depreciation of capital. Both of these variables are regarded here as branch specific rather than firm specific. This is an assumption which can be changed when the synthetic firm data which are currently used in the model are replaced by real firm data. It will then be possible also to let both DMTEC(j) and RHO(j) vary over time as well as between firms.

In order to limit the system further and focus the analysis, we also treated household demand for industrial goods by sector as exogenous, even though this set of variables is determined endogenously in the full version of the model. The version used here has interindustry markets and a full input/output system but no public and monetary sectors.[1)] The time period studied is 1955-75, and each simulation run covers 20 years.

Experiments with the Rates of Depreciation and Technological Change

Two sets of experiments were carried out. In the first set, the assumption in the original model regarding the longevity of capital DEPR(j) = 1/RHO(j) and the rate of growth of productivity of new investments DMTEC(j) were changed. The purpose of this experiment was to investigate the sensitivity of some key results in the model to changes of this sort.

In the second set of experiments, the idea was to apply empirical data from other sources regarding the rate of growth of labor productivity, i.e. the growth rate of TEC(t), in such a way that it was possible (1) to differentiate among the four industrial sectors in the model and (2) to determine what rate of change in the productivity of new capital, DMTEC(j), would be compatible with the observed differences in TEC(t), given the investments in each sector.

In the original model, the depreciation period of capital was assumed to be 10 years for all firms. In the first set of experiments the depreciation period was lengthened to 20 years and 30 years. At the same time, the assumed rate of growth of productivity of new investments, DMTEC, was allowed to vary from 3.0 percent per annum in the original model.

The combinations of assumptions made are shown in figure 2 and the results are summarized in figures 3-5, together with empirically observed trends. It can be seen that the rates of growth of labor productivity and production increase and the rate of decline of the industrial labor force slow down as the depreciation period is increased. The growth effect may seem surprising at first sight but it indicates that there is a capacity constraint depending on the longevity of capital which keeps down output and employment. A longer life of equipment, ceteris paribus, simply means that there will be more capital per employee to work with.

It is hardly surprising that production and labor productivity increase faster when the rate of growth of productivity of new capital rises. It is less obvious, however, that the rate of decline of the industrial labor force should not be correlated with the changes in

1) See Figures 1 and 6 in Eliasson's presentation of The Swedish Micro-to-Macro Model, the first paper in this conference volume.

the productivity of new capital. Note that industrial employment has declined in the last 20 years and that this is reflected in all the experiments reported here. As can be seen in figure 5, the rate of decline in industrial employment becomes somewhat slower as DMTEC rises from zero to 1.5%. Then the rate of decline increases as DMTEC continues to increase. Our interpretation is that, on the one hand, higher productivity of new capital yields a higher profit to firms, thus supporting investment and growth in output and hence more expansive labor recruitment plans. But, on the other hand, as the productivity of new capital reaches beyond a certain point, the labor requirement is reduced and hence industrial employment decreases. This result depends on the fact that economic growth is fully endogenized in the model within the capacity constraint set by the rate at which new technology (MTEC) enters in.

The conclusion from these experiments is that the results in the model are fairly sensitive to the changes in assumptions made here. Generally speaking, the results seem to improve relative to those of the original version of the model as the depreciation period is lengthened from 10 years to 30 years, although they still leave a good deal to be desired. The results as far as technological change goes are much less clear. Therefore, we will turn now to a sensitivity analysis using various numerical specifications of DMTEC.

Figure 2. <u>Assumptions</u>

		DEPR=10 DMTEC=0.03	
DEPR=20 DMTEC=0.00	DEPR=20 DMTEC=0.015	DEPR=20 DMTEC=0.03	DEPR=20 DMTEC=0.06
		DEPR=30 DMTEC=0.03	

Figure 3. <u>Rate of Growth of Labor Productivity</u>
% anually

		3.98	
3.78	3.88	4.14	4.41
		4.27	

Empirically observed value: 6.1%.

Figure 4. <u>Rate of Growth of Production</u>
% anually

		2.64	
2.35	2.90	3.06	3.14
		3.32	

Empirically observed value: 4.6 %/year

Figure 5. <u>Rate of Growth of Employment in Industrial Sector</u>
% annually

		-1.28	
-1.38	-0.94	-1.04	-1.22
		-0.90	

Empirically observed value: -0.9 %/year

Technological Change Broken Down by Sector

In a study published recently by the Industrial Institute for Economic and Social Research (IUI)[1], an attempt was made to estimate "total producitivity" growth after allowance has been made for the increase in labor and capital inputs (the so-called residual). This concept is very closely related to the rate of change of TEC(t) in our model. TEC(t) is normally determined endogenously in the model, based on assumptions on DMTEC(j) as shown above. In the original model, DMTEC(j) is set to 3.0 percent per year in all four industrial sectors. The basic idea behind the second set of experiments was to try to "estimate" DMTEC(j) in each sector, given TEC(t) as obtained from the study just mentioned, and given exogenous values on investment. In this sense, the procedure used here is the reverse of that normally used in the model.

An iterative approach was used. As a starting point, DMTEC(j) was set equal to the empirically observed trend for TEC(t) in each sector. The depreciation period was assumed to be 20 years. The results are shown in the upper part of figure 6. Under these assumptions, the resulting trend for TEC(t) turns out to be higher than that observed in all four sectors (cf. bottom line in the figure). This is true especially for the consumer goods sector.

In another iteration, the same assumptions were made except for a longer depreciation period, namely 35 years instead of 20 years. The results are very similar to those of the first iteration, as shown in the middle section of figure 6, i.e. the length of the depreciation period beyond 20 years does not seem to make much difference.

The assumption of a 35-year depreciation period is based on empirical studies[2] which estimate the depreciation time at 35-40 years (an average for machine and building investments) depending on the sector in question. The assumption of a 35-year depreciation period was retained throughout the rest of the iterations.

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1) G Eriksson, U Jakobsson and L Jansson, "Produktionsfunktioner och strukturomvandlingsanalys" (Production Functions and Analysis of Structural Change), in IUI:s långtidsbedömning 1976. Bilagor (IUI, Stockholm 1977).

2) E.g. C O Cederbladh,"Realkapital och avskrivning" (Real Capital and Depreciation), Urval, no 4, National Central Bureau of Statistics. Stockholm 1971.

In the lower section of figure 6, the results of the final iteration are shown. It turns out that the growth rates of the labor productivity associated with new capital which are compatible with the observed trends for TEC(t) are the following: 5.6% per year in the raw materials processing sector, 3.0% in the intermediate goods sector, 2.6% in the investment goods sector, and only 0.4% in the consumer goods sector. Thus, there seems to be a substantial reduction in the rate of growth of the labor productivity associated with new capital as we go from the heavy process industries to the light consumer goods industries, i.e., the rate of technological change seems to be reduced considerably. This is quite plausible, given the fact that technological change can be expected to be more embodied in highly capital intensive industries than in industries where capital plays a relatively insignificant rôle.

This result might indicate that the hypothesis that technological change is embodied attributes too much to capital, especially in the consumer goods industries. It appears reasonable that technological change is more disembodied in relatively labor and skill intensive industries than in capital intensive industries. This type of interpretation would explain why the difference between DMTEC(j) and the trend for TEC(t) is large in these industries and small in capital intensive industries. However, even if this should be true, the fact that the rate of growth of TEC(t) is relatively small in the consumer goods industries would indicate that the disembodied technological change has been slow, even if all technological change were attributed to this factor.

It can be demonstrated that if

DMTEC > (RHO + Net Capacity Growth),

i.e. if the rate of growth of marginal labor productivity is higher than the sum of the rate of depreciation and the net capacity growth, the growth of average productivity of firms would not be able to keep up with DMTEC but would lag more and more behind. With RHO = 2.9% per year (35-year depreciation), and as long as net capacity expands, such an increasing gap would arise only at rates of growth of MTEC substantially exceeding 2.9%. As is shown in the lower part of figure 6, this would be most likely to occur in the raw materials processing sector, since that is the only sector where

Figure 6. Results of Experiments with Varying Assumptions on Technological Change and the Longevity of Capital

	Raw Materials Processing	Inter-mediate Goods	Invest-ment Goods	Consumer Goods
DMTEC =	5.9%	3.9%	3.6%	1.5%
Resulting trend for TEC DEPR = 20 years	6,1%	4.8%	4.5%	2.7%
DMTEC =	5.9%	3.9%	3.6%	1.5%
Resulting trend for TEC DEPR = 35 years	5.8%	5.0%	4.5%	2.7%
DMTEC =	5.6%	3.0%	2.6%	0.4%
Resulting trend for TEC DEPR = 35 years	5.9%	3.9%	3.6%	1.5%
ACTUAL trend for TEC	5.9%	3.9%	3.6%	1.5%

DMTEC > 3%/year. However, even in this sector, like in the others, the "estimated" DMTEC is lower than the trend for TEC in all four sectors but especially in the consumer goods sector. This implies that investment must have taken place at such a high rate that the average labor productivity has risen faster than that of new capital, i.e. that the gap between average and best practice technology has diminished. This finding, if it is borne out in further analysis, is directly opposite to results obtained in some other IUI studies[1)] which have indicated an increasing gap.

The question thus arises whether the results in the studies cited here hold only for the relatively homogeneous sectors for which they were obtained or if they have more general application. This is being analyzed in a research project currently going on at the IUI. Another issue which is also the object of further study within the same project is whether it is true, as indicated above, that technological change has been more rapid in capital intensive than in labor and skill intensive industries and how such differences could be explained at both industry and firm level. The simulation model used in the current paper will provide a means of analyzing the impact at the macro (economy-wide) level of technological and productivity changes at the micro level.

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1) L Hjalmarsson and F Førsund, "Technical Progress and Structural Efficiency in Swedish Milk Processing", paper presented at the international colloquium on Capital in the Production Function at Paris-Nanterre, November 18-20, 1976; Hjalmarsson and Førsund, "Production Functions in Swedish Particle Board Industry", paper presented at the same conference; A Grufman, "Technical Change in the Swedish Hydro Power Sector 1900-1975", paper presented at the IUI Conference on Production, Technology and Structural Change, in Stockholm July 1977.

EXPECTATIONS, CYCLICAL FLUCTUATIONS AND GROWTH - - experiments on the Swedish Model [1)]

J Albrecht, Columbia University

This paper presents results from simulation runs on the "micro-macro interactive simulation model of the Swedish economy" (MOSES for short) that is being developed by Gunnar Eliasson at IUI. These results are based on what we call Version 96 of MOSES. As compared with the model presented in this conference volume by Eliasson, the 96 Version lacks an explicit treatment of intermediate goods (i.e., no inter-industry markets and no input-output matrix for each firm) and does not have a block for an active government sector. Yet to come in any version of the model (as of September, 1977) are blocks for a monetary sector and for long-term investment financing decisions. On the other hand, the 96 Version has been more completely calibrated and is more thoroughly documented (in Eliasson, Heiman and Olavi (1976) -- which I will refer to as the "documentation").

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1) This paper is based on simulation of the "Swedish" model which was described in Eliassons's paper presented at the conference. An alternative description of the model, one which is both more extensive and which describes a model more like the one I have simulated, is given in Eliasson, Heiman and Olavi (1976). A capsule version of the model may be found in Eliasson (1977). These bibliographic notes are for the reader who is not familiar with the model; a self-contained paper would necessarily be much lengthier.

Thanks to several of the conference participants for comments on the first draft and to Gunnar Eliasson and Gösta Olavi for originally explaining the model to me. Financial support was received through the Columbia Council for Research in the Social Sciences and Industriens Utredningsinstitut.

The purpose of these runs is to gain some insight into the role of business expectations in the cyclical fluctuation and growth of economies. Most economists regard the view of the future held by individual firms to be an important determinant of the course of the macro-economy, but our theoretical understanding of how this determination operates is rudimentary. As is so often the case in linking the micro- and macro-economies, we are in the position of having an intuitive, imprecise notion that a micro-phenomenom has a significant influence on the macro-economy without knowing how to model that influence in a precise, abstract way.

One motivation for developing and using micro-simulation models (and this is the primary motivation behind MOSES) is the desire to construct better theory. This can work in two ways. First, the discipline imposed during model construction by the requirement of internal consistency and by the need to pare away inessentials forces the model-builder to organize his thinking. Second, the generation of simulation results provides a sort of synthetic experience to be used as a basis for induction. Reality does not often provide us with *ceteris paribus* experience -- too many factors are changing simultaneously. One point of simulation is to generate a synthetic reality in which the phenomena of interest are isolated one at a time.

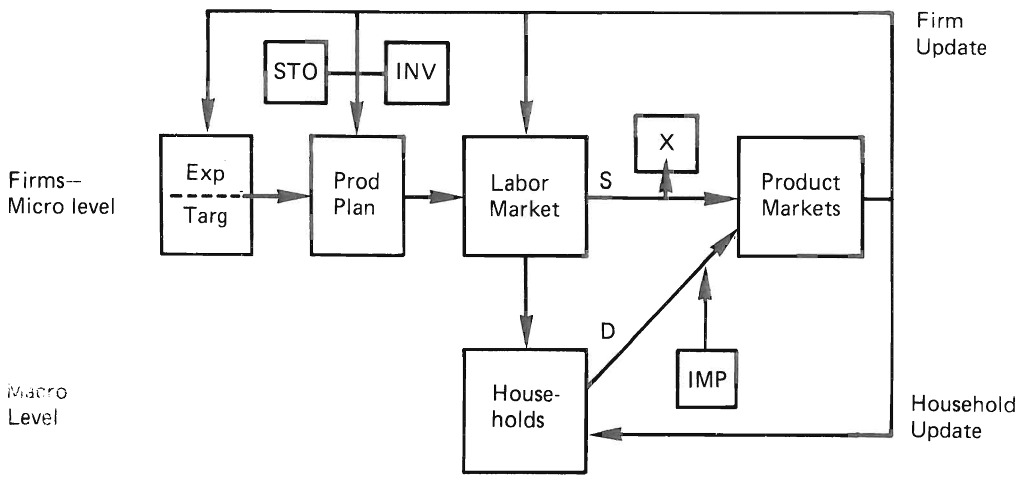
An obvious problem with this technique of creating synthetic experience is that it is difficult for the reader to judge the extent to which the simulation results represent a valid distillation of reality as opposed to idiosyncracies of model construction. It is necessary for the reader to have some feeling for how the model works, or else the simulation results are impossible to judge. Therefore, the first half of this paper gives an explanation of the basic operation of MOSES emphasizing the transmission of business expectations through the model.

The second half of the paper describes the simulation experiments and interprets their results. These experiments consist of modifications in the mechanisms generating price, sales and wage expectations in both an open (Sweden-like) and a closed (US-oid) economy and to some extent produce results contrary to what one might have expected. So, we are forced to trace back through the model and to try to decide to what extent these results suggest changes in the model and to what extent they suggest a re-thinking of our views about the role of expectations.

The MOSES economy

The operation of the MOSES economy is represented by the execution of a sequence of modules, and the completion of one sequence corresponds to one calendar quarter. The organization of these modules is pictured in Figure 1.

Figure 1



The micro aspect of MOSES is its business sector which is divided into a number of synthetic firm-like entities. The internal process of making decisions about production, employment, etc within these firms is modeled in detail (based on Eliasson(1976)), and the interactions between these firms, both in the labour market as demanders of labour, and in the product markets as suppliers of goods, are also specified in detail. In their internal planning processes and in their confrontations with one another these firms must start with some expectations about the options they face and they must have some performance criteria to guide their actions; thus, the forming of expectations and setting of targets come first in the module sequence.

Version 96 starts with 36 firms divided into 4 sectors, and each of these is assigned single-valued expectations -- expressed as percent changes -- about sales, prices and wages. For example, the expected percent change in sales on an annual basis for a given firm is computed as

$$EXPIDS_t = \lambda EXPIDS_{t-1} + (1-\lambda)\cdot\{DS_{t-1}+\alpha(DS_{t-1}-EXPDS_{t-1})\}$$

$$EXPDS_t = \gamma EXPXDS_t + (1-\gamma)EXPIDS_t,$$

where $EXPDS_t$ = expected annual %Δ in sales in year t,

DS_t = actual annual %Δ in sales in year t,

$EXPIDS_t$ = "internally generated" expected annual %Δ

in sales in year t,

$EXPXDS_t$ = "externally generated" expected annual %Δ

in sales in year t.

If $EXPXDS_t$ is constant for all t, then this formulation sets $EXPDS_t$ equal to a constant plus a sum of past actual annual percentage changes in sales with weights declining asymptotically to zero.

Expected percent changes in wages and prices are computed in an analogous way. Thus, explicit 1-year histories for sales, prices and wages are required to start up the model, and longer histories are implicit in the lagged internally generated expectations. (The routine that initializes the internally generated expectations is based on 5-year histories.)

This formulation gives a simple representation of several expectational phenomena. The parameter λ ($0 \leq \lambda \leq 1$) defines how quickly the firm reacts to changes in the economic environment; thus, λ is close to zero for firms that place almost all weight on their experiences in year t-1 and almost no weight on their experiences in years t-2, t-3,....etc. The parameter α ($\alpha \geq 0$) characterizes the firm's learning response -- how fast are expectations adjusted to eliminate systematic biases?[2] The parameter γ ($0 \leq \gamma \leq 1$) indicates the relative weight placed on external information (i.e., indicators other than, say, lagged sales) or, alternatively, on pure unexplainable intuition of the animal spirits variety. Of course, any effects that can be generated via variations in γ can just as well be generated by varying the "externally generated" expectations themselves; and since the latter technique is more easily interpreted, that is the one I have used.

This expectational sequence is computed at the start of each year. However, MOSES runs on a quarterly basis, so it is necessary to convert expected percent changes on an annual basis into a quarterly basis and to make allowance for the ability of firms to change their forecasts over the course of the year. This is done in a simple way. In the first quarter, before any contrary experience has occurred, the expected percent change in (say) sales for the quarter is computed simply as

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2) The expectations functions in MOSES also include a variance term to pick up business managers attitude to risk taking. (See Eliasson's model presentation in this conference volume, section 4.2 in chapter 2, p.p. 62 ff). Due to a misspecification I am unable to report on simulation results using this factor in this paper. Notice that the absence of the variance term makes the parameter α redundant.

$QEXPDS_t$ = EXPDS/4, and in quarters 2-4 as

$$QEXPDS_t = QEXPDS_{t-1} + \delta_s[QDS_{t-1} - (EXPDS/4)].$$

Here $QEXPDS_t$ = expected %Δ in sales in <u>quarter</u> t,

EXPDS = expected %Δ in sales on an annual basis,

QDS_{t-1} = actual %Δ in sales in quarter t-1

δ_s = sales adjustment parameter.

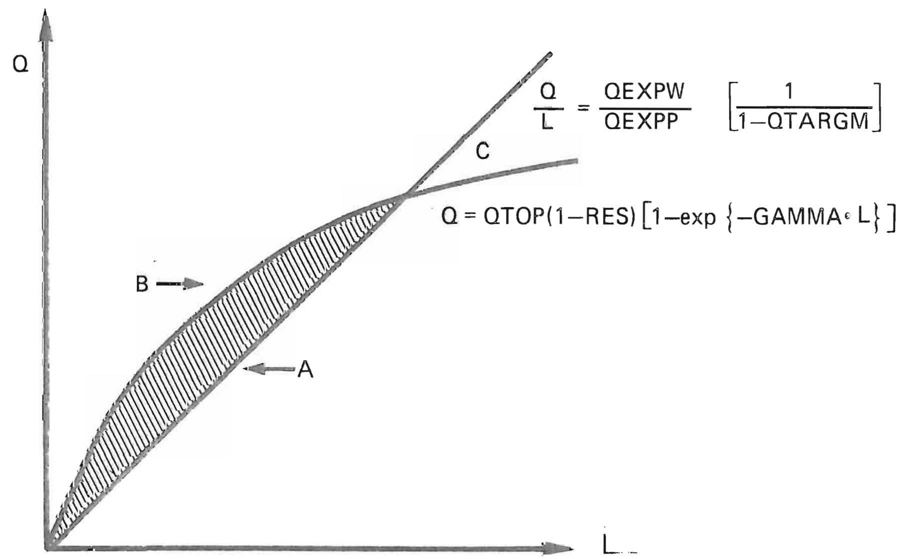
Quarterly expected percent changes in wages (QEXPDW) and in prices (QEXPDP) are computed analogously. Given QEXPDS, QEXPDW and QEXPDP, it is straightforward to compute the corresponding levels, QEXPS, QEXPW and QEXPP.

