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TECHNICAL CHANGE, EMPLOYMENT AND GROWTH

Experiments on a micro-to-macro model of the Swedish economy

by
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Förvaltningsbolaget Sindex, Stockholm 1980

FOREWORD

The present study is one of three IUI papers presented to the symposium on Industrial Policies for the 80's arranged by the Spanish Ministry of Industry and Energy in cooperation with the O.E.C.D. in Madrid, May 5-9, 1980. Partial financial support from the O.E.C.D. and from the Swedish Government Committee on Computers and Electronics is gratefully acknowledged.

The paper is part of a larger study which the Institute is conducting for the Committee. Professor Jim Albrecht, Columbia University and Thomas Lindberg at the IUI have designed and carried out the computer simulations.

Stockholm, May 25, 1980

Gunnar Eliasson

1980.12.30

TECHNICAL CHANGE, EMPLOYMENT AND GROWTH

Experiments on a micro-to-macro model of the Swedish economy[1]

1. Introduction

The potential impact of automation and technical change on employment and industrial structure has been the cause of much concern recently in the wake of the drawn-out world recession. For instance, the dramatic advances in micro processor technology and applications have given rise to much worrying among labor organizations in the "old" industrial world, and forecasts of a large and permanently unemployed fraction of the labor force have been presented.

On the part of governments both the unemployment side and the threatened competitive position of domestic industries have been in the focus of attention. Industrial policy making is the fashionable key word to a solution, and vast amounts of subsidies have been, or are being, poured into (for instance) the industries of West Germany, Britain, France and other countries to counter the so-called electronic threat of Japan and the U.S.

The basic assumption may be very correct. A grand leap in technology (especially electronics) and its applications will probably cause an enormous change in industrial structure across the world over the next few decades.

Much of the concern seems, however, utterly biased towards the creation of a partial, short term and perhaps quite misconceived picture of the consequences. One question is whether in fact (as has been argued) electronics acts primarily on the supply and pro-

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[1] An earlier draft from February 1979 has been circulated selectively.

duction of goods and services and if so, if this will lead to a cumulating unemployment problem that is not strongly countered by indirect demand creation and relative price change through structural adjustment.

Similarly, progress in the electronics field both on the technology and the applications side is extremely differentiated and subjected to a very fast rate of change. This together makes the suggestion that centralized governmental planners should have the overview and competence to make a safe and correct advance choice of which way to step to gain an informed initiative look somewhat overambitious and possibly dangerous to the national economy in question. The danger is that growing industrial policy ambitions and efforts in the old industrial world may detract attention from the importance of the natural adaptive mechanisms of a market economy. They may even hinder the structural adjustment process that would take place in the absence of those industrial policies, and prolong and worsen rather than soften the agony of structural change towards the new, "post oil crisis" economy - for the character of this economy is determined by the global competitive situation among trading economies rather than by national preferences or local options.

The problem of creeping industrial senility among mature, welfare economies that resist change by policy making will be left aside in this paper. The purpose of it is to highlight three closely related aspects of an externally (exogenously) imposed adjustment process caused by technical change in a broad sense, and to frame the discussion in such a way that we cannot forget or overlook the important effects on the total economic system of such changes. There is nothing new in principle in this statement, as in much of economics; only the form of demonstration and the method of quantification. For this case, we need a large scale econometric model of an entire national economy equipped with essential dynamic mechanisms across economic agents in markets and over time. The most important aspects of this model are:

(1) That the immediate and the longer term employment effects caused by domestic technical change of a general nature are very different since technical change usually generates both growth in capacity and in demand and hence new employments, at least with a time delay.

(2) That the nature of the market resource allocation mechanisms in the economy are important in determining the size and nature of economic systems effects from local or general shifts in technology respectively. We will investigate this proposition by comparing the total effects from an industry-wide, a sector-wide and a local, one-firm technology shift.

(3) That the effects on employment and on industrial structure from other countries adopting technical change faster and forcing local firms out of business in export and domestic markets through price competition may be far more severe than those occasioned by domestic (endogenous) technical change.

These properties of market based industrial economy can be demonstrated through very long (20 to 30 years) simulation experiments on a micro-to-macro model of the Swedish economy developed at the IUI. During such a demonstration, the economic argument, as defined, will be illustrated numerically in the micro-to-macro model. What is new with this model in this context is that resource allocation (labor, capital, technology) is explicit between firms through an endogenous market price mechanism. There is an important feedback from profits into investment, capacity growth and market supplies from individual firms that is normally missing in macro based, production-function-oriented structures.

Furthermore, the model has an explicit market price allocation mechanism that directs investment towards those firms that can make best economic use of it. It tracks Swedish growth and structural change over the period 1968-75 quite well, and price, wage and profit change very well. The cyclical pattern is typical, but not well mimicked over historic time. To the author this means that the time response coefficients of the model are not yet properly set, but that given time the long run growth patterns are picked up well anyhow. Extensive empirical work on the model is currently under way at the institute. In the first round an entirely new individual firm data base for the years 1975 to 1979, based inter alia on the planning survey of the Federation of Swedish Industries, will be created. This will considerably improve our knowledge of the micro structure of Swedish industry and allow the estimation of several firm parameters that have so far been outside reach of conventional econometric techniques.

In Appendix 1, a brief overview of the workings of the entire system is given together with references to publications on the model.

