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

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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

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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.

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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 short run 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

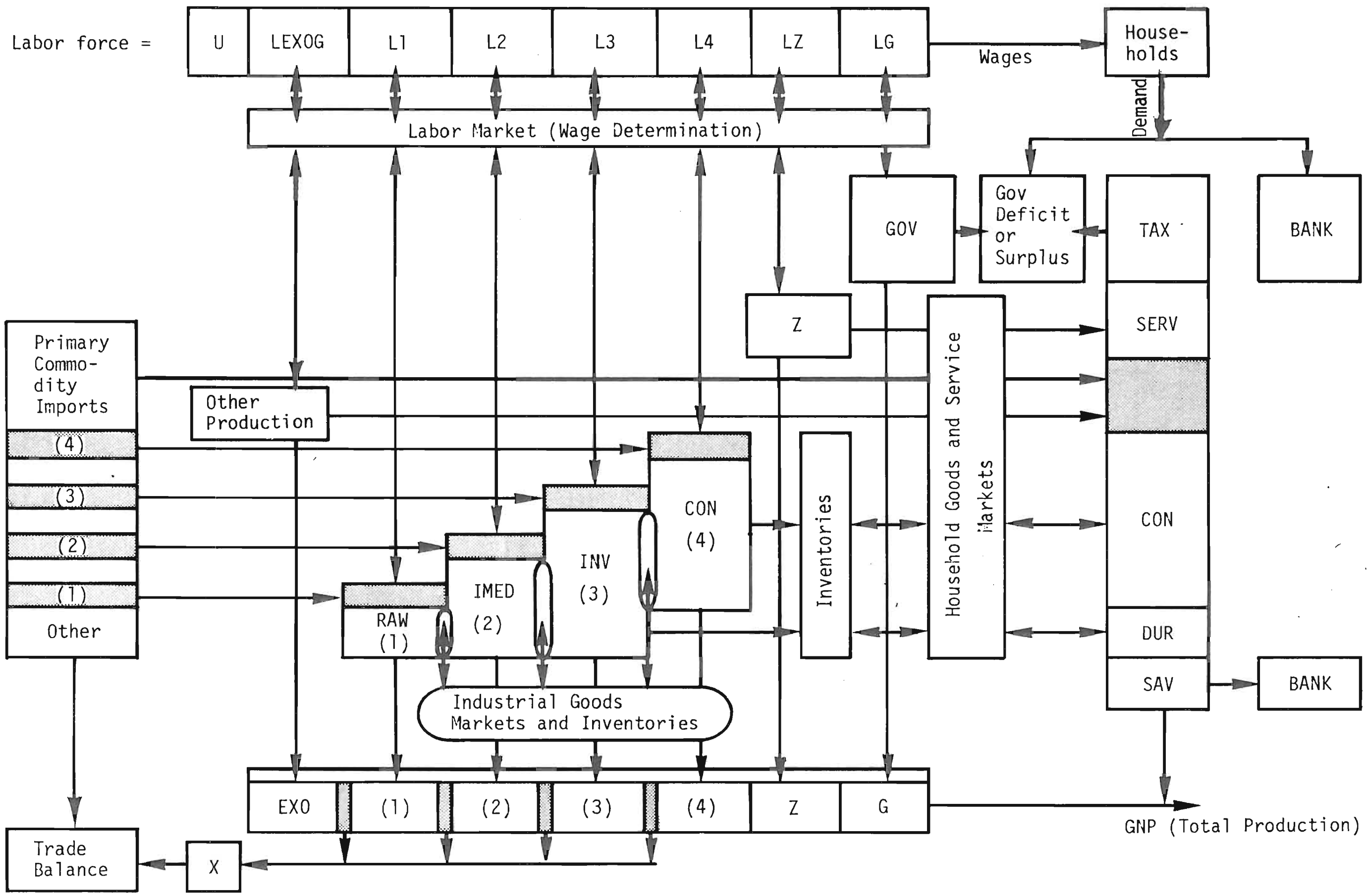


Figure 2 Business Decision System (One Firm)