Once computed, these forecasted levels are used in the 3 micro segments of MOSES -- internal production planning, the labour market confrontation and the product market confrontation. These segments combine each firm's expectations and profit targets with the constraints of technology and with the actions of other firms to produce a final quarterly outcome.

Production planning is carried out individually by each firm in the block PRODPLAN (see pp 108-36, 205-17 in the documentation). Within this block each firm chooses a preliminary planned output, labour combination (Q,L). The algorithm by which a (Q,L) plan is chosen is complicated, but the essentials can be seen in Figure 2.

In each quarter there is a set of feasible (Q,L) combinations (a short-run production possibilities set) open to a given firm that is defined by $Q \leq QTOP(1-RES)\{1-\exp(-GAMMA \cdot L)\}$. This feasible set is determined by the firm's past investments as these are embodied in QTOP, RES and GAMMA, and investment between quarters acts to enlarge this set. In addition to the set of <u>feasible</u> (Q,L) combinations, the firm has a set of <u>satisfactory</u> (Q,L) combinations. The satisficing criterion is given by a quarterly profit margin target (QTARGM), and this target is set in much the same manner as are expectations; i.e., the basic targeting is done on a yearly basis with quarterly adjustments, and profit margin targets adapt to experience. Given QTARGM

Figure 2



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

$$QTARGM \leq (QEXPP \cdot Q - QEXPW \cdot L)/QEXPP \cdot Q$$

This is expressed in Figure 2 as

$\frac{Q}{L} \geq \frac{QEXPW}{QEXPP}\left[\frac{1}{1-QTARGM}\right]$. A shorthand expression for the satisfaction of this inequality is to say that SAT(Q,L) holds.

The problem for the firm is thus to choose a (Q,L) plan that is both feasible and satisfactory, i.e., to choose a point within the lens area of Figure 2. The choice algorithm consists of a rule to specify an initial set of (Q,L) trial points and of rules to adjust these initial points if they are not simultaneously feasible and satisfactory.

The firm reaches an initial trial plan in the following way. It has inherited a labour force, net of retirements, from the preceding quarter; and this is taken as the initial trial level, L. The firm then computes expected sales in "physical units" as QEXPS÷QEXPP, and these expected physical sales are adjusted to allow for a range of inventory change, thus producting a trial interval of output plans.

For a given L this interval either consists of at least some points which are both feasible and satisfactory (i.e., in the lens), consists of points which are feasible but not satisfactory (Region A), consists of points which are satisfactory but not feasible (Region B), or consists of points which are neither feasible nor satisfactory (Region C). Overlapping is, of course, possible.

Should the interval contain a feasible and satisfactory (Q,L) point, then the firm's preliminary plan is set at the minimum Q such that SAT(Q,L) holds. If not, the adjustment algorithms come into play. In Region A the firm adjusts by planning to lay off labour, and if it can find a simultaneously feasible and satisfactory (Q,L) point by doing so, then the firm's preliminary plan is set at the minimum Q and the maximum L such that SAT(Q,L) holds. In Region B the firm adjusts by planning to hire more labour, and if it can find a simultaneously feasible and satisfactory (Q,L) point by doing so, then the firm's preliminary plan is set at the minimum feasible Q and L. These are simple adjustments in the sense that the firm adheres to its initial trial output interval.

The complexities in the adjustment algorithm arise when there is no Q in the initial interval that is both feasible and satisfactory at any L. This must occur in Region C and can occur in Regions A and B. The firm must either reduce its planned output or shift its production possibilities set by the activation of "reserve slack" (in the form of a reduction in RES). The mechanisms by which these adjustments are carried out are intricate, but they are not directly relevant to this paper.

This completes the production planning sequence. To summarize, expectational variables influence firms' plans in two ways. First, the ratio of wage and price expectations, together with QTARGM, is used to define the set of satisfactory (Q,L) plans. The intersection of the set of satisfactory (Q,L) plans with the set of feasible (Q,L) plans is the set of allowable (Q,L) plans. Second, the actual plan chosen within the set of allowable plans depends upon the initial trial (Q,L) plan, and the initial trial/output interval is computed by adjusting QEXPS÷QEXPP for a range of inventory changes.

After completing its PRODPLAN sequence, each firm has a planned labour force and a planned output level, but these plans may be infeasible in the aggregate. Firms must confront one another and interact with the consuming public to resolve any inconsistencies.

Each firm enters the labour market with a planned and an actual labour force; call the discrepancy CHL. If CHL ≤ 0 for a given firm, then that firm begins the process of laying off CHL workers. The mechanics of doing this are complicated by Sweden's Åman laws from the seventies, which require up to a 2-quarter lag between a layoff notification and the layoff itself, but the essential thing is that these firms do not desire additional labour. On the other hand, there may be firms for whom CHL ≥ 0, and these firms will be forced to "raid" either another firm or the pool of unemployed. A raid is "successful" (labour is shifted to the raiding firm) if the wage offer of the raiding firm sufficiently exceeds that of the raided firm. This is where expectations enter directly into the labour market confrontation -- the wage offer of a firm depends upon the wage level it expects will prevail, i.e., upon QEXPW.

Firms first bid against each other in a stylized labour market to produce final wage levels and employments for each firm.

To be more specific (see pp. 137-48, 218-27 in the documentation), let W be the wage paid by a firm in the preceding quarter. Then its wage offer is computed as $WW = W + \eta_1(QEXPW-W)$.

After computing a wage offer for all firms, the firms are ranked by their relative desire for additional labour, i.e., by CHL/L. The first firm in this ordering chooses to raid either the pool of unemployed or another firm, and the choice of a raiding target is determined by a random device in which the probability of being raided is related to the size of a potential target's labour force.

Let i index the raider and let j index the target. An attack is successful if $WW_i \geq (1+\eta_2)WW_j$, and labour in the amount of $\min(\eta_3 L_j, CHL_i)$ 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 $\min(\eta_3 LU, CHL_i)$ workers become employed in firm i. When an attack succeeds, CHL_i, CHL_j, L_i and L_j are adjusted in the obvious way, and the raided firm adjusts its wage offer upwards by $\Delta WW_j = \eta_4(WW_i-WW_j)$.

On the other hand, if the attack fails, then it **is the attacking firm that ad**justs by setting

$$\Delta WW_i = \eta_5 (WW_j (1+\eta_2) - WW_i)^3.$$

This describes the attacking procedure for the first firm, and the same scenario is repeated for firm 2, firm 3, etc. When all firms (for whom CHL > 0) have undertaken an attack, one market iteration is completed. The process is then continued through a pre-determined number of iterations. The result is a wage and an employment level for each firm, and thus a total wage bill for the economy. Given the initial vector of CHL that began the labour market process, the aggregate wage bill is thus determined by firms' wage expectations as manifested through their wage offers.

The final interaction takes place in the product market between firms as suppliers and households and firms as demanders (see pp. 164-91 and 230-40 in the documentation). 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. Also, it is quantity demanded rather than quantity supplied that responds to price within each quarter. Consumers are the active agents in the product markets, and supplies are predetermined except for possible inventory adjustments. From period to period, 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. Of course, firms' expectations also indirectly affect the operation of the product markets through the total amount of income that consumers have available for expenditure.

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3) The parameters $\eta_1,\ldots,\eta_5$ $(0 \leq \eta_k \leq 1)$ determine the speed of reaction to wage discrepancies in the labour market. In addition, the randomizer can be altered. In particular, it can be regulated in such a way that the unemployment rate generated by the MOSES economy is close to the observed level. The realism of the labour market process thus ought not be judged by the unemployment rate it produces.

How are starting prices and quantities set by firms on the product markets? At the end of the labour market sequence, firms may have found themselves unable to satisfy their desires for additional labour; consequently, output plans may need revision. Planned output (Q) is then specified for each firm as the smaller of the originally planned output (specified in PRODPLAN) and the maximum output attainable with the firm's post-labour market employment level. To move from Q to the initial offering of quantities on the domestic market, it is necessary to subtract off desired inventory changes (ΔSTO) and production for export markets. Let S = desired domestic market sales, and let x = the fraction of production for export. Then $S = (1-x)\cdot Q\cdot\{QEXPS/(QEXPS + QEXPP\cdot\Delta STO)\}$. The sum of S across all firms in a particular market determines the initial quantity offered in that sector.[4] The determination of initial market prices is also straightforward. Let j index the firms in this market so that these firms offer $\{S_j\}$ and expect prices $\{QEXPP_j\}$ in the current quarter. Then the initial offering price in this market is computed (approximately) as $P = \sum_j S_j QEXPP_j / \sum_j S_j$, i.e., as a weighted sum of price expectations.

Given an initial supply (ΣS_j) and supply price (P) on each market, it remains to be seen whether demand will correspond. Consumers express their willingness to allocate their income to each of the 4 sectors, to service goods and to savings. A modified linear expenditure system with habit formation is used as a demand system, with estimates of price and income elasticities from Dahlman and Klevmarken (1971). In addition, there is a demand for

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4) An export fraction is specified individually for each firm, but the change in these fractions depends upon the relative movement of domestic and foreign prices in the previous quarter on a market basis.

durables as investment goods by firms that is predetermined from the previous quarter. This constitutes the demand for firms' products, except that it is necessary to specify the fraction of demand that will be satisfied by imports (IMP). This fraction is determined in much the same way as the export fractions are determined; i.e., IMP is determined by the relative movement of domestic and foreign prices in the previous quarter on a market basis.

An adjustment by (1-IMP) gives desired purchases from domestic sources on each market (D), and a price adjustment mechanism is specified that tends toward the equation of demand and supply. Letting N denote the iteration number, the price adjusts by

$$\Delta P = (\lambda/N)\left[D-\sum_j S_j\right].$$

This is done on each market, leading to new market prices and new demands. The process is then allowed to run for a fixed number of iterations.

Upon completion of the product market sequence, the output of each firm has been specified and divided into domestic sales, foreign sales and inventory change (computed as a residual, but constrained to lie within certain bounds). A final (but not necessarily equilibrium) price has been computed for each market, implying an average rate of change which can then be spread across that market's firms. Employments and wage levels have been computed for each firm in the labour market. Thus, profits can be computed for each firm, and since (in the 96 Version) investment is financed out of profits, the link between quarters is made. Each firm's production possibilities set is updated according to its investments, and the entire process begins anew.

<u>The Simulations</u>

The simulations were designed to address two general types of questions. First, suppose that some "extraneous" events cause a short term change in business expectations; e.g., suppose a change in government induces a "wave of pessimism" among businessmen. Could this have any effect on the economy, and if so, would the effects persist over a long period of time?

Second, suppose the mechanism by which expectations are generated changes in some fundamental way. Will this change have any effect on economic performance? If so, can this change in the expectational mechanism be given a real-world interpretation?

These questions correspond roughly to two themes in the US business press -- that the economy is faltering either because businessmen "lack confidence" or because the "climate is too uncertain" for investment. One might view the simulations reported on below as an attempt to make some sense of these notions, but, of course, it is risky to use a model of the Swedish economy as a tool for reading US newspapers. One particular hazard is the extreme openness of the Swedish economy relative to that of the US economy. Holding all else constant, it seems much more likely that expectations would be capable of self-fulfillment in an economy that is close to being "self-contained"; i.e., there is an a priori reason to expect expectational phenomena to be more important in the US than in Sweden.

To check on this, we have constructed a "US-oid" economy to supplement the basic Swedish version of MOSES. This supplementary economy is based very roughly on the US national accounts, and it should be understood that this version of the model does not purport to represent the US. The US figures have been used only to provide a consistent basis for creating a relatively closed economy. Thus, two sets of simulations were run -- simulations on the model of the Swedish economy and simulations on a more closed, US-oid version of the model.

Questions about short term alterations in business expectations were addressed via changes in the "externally generated" expectations. In the reference cases these are set at EXPXDS = 0.07, EXPXDP = 0.03 and EXPXDW = 0.03 for all years. To model a short term burst of "bullish optimism," I have doubled EXPXDS, EXPXDP and EXPXDW in each of the first three years; thereafter they are reset to the reference case values. To model a short term period of "bearish pessimism," I have set EXPXDS = EXPXDP = EXPXDW = 0 for years 1-3; thereafter they are reset to the reference case values. One might question the sense in which a temporary increase in EXPXDW represents business optimism (or the sense in which setting EXPXDW = 0 represents pessimism), so I have also run simulations in which EXPXDS and EXPXDP are modified as described above but EXPXDW = 0.03 is maintained throughout. The results of these latter simulations are not qualitatively different.

To examine changes in the expectational mechanism, I have tried the simple experiment of allowing λ to vary. As compared with the reference run value of $\lambda = 0.5$, simulations were run with $\lambda = 0.1$ and $\lambda = 0.9$. The smaller value of λ allows a firm to change its expectations quite radically from year to year, whereas the larger value of λ builds in greater stability. These two cases are the only changes in the expectational mechanism that were considered; in particular, α and γ are left at their reference run values of $\alpha = 0.1$ and $\gamma = 0.5$.

Thus, there are 5 basic simulations for both the Swedish economy and the US-oid economy -- a reference case, the case of short term optimism (EXPXDS = 0.14, EXPXDP = 0.06 and EXPXDW = 0.06 for each of the first 3 years), the case of short term pessimism (EXPXDS = EXPXDP = EXPXDW = 0 for years 1-3), the case of $\lambda = 0.1$ and the case of $\lambda = 0.9$. Results for 20 year simulations are presented below. Table 1 gives the 20 year trends for selected key macro variables for the Swedish economy, and Table 2 gives comparable figures for the US-oid economy. These trends are measured as geometric means of percentage increase; e.g., if Q_1 denotes output's initial value and Q_{20} its terminal value, then the trend figure for output is computed as $(Q_{20}/Q_1)^{1/20}-1$.

Looking first at the Swedish economy, one can see that the reference case produces the greatest long-run rate of growth in output and productivity. The cases of pessimism and $\lambda = 0.1$ produce rates of growth only slightly below those of the reference case; however, the cases of optimism (NB) and of $\lambda = 0.9$ produce rather disasterously sub-par rates of growth. In terms of inflation, the reference case produces a slightly higher rate than any of the other simulations, but in general the 20 year rates of price increase do not vary much between cases. Finally, with the

TABLE 1

Swedish economy - Key 20 year trends

	0	1	2	3	4
Q	4.6	3.1	4.2	2.5	3.9
PROD	7.2	5.6	7.1	6.2	6.7
P	4.8	4.6	4.8	4.5	4.8
W	11.8	10.5	12.2	7.7	12.0
S	9.5	7.8	9.0	7.1	8.8

TABLE 2

US-oid economy - Key 20 year trends

	0	1	2	3	4
Q	3.6	2.4	3.8	2.7	2.8
PROD	5.6	4.2	5.8	5.4	5.2
P	4.7	4.5	4.6	4.3	4.5
W	9.8	8.9	9.8	7.8	9.9
S	8.4	6.9	8.4	7.1	7.3

Key:

Cases --

0 = reference run
1 = increase in EXPXDS, EXPXDP in years 1-3
2 = decrease in EXPXDS, EXPXDP in years 1-3
3 = λ=0.9
4 = λ=0.1

Variables --

Q = real output
PROD = real Q per labor hour
P = price
W = wage
S = sales

exception of the case of $\lambda = 0.9$, rates of wage inflation do not differ dramatically between cases.

The performance of the US-oid economy is roughly similar, except that the case of pessimism produces better performance than the reference run and the case of $\lambda = 0.1$ produces a much inferior performance. Rates of inflation are again nearly identical in all simulations. This was to be expected in the Swedish economy since the sectoral inflation rates must be "imported" to some degree (i.e., determined by inflation rates in comparable foreign markets) and the model has been fed constant exogenous rates of foreign price increases. However, one might have expected more independence of foreign inflation rates in the more closed US-oid economy.

It is also useful to look at Figures 3-6. Figure 3 charts the course of the level of real output for each of the four cases (optimism, pessimism, $\lambda = 0.1$ and $\lambda = 0.9$) relative to the reference case level of output for the Swedish economy with the reference case level normalized to 100. Figure 4 does likewise for the US-oid economy. Figures 5 and 6 chart the course of the price level generated by each of the 4 cases relative to that of the reference case for the Swedish and US-oid economies, respectively. It should be understood that these are charts of relative levels. When, for example, Fig 3 shows a decline in the $\lambda = 0.9$ series, this need not mean that output has fallen. Rather, it may mean that output in the $\lambda = 0.9$ case is rising less rapidly than in the reference case.

Figures 3 and 4 tell similar relative output stories. In both the Swedish and US-oid economies the expectational changes have a minor short term effect. After 5 years the largest deviation from the reference case is only +1.9% (for pessimism) in the Swedish case and +2.5% (for $\lambda = 0.9$) in the US-oid case. However, after 7-8 years of simulation, some dramatic changes occur. The outputs of the pessimism and $\lambda = 0.1$ cases suddenly exhibit strong growth relative to the reference case, but the cases of optimism and $\lambda = 0.9$ exhibit strong declines relative to the reference case. Thereafter, the two economies