2. The Technical Change Factor

The total model operates under an upper technology constraint in the sense that the quality of new investments at the individual firm level (measured by labor productivity) is upgraded at an exogenously set rate, in the following called DMTEC. Measures on these rates for some production lines in Swedish industry have been obtained for the first time for the periods 1955/65 and 1965/75 (10 year averages) in a recently concluded joint research project between the IUI and the Swedish Academy of Engineering Sciences, and in several follow-up case studies on individual firms in progress at the IUI. Actual growth in output and productivity of individual firms, sectors and the entire economy, however, depends on how much is invested, in which firms investment takes place, and how efficiently equipment is used. The maximum output of one unit of investment, furthermore, is also governed by marginal capital output ratios (called INVEFF) that are individually assigned for each firm.[1]

3. Simulation Results

The introductory argument was that technical change may affect a country in many different ways; universally through foreign price competition, domestically in all industry, in a sector or in a few firms only. Also, total system effects and the speed and character of the structural adjustment process depend on how and where these effects originated, and how efficiently competition in the markets forces the structure of the economy to adjust.

a) Universal technical change at uniform rate in entire industry

The first Diagram 1 illustrates the output effects (industry) from a universal ±1 percent extra (faster) rate of technical change (DMTEC). The variables are in index form, the base being the same variable in a reference simulation scenario. Index 110 hence means that the experimental run that year generated an output level 10 percent above that in the reference case the same year.

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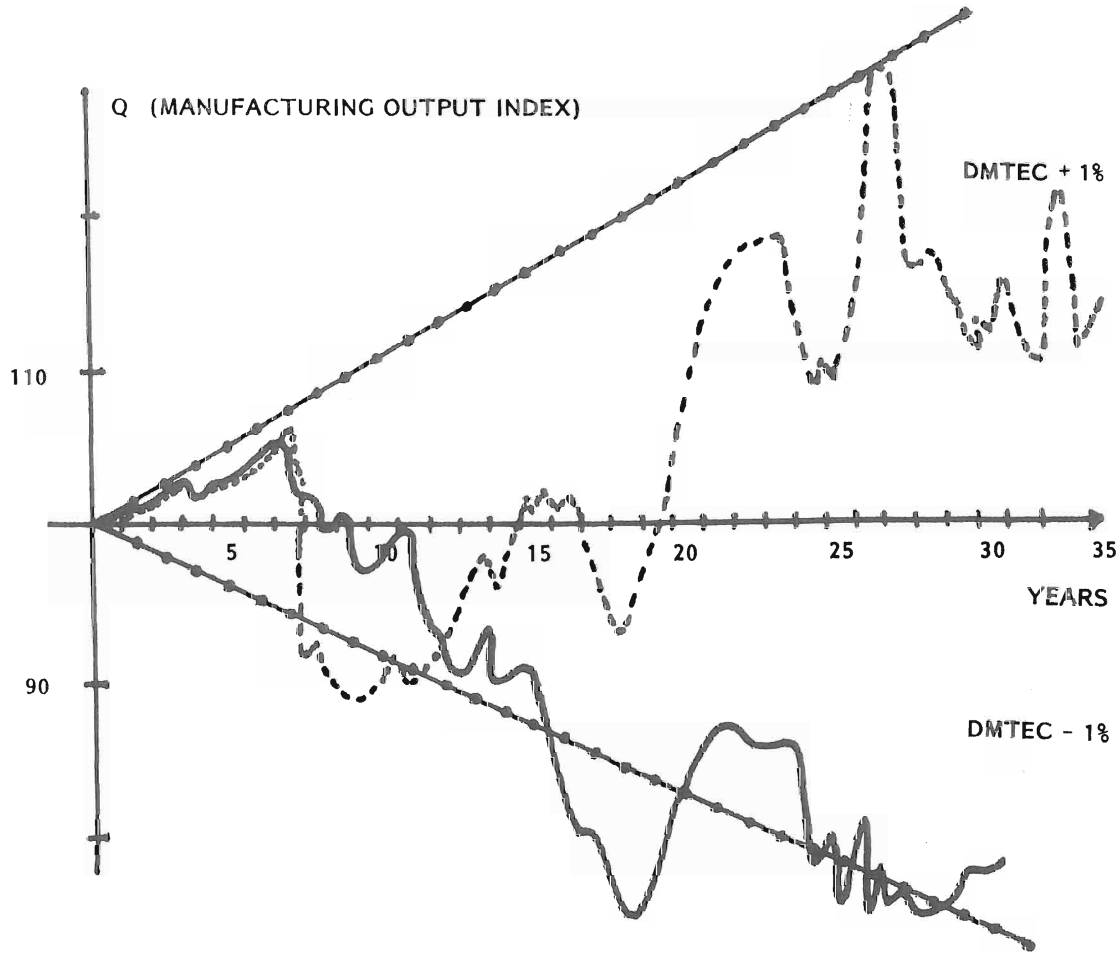
[1] The necessary specifications needed to understand exactly how technical change enters the production system of one firm and since empirical measurements are presented in Carlsson-Olavi, "Technical Change and the Longevity of Capital in a Swedish Simulation Model" (in Eliasson, A Micro-to-Macro Model of the Swedish Economy. IUI Conference Reports 1978:1); in Eliasson, "Relative Price Change and Industrial Structure - The 'Norwegian case'; and Albrecht, "Production Frontiers of Individual Firms in Swedish Manufacturing 1975 and 1976" (both in Carlsson-Eliasson-Nadiri, The Importance of Technology and the Permanence of Structure in Industrial Growth. IUI Conference Reports 1978:2).

DIAGRAM 1

EFFECTS ON TOTAL MANUFACTURING OUTPUT IN THE TOTAL INDUSTRY FROM GENERALLY SPEEDED UP AND SLOWED DOWN TECHNICAL CHANGE IN NEW INVESTMENTS



NOTE: INDEX = 100 = REFERENCE RUN

The straight lines tell the change in potential output at full capacity operation of the entire industry at each point in time when all (new and old) installed capacity is upgraded or downgraded with the same extra amount of technical change.