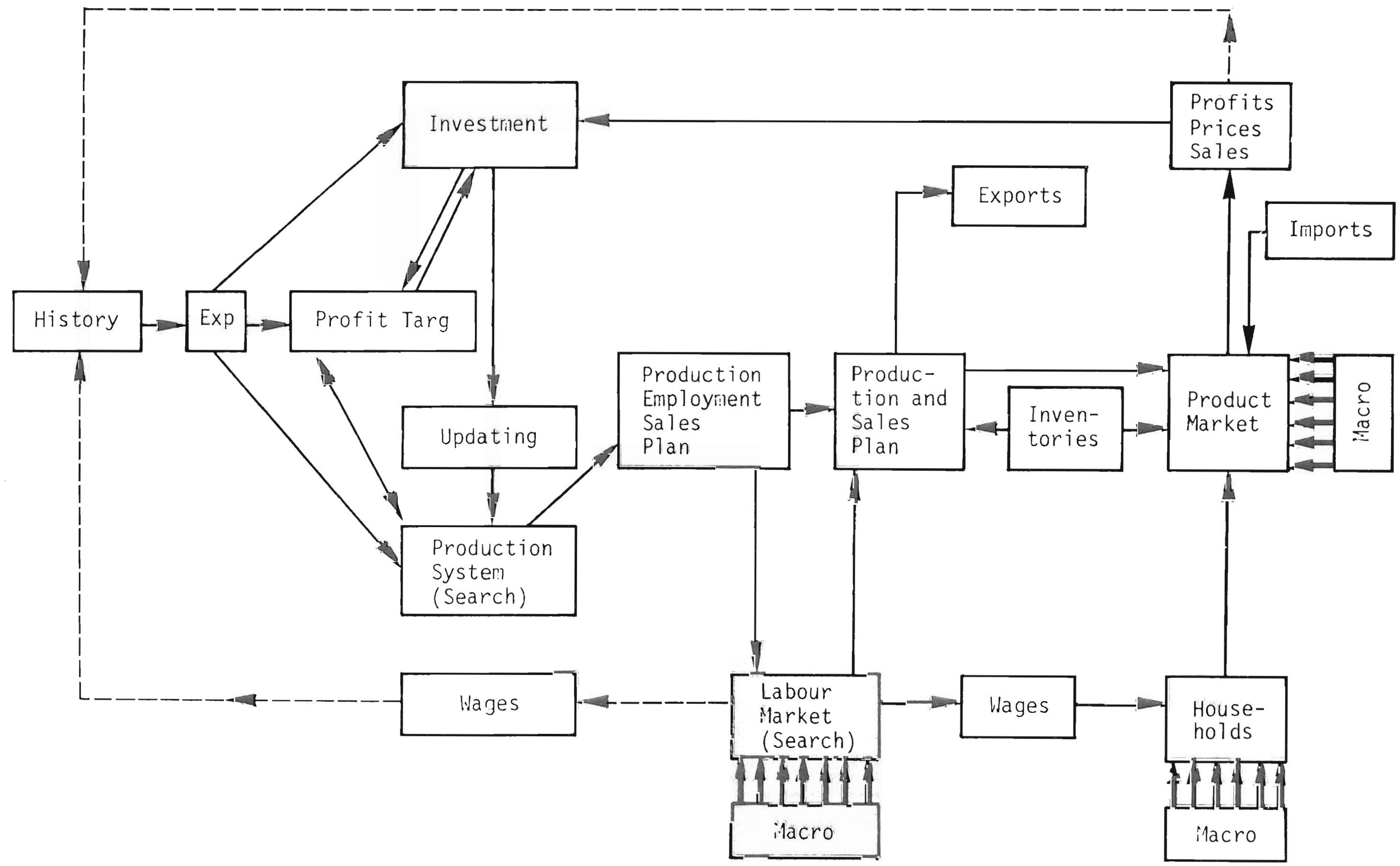
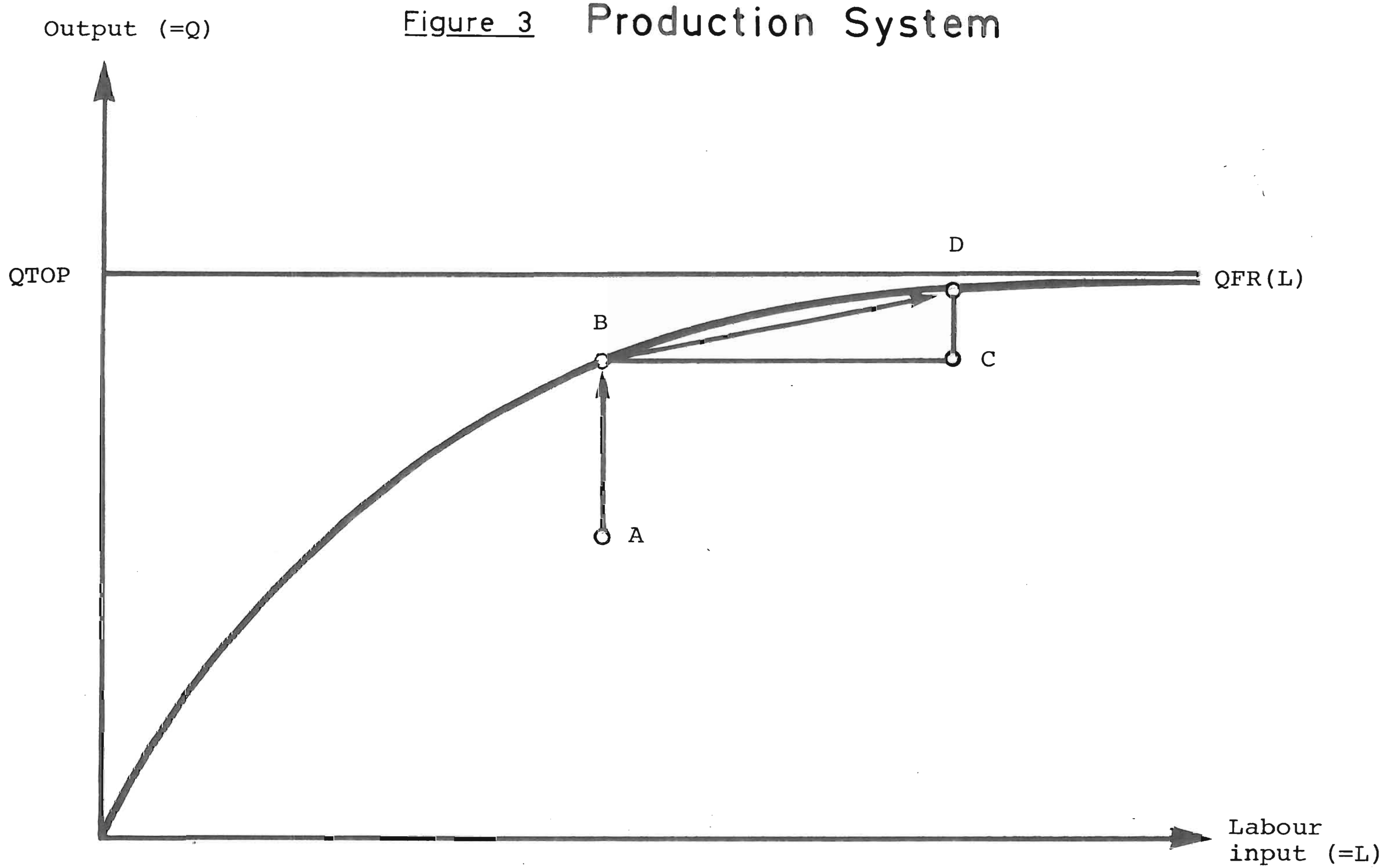