Figure 3. Swedish economy: Outputs relative to reference case

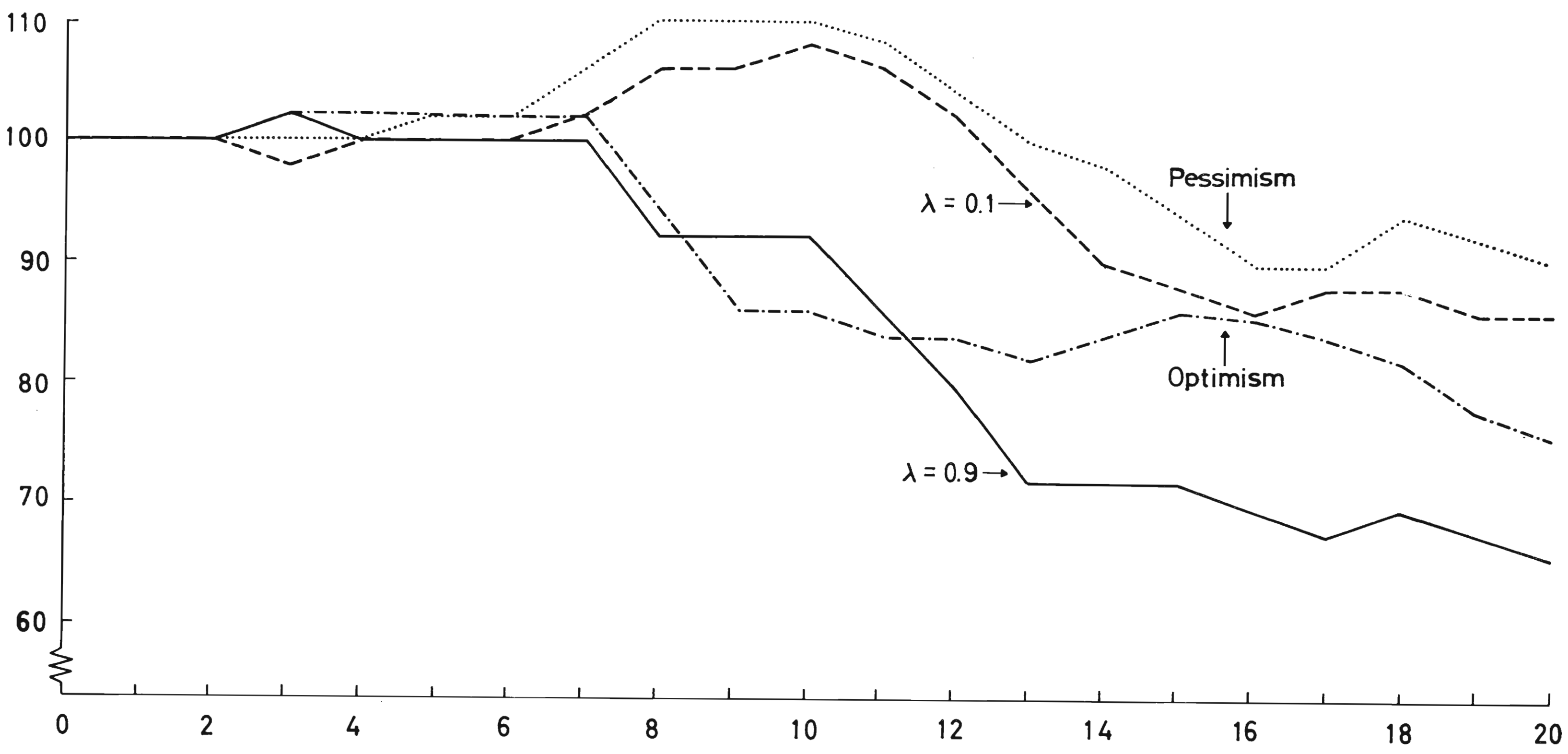


Figure 4. US-oid economy: Outputs relative to reference case

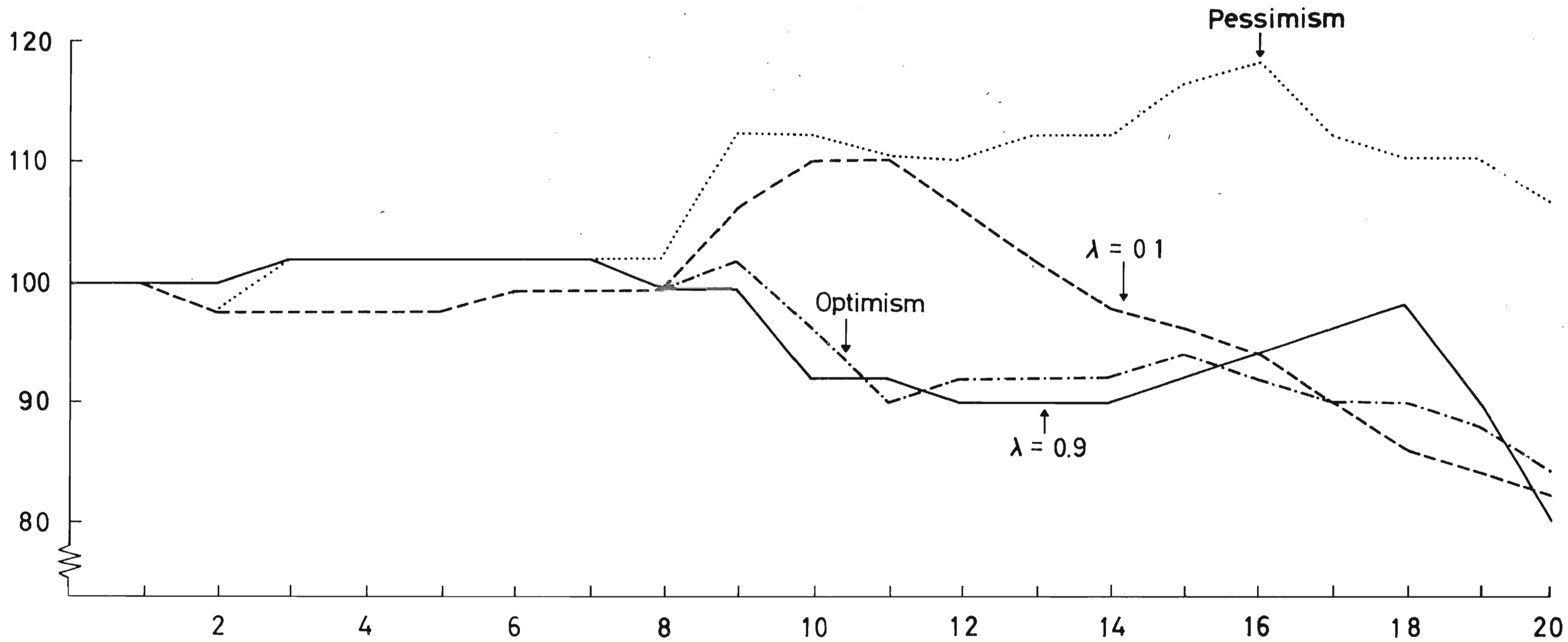


Figure 5. Swedish economy: Price level relative to reference case

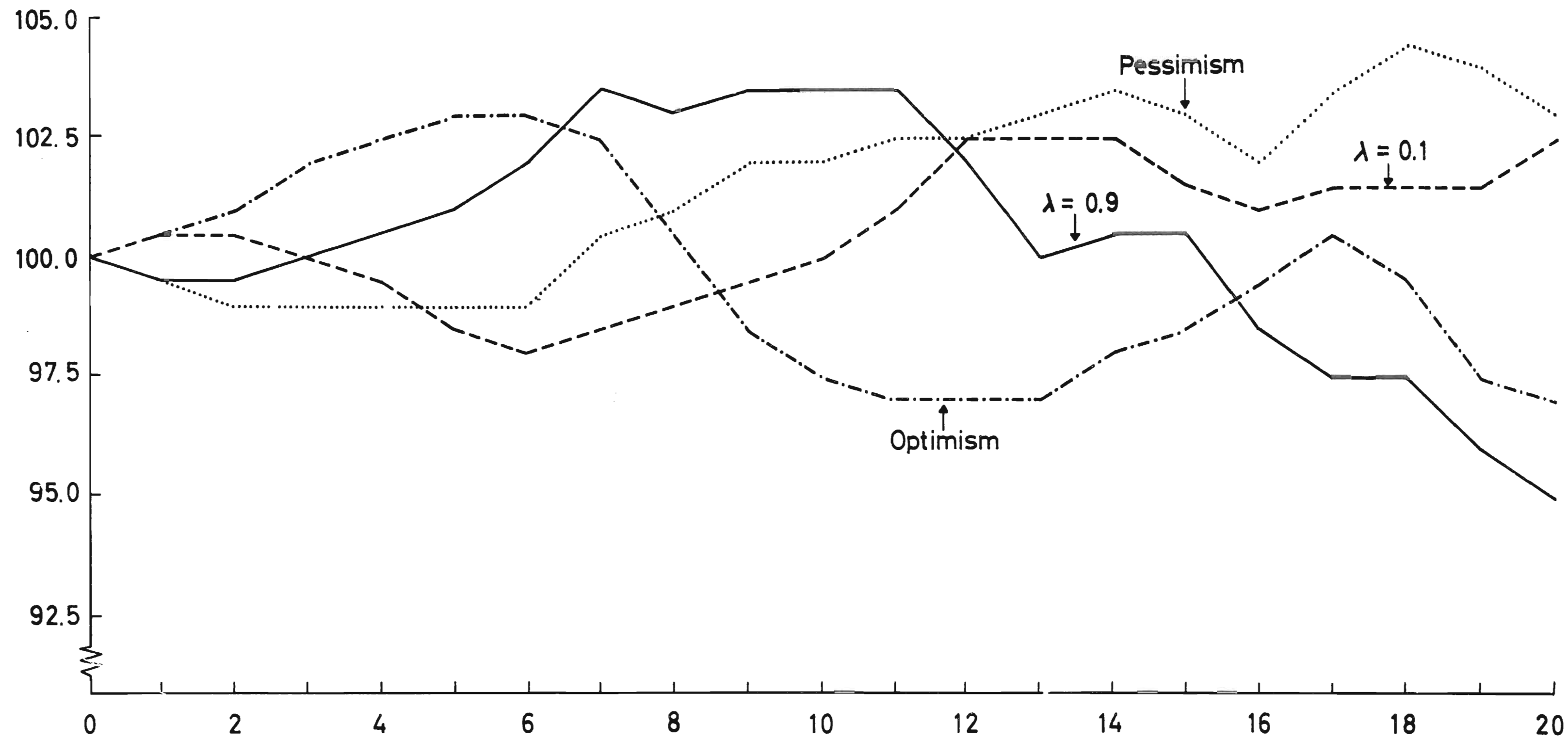
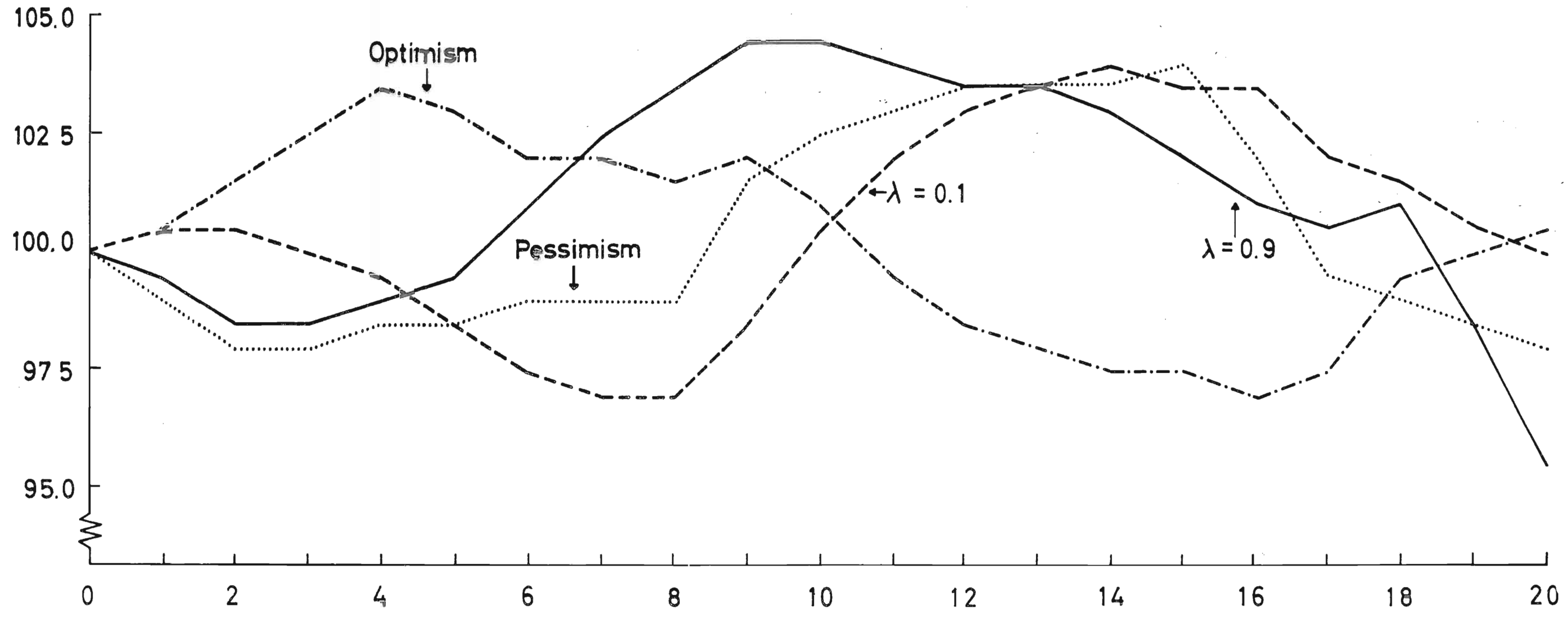


Figure 6. US-oid economy: Price level relative to reference case



differ slightly. In the Swedish economy all cases fall off gradually relative to the reference case, whereas in the US-oid economy the pessimism case maintains a rate of growth comparable to that of the reference case and the case of $\lambda = 0.1$ shows a serious decline.

Figures 5 and 6 show that the paths of relative prices over time fluctuate much less than do the paths of relative outputs. (Note the scales of Figs 3-4 relative to those of Figs 5-6). In contrast to output, price fluctuation relative to the reference case can be seen at a very early date. The optimism case exhibits strong price growth relative to the reference case in the first 4-5 years, then falls off for a long period (up to year 14 in the Swedish economy and up to year 16 in the US-oid economy) and finally begins to recover. The case of pessimism is close to a mirror image of optimism, and the cases of $\lambda = 0.1$ and 0.9 are also close to being mirror images of one another.

Interpretations

I examine the cases of $\lambda = 0.9$ and 0.1 first since the results of these simulations are probably least difficult to reconcile with one's intuition. The results for the cases of optimism and pessimism are perhaps more mysterious.

Recall that λ characterizes the speed at which firms react to changes in the economic environment. When $\lambda = 0.9$, firms do not change their expectations much from year to year, but rather rely on a longer historical perspective. One might say that firms are behaving very cautiously or acting as if they were very uncertain. Why does caution breed such poor economic performance in this model?

The problem is not one of caution making businessmen unwilling to invest, thereby eventually dragging down output. In fact, investment (and the profits from which investment is generated) are slightly larger in the case of $\lambda = 0.9$ than in the reference case. The problem is rather that the rate of capacity utilization is abysmally low. Firms are neither hiring enough labour to fully utilize their accumulated capacity nor are they utilizing the labour that they do hire very efficiently. What happens is that at some point firms' expectations "fall behind" reality. In setting their output plans firms start to think in terms of an output range that is too low. The aggregate *ex post* result of these plans is a high profit margin on a low volume of output. This result tends to reproduce itself in the sense that businessmen tend to get used to very small percentage increases in output each year while at the same time they come to expect ever-increasing profit margins since their profit margin targets adapt to past performance. With $\lambda = 0.9$ and with the rules of thumb for setting output/labour plans which have been ascribed to businessmen, firms in effect eventually behave like very satisfied monopolists. They are behaving this way, of course, not as optimizers, but rather because sluggish reactions on their parts happened to place them in a monopoly-like position. Once in such a position, the MOSES firms with adapting profit targets find the situation quite satisfactory.

The case of $\lambda = 0.1$ occupies the opposite end of the spectrum. When $\lambda = 0.1$, firms react very vigorously to short run changes. As a result they tend to operate at very high rates of capacity utilization but with relatively low profit margins. This produces a fairly strong economic performance for 8-10 years, but eventually a lack of profits and a concommitant lack of investment leads to a diminished capacity relative to that of the reference case. By the end of the 20 year simulation, "effective capacity" in the $\lambda = 0.1$ case is only 2/3 of what it is in the reference case.

What do these results tell us about the economy and what do they tell us about the model? If one believes that investments are generated primarily out of retained profits, then the suggestion is that in terms of aggregate economic growth there is a happy medium between firms having to compete vigorously for every dollar of profit on the one hand and having too easy a time of it on the other. If all firms live in a hyper-competitive environment (as generated by their quick adaptations), then too little profit will be generated to sustain investments; but, if profits come too easily, then firms will lack the incentive to make the most effective use of their capacities.

Of course, one could criticize the model for generating these results. The case of $\lambda = 0.9$ is bad for economic growth only because firms are able to settle into very lazy, albeit profitable, conditions. The classic economic remedy for this situation is simply to allow for the entry of new firms, and it is hard to believe that if profit margins were as large as they are in these simulations (and some are greater than 50%), new entrants would not be attracted. Conceptually, it is not difficult to modify MOSES to allow for the endogenous entry of new firms, and a simple experiment along these lines has in fact been undertaken. (See pp. 52-53 in Eliasson's paper on the total model in this conference volume). The results from the $\lambda = 0.1$ simulations might be criticized from another perspective. The reason that these simulations eventually show a slackening in growth is that firms are forced to finance all of their investments out of profits. If the model contained a functioning monetary sector (not yet ready), then this might not be such a serious problem; but it may be the case in reality (especially in Sweden) that financial markets are insufficiently developed to provide more than a partial remedy.

Finally, the cases of optimism and pessimism can be examined. The scenario that one might have envisioned in the optimism case is as follows. Firms start out with optimistic expectations and accordingly plan for a high level of output requiring substantial employment. They then bid aggressively for labour, thus fulfilling their wage expectations and creating a large total wage bill. This translates into a high level of disposable income, so firms' optimistic sales expectations are fulfilled. The pessimism case would be exactly the opposite -- pessimistic expectations feed upon themselves to produce unhappy results.

This is, of course, nothing but a simple multiplier story in which expectations provide the starting impulse. Although it is difficult to see in Figures 3-6, this story does have some merit during the first 5-8 years. Relative to the reference case, output, prices and wages all rise in the optimism case. The question is why the relative increase is so small. One answer is that the use of the LESH-type demand system makes it very difficult to get the multiplier going. Using a demand system with a heavy emphasis on habit formation makes consumption much less sensitive to aggregate income.

Instead, as income goes up, savings also go up; and in fact, savings are somewhat greater in the optimism case for the early years than in the reference case.

Another problem is that a significant fraction of the increase in disposable income gets spent on imports. Some of the multiplier effect leaks outside the country, something that is quite consistent with Sweden's experience.

The most serious jolt to the intuition is given by the performances of the optimism and pessimism cases after years 7 or 8. What explanation can be given for the collapse of the optimism economy? By the seventh year most of the effects of the initial changes in the "externally generated" expectations will have worked their way through the expectations mechanism; i.e., there is almost no "lingering" optimism or pessimism remaining through lagged expectations. There is, however, a counterbalancing effect in that the firms in the optimism case will have tended to err on the side of optimism for 7 years and the firms in the pessimism case will have tended to err on the opposite side. This creates some tendency at this point for the originally optimistic firms to begin to expect smaller percentage changes in output, and conversely for the originally pessimistic firms. Whatever the cause, firms in the optimistic case get trapped in a low output, low capacity and low profits syndrome. This is somewhat like the $\lambda = 0.9$ case except that firms are gloomy about price as well as output, so high profit margins do not develop. Not only is this state of affairs bad from the point of view of aggregate economic performance, but firms cannot be too happy either. It is the expression of the satisficing criterion in terms of profit margin targets that keeps firms from reacting to this situation.

Again, one can ask what changes in the model would produce more "realistic" results. One particular addition that has the potential to change the optimism/pessimism results is the long term investment financing block. In this block firms' "animal spirits" (or lack thereof) will be capable of being translated directly into a device for investment financing; i.e., firms will be allowed to indulge in a sort of optimism that is more likely to generate long term effects. This block has been designed but is not yet ready in the program. (See Eliasson-Heiman-Olavi (1976, chapter III).) Any of the other obvious devices for making the multiplier more potent, e.g., changing the demand system or lowering import flexibility, would seem to produce the "desired" results at the cost of sacrificing reality.

A final comment on the simulations is to note a recurrent pattern. In each simulation firms settle into an economic niche in the sense of falling into a pattern of behaviour that they lack sufficient incentive to change. In terms of Figure 2 firms tend to find themselves at approximately the same relative point in the lens area year after year. Thus, the model suggests that there are a number of potential output paths which are sustainable for a significant period of time, some of which are definitely superior to others. It should be understood that it is the behavioral rules ascribed to firms that allows the possibility of "multiple equilibria". Firms are satisficers in the sense that they lack the information to make "optimal" decisions and in the sense that their goals adapt to past experience. Were firms optimizers with perfect information, there could be only one possible sustainable path in this model. It is up to the reader to decide which picture of firm behaviour he finds most reasonable.

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THE MARKET ORIENTED INTER-INDUSTRY STOCK AND FLOW DATA AGGREGATION SCHEME USED IN THE SWEDISH MODEL

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The objectives of the Swedish Micro-to-Macro Model have been stated as

1. to formulate a micro explanation for inflation and

2. to study the relationships between inflation, profits, investment and growth.

The model thus places heavy emphasis on the market process and its importance for price and income determination and growth at the macro level. The chosen problems, however, also relate to typical dynamic processes and hence require that the time dimension and the cyclical features of simulations are quite well controlled empirically. For this reason an aggregation scheme that centers on markets and the use of industrial products rather than on the ordinary classification according to the production technique and raw material base has been necessary. We have chosen an aggregation level with four industrial production sectors:

Raw Material Processing Industries (RAW)
Intermediate Goods Industries (IMED)
Investment and Consumer Durable Goods Industries (DUR)
Non Durable Consumption Goods Industries (NDUR)

The reason for choosing such a small number of sectors is not only to keep the statistical work input within limits and to avoid getting bogged down in unnecessary detail. It can be shown that this particular aggregation principle emphasizes the variations in activity over the cycle as well as between industry sectors.[1] It can also be claimed that this aggregation has certain advantages over alternative ones, since the input-output matrix obtains an easily understood structure that has a tendency towards a one-way delivery pattern. This in turn facilitates a consistent projection of changes in the input-output coefficients.