Consistent with the general set of properties of the model, the change spins off a cyclical pattern represented by the curves, along upward and downward sloping trends. The upward trend is lower than the straight line, as it should be, since in this case only new investment vintages are technologically upgraded. The juvenilization of machinery and equipment depends, of course, on the rate of investment.

In the downward technical change experiment[1] on the other hand, the downward output trend more or less follows the straight line. This is not as easy to understand since the experiment implies that firms are equipped with a better average technical standard (in both cases, old investments are neither up- nor downgraded), than the straight line implies. The result therefore suggests a worsening of the efficiency and/or capacity utilization levels of the industry sector due to the negative technical change imposed on the whole economy by the slower absorption of technology - a property that is never or seldom featured by the existing repertoire of model structures.

What in fact happens is that the slower technical change imposed makes firms less competitive in foreign markets (characterized by exogenously assumed price levels). To some extent, this is countered by an adjustment in the real wage level (since technical change is universal), but the remaining effect forces firms to reduce investment since profits come down, and also to reduce operating levels.

[1] Note that technical change is not negative. It is negative compared to the base reference case (Index=100); that is, slower than in the base case, but still positive.

On the employment side (Diagram 2) the new cycle is again present but this time around a horizontal trend line. Quite in keeping with general expectations, employment is down in the short term (2 years) as the immediate consequence when new, better techniques are being introduced, and vice versa for as universally deteriorating technical level. After ca two years, the effect reverses substantially in both cases, and a cyclical impulse is moved forward in time with a long term employment effect amounting to zero. The results suggest that beyond the immediate, and expected, two year impact effect, no detailed conclusions should be drawn from the diagram except that the long term effect on employment is roughly neutral. Since the underlying reference run also exhibits an employment cycle, the swings exhibited by the simulation convey no welfare implications on the employment side, except that the employment effects are somewhat differently located in time compared to the reference case. The seemingly violent swings that occur after ca 15 years depend on a temporary reinforcement of the base cycle in the reference case, caused by the technical change.[1] During the next decade the new, superimposed cycle dampens. Underlying these "anonymous macro results" is the fact that the composition of labor and its distribution among jobs and firms of course may have changed substantially with time together with the entire relative factor and product price structure. Structural change is so to speak endogenous in the model economy. Some further illustrations of this will be presented below.

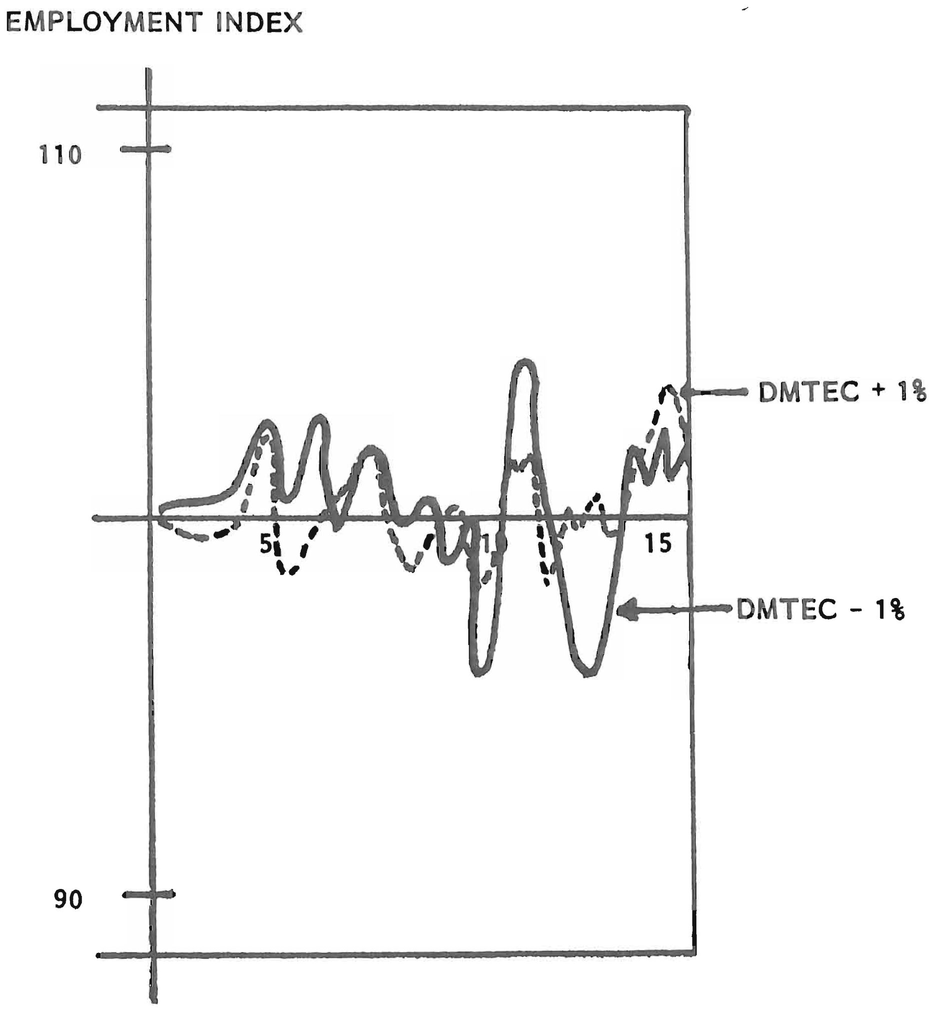
b) Universal technical change relative to foreign production in one market only

The previous experiment dealt with a universal change in technology. Diagram 3 shows what happens to output when one sector

[1] Any change could generate that effect. Also note the scale.