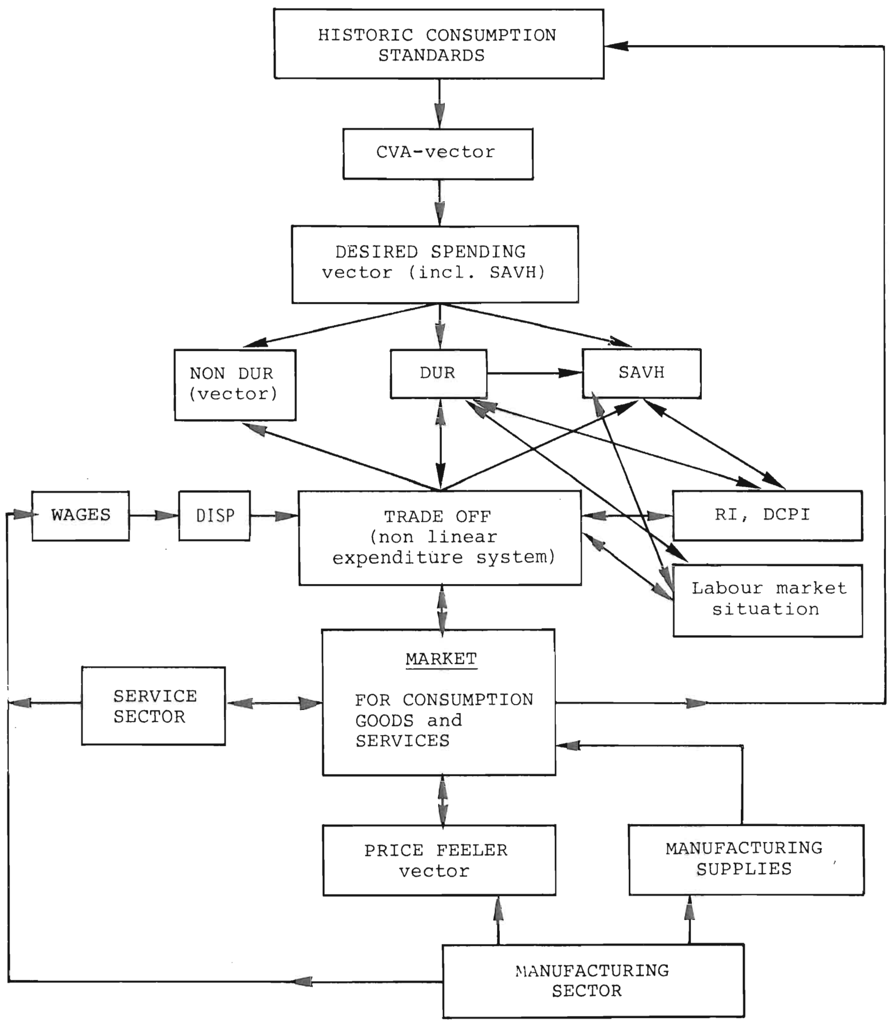