Four industrial production sectors is a small number compared to what is normal in contemporary input-output models. However, in strong contrast to other model work - even of the microsimulation kind - each sector (market) in MOSES holds a large number of individual firms. The market processes in the model operate both between and within the above four sectors. The basic micro feature in MOSES in fact lies in the large number of firms within each sector and the aggregation scheme has been designed accordingly. This also means that the capacity utilization data from the Annual Planning Survey of the Federation of Swedish Industries can be used directly in the model.[2] On the other hand we run into difficulties when dealing with macro data. We have had to develop a market oriented classification scheme of our own in order to adapt the national accounts macro statistics to our micro based sector classification. Also lack of some firm data makes it necessary to use industrial macro data as substitutes.[3] The input-output matrix is one example where such simplifications have been necessary. Finally we have had to put in substantial effort to overcome inconsistencies in the data base that have crept in not only because of our new aggregation type but also because of inconsistencies between the various parts of the national accounts statistics themselves. We have found by experience that a consistent data base for the first period of a simulation is imperative for a proper tracking by the model of historic macro test data.

1) See Virin, O, "Industrins Utveckling 1974-76, enligt Industriförbundets planenkät 1975/76", Industrikonjunkturen, Våren 1976, Special Study D.

2) This planning survey covering all Swedish firms with more than 200 employees has in fact been designed on the format of MOSES.

3) For a description of how macro data are combined with real firm data see Eliasson, G, A Micro Simulation Model of a National Economy, chapter 3 on estimation methods, in this conference report.

In our efforts to obtain consistency in the data base it has been natural to use the input-output matrix as the reference base towards which adjustments are made. The input-output matrix for the total production system in MOSES consists of ten sectors:

1. Agriculture, Forestry and Fishing (A/F/F: 1.10 + 4.10)
2. Mining and Quarrying (ORE: 1.20 + 4.20)
3. Petroleum Products Imports (OIL: 5.11)
4. Raw Material Processing Industries (RAW: 2.10 + 5.10 excl 5.11)
5. Intermediate Goods Industries (IMED: 2.20 + 5.20)
6. Investment and Consumer Durable Goods Industries (DUR: 2.30 + 5.30, 2.51 + 5.51)
7. Construction (CONSTR: 2.40 + 5.40)
8. Non Durable Consumption Goods Industries (NDUR: 2.52 + 5.52, 2.53 + 5.53)
9. Electricity (EL: 3.10 + 6.10)
10. Other Services: (SERVICE: 3.20 + 6.20).

This aggregation corresponds to the general structure related to the input-output statistics (I/O) published by the Central Bureau of Statistics, that is described in Table 1. Of the four industrial production sectors that hold individual firms DUR and NDUR have a product content that differs somewhat from what is conventional as to the treatment of Capital Goods (2.51 + 5.51). In the input-output matrix we have included Consumer Capital Goods with Investment Goods, thus referring to this group as DURables and calling the remainder of Consumption Goods NonDURables. The six non-industry sectors (A/F/F, ORE, OIL, CONSTR, EL and SERVICE) are "external sectors" to the model appearing only as suppliers of certain goods in the conventional input-output fashion. Note here that the I-O sectors "Construction of Buildings" and "Letting of Dwellings and Use of Owner-Occupied Dwellings" - rents - both go into the CONSTRuction sector.

In order to obtain the general classification described in Table 1, we have constructed a weighting matrix, based on value added, by which the allocation is made. Since this allocation is based on macro data there is not necessarily a one-to-one correspondence between these data (allocated according to the market defined classification) and data based on industrial activities (SNI). Statistically the demand and output classification hence will be approximate when translated either way. When total value added for each market defined sector was compared to total value added, obtained by assigning specific companies to the market defined sectors, the correspondence was very good, however.

Table 1.1 Input

	ROW	I/O
I. Produced Commodities	1-11	1-34
1.00 Primary Production	1-2	1-4
1.10 Agriculture, Forestry and Fishing	1.	1-3
1.20 Mining and Quarrying	2.	4
2.00 Industrial Production	3-9	5-22 [a]
2.10 Raw Material Processing	3.	
2.20 Intermediate Goods	4.	
2.30 Investment Goods	5.	
2.40 Construction incl Rents	6.	
2.50 Consumption Goods	7-9	
2.51 Capital Goods	7.	
2.52 Food and Beverage	8.	
2.53 Other Consumer Goods	9.	
3.00 Services	10-11	23-34 [a]
3.10 Electricity	10.	24
3.20 Other Services excl Rents	11.	23-34 excl 24 [a]

a) The sectors 25, 31 and 32 are included in Industrial Production and excluded from Services.

II. Primary Commodities	12-30 excl 13, 16-18	36-42 45-48
4.00 Primary Production Imports	12+14	(1-4) [b]
4.10 Agricultural, Forestry and Fish Products	12	(1-3)
4.11 Agricultural Products	13	(1)
4.20 Mineral Products excl Crude Oil	14(excl Crude Oil)	(4)
5.00 Industrial Production Imports	15+(19-24)	(5-22)
5.10 Raw Material Processing Imports	15	
5.11 Petroleum Products Imports incl Crude Oil	16(incl Crude Oil)	
5.12 Ferrous Metal Imports	17	
5.13 Non Ferrous Metal Imports	18	
5.20 Intermediate Goods Imports	19	
5.30 Investment Goods Imports	20	
5.40 Construction Material Imports	21	
5.50 Consumption Goods Imports	22-24	
5.51 Capital Goods Imports	22	
5.52 Food and Beverage Imports	23	
5.53 Other Consumer Goods Imports	24	
6.00 Imports of Services	25-26	(23-34) [a]
6.10 Electricity Imports	25	(24)
6.20 Other Imports of Services	26	(23-34 excl 24) [a]
7.00 Duties, Taxes, Subsidies etc	27-28	37-42, 45-47
7.10 Commodity Taxes and Subsidies, Duties etc	27	37-42
7.20 Non Commodity Indirect Taxes and Subsidies	28	45-47
8.00 Value Added (SNR)	29-30	48
8.10 Wages	29	49
8.20 Profits and Depreciation	30	50
9.00 Total Input	1-30 excl 13, 16-18	51

a) The sectors 25, 31 and 32 are included in Industrial Production and excluded from Services.

b) Numbers within parenthesis refer to imports (table 5b in SCB Statistical Reports 1972:44).

Table 1.2 Output

		Column	I/O
I.	Use Within Prod. System	1-11	1-34
	1.00 Primary Production	1-2	1-4
	1.10 Agriculture, Forestry and Fishing	1.	1-3
	1.20 Mining and Quarrying	2.	4
	2.00 Industrial Production	3-9	5-22[a)]
	2.10 Raw Material Processing	3.	
	2.20 Intermediate Goods	4.	
	2.30 Investment Goods	5.	
	2.40 Construction Material	6.	
	2.50 Consumption Goods	7-9	
	2.51 Capital Goods	7.	
	2.52 Food and Beverage	8.	
	2.53 Other Consumer Goods	9.	
	3.00 Services	10-11	23-34[a)]
	3.10 Electricity	10.	24
	3.20 Other Services	11.	23-34 excl 24[a)]
II.	Final Consumption	12-16	37-41
	4.00 Public Consumption	12	37
	5.00 Private Consumption	13	38
	6.00 Gross Investments	14	39
	7.00 Change in Stocks	15	40
	8.00 Exports	16	41
	9.00 Total Output	1-16	43

a) The sectors 25, 31 and 32 are included in Industrial Production and excluded from Services.

Since the MOSES aggregation scheme centers on markets and the use of industrial products the input-output structure does not differentiate between imports and produced commodities. Instead import shares obtained from macro National Accounts time series data are varied over time for the four industrial production sectors. The same proportion of imports regardless of sector origin is assumed. The input-output structure is specified in basic values ("ungefärlig produktionskostnad") and thus makes use of available information on trade margins. Since our input-output matrix is specified in basic values it has been necessary to adjust all macro time series brought into the data base to this value level in order to obtain consistency in the "initialization" - the start-up of a simulation. A not insignificant amount of data are compiled from industrial statistics or other macro statistics which are not readily obtainable in basic values. This has created problems which have forced us to make a number of simplifying assumptions. On a number of occasions we have for instance assumed the same growth pattern for our variables specified in basic values as for time series valued at purchaser's prices. This implies that trade margins and commodity indirect taxes are growing proportionately. It is likewise assumed that margins and indirect taxes are identical for all inputs into each production system sector or final demand category regardless of sector origin. On the other hand we have managed to avoid problems with secondary production by using a commodity by commodity specification.[1)]

The input-output coefficients of one cell in the input-output matrix are allocated to each firm in that particular market. The coefficients of each firm are kept constant over time in the model (for the time being we use 1968 figures - see Table 2.1). Since individual firms within and between markets meet with success and failure very differently in the model they also grow at very different rates. Thus the macro input-output coefficients vary endogenously over time. Here we have had to assume, however, that price increases are the same for products from the four industrial production sectors regardless of which sector they are sold to as inputs or as final demand. The average spending shares for the five final demand categories - GOVernmenT, Household CONSumption, INVestments, Change in Stocks (ΔSTO) and EXports - are shown in Table 2.2.

The use of 1968 I/O coefficients each year clearly means introducing an inconsistency in the macro data basic system even though the macro coefficients will vary because of the way they are used in individual firms. This assumption will have to be relaxed in the future. Until we have got the necessary statistical information to allow time dependent I/O coefficients, however, we will have to be satisfied with the fixed coefficient assumption.

---

1) For a detailed discussion of alternative methods in input-output analysis, see Höglund, B and Werin, L, The Production System of the Swedish Economy, An Input-Output Study, IUI, 1964.

Finally, it should be pointed out how the input-output structure is used in MOSES. The model is not solved by inverting the input-output matrix in the traditional way. For the four industrial production sectors the production volume is determined in the business system block while the corresponding input-output coefficients determine the amount of inputs needed to make this level of production possible. At both ends of these sectors, that is at both ends of each individual firm, there are buffer stocks to even out production flows. For the remaining six "external sectors" on the other hand the input-output matrix is operating as in a conventional macro input-output model complemented with a Keynesian demand system.

TABLE 2.1
INPUT OUTPUT COEFFICIENT MATRIX, 1968

	A/F/F	ORE	OIL	RAW	IMED	DUR	CONSTR	NDUR	EL	SERVICE	TOTAL
A/F/F	.02	.00	.00	.07	.06	.01	.01	.22	.00	.00	.04
ORE	.00	.07	.00	.06	.01	.00	.01	.00	.00	.00	.01
OIL	.01	.01	.00	.07	.01	.00	.00	.00	.03	.01	.01
RAW	.01	.02	.00	.18	.07	.10	.05	.02	.01	.01	.05
IMED	.03	.02	.00	.07	.14	.08	.03	.06	.00	.02	.05
DUR	.02	.04	.00	.04	.07	.18	.06	.02	.00	.02	.05
CONSTR	.07	.02	.00	.03	.03	.04	.11	.02	.09	.07	.06
NDUR	.09	.01	.00	.03	.08	.03	.02	.22	.01	.05	.07
EL	.01	.03	.00	.02	.02	.01	.01	.01	.03	.01	.01
SERVICE	.08	.05	.00	.09	.06	.06	.09	.06	.03	.16	.10
TAXES	.06	.09	.00	.03	.02	.03	.04	.00	.03	.01	.02
VA	.60	.64	.00	.32	.42	.46	.56	.37	.82	.66	.53
TOTAL	1.00	1.00	.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TABLE 2.2
AVERAGE SPENDING SHARES, 1968

	GOVT	CONS	INV	STO	EXP	TOTAL
A/F/F	.01	.03	.00	.19	.03	.06
ORE	.00	.00	.00	.01	.03	.01
OIL	.02	.01	.00	.00	.01	.01
RAW	.01	.01	.00	.21	.15	.07
IMED	.11	.03	.04	.03	.18	.09
DUR	.23	.04	.20	.24	.28	.14
CONSTR	.21	.19	.69	.08	.07	.25
NDUR	.17	.20	.01	.29	.09	.15
EL	.03	.01	.00	.00	.00	.02
SERVICE	.29	.33	.02	.02	.16	.25
TAXES	.08	.15	.03	.04	.01	.08
TOTAL	1.00	1.00	1.00	1.00	1.00	1.00

TECHNICAL SPECIFICATIONS
for Swedish Micro Based Macro Model

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These specifications cover the so called 96 model version in full. They are almost identical to the technical specifications chapter (pages 195–267) in Eliasson – Heiman – Olavi: "A Micro-Macro Interactive Simulation Model of the Swedish Economy", December 1976, Federation of Swedish Industries, Economic Research Report B 15. – The 96 version can be run on the IBM 5100 Desk Computer (64K).

MODEL SPECIFICATIONS

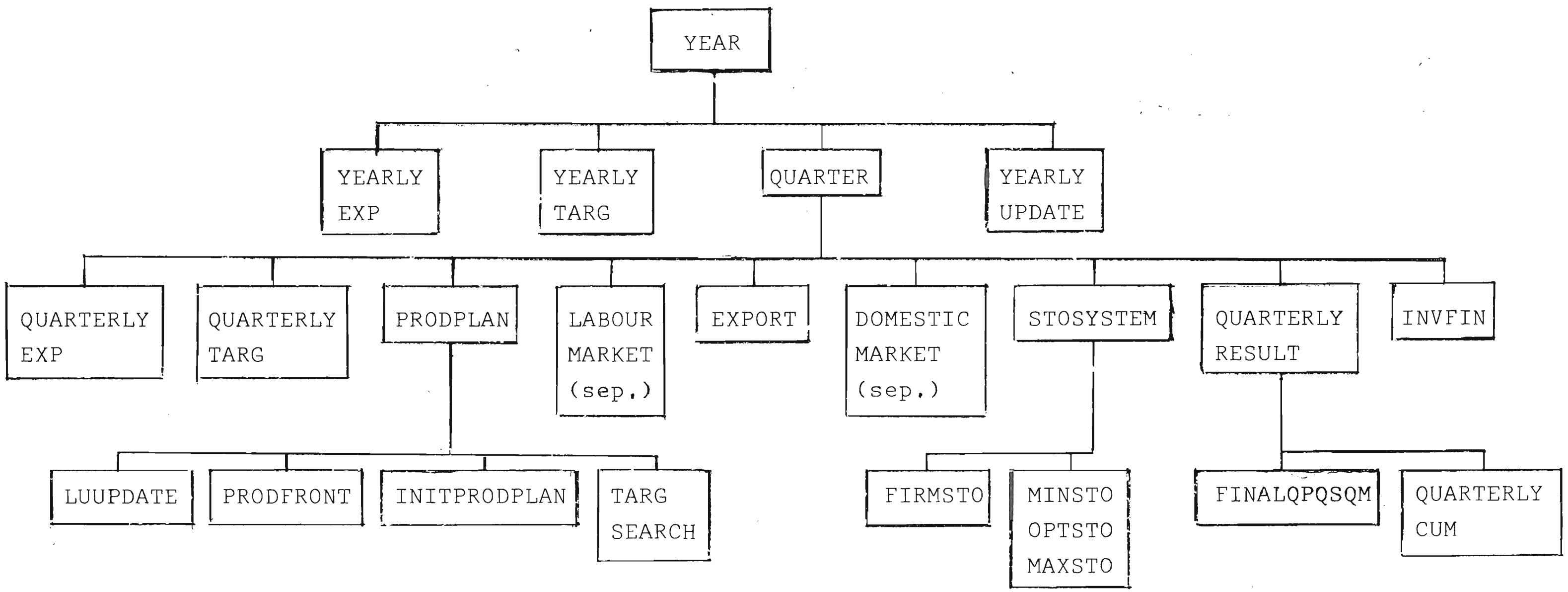
The computer simulation program of this model is written in the APL language. In this publication we do not include a listing of the program: instead we give the following specifications, which in a more English-like syntax depict the APL program.

The computer simulation is forwarded through time in a very straightforward way. Unless otherwise indicated by branching instructions, etc, the equations are executed one by one. (For one year, the quarterly blocks 3–9 are repeated 4 times.)

Note that we have a micro-based model. The execution of one equation thus often means several assignments, for firms, markets, household groups, etc. We do not use an indexing system in the pseudo-code; in general it will be clear from the context if equations (and variables and parameters) refer to global entities or to firms, markets, etc. This information can also be found in the variable listing which concludes this section.

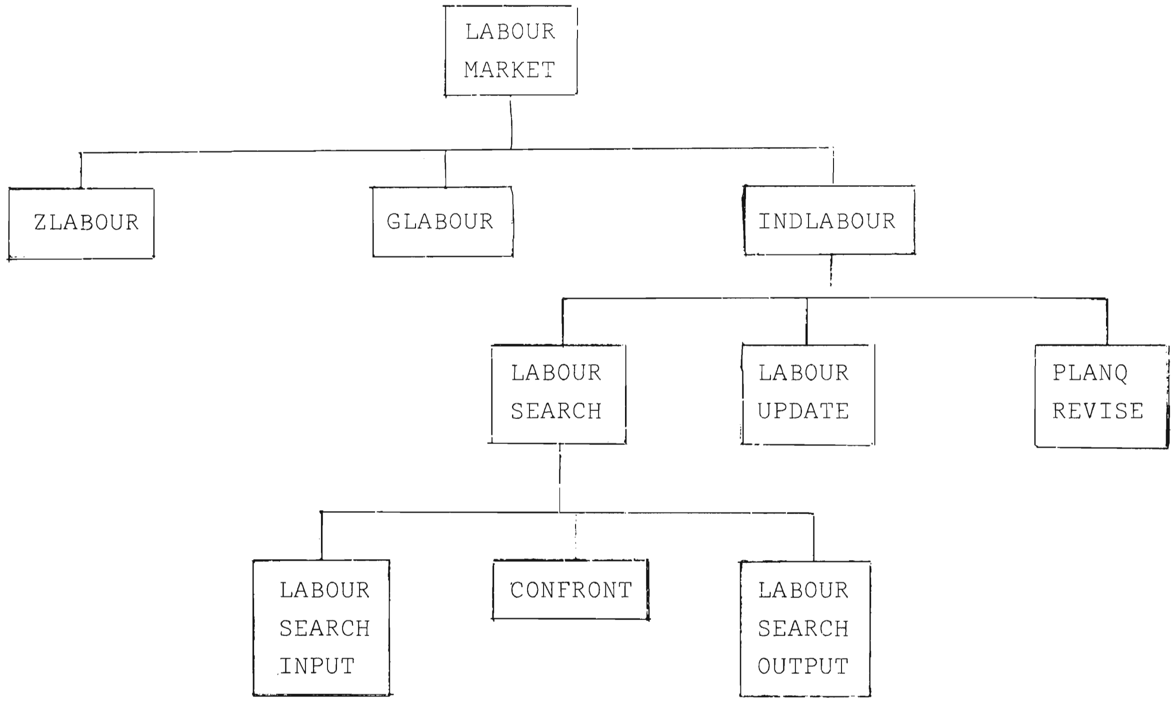
We use the acronym MOSES to denote the model program. This stands for "Model for Simulation of the Economy in Sweden".

Part 1 of 3

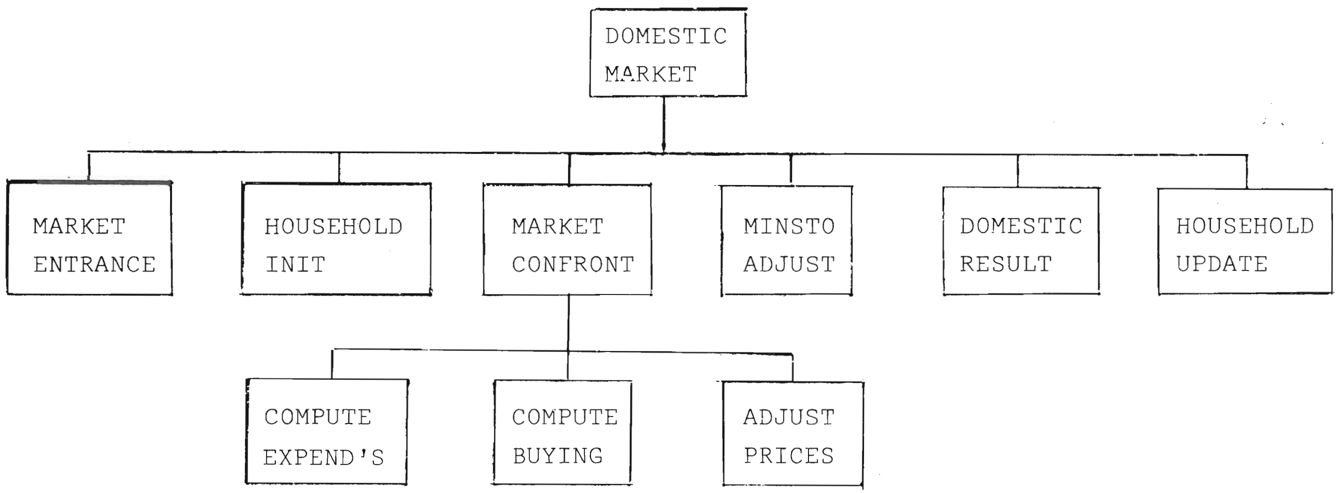


MOSES Block Diagram

Part 2 of 3



MOSES Block Diagram:
Detail of Labour Market block



MOSES Block Diagram:
Detail of Domestic Market block

0. Yearly initialization
(YEARLY INIT)

At the beginning of each year, the following variables are set to zero:

CUMQ, CUMM, CUMSU, CUMS, CUMWS, CUML

They are all updated each quarter in the block "Quarterly Cumulation".