DIAGRAM 2

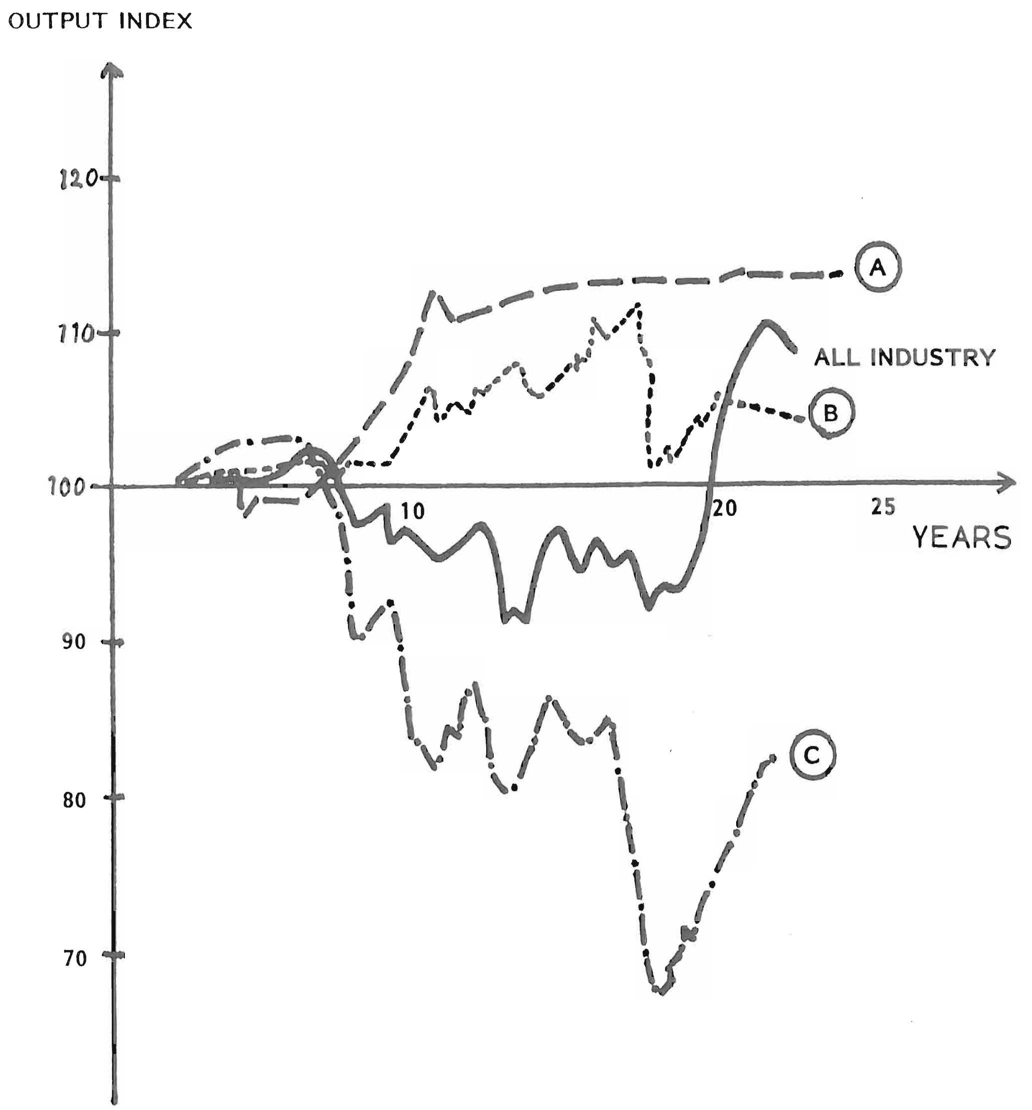
EFFECTS ON INDUSTRIAL EMPLOYMENT IN THE TOTAL INDUSTRY OF GENERALLY SPEEDED UP OR SLOWED DOWN TECHNICAL CHANGE



NOTE: INDEXES AS IN DIAGRAM 1

DIAGRAM 3

EFFECTS OF TECHNICAL CHANGE ABROAD THROUGH PRICE COMPETITION IN CONSUMER GOODS MARKETS AND CORRESPONDING DOMESTIC TECHNICAL CHANGES IN CONSUMER GOODS PRODUCTION



INDEX : AS IN DIAGRAM 1

(consumer goods industries, accounting for close to 25 percent of Swedish manufacturing output) is selectively and symmetrically (all firms equally) either affected by a one percent extra worsening of its foreign (export) price level each year, or a one percent extra improvement of it, depending on its own technological progress relative to that among foreign competitors. The first case thus illustrates a "lagging" industry that is hurt by foreign competitors that pick up the new technologies faster and exploit them by lowering prices.[1] The domestically oriented consumer goods sector is affected directly in foreign markets but also indirectly at home through correspondingly cheaper import competition.

The two cases are not fully on quantitatively compatible terms, but they nevertheless illustrate the dynamics of the effect transmission.

Technical change of 1 extra percent per year (±1% DMTEC), now only in domestic consumer goods industries, takes a long time to generate a larger output level. This is the way firms behave in the model and presumably in reality. Not until competitive or cyclical pressure is brought to bear on the market is the potential fully realized.[2] This happens in year 1 and gives rise to a strong upswing in real sector output (line A in Diagram 3). The positive effect on total industry output begins earlier, since the consumer goods sector initially releases labor (with lowering output) and makes it available for other sectors (line B).