Figure 3 Production System



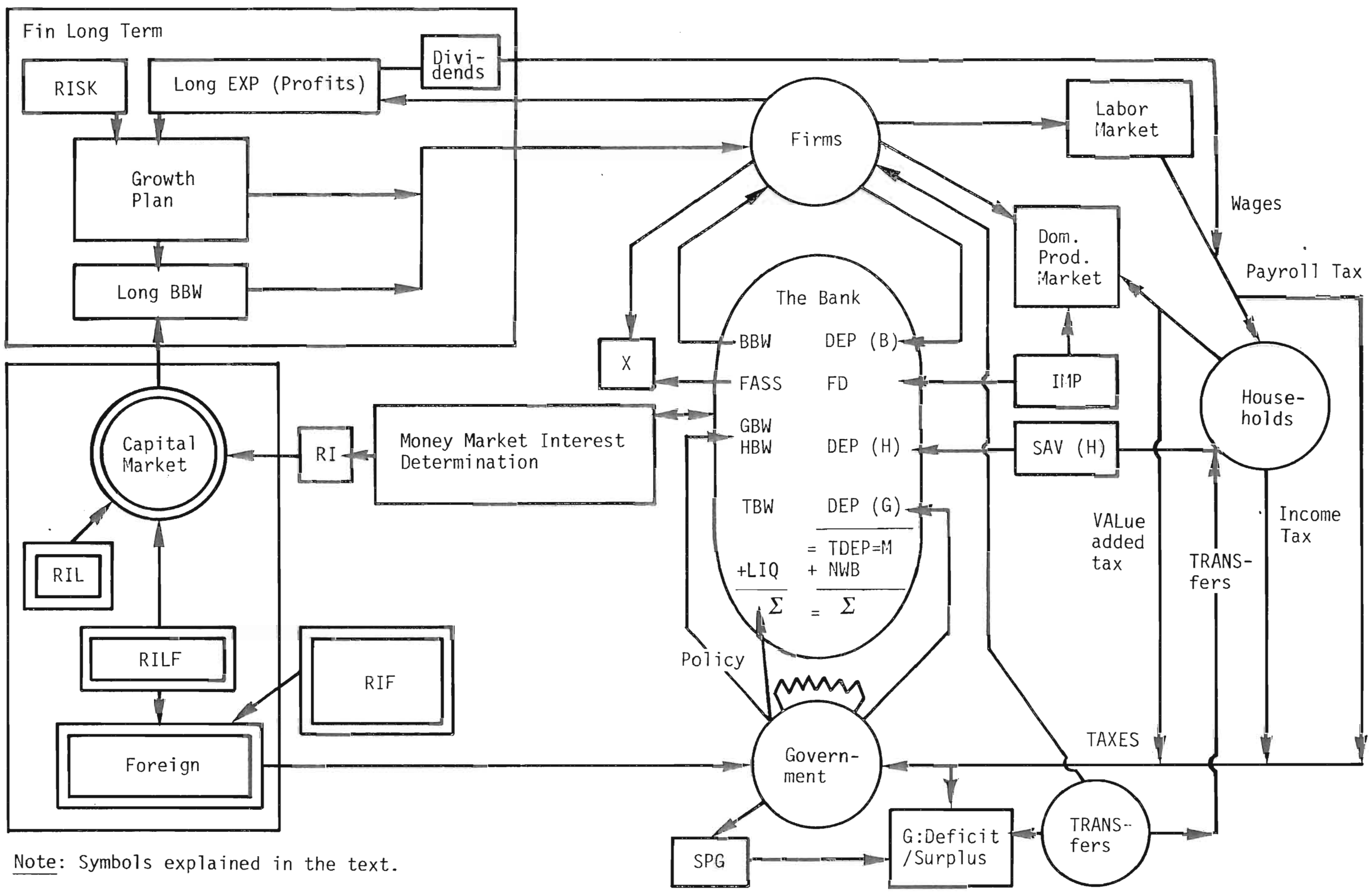
Note: Also see pp. 63 ff.