1. Yearly Expectations
(YEARLY EXP)

Exponential smoothing is used as a special case of weighted time averages in chapter II. The smoothing factors SMP, SMW, SMS and the exogenous constants E1, E2 and the "extroversion" coefficient R do not vary between firms. DP, DW, DS were computed last year in block "Yearly update".

1.1 Prices

1.1.1 $EXPIDP := SMP \times EXPIDP + \{1-SMP\} \times \{DP + E1 \times (DP-EXPDP) - E2 \times (DP-EXPDP)^2\}$

1.1.2 EXPXDP:= EXOGENOUS

1.1.3 $EXPDP := (1-R) \times EXPIDP + R \times EXPXDP$

1.2 Wages

1.2.1 $EXPIDW := SMW \times EXPIDW + \{1-SMW\} \times \{DW+E1 \times (DW-EXPDW) - E2 \times (DW-EXPDW)^2\}$

1.2.2 EXPXDW:= EXOGENOUS

1.2.3 EXPDW:= (1-R) x EXPIDW + R x EXPXDW

1.3 Sales.

1.3.1 EXPIDS:= SMS x EXPIDS
+ {1-SMS} x {DS + E1 x (DS-EXPDS) - E2 x $(DS-EXPDS)^2$}

1.3.2 EXPXDS:= EXOGENOUS

1.3.3 EXPDS:= (1-R) x EXPIDS + R x EXPXDS

2. <u>Yearly Targeting</u>
(YEARLY TARG)

The targeting function is a special case of the smoothing device in block 1, with R = E1 = E2 = 0. The fed-back value of margin M is computed in the block "Yearly update". The fraction EPS increases target pressure (if it is not = zero).

2.1 MHIST:= SMT x MHIST + (1-SMT) x M

2.2 TARGM:= MHIST x (1 + EPS)

3.1 <u>Quarterly Expectations</u>
(QUARTERLY EXP)

Long-term expectations are transformed to a quarterly basis. In all quarters except the first one, a trade-off takes place with respect to immediate experience.

3.1.1 $QEXPDP := \frac{EXPDP}{4}$

$QEXPDW := \frac{EXPDW}{4}$

$QEXPDS := \frac{EXPDS}{4}$

3.1.2 (Not in the first quarter each year)

QEXPDP:= QEXPDP + FIP x (QDP - QEXPDP)
QEXPDW:= QEXPDW + FIW x (QDW - QEXPDW)
QEXPDS:= QEXPDS + FIS x (QDS - QEXPDS)

3.1.3 QEXPP:= QP x (1 + QEXPDP)
QEXPW:= QW x (1 + QEXPDW)
QEXPS:= QS x (1 + QEXPDS)

3.2 <u>Quarterly Targeting</u>
(QUARTERLY TARG)

CUMM from block "Quarterly cumulation"

3.2.1 $QTARGM := TARGM + \frac{NRS-1}{5-NRS} \times (TARGM-CUMM)$

(This formula may generate too high "target pressure" on firms. As a consequence, an unrealistically large number of firms contract production to zero and go out of production. A device called NOPRESSURE can be used in simulation experiments to assure that always QTARGM = TARGM)

4.LU Updating of unemployment
(LUUPDATE)

Retirements are computed, and new entries to the labour force are added to the pool of unemployed.

4.LU.1 LF:= LU + LZ + LG + SUM(L)

4.LU.2 L:= L x (1-RET)

4.LU.3 AMAN1,2,3:= AMAN1,2,3 x (1-RET)

4.LU.4 LU:= LU x (1-RET)

4.LU.5 LU:= LU + ENTRY x LF

4.0 Production Possibility Frontier

In block 4, the following function describes the relationship between labour input and maximum production for a firm under normal profitability conditions:

4.0.1 $$QFR(L) = (1\text{-}RES) \times QTOP \times (1 - e^{-\frac{TEC}{QTOP} \times L})$$

The inverse of this function will also be used:

4.0.2 $$RFQ(Q) = \frac{QTOP}{TEC} \times \ln \frac{(1\text{-}RES) \times QTOP}{(1\text{-}RES) \times QTOP - Q}$$

4.1 Determining Change in Production Frontier (PRODFRONT)

Productivity of modern equipment is updated. Depreciation is accounted for. A fraction of total investment (LOSS) does not influence production capacity directly but is directed to the "residual slack", and can be used in future expansions only if current slack is low. Productivity has to be updated since old and new equipment differ in quality.

4.1.1 $MTEC := MTEC \times (1 + QDMTEC)$

(QDMTEC is entered exogenously)

4.1.2 $QTOP := QTOP \times (1-RHO)$

4.1.3 $QCHQTOP1 := (1-LOSS) \times \frac{QINV \times INVEFF}{QP}$

(QINV and INVEFF from investment-financing block)

4.1.4 $QCHQTOP2 := MIN\left(LOSS \times \frac{QINV \times INVEFF}{QP} \times \frac{RESMAX-RES}{RESMAX},\ \frac{RESMAX-RES}{1-RESMAX} \times (QTOP+QCHQTOP1)\right)$

(The slack RES cannot exceed RESMAX)

4.1.5 $QCHQTOP := QCHQTOP1+QCHQTOP2$

4.1.6 $RES := \frac{RES \times (QTOP+QCHQTOP1) + QCHQTOP2}{QTOP+QCHQTOP}$

4.1.7 $TEC := \frac{QTOP+QCHQTOP}{\frac{QTOP}{TEC} + \frac{QCHQTOP}{MTEC}}$

4.1.8 $QTOP := QTOP + QCHQTOP$

4.2 Initial Quarterly Production Plan
(INITPRODPLAN)

This initial plan is based on the sales forecast, plus the desire to keep the stock at its "optimal" level.

4.2.1 $$QEXPSU := \frac{QEXPS}{QEXPP}$$

4.2.2 $$QPLANQ := MAX \left\{ 0, QEXPSU + \frac{OPTSTO - STO}{4 \times TMSTO} \right\}$$

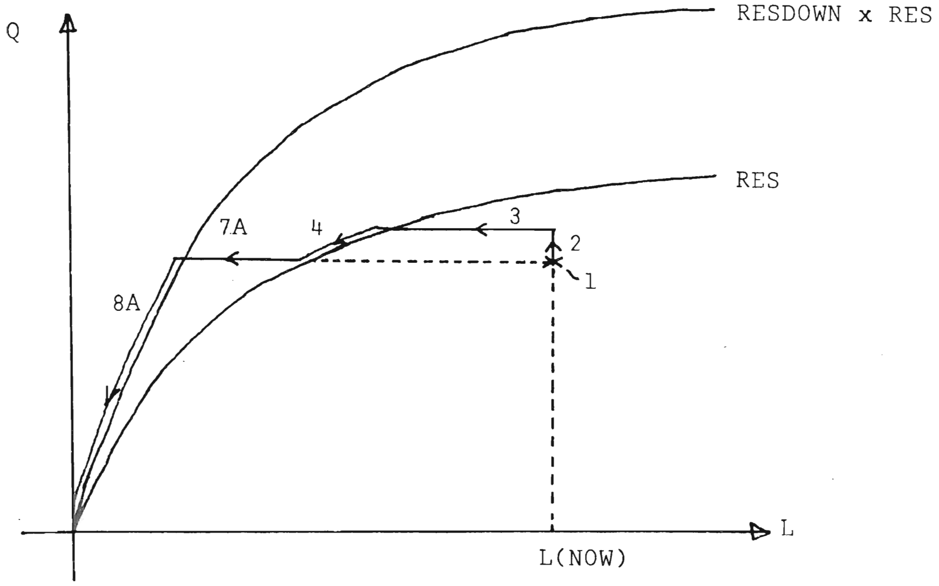
4.3 Search for Target Satisfaction
(TARGSEARCH)

This block describes how a firm varies its combination of labour input and production level to satisfy its profit margin requirement (QTARGM). When the target is reached, search is terminated; this means that each section within 4.3 is entered only if the firm has not yet found a satisfactory plan.

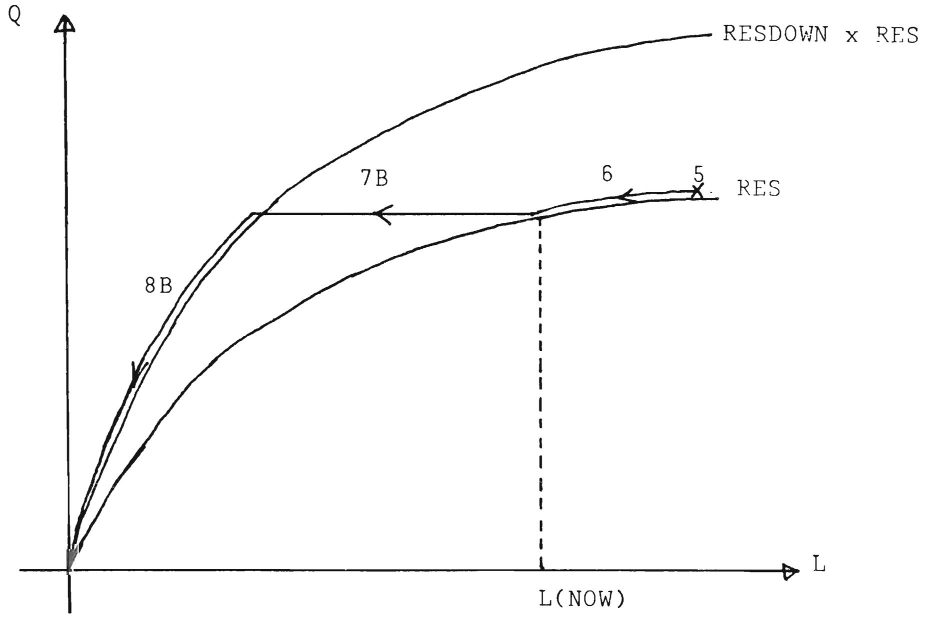
The diagrams and search paths on the next page explain how this search process has been modelled. Note that search will probably terminate within one of the paths, and not at a corner. Two cases can be distinguished, depending on whether the initial plan implies recruitment or not.

Two devices called "SAT" and "SOLVE" are referred to throughout the block; they are described in 4.3.11 and 4.3.12.

The specification in 4.3 holds for each firm, one at a time.



Search path, case A: QPLANQ < QFR(L)



Search path, case B: QPLANQ > QFR(L)

4.3.0 Is the initial plan feasible, and does it imply recruitment?

```
IF QPLANQ ≥ QTOP x (1-RES)
   THEN GOTO 4.3.6
   ELSE IF QPLANQ > QFR(L)
           THEN GOTO 4.3.5
           ELSE CONTINUE
```

4.3.1 Does the initial plan give satisfaction at "1" in the diagram?:

```
IF SAT(QPLANQ,L)
   THEN QPLANL:=L
        GOTO 4.3.10
```

4.3.2 Increase production with same labour force. Raise until production frontier or stock limit is reached (path 2).

```
Q2:=MIN(QFR(L),QEXPSU + MAXSTO - STO)
IF SAT(Q2,L)
```

$$\text{THEN QPLANQ} := \frac{L \times (QEXPW/4)}{(1-QTARGM) \times QEXPP}$$

```
        QPLANL:=L
        GOTO 4.3.10
   ELSE IF Q2=QFR(L)
           THEN GOTO 4.3.4
           ELSE CONTINUE
```

4.3.3 Cut down labour force, still producing up to the stock limit (path 3).

```
IF SAT(Q2,RFQ(Q2))
   THEN QPLANQ:=Q2
```

$$\text{QPLANL} := \frac{(1-QTARGM) x Q2 x QEXPP}{QEXPW/4}$$

```
        GOTO 4.3.10
```

4.3.4 Reduce production down to QPLANQ, with corresponding decrease in labour force (path 4).

```
IF SAT (QPLANQ,RFQ(QPLANQ))
   THEN QPLANQ,QPLANL:=SOLVE
        GOTO 4.3.10
   ELSE Q7:=QPLANQ
        GOTO 4.3.7
```

4.3.5 With an initial plan implying recruitment, will the profit target be reached?

```
IF SAT(QPLANQ, RFQ(QPLANQ))
   THEN QPLANL:= RFQ(QPLANQ)
        GOTO 4.3.10
```

4.3.6 First step in search when initial plan implies recruitment (path 6).

```
IF SAT(QFR(L),L)
   THEN QPLANQ,QPLANL:=SOLVE
        GOTO 4.3.10
   ELSE Q7:=QFR(L)
```

4.3.7 Keep production at the level Q7 (as it resulted from 4.3.4 or 4.3.6), but reduce the slack RES and thereby the labour force. RESDOWN is an exogenous constant (path 7), telling how much slack can be reduced during a single quarter.

<u>IF</u> SAT(Q7,RFQ($\frac{\text{1-RES}}{\text{1-RESDOWNxRES}}$ x Q7))

<u>THEN</u> QPLANQ:=Q7

QPLANL:= $\frac{\text{(1-QTARGM)xQ7xQEXPP}}{\text{QEXPW/4}}$

RES:=1- $\frac{\text{Q7x(1-RES)}}{\text{QFR(QPLANL)}}$

GOTO 4.3.10

<u>ELSE</u> RES:=RESDOWNxRES

4.3.8 With the new, lower, slack from 4.3.7, try to reach target by reducing production and labour force (path 8).

<u>IF</u> SAT(0,0)

<u>THEN</u> QPLANQ,QPLANL:=SOLVE

GOTO 4.3.10

4.3.9 No plan could be found that satisfies profit target. The firm is eliminated from the model, and the labour force is added to the pool of unemployed.

LU:=LU+L

NULLIFY this firm

4.3.10 QPLANQ and QPLANL have now been decided. The AMAN vector, describing the 2-quarter lag of firings, is updated. (AMAN1 can be fired this quarter).

LAYOFF:=MAX(L-QPLANL,0)

AMAN1:=MIN(LAYOFF,AMAN2)

AMAN2:=MIN(LAYOFF-AMAN1,AMAN3)

AMAN3:=LAYOFF-AMAN1-AMAN2

4.3.11 "SAT": This device is used to find out if a certain combination Q/L of planned production and labour force will satisfy profit targets.

IF L > 0
THEN MARGIN:= $1- \frac{Lx(QEXPW/4)}{QxQEXPP}$

ELSE (L=0) MARGIN:= $1- \frac{QEXPW/4}{(1-RES)xTECxQEXPP}$

(The case L=0 is used in 4.3.8)

IF MARGIN ≥ QTARGM
THEN SAT:= TRUE
ELSE SAT:= FALSE

4.3.12 "SOLVE": This device solves the equation:

$$1 - \frac{QPLANL\ x\ (QEXPW/4)}{QFR(QPLANL)xQEXPP} = QTARGM$$

for QPLANL, with an error less than 0.1 %. Once QPLANL is found, QPLANQ is also calculated as

QPLANQ:= QFR(QPLANL)

(See the program for details on how the equation is solved, using the Newton-Raphson iteration method).

4.3.12 SOLVE in detail

The equation is

$$1 - \frac{QPLANL \times (QEXPW/4)}{(1\text{-}RES) \times QTOP \times \left\{1 - e^{-\frac{TEC}{QTOP} \times QPLANL}\right\} \times QEXPP} = QTA$$

Substitute $y = \frac{TEC}{QTOP} \times QPLANL$

$$1 - \frac{\frac{QTOP}{TEC} \times y \times (QEXPW/4)}{(1\text{-}RES) \times QTOP \times (1-e^{-y}) \times QEXPP} = QTARGM$$

$$1-e^{-y} = \frac{QEXPW}{(1\text{-}QTARGM) \times (1\text{-}RES) \times TEC \times QEXPP \times 4} \times y$$

With a substitution this gives

$$1-e^{-y}=b.y$$

or $f(y) = b.y + e^{-y} - 1 = 0$

with $f'(y) = b - e^{-y}$

($b>0$ must hold when we enter SOLVE, else no solution can be found).

We want to use Newton-Raphson's formula

$$y := y - \frac{f(y)}{f'(y)}$$

with the starting value $y_o := 1/b$, which is surely greater than the exact root, and gives convergence with all f/f' positive.

Example of one-firm SOLVE:

```
    ∇ SOLVE
[1]   Y←÷B←QEXPW÷(1-QTARGM)×(1-RES)×TEC×QEXPP×4
[2]  LOOP:→LOOP+D<0.001×Y←Y-D←((B×Y)+(*-Y)-1)÷(B-(*-Y))
[3]   QPLANQ←QFR QPLANL←Y×QTOP÷TEC
    ∇
```

For b $\geqslant$ 1, this algorithm gives the correct result y = 0. The possibility of b $\leqslant$ 0 must be checked, however.

The algorithm is easily modified to the case where it should be applied to several equations simultaneously.

5. LABOUR MARKET
(LABOUR MARKET)

5.1 Updating of unemployment
(LUUPDATE)

(This block has been moved to block 4).

5.2 Service sector labour market
(ZLABOUR)

Service sector takes the labour it wants from the pool of unemployed. Wage increase in service sector is equal to average wage increase in industry last quarter. Offering price is calculated.

5.2.1 TECZ:= TECZ x (1 + ODTECZ)
(QDTECZ is entered exogenously)

5.2.2 QCHLZ is calculated to use last quarter's surplus (or deficit) profit (compared with targets) to increase (or diminish) labour force. Notice that QCHLZ also includes substitutes for the retired.

$$QCHLZ := \frac{(QMZ-QTARGMZ) x QPZ x TECZ x LZ}{QWZ/4} + RET x LZ$$

(QTARGMZ is entered exogenously)
(If QCHLZ $>$ LU we put QCHLZ=LU)

5.2.3 LZ:=LZ+QCHLZ-RETxLZ

5.2.4 LU:=LU-QCHLZ
Notice that if QCHLZ $<$ 0, this means that people are fired from service sector.

5.2.5 QWZ:=QWZx(1+QDWIND)

5.2.6 QQZ:= TECZ x LZ

5.2.7 Offering price is calculated to make QMZ=QTARGMZ
QPRELPZ:=QPZx(1+QDWIND-QDTECZ)

5.3 Government sector labour market (GLABOUR)

Government sector takes the labour it wants from the pool of unemployed. Wage increase is equal to average wage increase in industry last quarter. As government services are provided free, there are no prices or profit margins.

5.3.1 QCHLG:=LGxRET+REALCHLG
(REALCHLG is entered exogenously)
(If QCHLG > LU we put QCHLG=LU)

5.3.2 LG:=LG+QCHLG-RETxLG

5.3.3 LU:=LU-QCHLG
Notice that if QCHLG < 0, this means that people are fired from government sector.

5.3.4 QWG:=QWGx(1+QDWIND)

5.4 <u>Industry sector labour market</u>
(INDLABOUR)

This block consists of three parts:
- Labour search
- Labour update
- Revision of production plans

They are all further specified below.

5.4.1 <u>Labour search</u>
(LABOUR SEARCH INPUT; CONFRONT; LABOUR SEARCH OUTPUT)

Describes the sequence of actions that determine the labour force in every firm for the next quarter.

In LABOUR SEARCH INPUT, (5.4.1.0) some help variables are introduced.

In CONFRONT (5.4.1.1 - 5.4.1.11) the actual interaction for new labour takes place.

Firms are ranked in order of the planned relative change in recruitment. Each firm is allowed to "attack" another firm, chosen at random (the probability for a given firm to be chosen is proportional to its size). The desired change in new employment (CHL) is continuously changed. Firms strive to make CHL equal to zero. Firms that achieve this objective refrain from further raiding of other firms. This procedure is repeated NITER times (NITER is an exogenouosly given number).