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[1] On the foreign side the assumption corresponds to saying that all foreign competitors upgrade all their equipment along the upward straight line in Diagram 1 or that marginal producers entering the international markets with new upgraded equipment set the international price.

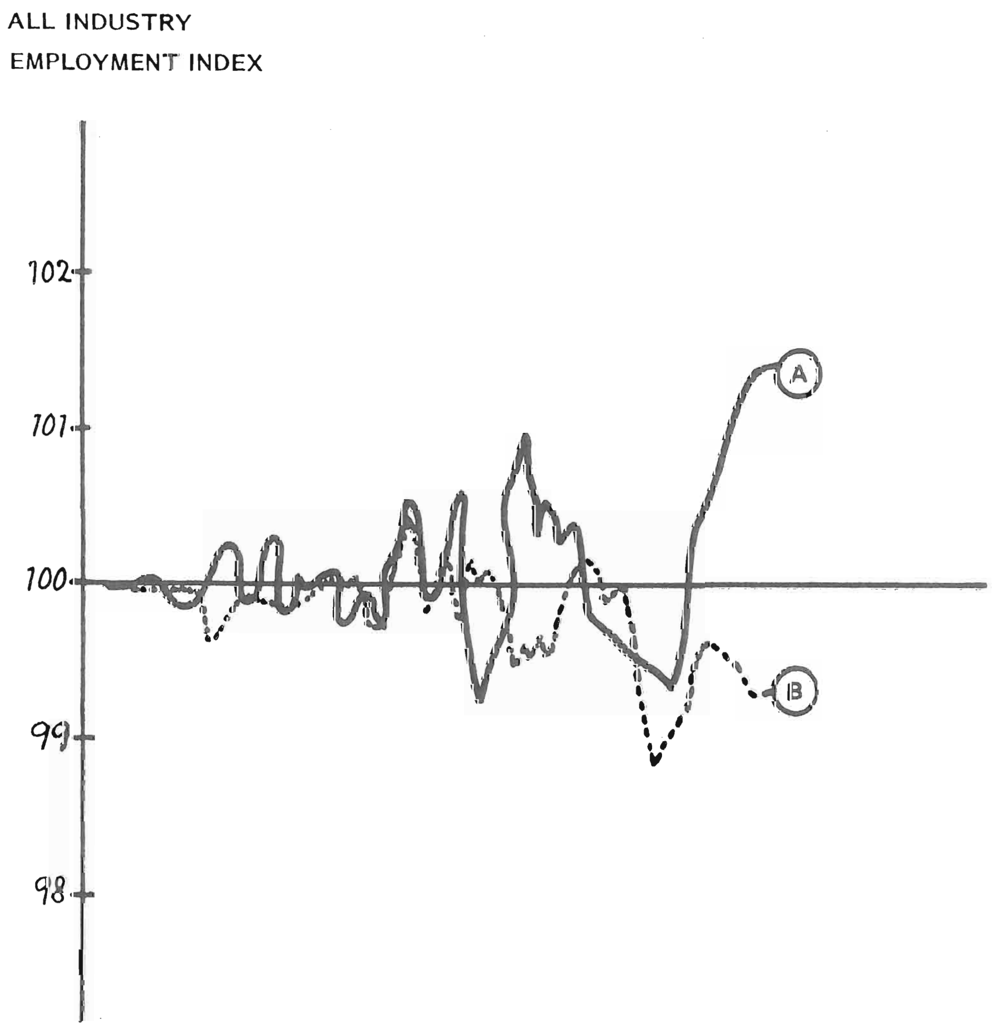
[2] The same effects appear in the relative price change simulations on p. 72 ff in Carlsson-Eliasson-Nadiri (1978), op cit.

The output effects from foreign price competition on the other hand are much stronger (line C). In the model this is engineered by assuming that the domestic industry responds by lowering its export and input prices for consumer goods by one extra percent each year in order to stay competitive. The consumer goods sector first responds by growth (using existing capacity more efficiently), but in the longer term this does not help and profit motivated firms begin to reduce output and investment compared to the reference case.

Now quite interesting effects begin to appear, mainly through the labor market. After an initial downgrading of total industry output of fairly long duration, total industry output begins to increase again after some 20 years. The reason is obvious. Labor resources freed from the depressed consumer goods sector (say textile firms) are reallocated to new and more profitable and efficient firms in other sectors. Diagram 4 exhibits what happens at total industry employment levels (line A). What is particularly interesting are the small dips in employment in some quarters telling that a particular and fairly major firm in the consumer goods sector has shut down operations and laid off all labor.

By one or not more than two quarters later, all laid-off labor has been absorbed by other expanding firms. Shutdowns, of course, occur also in the expansive technical change experiment, although not as frequently, and one can observe that the absorption of laid-off labor is faster in a more pronounced growth environment (line B in Diagram 4). These effects come in two ways. Layoffs mean, at least in the model, that labor is supplied in the market and that it is also forthcoming at a lower real wage change than is needed in a tighter labor market. This effect feeds back into the model, positively, via rising profits and thereby into more investment and expansion of both output and employment. Later experiments on the model have in fact demon-