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 <u>coded</u> 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) } Horizontal trend
Capacity utilization rate (SUM) }

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.

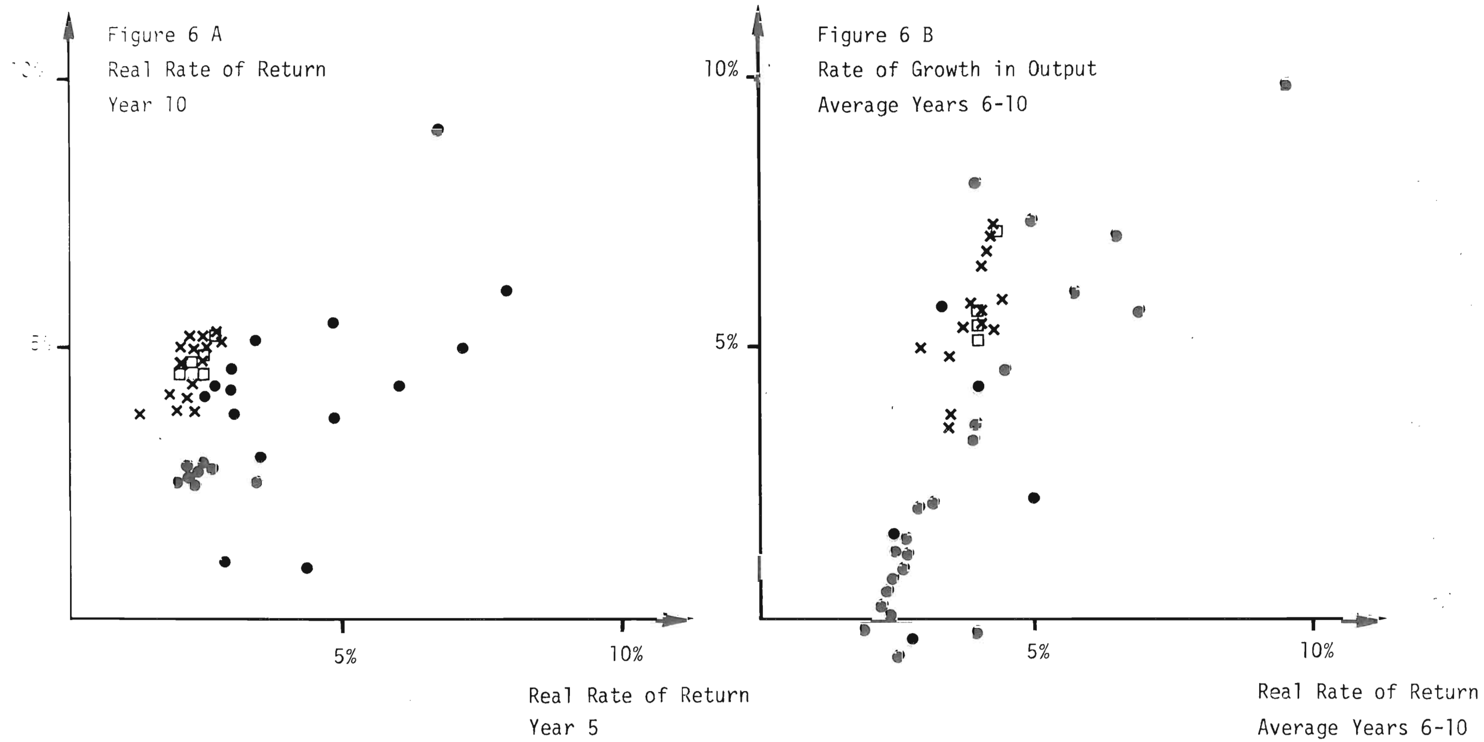
---

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

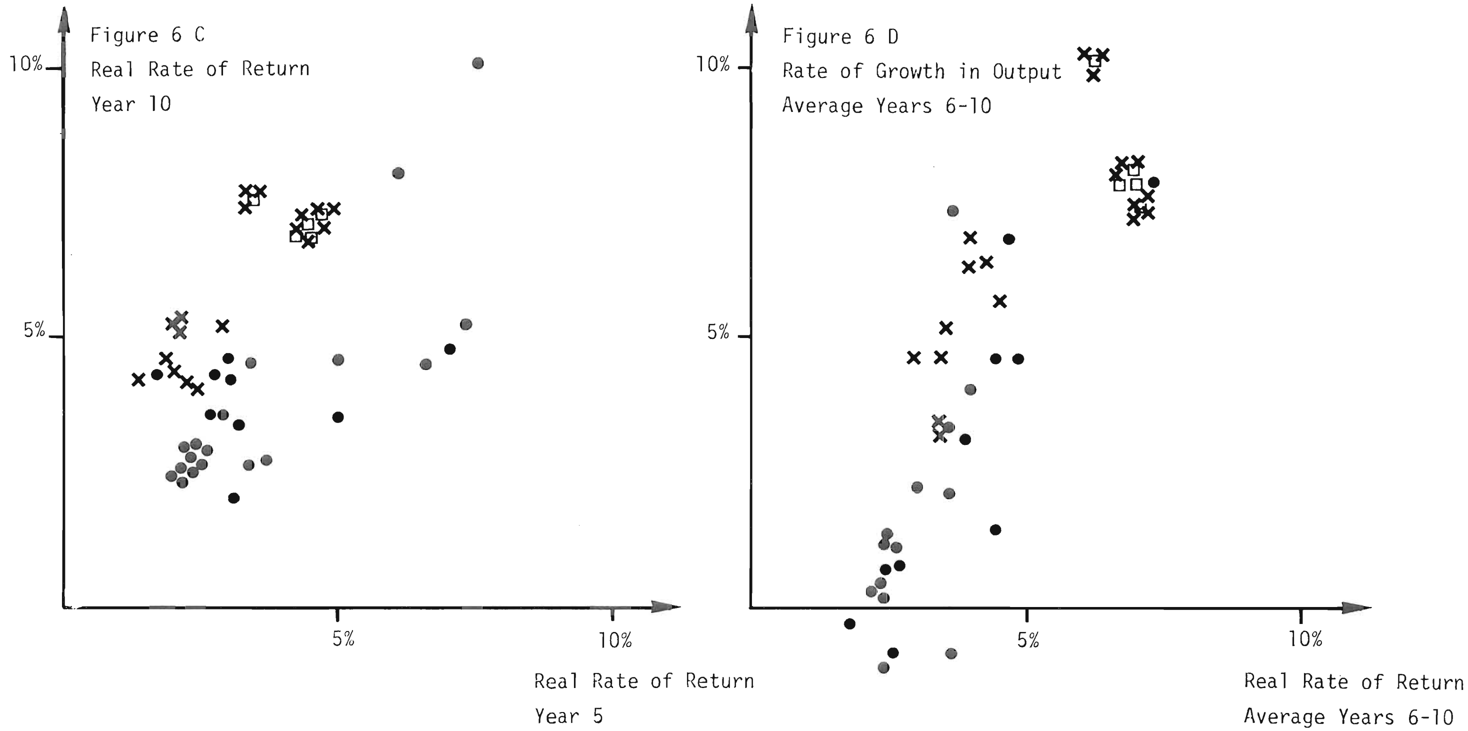
Entry of New "Average" Firms in Market for Intermediate Products