In LABOUR SEARCH OUTPUT (5.4.1.12 - 5.4.1.13), results are summarized and layoff lags accommodated.

5.4.1.0 Help variables and initial wage offering:

CHL:= QPLANL - L
WW:= QW + IOTA x (QEXPW - QW)
LL:= L concatenated to LU (The pool of unemployed will take part in the interactions)

5.4.1.1 Rank firms in decreasing order after CHL/L.

5.4.1.2 Repeat 5.4.1.3 - 5.4.1.10 NITER times (one time representing one attack from each firm).

5.4.1.3 Repeat 5.4.1.4 - 5.4.1.11 NTOT times (one time representing an attack from one firm).

5.4.1.4 Select the firm that is to perform the next attack (from the ordering in 5.4.1.1). Denote it by I.

5.4.1.5 IF CHL(I) ≤ 0 THEN go to 5.4.1.10 (in this case the firm does not want any more labour).

5.4.1.6 Choose a firm to attack. Denote the firm being attacked by II. (The selection is done at random by a function called CHOOSE. The probability for a certain firm to be choosen is the size of its labour force, divided by the sum of the labour forces in all firms plus the number of unemployed).

5.4.1.7 We now check whether the attacked object really was a firm (II ≤ NTOT), or whether it was the unemployed (II=NTOT+1) (cf comment to 5.4.1.0).

```
IF II ≤ NTOT
   THEN go to 5.4.1.8
   ELSE go to 5.4.1.9
```

5.4.1.8 We now check whether the attack was a success (i.e. whether the wage of the attacking firm was high enough) or not.

```
IF WW(I) ≥ WW(II)*(1+GAMMA)
   THEN WW(II):=WW(II)+KSISUCCx(WW(I)-WW(II))
        go to 5.4.1.9
   ELSE WW(I):=WW(I)+KSIFAILx(WW(II)*(1+GAMMA)-WW(I))
        go to 5.4.1.10
```

5.4.1.9 If we come to this statement, the attack was a success, and labour is moved from firm II to firm I. If the "attacked firm" was the unemployed, (i.e. II>NTOT) the attack is always a success. (In the program 5.4.1.9 is a function called TAKE L FROM)

```
CHLNOW:=MIN(THETA*LL(II),CHL(I))
LL(I):=CHL(I)+CHLNOW
CHL(I):=CHL(I)-CHLNOW
LL(II):=LL(II)-CHLNOW
IF II ≤ NTOT
   THEN CHL(II):=CHL(II)+CHLNOW
```

5.4.1.10 One attack is completed, go to 5.4.1.3.

5.4.1.11 All firms have had the opportunity to attack once, go to 5.4.1.2.

(Labour market interactions are now completed).

5.4.1.12 Summarize results; abandon help variables:

```
LU:= Last component in LL
QCHL:= LL - L
QCHW:= WW - QW
```

5.4.1.13 People who leave one firm for another are subtracted from the layoff-lagging vector AMAN in their first firm.

```
EXIT:= MAX(0,-QCHL)
IF EXIT > AMAN1 + AMAN2
   THEN AMAN3:= AMAN3 - (EXIT-AMAN1-AMAN2)
   (but AMAN3 ≥ 0 must hold)
IF EXIT > AMAN1
   THEN AMAN2:= AMAN2 - (EXIT - AMAN1)
   (but AMAN2 ≥ 0 must hold)
IF EXIT > 0
   THEN AMAN1:= AMAN1 - EXIT
   (but AMAN1 ≥ 0 must hold)
```

5.4.2 Labour update (LABOUR UPDATE)

Layoff is accomodated. Wage increase in the industry is computed. Labour force and wage is updated for each firm, as described in the previous block.

5.4.2.1 Layoffs; AMAN1 is a limit on how many people a firm can fire this quarter.

```
SACK:= MIN(AMAN1, MAX(0,L + QCHL - QPLANL))
QCHL:= QCHL - SACK
AMAN1:= AMAN1 - SACK
LU:= LU + SUM(SACK)
```

5.4.2.2 Wage average and trend:

$$OLDQW := \frac{SUM(L \times QW)}{SUM(L)}$$

$$NEWQW := \frac{SUM\{(L+QCHL) \times (QW+QCHW)\}}{SUM\{L+QCHL\}}$$

$$QDWIND := \frac{NEWQW}{OLDQW} - 1$$

5.4.2.3 Update labour force and wage:

$$L := L + QCHL$$

$$QDW := \frac{QCHW}{QW}$$

$$QW := QW + QCHW$$

5.4.2.4 Unemployment:

$$CHRU := \frac{LU}{LU + LZ + LG + SUM(L)} - RU$$

$$RU := RU + CHRU$$

5.4.3 Revision of Production Plans (PLANQREVISE)

If a firm has lost too much of its labour force, or could not meet recruitment plans, its production plan must be reduced. The new level of production assigned to the variable QQ is determined in this block. Optimum sales volume is computed.

5.4.3.1 QPLANQ:= MIN(QPLANQ, QFR(L))
(QFR is the production frontier as described in block 4.0)

5.4.3.2 $QDQ := \frac{QPLANQ}{QQ} - 1$

5.4.3.3 $QQ := QQ \times (1 + QDQ)$

5.4.3.4 $QOPTSU := MAX\left\{0, QEXPSU \times \frac{QQ}{QEXPSU + \frac{OPTSTO-STO}{4 \times TMSTO}}\right\}$

6. EXPORT MARKETS
(EXPORT)

Export share and supply, price and sales in foreign markets are determined.

6.1.1 IF $QPDOM \geqslant QPFOR$

$$\text{THEN } X := X - X \times \frac{1}{4 \times TMX} \times \frac{QPDOM - QPFOR}{QPFOR}$$

$$\text{ELSE } X := X + (1-X) \times \frac{1}{4 \times TMX} \times \frac{QPFOR - QPDOM}{QPDOM}$$

This formula can make $X > 1$ or $X < 0$. If this happens, X is put equal to one (or to zero).

6.1.2 $QSUFOR := X \times QOPTSU$

6.1.3 $QPFOR := (1 + QDPFOR) * QPFOR$
(QDPFOR is entered exogenously).

6.1.4 $QSFOR := QSUFOR * QPFOR$

7 Domestic Product Market

(DOMESTIC MARKET)

This block describes the interaction between firms and households, resulting in domestic prices and sales volumes for a quarter (service sector is also treated). It consists of the following parts:

1. Market Entrance
2. Household Initialisation
3. Market Confrontation
4. Computation of Household Expenditures
5. Computation of Total Buyings
6. Price Adjustments
7. Adjustment to Minimum Stock
8. Domestic Result
9. Updating of Households´ Data

Computationally, blocks 4, 5, 6 are sub-blocks to "Market Confrontation".

Functionally, blocks 1, 6, 7, 8 describe the behaviour of firms. Blocks 2, 4, 9 form an integrated model of household behaviour and can be studied separately.

Block 3 is the link between firms and households. Block 5 is included to adjust demand to import competition and to handle the firms´ investments.

The following abbreviations denote household expenditure categories:

NDUR - Services and non-durable goods.

Z - Service (subset of NDUR).

DUR - Durable goods.

MKT - All NDUR and DUR, with the exception of the service sector.

SAV - Household saving.

7.1 Market Entrance
(MARKET ENTRANCE)

Each firm computes its optimum sales volume. When determining an initial offering price, firms plan as if prices in domestic and foreign markets will develop similarly.

7.1.1 $QOPTSUDOM := (1-X) \times QOPTSU$

7.1.2 $$QPRELPDOM := QPDOM \times \frac{SUM\left\{QOPTSUDOM \times \frac{QEXPP}{QP}\right\}}{SUM(QOPTSUDOM)}$$

(The average is from firms to markets, giving one preliminary price for each market)

7.2 Household Initialisation
(HOUSEHOLD INIT)

7.2.1 Disposable income per household

$$QDI := \left\{QMZ \times QSZ + LZ \times \frac{QWZ}{4} + LG \times \frac{QWG}{4} + SUM(L \times \frac{QW}{4})\right\}/NH$$

$$+ WH \times \frac{RI}{4}$$

7.2.2 "Essential" consumption volume (NDUR,DUR)

CVE(I):= ALFA1(I) + ALFA2(I) x CVA(I)
(CVA, "addicted" volume, is updated each quarter in 7.9.4).

7.3 Market Confrontation
(MARKET CONFRONT)

(This market specification subroutine is provisional. We should 1) Have a more sophisticated termination criterion than simply a fixed number of iterations or 2) Let each iteration correspond to a period of time within the quarter, having the cumulated lapse of time terminate iterations at the end of a quarter).

Adjust import shares IMP. Form the vector PT of trial prices. Let firms and households interact a pre-specified number of times.

7.3.1 IF QPDOM $\geq$ QPFOR

$$\text{THEN IMP} := \text{IMP} + \frac{1 - \text{IMP}}{4 \times \text{TMIMP}} \times \frac{\text{QPDOM} - \text{QPFOR}}{\text{QPFOR}}$$

$$\text{ELSE IMP} := \text{IMP} - \frac{\text{IMP}}{4 \times \text{TMIMP}} \times \frac{\text{QPFOR} - \text{QPDOM}}{\text{QPDOM}}$$

This formula can make $X > 1$ or $X < 0$.
If this happens, X is put equal to one (or to zero).

7.3.2 PT(MKT):= QPRELPDOM
PT(Z):= QPRELPZ

7.3.3 Perform 7.3.3 - 7.3.5 MARKET-ITER times:

7.3.4 Compute household expenditures (see 7.4)

7.3.5 Compute total buyings (see 7.5)

7.3.6 (Not in the last iteration)
Adjust prices (see 7.6)

7.4 Computation of Household Expenditures
(COMPUTE EXPENDITURES)

This block describes how households react to a set of trial offering prices in respective expenditure categories. It will interact with firms several times in an iterative manner. The expenditure categories correspond to the firms' markets and the service sector.
Prices are called PT (trial) and QPH (last quarter's final prices).
QDI and CVE come from block 7.2.

All variables have an order of magnitude referring to <u>one</u> household, not to the aggregate.

7.4.1 Preliminary Consumer Price Index (CPI), based on new prices in all expenditure categories:

$$QPRELCPI := \frac{SUM(QC(I))}{SUM\left\{\frac{QC(I)}{PT(I)}\right\}}$$ x)

$$CHDCPI := \frac{QPRELCPI}{QCPI} - 1 - QDCPI$$

7.4.2 Essential nondurables consumption.

$$QSPE(NDUR) := CVE(NDUR) \times PT(NDUR)$$

7.4.3 Essential consumption of durable goods:

$$SWAP := ALFA3 \times \left(\frac{CHRI}{4} - CHDCPI\right) + ALFA4 \times CHRU$$

$$QSPE(DUR) := \frac{PT(DUR) \times CVE(DUR)}{RHODUR} -$$

$$- \frac{PT(DUR)}{QPH(DUR)} \times STODUR - QDI \times SWAP$$

---

x) Experiments will also be made with the following formula:

$$QPRELCPI := \frac{SUM\{CVA(I) \times PT(I)\}}{SUM(CVA(I))}$$

7.4.4 Essential level of saving:

QSPE(SAV):= (WHRAxQDI-WH)+QDIxSWAP
(WHRA is updated in 7.9.4)

7.4.5 Adjustment to income constraint
("I" denotes NDUR,DUR,SAV)

$$QSP(I):=BETA1(I)xQSPE(I) + \left\{BETA2(I) + \frac{BETA3(I)}{QDI/QPRELCPI}\right\}x\left\{QDI - SUM(BETA1(I)xQSPE(I))\right\}$$

where all BETA1 $\geq$ 0
SUM(BETA2)=1
SUM(BETA3)=0

7.4.6 For all non-saving categories, QSP$\geq$ 0 is enforced. Thus at this stage SUM(QSP) $>$ QDI might hold. This is accomodated in the block "Household Update", where savings are recomputed as a residual.

7.5 Computation of total buyings
(COMPUTE BUYING)

Sum over households to obtain total spending for each expenditure category (= market). Add firms' investment to demand in durables sector (fixed sum of money, no matter what the price is).
Adjust for import fraction and convert from money to volume.

7.5.1 QTSP:= SUM(QSP)
(Sum over households, not over categories)

7.5.2 QTSP(DUR):= QTSP(DUR) + SUM(QINVLAG)
(Sum over all firms).

7.5.3 QTBUY:= (1-IMP) x QTSP/PT

7.6 <u>Price Adjustments</u>
(PRICE ADJUST)

This block describes how firms (in each iteration) adjust their prices, once households have responded to a set of prices with provisional expenditures.

The common goals of the firms in a market is to keep prices (sales sum) up and the stock at OPTSTO.

7.6.1 IF QTBUY $<$ SUM(QOPTSUDOM)

$$\text{THEN PT:= PT} - \frac{\text{MAXDP x PT}}{\text{4 x (MARKET ITER-1)}}$$

$$\text{ELSE PT:= PT} + \frac{\text{MAXDP x PT}}{\text{4 x (MARKET ITER-1)}}$$

where MAXDP is an exogenous fraction.

7.7 Adjustment to Minimum Stock
(MINSTO ADJUST)

Market interactions may result in a demand that would lower stocks below minimum levels. In that case, purchasing is reduced in this block. (Equations 7.7.1-7.7.4 hold for markets, not for individual firms. 7.7.2 - 7.7.3 also hold for service).

7.7.1 $\text{QMAXTSUDOM} := \text{MAX}\left\{0, \text{SUM}[\text{QQ} + (\text{STO}-\text{MINSTO}) - \text{QSUFOR}]\right\}$

7.7.2 $\text{REDUCE} := \text{MIN}\ (1, \frac{\text{QMAXTSUDOM}}{\text{QTBUY}})$

(For service, $\text{REDUCE} := \text{MIN}\ (1, \frac{\text{QQZ}}{\text{QTBUY}})$)

7.7.3 QSP:= QSP x REDUCE

7.7.4 QTBUY:= QTBUY x REDUCE

7.7.5 QINVLAG:= QINVLAG x REDUCE(DUR)
(Holds for each firm).

7.8 Domestic Result
(DOMESTIC RESULT)

Domestic price is updated in each market (cf. QPH in 7.9.5 which also contains the service sector price).

Total change in stock level is computed for each market. If demand was so small that the maximum (total) stock level is exceeded, the excess quantity is assumed wasted.

7.8.1 $QDPDOM := \frac{PT(MKT)}{QPDOM} - 1$

7.8.2 QPDOM:= PT(MKT)

7.8.3 QPZ:= PT(Z)

7.8.4 QCHTSTO:= MIN(SUM(MAXSTO-STO), SUM(QQ-QSUFOR)-QTBUY)

7.8.5 QSZ:= QTBUY(Z) x QPZ

7.9 Updating of Households' Data
(HOUSEHOLD UPDATE)

This block adjusts household variables after firm-households interactions, resulting in a set of prices and a final household expenditure pattern. Trial prices (PT) are then made final (QPH).

7.9.1 Nondurables consumption
QC(NDUR):= QSP(NDUR)

7.9.2 Durables consumption and update

$STODUR := \frac{PT(DUR)}{QPH(DUR)} \times STODUR + QSP(DUR)$

QC(DUR):= RHODUR x STODUR

STODUR:= (1-RHODUR) x STODUR

7.9.3 Saving
$QSP(SAV) := QSAVH := QDI - SUM\{QSP(NDUR,DUR)\}$
WH:= WH + QSAVH

7.9.4 Addicted levels

(I denotes NDUR and DUR)

$$CVA(I) := SMOOTH(I) \times CVA(I) + (1 - SMOOTH(I)) \times \frac{QC(I)}{PT(I)}$$

$$WHRA := SMOOTH(SAV) \times WHRA + (1 - SMOOTH(SAV)) \times \frac{WH}{QDI} \quad ^{xx)}$$

7.9.5 Prices

QPH:= PT

OLDQCPI:= QCPI

$$QCPI := \frac{SUM(QC(I))}{SUM\left\{\frac{QC(I)}{QPH(I)}\right\}} \quad ^{x)}$$

QDCPI:= (QCPI - OLDQCPI)/OLDQCPI

---

x) See note to 7.4.1

xx) In a first phase of the project, SMOOTH(SAV)=1 will be used. This will have the effect of a fixed (exogenous) WHRA.

8. INVENTORY SYSTEM
(STOSYSTEM)

8.1 Distributing change in inventories over firms
(FIRMSTO)

Change in inventories industry by industry (from block 7) is distributed over individual firms in each industry. Thereafter domestic sales are calculated as a residual.

8.1.1 Some firms might end up with inventories outside the prespecified limits. We adjust for that:

```
IF STO > MAXSTO
   THEN QCHTSTO:=QCHTSTO+STO-MAXSTO
        STO:=MAXSTO
   ELSE IF  STO < MINSTO
            THEN QCHTSTO:=QCHTSTO+STO-MINSTO
                 STO:=MINSTO
```

8.1.2 The rest of QCHTSTO is distributed over the firms.

IF QCHTSTO > 0

THEN $STO:=STO+\frac{MAXSTO-STO}{SUM(MAXSTO-STO)} \times QCHTSTO$

ELSE $STO:=STO+\frac{MINSTO-STO}{SUM(MINSTO-STO)} \times QCHTSTO$

8.1.3 Domestic sales are calculated.

QSUDOM:= QQ-QSUFOR-QCHSTO

QSDOM:= QSUDOM x QPDOM

(Where QCHSTO for each firm is the sum of the changes in inventories made in 8.1.1 and 8.1.2.)

8.2 Reference Inventory Levels

The levels MINSTO, MAXSTO, OPTSTO are computed based on last quarter's sales as follows:

8.2.1 $\text{MINSTO} := \text{SMALL} \times (4 \times \frac{\text{QS}}{\text{QP}})$

8.2.2 $\text{MAXSTO} := \text{BIG} \times (4 \times \frac{\text{QS}}{\text{QP}})$

8.2.3 $\text{OPTSTO} := \text{MINSTO} + \text{BETA} \times (\text{MAXSTO} - \text{MINSTO})$

(In the computer program, these levels are not implemented as variables but as value-returning sub-routines).

9.1 Calculating final prices, sales and profits (FINALQPQSQM)

We have the values of prices and sales in foreign and domestic markets, and calculate total sales and average prices. This enables us to determine this quarter's profits.

9.1.1 $\text{QSU} := \text{QSUFOR} + \text{QSUDOM}$

9.1.2 $\text{QDS} := \frac{\text{QSFOR} + \text{QSDOM}}{\text{QS}} - 1$

9.1.3 $\text{QS} := \text{QSFOR} + \text{QSDOM}$

9.1.4 $\text{QDP} := \frac{\text{QS/QSU}}{\text{QP}} - 1$

9.1.5 $\text{QP} := \text{QS/QSU}$

9.1.6 $\text{QM} := 1 - \frac{\text{L} \times (\text{QW}/4)}{\text{QS}}$

9.1.7 $\text{QMZ} := 1 - \frac{\text{LZ} \times (\text{QWZ}/4)}{\text{QSZ}}$

9.2 Quarterly Cumulation
(QUARTERLY CUM)

Production, sales, wage sum, and labour force are cumulated. An up-till-now margin is computed.

9.2.1 $CUMQ := CUMQ + QQ$

9.2.2 $CUMS := CUMS + QS$

9.2.3 $CUMSU := CUMSU + QSU$

9.2.4 $CUMWS := CUMWS + L \times \frac{QW}{4}$

9.2.5 $CUML := \frac{(NRS-1) \times CUML + L}{NRS}$

9.2.6 $CUMM := 1 - \frac{CUMWS}{CUMS}$

10. Investment Financing (provisional)
(INVFIN)

Update book value of production equipment, and calculate this quarter's rate of return. New borrowing depends on inflation and on current rate of interest.
Investment has a one-quarter delivery lag. Profits and new borrowing are used for investment, except for an amount RW x 4 x QCHS used to keep working capital at a certain fraction RW of sales.