DIAGRAM 4



A : FOREIGN PRICE COMPETITION IN CONSUMER GOODS INDUSTRIES

B : TECHNICAL CHANGE IN CONSUMER GOODS INDUSTRIES strated that tax stimulated investments and the maintenance of production in relatively low efficiency production clearly retards growth in other, more productive sectors through an artificially high wage level being maintained in the low productivity industries. This makes wage incentives for labor to leave these sectors. However, there are neither negative nor positive long run total employment effects. It all impacts labor through a slower growth in real income. This is a symmetrical effect quite in keeping with the above mentioned effects on employment through technical change.

c) Technology shift in one firm only

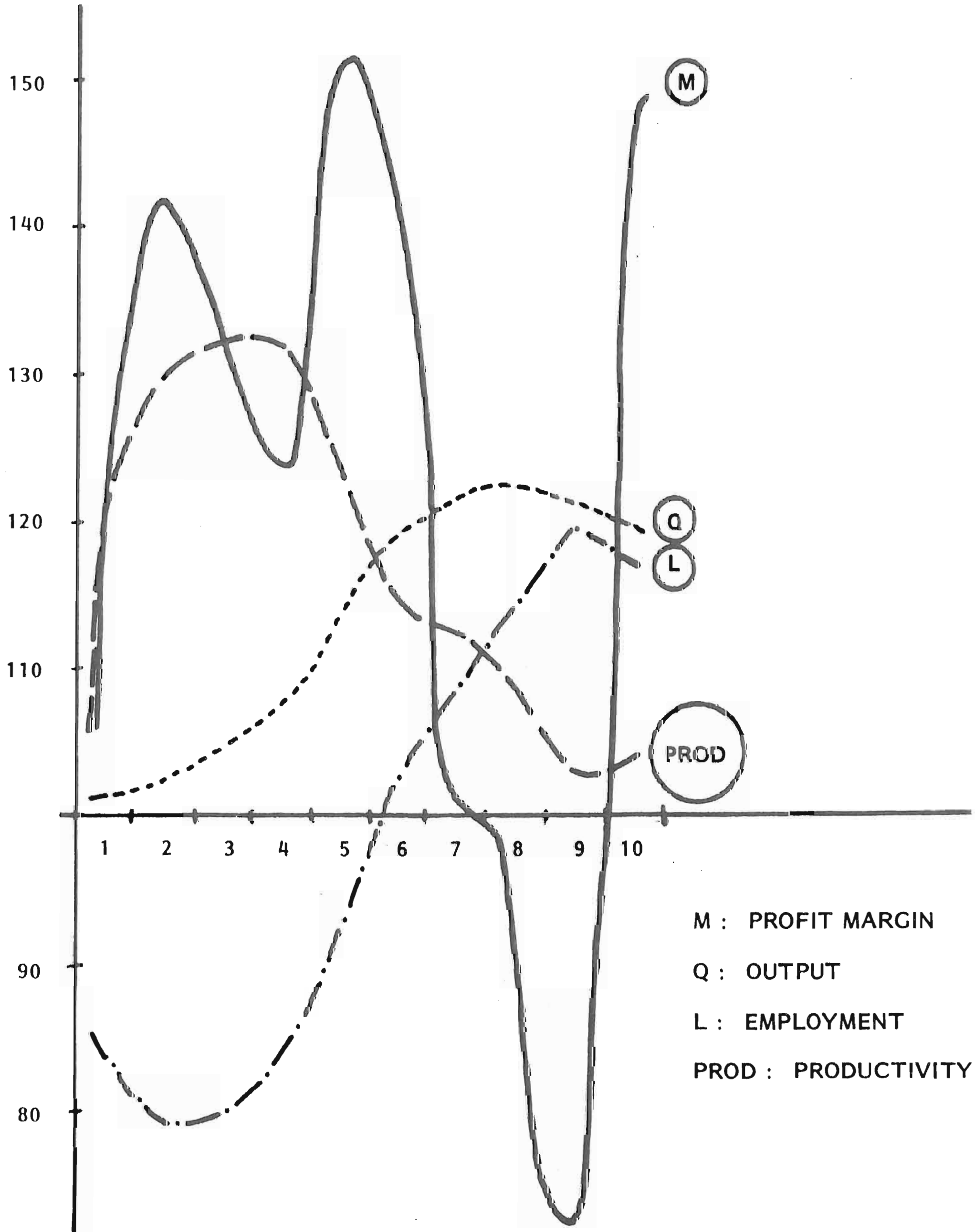
This time one firm has been picked from the investment goods sector, which accounts for ca 5 percent of output in that sector. Compared to the reference run, a large investment program was "imposed" upon the firm in the first year (five times that in the reference run). Investments, furthermore, were made 50 percent more efficient than in the reference case in the sense that each unit of investment added 50 percent more output capacity at the same level of labor input as first year investments in the reference case. From then on, the model firm was allowed to behave as before according to the model mechanisms, and on the same data.

Note the following things from Diagrams 5 and 6. The firm experiences a strong improvement in productivity and profit margins. Wages are set by the entire economic system through an efficient labor market arbitrage. Hence superior profit performance of one firm affects market wages only marginally. The firm wage level has to be raised somewhat above the market wage level through wage drift, if the firm wants to expand its employment. This firm, however, does not need new labor to begin with