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

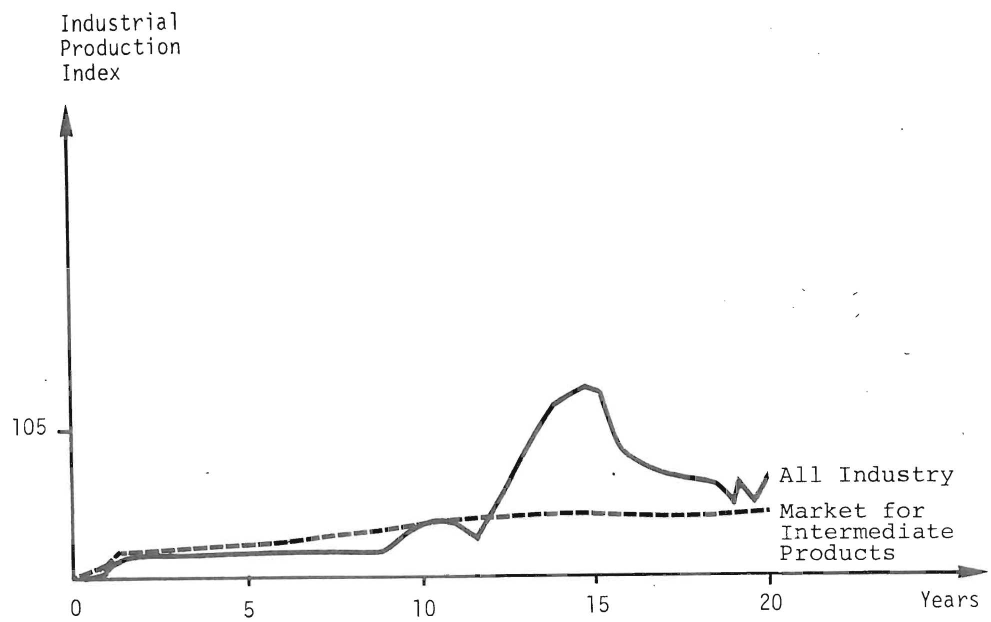


Figure 6E finally pictures the industrial production effect of the new (average, this case) entrants. Both output curves are compared on index form with a reference case. As one can see, the output effect is positive and slowly growing as expected. One interesting thing happens in year 13 when new capacity 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