10.1 $K1 := K1 \times (1-RHO+QDPDOM(DUR)) + QINV \times (1-RHO)$

10.2 $QRR := 4 \times \frac{QMxQS-RHOxK1}{K1+K2+STOxQP}$

10.3 $QCHS := QS \times \frac{QDS}{1+QDS}$

10.4 QCHK2:= RW x 4 x QCHS

10.5 K2:= K2 + QCHK2

10.6 $QCHBW := BWx(ALFABW+BETABWx(\frac{QRR}{4}+QDPDOM(DUR)-\frac{RI}{4}))$

10.7 BW:= BW + QCHBW

10.8 NW:= K1 + K2 + STO x QP - BW

10.9 QINV:= QINVLAG

10.10 $QINVLAG := MAX\left\{0, QMxQS-QCHK2 + QCHBW - \frac{RI}{4} \times BW\right\}$

10.11 $INVEFF := \frac{QTOPxQP}{K1}$

11. Yearly Update
(YEARLY UPDATE)

Yearly production, price, wage, sales, and margin are computed, based on cumulation in block "Quarterly Cum".

11.1 $DQ := \frac{CUMQ}{Q} - 1$

Q:= Q x (1 + DQ)

11.2 $DP := \frac{CUMS/CUMSU}{P} - 1$

P:= P x (1 + DP)

11.3 $DW := \frac{CUMWS/CUML}{W} - 1$

W:= W x (1 + DW)

11.4 $DS := \frac{CUMS}{S} - 1$

$S := S \times (1 + DS)$

11.5 $CHM := CUMM - M$

$M := M + CHM$

Listing of Variables and Parameters

The following pages give a description of all variables and parameters occurring in the pseudo-code (and hence in the computer program). Variables and parameters described in the textual documentation, but not yet included in the computer program, are explained in the main text when they are first introduced.

Exogenous Variables:

The following variables are treated as exogenous, as the model now stands (see the following pages for an explanation of each variable):

Related to foreign markets: QDPFOR

Related to technological progress: QDMTEC, QDTECZ

Related to expectations: EXPXDP, EXPXDS, EXPXDW

Related to public sector: REALCHLG, RI

Others: ENTRY; TARGMZ

ALFABW - CONSTANT USED IN 'INVFIN' TO DETERMINE FIRMS' CHANGE IN BORROWING.

ALFA1 - CONSTANTS USED IN 'HOUSEHOLD INIT' TO DETERMINE 'ESSENTIAL' CONSUMPTION VOLUME FOR EACH EXPENDITURE CATEGORY.

ALFA2 - CONSTANTS USED IN 'HOUSEHOLD INIT' TO DETERMINE 'ESSENTIAL' CONSUMPTION VOLUME FOR EACH EXPENDITURE CATEGORY.

ALFA3 - CONSTANT USED IN 'COMPUTE EXPENDITURES' TO DETERMINE THE SHORT-TERM SWAP BETWEEN SAVINGS AND EXPENDITURES ON DURABLES.

ALFA4 - CONSTANT USED IN 'COMPUTE EXPENDITURES' TO DETERMINE THE SHORT-TERM SWAP BETWEEN SAVINGS AND EXPENDITURES ON DURABLES.

AMAN - FOR EACH FIRM, A THREE-COMPONENT VECTOR ACCOMODATING THE TWO-QUARTER LAG OF LAYOFFS. THE FIRST COMPONENT HOLDS THE NUMBER OF PEOPLE THAT CAN BE FIRED THIS QUARTER, ETC.

BETA - CONSTANTS USED TO COMPUTE OPTIMUM INVENTORY LEVELS IN RELATION TO 'MINSTO' AND 'MAXSTO'. SAME FOR ALL FIRMS WITHIN A MARKET.

BETA1 - CONSTANTS USED IN 'COMPUTE EXPENDITURES' TO ADJUST EXPENDITURES IN DIFFERENT CATEGORIES TO THE INCOME CONSTRAINT. ALL BETA1≥0

BETA2 - CONSTANTS USED IN 'COMPUTE EXPENDITURES' TO ADJUST EXPENDITURES IN DIFFERENT CATEGORIES TO THE INCOME CONSTRAINT. SUM(BETA2)=1.

BETA3 - CONSTANTS USED IN 'COMPUTE EXPENDITURES' TO ADJUST EXPENDITURES IN DIFFERENT CATEGORIES TO THE INCOME CONSTRAINT. SUM(BETA3)=0.

BIG - ON EACH MARKET, THE FRACTION OF YEARLY SALES THAT FIRMS CONSIDER AS INVENTORY MAXIMUM.

BW - A FIRM'S TOTAL BORROWING. UPDATED IN 'INVFIN'.

CHDCPI - ATTEMPTED RISE IN CONSUMER PRICE INDEX BETWEEN QUARTERS (A FRACTION). COMPUTED IN 'COMPUTE EXPENDITURES' EACH TIME HOUSEHOLDS MEET AN OFFERING PRICE VECTOR 'PT'.

CHL - EACH FIRM'S CHANGE IN LABOUR FORCE. A HELP VARIABLE USED WITHIN 'LABOUR SEARCH' TO ACCOMODATE MARKET INTERACTIONS.

CHM - FOR EACH FIRM, ITS CHANGE IN PROFIT MARGIN FROM ONE YEAR TO ANOTHER (A DIFFERENCE BETWEEN FRACTIONS). COMPUTED IN 'YEARLY UPDATE'.

CHRU - QUARTERLY CHANGE IN RATE OF UNEMPLOYMENT (A DIFFERENCE BETWEEN FRACTIONS). COMPUTED IN 'LABOUR UPDATE'.

CUML - FOR EACH FIRM, A CUMULATION OVER THE YEAR OF THE NUMBER OF EMPLOYED. UPDATED IN 'QUARTERLY CUM'.

CUMM - FOR EACH FIRM, A CUMULATION OVER THE YEAR OF ITS PROFIT MARGIN. UPDATED IN 'QUARTERLY CUM'.

CUMQ - FOR EACH FIRM, A CUMULATION OVER THE YEAR OF ITS PRODUCTION VOLUME. UPDATED IN 'QUARTERLY CUM'.

CUMS - FOR EACH FIRM, A CUMULATION OVER THE YEAR OF ITS SALES VALUE. UPDATED IN 'QUARTERLY CUM'.

CUMSU - FOR EACH FIRM, A CUMULATION OVER THE YEAR OF ITS SALES VOLUME. UPDATED IN 'QUARTERLY CUM'.

CUMWS - FOR EACH FIRM, A CUMULATION OVER THE YEAR OF ITS WAGE SUM. UPDATED IN 'QUARTERLY CUM'.

CVA - A HOUSEHOLD'S 'ADDICTED' CONSUMPTION VOLUME IN EACH EXPENDITURE CATEGORY (UNITS PER QUARTER). UPDATED IN 'HOUSEHOLD UPDATE'.

CVE - A HOUSEHOLD'S 'ESSENTIAL' CONSUMPTION IN EACH EXPENDITURE CATEGORY (UNITS PER QUARTER). COMPUTED IN 'HOUSEHOLD INIT'.

DISTR - *A HELP VARIABLE USED IN 'FIRMSTO' TO DISTRIBUTE INVENTORY ADJUSTMENTS AMONG FIRMS.*

DP - *FOR EACH FIRM, ITS YEARLY CHANGE IN SALES PRICE (A FRACTION). COMPUTED IN 'YEARLY UPDATE'.*

DQ - *FOR EACH FIRM, ITS YEARLY CHANGE IN PRODUCTION VOLUME (A FRACTION). COMPUTED IN 'YEARLY UPDATE'.*

DS - *FOR EACH FIRM, ITS YEARLY CHANGE IN SALES VALUE (A FRACTION). COMPUTED IN 'YEARLY UPDATE'.*

DUR - *A VECTOR INDEX, GIVING 'DURABLES'/'INDUSTRIAL INVESTMENT GOODS' DATA FROM A VECTOR.*

DW - *FOR EACH FIRM, ITS YEARLY WAGE CHANGE (A FRACTION). COMPUTED IN 'YEARLY UPDATE'.*

ENTRY - *A PARAMETER REGULATING THE INFLOW OF NEW PERSONS TO THE LABOUR MARKET (QUARTERLY FRACTION OF THE TOTAL LABOUR FORCE). SOFAR EXOGENOUS AND CONSTANT.*

EPS - *A CONSTANT FORCING FIRMS TO SHARPEN THEIR PROFIT-MARGIN TARGETS AS COMPARED WITH HISTORICAL DATA.*

EXIT - *FOR EACH FIRM, DISCREPANCY BETWEEN ACTUAL AND PLANNED LABOUR FORCE (AFTER MARKET INTERACTIONS). HELP VARIABLE USED IN 'LABOUR SEARCH' TO ACCOMODATE 'AMAH' LAYOFF LAG.*

EXPDP - *EACH FIRM'S EXPECTED CHANGE IN SALES PRICE FOR A YEAR (A FRACTION). COMPUTED IN 'YEARLY EXP'.*

EXPDS - *EACH FIRM'S EXPECTED CHANGE IN SALES FOR A YEAR (A FRACTION). COMPUTED IN 'YEARLY EXP'.*

EXPDW - *EACH FIRM'S EXPECTED WAGE CHANGE FOR A YEAR (A FRACTION). COMPUTED IN 'YEARLY EXP'.*

EXPIDP - *EACH FIRM'S 'INTERNALLY' EXPECTED CHANGE IN SALES PRICE FOR A YEAR (A FRACTION). UPDATED IN 'YEARLY EXP'.*

EXPIDS - EACH FIRM'S 'INTERNALLY' EXPECTED CHANGE IN SALES FOR A YEAR (A FRACTION). UPDATED IN 'YEARLY EXP'.

EXPIDW - EACH FIRM'S 'INTERNALLY' EXPECTED CHANGE IN WAGE FOR A YEAR (A FRACTION). UPDATED IN 'YEARLY EXP'.

EXPXDP - IN EACH MARKET, THE 'EXTERNALLY' EXPECTED CHANGE IN SALES PRICE FOR A YEAR (A FRACTION). ENTERED EXOGENOUSLY.

EXPXDS - IN EACH MARKET, THE 'EXTERNALLY' EXPECTED CHANGE IN SALES FOR A YEAR (A FRACTION). ENTERED EXOGENOUSLY.

EXPXDW - IN EACH MARKET, THE 'EXTERNALLY' EXPECTED CHANGE IN WAGE FOR A YEAR (A FRACTION). ENTERED EXOGENOUSLY.

E1 - A CONSTANT USED IN 'YEARLY EXP' TO UPDATE 'INTERNAL' EXPECTATIONS ON PRICES, SALES, AND WAGES.

E2 - A CONSTANT USED IN 'YEARLY EXP' TO UPDATE 'INTERNAL' EXPECTATIONS ON PRICES, SALES, AND WAGES.

FIP - A CONSTANT DESCRIBING HOW FIRMS TRADE OFF ONLY JUST EXPERIENCED PRICE CHANGE AGAINST LONGER-TERM EXPECTATIONS. USED IN 'QUARTERLY EXP'.

FIS - A CONSTANT DESCRIBING HOW FIRMS TRADE OFF ONLY JUST EXPERIENCED SALES VALUE CHANGE AGAINST LONGER-TERM EXPECTATIONS. USED IN 'QUARTERLY EXP'.

FIW - A CONSTANT DESCRIBING HOW FIRMS TRADE OFF ONLY JUST EXPERIENCED WAGE CHANGE AGAINST LONGER-TERM EXPECTATIONS. USED IN 'QUARTERLY EXP'.

GAMMA - A CONSTANT TELLING HOW BIG WAGE INCREASE IS NEEDED FOR A PERSON THAT HE SHOULD LEAVE HIS JOB FOR A NEW ONE. USED IN 'LABOUR SEARCH'.

IMP - IMPORT SHARE IN EACH MARKET. UPDATED IN 'MARKET CONFRONT'.

INVEFF - FOR EACH FIRM, ITS INVESTMENT EFFECIENCY (INCREASE IN QUARTERLY PRODUCTION VALUE, DIVIDED BY INVESTMENT). COMPUTED IN 'INVFIN'.

IOTA - A CONSTANT USED BY FIRMS TO FORM THEIR INITIAL WAGE OFFER IN 'LABOUR SEARCH'.

KSIFAIL - A CONSTANT, USED IN 'LABOUR SEARCH', WHICH TELLS BY HOW MUCH A FIRM RAISES ITS OWN WAGE LEVEL AFTER IT HAS PERFORMED AN UNSUCCESSFUL ATTACK.

KSISUCC - A CONSTANT, USED IN 'LABOUR SEARCH', WHICH TELLS BY HOW MUCH AN ATTACKED FIRM RAISES ITS WAGE LEVEL AFTER IT HAS LOST PART OF ITS LABOUR FORCE.

K1 - FOR EACH FIRM, THE BOOK VALUE OF ITS PRODUCTION EQUIPMENT. UPDATED IN 'INVFIN'.

K2 - FOR EACH FIRM, ITS CURRENT ASSETS. UPDATED IN 'INVFIN'.

L - FOR EACH FIRM, ITS LABOUR FORCE. UPDATED IN 'LUUPDATE' (RETIREMENTS) AND IN 'LABOUR UPDATE' (OTHER CHANGES).

LAYOFF - FOR EACH FIRM, DISCREPANCY BETWEEN ACTUAL AND PLANNED LABOUR FORCE (BEFORE MARKET INTERACTIONS). HELP VARIABLE USED IN 'TARGET SEARCH' TO ACCOMODATE 'AMAN' LAYOFF LAG.

LF - TOTAL LABOUR FORCE IN THE ECONOMY. UPDATED IN 'LUUPDATE'.

LG - GOVERNMENT LABOUR FORCE. UPDATED IN 'GLABOUR'.

LL - EACH FIRM'S LABOUR FORCE. A HELP VARIABLE USED WITHIN 'LABOUR SEARCH' TO ACCOMODATE THE MARKET INTERACTIONS.

LOSS - A CONSTANT, TELLING HOW MUCH OF FIRMS' INVESTMENTS THAT ARE DIRECTED TO THE STRUCTURAL SLACK.

LU - NUMBER OF PEOPLE UNEMPLOYED. UPDATED IN 'LUUPDATE' AND AT VARIOUS PLACES WITHIN BLOCK 'LABOUR MARKET'.

LZ - SERVICE SECTOR LABOUR FORCE. UPDATED IN 'ZLABOUR'.

M - FOR EACH FIRM, ITS YEARLY PROFIT MARGIN (A FRACTION). COMPUTED IN 'YEARLY UPDATE'.

MARKETITER - NUMBER OF ITERATIONS ON DOMESTIC PRODUCT MARKET. USED IN 'MARKET CONFRONT'.

MAXDP - A FRACTION WHICH DETERMINES MAXIMUM YEARLY DEVIATION IN DOMESTIC PRICES FROM WHAT FIRMS EXPECT. USED IN 'ADJUST PRICES' TO ACCOMODATE SUPPLY-DEMAND INTERACTIONS.

MAXSTO - FOR EACH FIRM, ITS 'MAXIMUM' INVENTORY LEVEL (VOLUME TERMS). COMPUTATION IS DESCRIBED WITHIN BLOCK 'STOSYSTEM'.

MHIST - FOR EACH FIRM, AN AVERAGE OF PAST PROFIT MARGINS (A FRACTION). UPDATED IN 'YEARLY TARG'.

MINSTO - FOR EACH FIRM, ITS 'MINIMUM' INVENTORY LEVEL (VOLUME TERMS). COMPUTATION IS DESCRIBED WITHIN BLOCK 'STOSYSTEM'.

MKT - INDEX VARIABLE, EXTRACTING FROM 'EXPENDITURE CATEGORY' VECTORS DATA THAT APPLY TO INDUSTRIAL MARKETS.

MTEC - ON EACH MARKET, TECHNOLOGY FACTOR OF MODERN EQUIPMENT (POTENTIALLY PRODUCED UNITS PER PERSON AND QUARTER). UPDATED IN 'PRODFRONT'.

NDUR - INDEX VARIABLE, EXTRACTING FROM 'EXPENDITURE CATEGORY' VECTORS DATA THAT APPLY TO NON-DURABLE CONSUMPTION CATEGORIES.

NH - NUMBER OF HOUSEHOLDS - A CONSTANT, AS THE MODEL NOW STANDS.

NITER - NUMBER OF ITERATIONS ON THE LABOUR MARKET EACH QUARTER. USED IN 'LABOUR SEARCH'.

NW - FOR EACH FIRM, ITS NET VALUE AS THE RESIDUAL BETWEEN TOTAL ASSETS AND BORROWING. COMPUTED IN 'INVFIN'.

OPTSTO - FOR EACH FIRM, ITS 'OPTIMUM' INVENTORY LEVEL (VOLUME TERMS). COMPUTATION IS DESCRIBED WITHIN BLOCK 'STOSYSTEM'.

ORDER - VECTOR, TELLING IN WHICH SEQUENCE FIRMS ARE ALLOWED TO MAKE ATTACKS ON THE LABOUR MARKET (BIG RELATIVE RECRUITMENT PLAN GOES FIRST).

P - FOR EACH FIRM, ITS YEARLY AVERAGE SALES PRICE. UPDATED IN 'YEARLY UPDATE'.

PRIMCHSTO - A HELP VARIABLE USED IN 'FIRMSTO' TO DISTRIBUTE INVENTORY ADJUSTMENTS AMONG FIRMS.

PROPCHSTO - A HELP VARIABLE USED IN 'FIRMSTO' TO DISTRIBUTE INVENTORY ADJUSTMENTS AMONG FIRMS.

PT - ON EACH MARKET, FIRMS' COMMON OFFERING PRICE TO HOUSEHOLDS IN ONE ITERATION. FIRST COMPUTED IN 'MARKET CONFRONT'; LATER UPDATED IN 'ADJUST PRICES'.

Q - FOR EACH FIRM, ITS TOTAL PRODUCTION FOR A YEAR (VOLUME). UPDATED IN 'YEARLY UPDATE'.

QC - A HOUSEHOLD'S CONSUMPTION IN EACH OF THE EXPENDITURE CATEGORIES (VALUE PER QUARTER). COMPUTED IN 'HOUSEHOLD UPDATE'.

QCHBW - FOR EACH FIRM, ITS QUARTERLY CHANGE IN BORROWING. COMPUTED IN 'INVFIN'.

QCHK2 - FOR EACH FIRM, ITS QUARTERLY CHANGE IN CURRENT ASSETS. HELP VARIABLE USED IN 'INVFIN'.

QCHL - FOR EACH FIRM, ITS QUARTERLY LABOUR FORCE CHANGE DUE TO LABOUR MARKET INTERACTIONS (RETIREMENTS ARE NOT INCLUDED). COMPUTED LAST IN 'LABOUR SEARCH'; UPDATED IN 'LABOUR UPDATE' IF LAYOFFS OCCUR.

QCHLG - NUMBER OF NEW PERSONS IN GOVERNMENT SECTOR LABOUR FORCE EACH QUARTER (INCLUDING REPLACEMENTS FOR RETIREMENTS).

QCHLZ - NUMBER OF NEW PERSONS IN SERVICE SECTOR LABOUR FORCE EACH QUARTER (INCLUDING REPLACEMENTS FOR RETIREMENTS).

QCHQTOP - FOR EACH FIRM, QUARTERLY CHANGE IN PRODUCTION CAPACITY 'QTOP' DUE TO INVESTMENTS. COMPUTED IN 'PRODFRONT'.

QCHQTOP1 - PRODUCTION CAPACITY INCREASE THAT CAN BE USED REGARDLESS OF SLACK CONSIDERATIONS. COMPUTED IN 'PRODFRONT'.

QCHQTOP2 - THAT PART OF A PRODUCTION CAPACITY INCREASE WHICH IS DIRECTED TO THE FIRM'S SLACK. COMPUTED IN 'PRODFRONT'.

QCHS - FOR EACH FIRM, ITS QUARTERLY CHANGE IN SALES (ABSOLUTE VALUE TERMS). HELP VARIABLE IN 'INVFIN'.

QCHTSTO - ON EACH MARKET, TOTAL QUARTERLY CHANGE IN INVENTORY TO BE DISTRIBUTED BETWEEN FIRMS. COMPUTED IN 'DOMESTIC RESULT'.

QCHW - FOR EACH FIRM, ITS QUARTERLY WAGE CHANGE IN ABSOLUTE TERMS. COMPUTED LAST IN 'LABOUR SEARCH'.

QCPI - CONSUMER PRICE INDEX, UPDATED IN 'HOUSEHOLD UPDATE'.

QDCPI - QUARTERLY CHANGE IN CONSUMER PRICE INDEX (A FRACTION). COMPUTED IN 'HOUSEHOLD UPDATE'.