DIAGRAM 5

TECHNICAL CHANGE IN ONE FIRM - FIRM EFFECTS

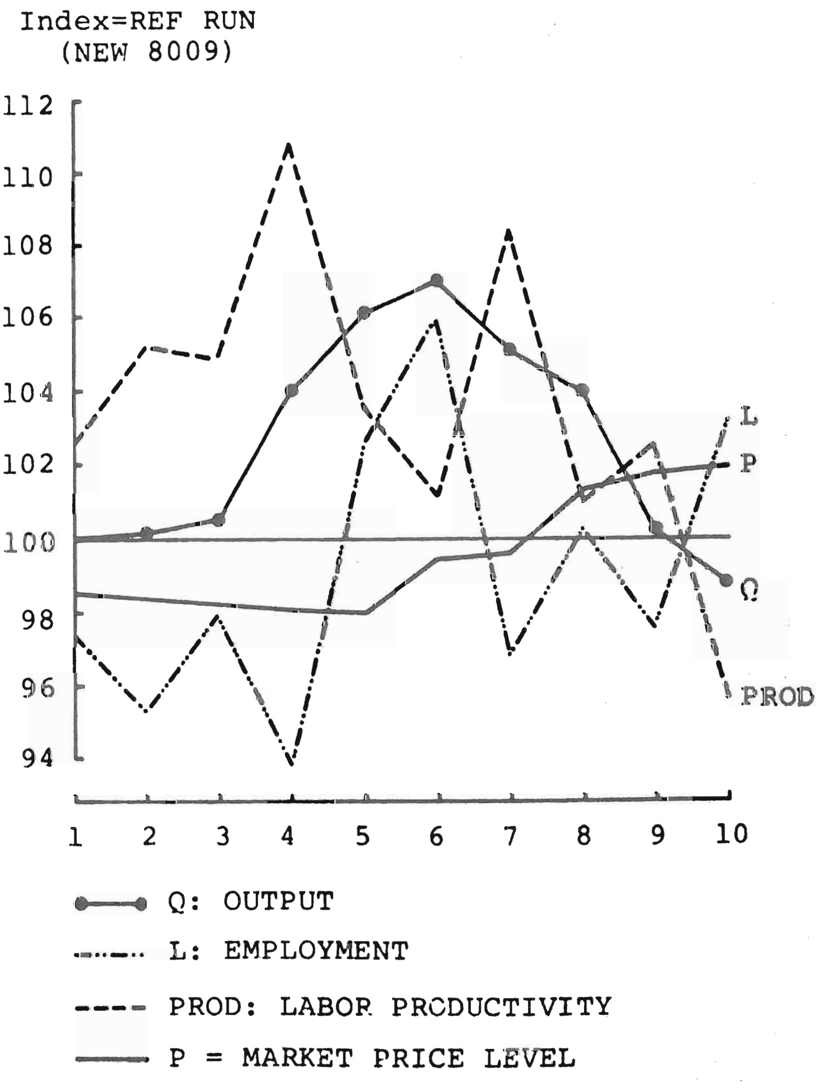
INDEX (ON REFERENCE CASE)



NOTE: INDEX COMPARES FIRM WITH ITSELF IN REFERENCE RUN

DIAGRAM 6

TECHNICAL CHANGE IN ONE FIRM - SECTOR EFFECTS



since there is an inevitable lag in the model before a firm can capture the new competitive potential by speeding up growth. Employment in fact decreases as a start, since all labor is no longer needed.

The interesting impact effect is the lowering of the entire market price level through supply competition of only this one firm (Diagram 6). This result can be compared with the effects on the domestic economy (Sweden) from technical change abroad manifesting itself in foreign price competition as described in earlier simulation runs. The firm is slow to capture its new potential. It reduces employment and limits further investment spending, idling away on its superior techniques. Eventually, management cost control slackens and the initial productivity edge created by the initial "super efficient investment" begins to erode away fast from year 5 and on. The lowered price level persists in the industry, and eventually the sector as a whole is back where it started, with a smaller number of production units. Some smaller inefficient units have been competed out of business by the firm, which is now (after 10 years) just above 20 percent larger than its original size. It is, however, not more efficient any longer compared to its own performance in the reference run (Diagram 5).

This case illustrates a corporate cycle which is not uncommon, where the failure consistently to protect a position of technological leadership - due to management laxness or other causes - could lead a corporation into a crisis situation in a fairly short period of time.

4. Conclusions

Our simulation runs do not yield any pathbreaking new insights. They do, however, demonstrate the existence of some total economic system responses to technical change of such a nature that we cannot deny their real existence out of hand. Perhaps the simulation runs also give a good indication of the size and time dimension of these effects, although the model is not yet ready for quantifications of this kind, except in some restricted applications. So this is all we could hope to achieve at this step.

One conclusion is that employment will be more or less full in the long run. It rests on well established dynamic principles of economics, embedded in the model and substantiated by observation. The job composition in the labor market may, however, change substantially.

One clear conclusion is that it is far worse for employment in a country during a medium term adjustment period to see technical change appear through price pressure from foreign competitors than to see fast technical change originate in leading domestic industries. In the latter case indirect demand growth effects (domestic and foreign, through efficient price competition) dominate over rationalization effects on the employment side, except for a brief transitory period.

Technical change of the kind investigated will be absorbed in the long run by increases and decreases in real income, and the speed of the adjustment to changing circumstances very much depends on the rate of growth in the economy; that is, on the opening up of new job opportunities elsewhere in the economy. Hence, the duration of unemployment caused in particular places is very brief in a growth environment, characterized by a flexible market adjustment process, but may extend longer in time in a stagnating economy. The worst case for employment is stagnating demand and strong price pressure from abroad in combination with a slow reallocation of labor resources. One reason for a slow adjustment may be subsidies to commercially less viable production supporting an artificially high wage level in such lines of business, that makes it less attractive for labor to leave. Such market imperfections both prolong unemployment situations and slow down growth. However, in the longer run, as stated already, the market sees to it that employment is more or less full. The fundamental conclusion is that the speed of market adjustment to changing competitive circumstances determines the time profile of both the labor and the real income effects.