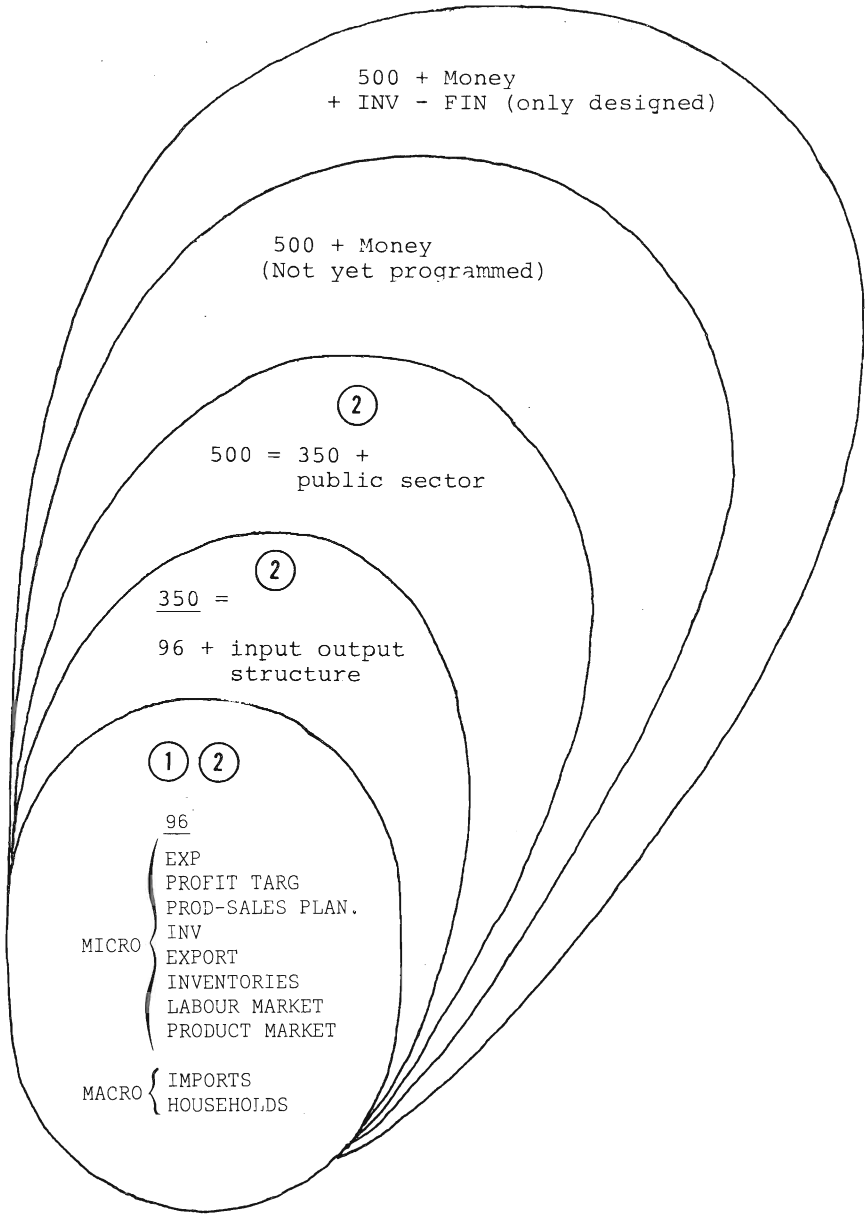
This section highlights some "analytical" features of the so called 96-version of the Swedish micro-to-macro model. A full and quite extensive presentation is found in Eliasson (1976 b, chapters 2 through 8). This presentation does not include more than the most important behavioral and market specifications 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)

$K2 \equiv A-K1$ = 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 ($BW/NW=\varphi$).

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)]

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

$$TARG(M) := (1-R) * MHIST * (1+\varepsilon) + R * TARGX(M) \qquad (1.1b)^{2)}$$

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

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

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).

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

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

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

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

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

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).

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

β * 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,

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

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

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

If we define

$$TEC = \gamma * QTOP \qquad (3d)$$

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

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

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 [= $CHQTOP * \left(1 - \exp\left(-\frac{MTEC * L}{CHQTOP}\right)\right)$] 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]:

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

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

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.

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

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

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 <u>total model</u> would be an ideal instrument for probing deeper into that controversial issue, if one so wishes.

4.5 <u>Production solution search</u>

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 <u>PLAN</u>:

---

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

START

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

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

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)$\in$ (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 $\Rightarrow$ PLAN(Q) $>$ Q(B) $\Rightarrow$ 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 <u>rational</u> 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 <u>rational</u> 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 <u>if</u> 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

$$\text{PLAN}(Q,L)$$

and the offering wage

$$\text{QFFER}(W) := W + \text{IOTA} * [\text{EXP}(W) - W]$$

$$\text{PLAN}(Q) \geq 0$$

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 ⇒ pool of unemployed ⇒ [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).

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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: = $(1-\rho)$*(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 ≥ 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.

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)

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

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

WH = household wealth

SWAP-function

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

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) $SP(6) = SAVH \equiv DI - \underset{(1,5)}{SUM}[SP(i)]$ (8g)

Consumer price index

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

SUPPLEMENT: PROOF OF SEPARABLE ADDITIVE TARGETING FUNCTION

Assume no taxes.[1)]

Cash flow identity

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

Definition of gross investment spending:

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

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:

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

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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