QDI - A HOUSEHOLD'S DISPOSABLE INCOME FOR ONE QUARTER. COMPUTED IN 'HOUSEHOLD INIT'.

QDMTEC - ON EACH MARKET, THE RATE OF TECHNOLOGY UPGRADE FOR PRODUCTION EQUIPMENT (A FRACTION ON QUARTERLY BASIS). ENTERED EXOGENOUSLY.

QDP - FOR EACH FIRM, ITS QUARTERLY INCREASE IN SALES PRICE (A FRACTION). COMPUTED IN 'FINALQPQSQM'.

QDPDOM - ON EACH MARKET, THE QUARTERLY INCREASE IN DOMESTIC PRICE (A FRACTION). COMPUTED IN 'DOMESTIC RESULT'.

QDPFOR - ON EACH MARKET, THE QUARTERLY INCREASE IN FOREIGN PRICE (A FRACTION). EXOGENOUSLY ENTERED IN 'EXPORT'.

QDQ - FOR EACH FIRM, ITS QUARTERLY INCREASE IN PRODUCTION VOLUME (A FRACTION). COMPUTED IN 'PLANQREVISE'.

QDS - FOR EACH FIRM, ITS QUARTERLY INCREASE IN SALES VALUE (A FRACTION). COMPUTED IN 'FINALQPQSQM'.

QDTECZ -	QUARTERLY UPGRADE OF TECHNOLOGY FACTOR FOR THE SERVICE SECTOR (A FRACTION). EXOGENOUSLY ENTERED IN 'ZLABOUR'.
QDW -	FOR EACH FIRM, ITS QUARTERLY WAGE INCREASE (A FRACTION). COMPUTED IN 'LABOUR UPDATE'.
QDWIND -	AVERAGE WAGE INCREASE IN THE INDUSTRY DURING ONE QUARTER (A FRACTION). COMPUTED IN 'LABOUR UPDATE'.
QEXPDP -	FOR EACH FIRM, ITS EXPECTATION ON PRICE INCREASE FOR THE NEXT QUARTER (A FRACTION). HELP VARIABLE USED IN 'QUARTERLY EXP'.
QEXPDS -	FOR EACH FIRM, ITS EXPECTATION ON SALES VALUE INCREASE FOR THE NEXT QUARTER (A FRACTION). HELP VARIABLE USED IN 'QUARTERLY EXP'.
QEXPDW -	FOR EACH FIRM, ITS EXPECTATION ON WAGE INCREASE FOR THE NEXT QUARTER (A FRACTION). HELP VARIABLE USED IN 'QUARTERLY EXP'.
QEXPP -	FOR EACH FIRM, ITS EXPECTED SALES PRICE FOR THE NEXT QUARTER. COMPUTED IN 'QUARTERLY EXP'.
QEXPS -	FOR EACH FIRM, ITS EXPECTED SALES VALUE FOR THE NEXT QUARTER. COMPUTED IN 'QUARTERLY EXP'.
QEXPW -	FOR EACH FIRM, ITS EXPECTED WAGE LEVEL FOR THE NEXT QUARTER (EXPRESSED ON A YEARLY BASIS). COMPUTED IN 'QUARTERLY EXP'.
QFR -	FOR EACH FIRM, ITS PRODUCTION POSSIBILITY FRONTIER (VOLUME PER QUARTER) AS A FUNCTION OF ITS LABOUR FORCE. COMPUTATION IS DESCRIBED WITHIN BLOCK 'PRODPLAN'.
QINV -	FOR EACH FIRM, ITS QUARTERLY INVESTMENT (VALUE TERMS). COMPUTED IN 'INVFIN'.
QINVLAG -	FOR EACH FIRM, ITS INVESTMENT FOR THE <u>NEXT</u> QUARTER (VALUE TERMS). COMPUTED IN 'INVFIN'.
QM -	FOR EACH FIRM, ITS PROFIT MARGIN DURING A QUARTER (A FRACTION). COMPUTED IN 'INVFIN'.

QMAXTSUDOM - FOR EACH MARKET, MAXIMUM SALES VOLUME FOR A QUARTER DUE TO 'MINSTO' CONSIDERATIONS. HELP VARIABLE USED WITHIN 'MINSTO ADJUST'.

QMZ - PROFIT MARGIN IN THE SERVICE SECTOR DURING A QUARTER (A FRACTION). COMPUTED IN 'FINALQPQSQM'.

QOPTSU - FOR EACH FIRM, ITS OPTIMUM SOLD VOLUME DURING A QUARTER. COMPUTED IN 'PLANQREVISE'.

QOPTSUDOM - OPTIMUM SOLD VOLUME ON THE DOMESTIC MARKET (UNITS PER QUARTER). COMPUTED FOR EACH FIRM IN 'MARKET ENTRANCE'.

QP - FOR EACH FIRM, ITS SALES PRICE DURING A QUARTER (AN AVERAGE BETWEEN FOREIGN AND DOMESTIC PRICE). UPDATED IN 'FINALQPQSQM'.

QPDOM - ON EACH MARKET, THE DOMESTIC PRICE DURING ONE QUARTER. UPDATED IN 'DOMESTIC RESULT'.

QPFOR - ON EACH MARKET, THE FOREIGN PRICE DURING ONE QUARTER. UPDATED IN 'EXPORT'.

QPH - DOMESTIC PRICE IN EACH EXPENDITURE CATEGORY AS HOUSEHOLDS SEE THEM. UPDATED IN 'HOUSEHOLD UPDATE'.

QPLANL - FOR EACH FIRM, ITS PLANNED LABOUR FORCE FOR A QUARTER. COMPUTED IN 'TARGET SEARCH'.

QPLANQ - FOR EACH FIRM, ITS PLANNED PRODUCTION VOLUME DURING A QUARTER. COMPUTED IN 'INITPRODPLAN'; REVISED IN 'TARGET SEARCH' AND IN 'PLANQREVISE'.

QPRELCPI - PRELIMINARY CONSUMER PRICE INDEX. COMPUTED IN 'COMPUTE EXPENDITURES' EACH TIME HOUSEHOLDS MEET AN OFFERING PRICE VECTOR 'PT'.

QPRELPDOM - ON EACH MARKET, THE FIRMS' INITIAL OFFERING PRICE TO HOUSEHOLDS. COMPUTED IN 'MARKET ENTRANCE'.

QPRELPZ - PRELIMINARY PRICE IN THE SERVICE SECTOR DURING THE QUARTER TO COME. COMPUTED IN 'ZLABOUR'.

QPZ - PRICE IN THE SERVICE SECTOR DURING ONE QUARTER. COMPUTED IN 'DOMESTIC RESULT'.

QQ - PRODUCTION FOR A FIRM (UNITS PER QUARTER). COMPUTED IN 'PLANQREVISE'.

QQZ - (POTENTIAL) PRODUCTION IN THE SERVICE SECTOR DURING ONE QUARTER (VOLUME). COMPUTED IN 'ZLABOUR'.

QRR - FOR EACH FIRM, ITS RATE OF RETURN (A FRACTION ON A YEARLY BASIS). COMPUTED IN 'INVFIN' EACH QUARTER.

QS - FOR EACH FIRM, ITS SALES VALUE DURING ONE QUARTER. COMPUTED IN 'FINALOPQSQM'.

QSAVH - HOUSEHOLD SAVINGS (PER QUARTER AND HOUSEHOLD). COMPUTED IN 'HOUSEHOLD UPDATE' AS A RESIDUAL.

QSDOM - FOR EACH FIRM, ITS DOMESTIC SALES VALUE DURING ONE QUARTER. COMPUTED IN 'FIRMSTO'.

QSFOR - FOR EACH FIRM, ITS FOREIGN SALES VALUE DURING ONE QUARTER. COMPUTED IN 'EXPORT'.

QSP - HOUSEHOLD PURCHASING IN EACH EXPENDITURE CATEGORY (VALUE PER QUARTER). COMPUTED IN 'COMPUTE EXPENDITURES' IN EACH ITERATION ON THE DOMESTIC MARKET.

QSPE - 'ESSENTIAL' HOUSEHOLD PURCHASING IN EACH EXPENDITURE CATEGORY (VALUE PER QUARTER). HELP VARIABLE USED WITHIN 'COMPUTE EXPENDITURES'

QSU - FOR EACH FIRM, ITS SALES VOLUME DURING ONE QUARTER. COMPUTED IN 'FINALOPQSQM'.

QSUDOM - FOR EACH FIRM, ITS DOMESTIC SALES VOLUME DURING ONE QUARTER. COMPUTED IN 'FIRMSTO'.

QSUFOR - FOR EACH FIRM, ITS FOREIGN SALES VOLUME DURING ONE QUARTER. COMPUTED IN 'EXPORT'.

QSZ - QUARTERLY SALES VALUE IN THE SERVICE SECTOR. COMPUTED IN 'DOMESTIC RESULT'.

QTARGM - FOR EACH FIRM, ITS PROFIT-MARGIN TARGET FOR A QUARTER (A FRACTION). COMPUTED IN 'QUARTERLY TARG'.

QTBUY - TOTAL BUYING IN EACH EXPENDITURE CATEGORY (UNITS PER QUARTER). COMPUTED IN 'COMPUTE BUYING' IN EACH ITERATION ON THE DOMESTIC MARKET.

QTOP - POTENTIAL OUTPUT FOR A FIRM (UNITS PER QUARTER) AT ZERO SLACK AND INFINITE LABOUR FORCE. UPDATED IN 'PRODFRONT'.

QTSP - AGGREGATE HOUSEHOLD PURCHASING IN EACH EXPENDITURE CATEGORY (VALUE PER QUARTER). HELP VARIABLE USED WITHIN 'COMPUTE BUYING'.

QW - FOR EACH FIRM, ITS WAGE LEVEL (EXPRESSED ON A YEARLY BASIS) DURING ONE QUARTER. UPDATED IN 'LABOUR UPDATE'.

QWG - GOVERNMENT WAGE LEVEL (EXPRESSED ON A YEARLY BASIS) DURING ONE QUARTER. UPDATED IN 'GLABOUR'.

QWZ - SERVICE SECTOR WAGE LEVEL (EXPRESSED ON A YEARLY BASIS) DURING ONE QUARTER. UPDATED IN 'ZLABOUR'.

Q2 - FOR EACH FIRM, MAX PRODUCTION FOR A QUARTER REGARDING SALES PLAN AND INVENTORY MAXIMUM. HELP VARIABLE USED WITHIN 'TARGET SEARCH'.

Q3 - FOR EACH FIRM, MAX PRODUCTION FOR A QUARTER REGARDING ACTUAL LABOUR FORCE AND SLACK LIMITATIONS. HELP VARIABLE USED IN 'TARGET SEARCH'.

Q7 - FOR EACH FIRM, A QUARTERLY PRODUCTION LEVEL, BELOW WHICH STRUCTURAL SLACK IS REALIZED. HELP VARIABLE USED WITHIN 'TARGET SEARCH'.

R - A CONSTANT IMPLYING HOW MUCH FIRMS RELY ON EXTERNAL INFORMATION WHEN THEY FORM EXPECTATIONS (IN 'YEARLY EXP')

REALCHLG - NET CHANGE IN GOVERNMENT EMPLOYMENT (PERSONS PER QUARTER). ENTERED EXOGENOUSLY IN 'GLABOUR'.

REDUCE - FOR EACH EXPENDITURE CATEGORY, A FRACTION BY WHICH EXPENDITURES MUST BE REDUCED DUE TO LIMITED SUPPLY. HELP VARIABLE USED WITHIN 'MINSTO ADJUST'.

RES -	*STRUCTURAL SLACK FOR A FIRM (FRACTION). UPDATED IN 'PRODFRONT' AND (UNDER TARGET PRESSURE ONLY) IN 'TARGET SEARCH'.*
RESDOWN -	*A CONSTANT TELLING BY HOW MUCH FIRMS CAN REDUCE THEIR SLACK DURING ONE QUARTER.*
RESMAX -	*A CONSTANT TELLING MAXIMUM SLACK ANY FIRM CAN POSSIBLY HAVE.*
RET -	*RETIREMENT RATE ON THE LABOUR MARKET (A FRACTION ON QUARTERLY BASIS).*
RFQ -	*FOR EACH FIRM, THE MINIMUM LABOUR FORCE NEEDED AS A FUNCTION OF DESIRED PRODUCTION (VOLUME PER QUARTER). THE COMPUTATION IS DESCRIBED WITHIN BLOCK 'PRODPLAN'; THIS IS THE INVERSE FUNCTION TO 'QFR(L)'.*
RHO -	*DEPRECIATION RATE OF PRODUCTION EQUIPMENT (A FRACTION ON QUARTERLY BASIS).*
RHODUR -	*DEPRECIATION RATE OF CONSUMER DURABLE GOODS (A FRACTION ON QUARTERLY BASIS).*
RI -	*RATE OF INTEREST, EXPRESSED ON A YEARLY BASIS. ENTERED EXOGENOUSLY.*
RU -	*RATE OF UNEMPLOYMENT (A FRACTION). UPDATED IN 'LABOUR UPDATE'.*
RW -	*A CONSTANT GIVING FIRMS' DESIRED AMOUNT OF WORKING CAPITAL AS A FRACTION OF SALES.*
S -	*FOR EACH FIRM, ITS SALES VALUE DURING ONE YEAR. UPDATED IN 'YEARLY UPDATE'.*
SACK -	*FOR EACH FIRM, NUMBER OF PEOPLE FIRED DURING A QUARTER. HELP VARIABLE WITHIN 'LABOUR UPDATE'.*
SAV -	*INDEXING VARIABLE, GIVING SAVINGS COMPONENT OF HOUSEHOLD EXPENDITURE VECTORS.*
SMALL -	*ON EACH MARKET, THE FRACTION OF YEARLY SALES THAT FIRMS CONSIDER AS INVENTORY MINIMUM.*
SMOOTH -	*CONSTANT USED BY HOUSEHOLDS TO (EACH QUARTER) TIME-SMOOTH THEIR ADDICTED CONSUMPTION LEVELS AND SAVINGS RATIO.*

SMP - CONSTANT USED BY FIRMS TO (EACH YEAR) TIME-SMOOTH THEIR PRICE EXPERIENCES.

SMS - CONSTANT USED BY FIRMS TO (EACH YEAR) TIME-SMOOTH THEIR SALES EXPERIENCES.

SMT - CONSTANT USED BY FIRMS TO (EACH YEAR) TIME-SMOOTH THEIR PROFIT-MARGIN HISTORY.

SMW - CONSTANT USED BY FIRMS TO (EACH YEAR) TIME-SMOOTH THEIR WAGE EXPERIENCES.

STO - FOR EACH FIRM, ITS CURRENT INVENTORY LEVEL (VOLUME TERMS). UPDATED IN 'FIRMSTO'.

STODUR - EACH HOUSEHOLD'S STOCK OF DURABLE GOODS (VALUE TERMS). UPDATED IN 'HOUSEHOLD UPDATE'.

SWAP - A FACTOR DETERMINING THE SHORT-TERM TRADE-OFF BETWEEN SAVINGS AND EXPENDITURES ON CONSUMER DURABLES. COMPUTED IN 'COMPUTE EXPENDITURES'.

TARGM - FOR EACH FIRM, ITS PROFIT-MARGIN TARGET FOR ONE YEAR (A FRACTION). COMPUTED IN 'YEARLY TARG'.

TARGMZ - PROFIT-MARGIN TARGET IN THE SERVICE SECTOR (A FRACTION). ENTERED EXOGENOUSLY.

TEC - TECHNOLOGY FACTOR FOR A FIRM (UNITS PER MAN AND QUARTER). UPDATED IN 'PRODFRONT'.

TECZ - TECHNOLOGY FACTOR FOR THE SERVICE SECTOR (POTENTIALLY PRODUCED VOLUME PER MAN AND QUARTER). UPDATED IN 'ZLABOUR'.

THETA - MAXIMUM FRACTION OF A FIRM'S LABOUR FORCE THAT IT CAN LOOSE AT ONE LABOUR MARKET ATTACK. USED IN 'LABOUR SEARCH'.

TMIMP - FOR EACH MARKET, THE TIME CONSTANT TO ADJUST IMPORT SHARE.

TMSTO - TIME CONSTANT FOR FIRMS WHEN ADJUSTING INVENTORY DISCREPANCY (YEARS). USED IN 'INITPRODPLAN' AND IN 'PLANQREVISE'.

TMX - TIME CONSTANT FOR FIRMS WHEN ADJUSTING EXPORT SHARE IN 'EXPORT' (YEARS; COMMON TO ALL FIRMS ON A MARKET).

W - *FOR EACH FIRM, ITS AVERAGE WAGE DURING ONE YEAR. COMPUTED IN 'YEARLY UPDATE'.*

WH - *EACH HOUSEHOLD'S WEALTH (CURRENT VALUE OF ITS BANK DEPOSITS). UPDATED IN 'HOUSEHOLD UPDATE'.*

WHRA - *EACH HOUSEHOLD'S ADDICTED WEALTH RATIO (QUOTIENT BETWEEN BANK DEPOSITS AND QUARTERLY DISPOSABLE INCOME). UPDATED IN 'HOUSEHOLD UPDATE'.*

WW - *EACH FIRM'S WAGE. A HELP VARIABLE USED WITHIN 'LABOUR SEARCH' TO ACCOMODATE MARKET INTERACTIONS.*

X - *FOR EACH FIRM, ITS EXPORT SHARE (FRACTION OF SOLD VOLUME). UPDATED IN 'EXPORT'.*

Z - *INDEXING VARIABLE, EXTRACTING SERVICE SECTOR DATA FROM A EXPENDITURE CATEGORY VECTOR.*

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IUI - IBM SWEDEN
MICRO SIMULATION SEMINAR

Stockholm September 19-22, 1977

(Original program)

September 19, Monday

Session A
Chairman: R Clover, UCLA, USA

A1	The Transaction Model of the United States	B Bergmann, University of Maryland, USA
A2	Microanalytic Modeling and Simulation	G Orcutt, A Glaser, Yale University, USA
A3	A Microsimulation Model of a National Economy	G Eliasson, IUI, Sweden

September 20, Tuesday

Session B
Chairman: D Nichols, US Department of Labor, USA

B1	Hypothesis Formulation Testing and Estimation	G Orcutt, Yale University, USA
B2	Choices of Strategy in Assigning Parameter Values in a Microsimulated Model	B Bergmann, University of Maryland, USA
B3	Stepwise Parameter Estimation of Micro Simulation Models	G Eliasson, IUI, Sweden G Olavi, IBM, Sweden

September 21, Wednesday

Session C
Chairman: B Bergmann, University of Maryland, USA

C1	The Equilibrium Level of Unemployment: A Simulation	D Nichols, US Department of Labor, USA
C2	Simulating the Distribution of Wealth - a Progress Report	G Orcutt, S Franklin, Yale University, USA J. Smith, Pennsylvania University, USA
C3	How does Inflation Affect Growth - Experiment on the Swedish Model	G Eliasson, IUI, Sweden
	Demonstration of Swedish Model	G Olavi, IBM, Sweden

Session D
Chairman, A Hart, Columbia University, USA

D1	Microanalytic Simulation and the Study of Comparative Economic Systems	F Pryor, Swarthmore College, USA
D2	Expectations, Cyclical Fluctuations and Growth, Experiments on the Swedish Model	J Albrecht, Columbia University, USA

September 22, Thursday

Session E
Chairman: G Orcutt, Yale University, USA

E1	Banks and Financial Intermediaries in the Micro Simulated Transaction Model of the US Economy	R Bennett, University of Maryland, USA

Special Project Reports

E2	A Description of the Aggregation Scheme Used in the Swedish Model	L Ahlström, IUI, Sweden
E3	The Sociopolitical Decision and Indicator System for the Federal Republic of Germany; A Review	R Brennecke, Frankfurt, W Germany
E4	The Computer Aided Planning System for the German Federal Student-aid PROGRAM	D Bungers, GMD, Bonn, W Germany
E5	Estimating the Rate of Technological Growth in the Swedish Model	B Carlsson, IUI, Sweden G Olavi, IBM, Sweden
E6	MICS- A Micro Simulation Model for Wage-earner Households	Ch Sørensen, Allerød, Denmark
E7	Computerisation of Micro Founded Macro Econometric Models	E Yndgaard, Aarhus, Denmark
E8	General Discussion	

End of program

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