The model simulations hence do not support the contention that large disequilibrium situations (like mass unemployment) will be maintained for long in an economy where market price mechanisms are allowed to function reasonably well. Technical change creates indirect demand through high wages and wages lag in depressed sectors (for instance due to technical superiority among foreign competitors) creating wage differentials between firms and sectors that stimulates mobility. If substantial unemployment situations tend to persist or worsen one may be more sucessful when looking for the reasons in the functioning of the total economic system and its markets rather than trying to pin-point particular factors like electronics or technical change to blame.

One operational hypothesis that emerges from this model excercise, that should be tested further, is whether industrial policy making, rather than being directed towards being involved in business decision making, should set as its objective to improve the efficiency of the market process in order to prepare an economy for and adapt its structure to rapid technical change. This partly involves seeing to it that inefficient firms or production units within firms are allowed to close down if they cannot meet foreign or domestic competition.

APPENDIX

The Swedish Micro-to-Macro Model - an Overview

The model is based on (1) a variable number of individual firm, production planning and investment financing models, that are (2) integrated (and aggregated) through explicitly modelled labor, product and credit markets, all being (3) constrained within the framework of a traditional macro model. The most important exogenous variables besides Government policy parameters are foreign prices (one index for each market), the foreign interest rate, and the rate of technical change (embodied in new investment and total labor supply). The model represents a disequilibrium economic system in the sense that markets are never fully cleared and stocks are seldom kept at desired levels. Rather, markets adjust each period towards equilibrium in discrete steps. However, this hypothetical equilibrium position moves from period to period and this movement depends on the paths all firms follow in their individual adjustments. Hence there is no determinate action in the model despite the absence of random mechanisms.[1] The prime guiding variables are the endogenously determined relative factor and product price structures.

The model has a very elaborately developed short-term and long-term supply side embodied in the individual firm planning process. There is a feedback, from the price and quantity outcomes in markets through profit determination and cash flows via rate of return and borrowing considerations to the investment decision in individual firms, that brings in new techniques of production. This makes structural change endogenous. There is another complete integration between a monetary sector and the real system.

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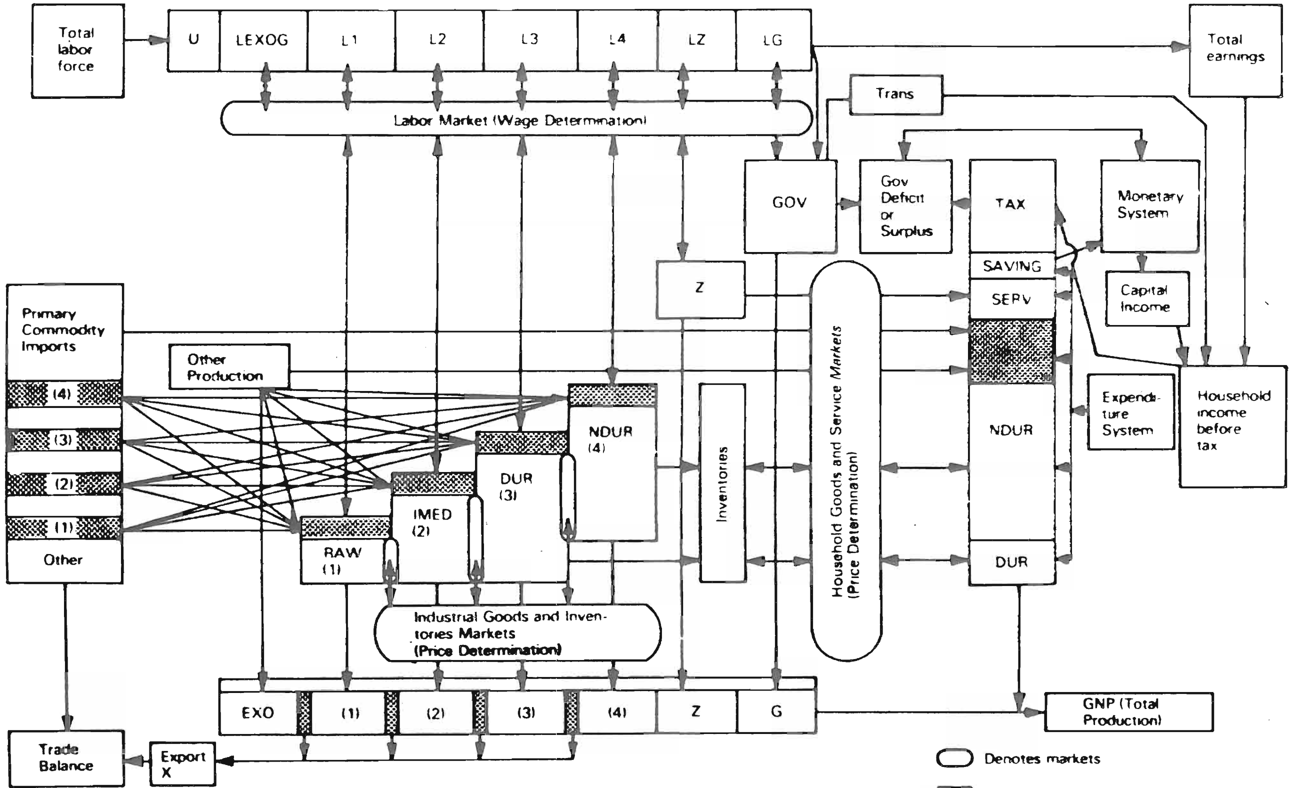
[1] There is one exception to this. See Eliasson, A Micro-to-Macro Model of the Swedish Economy, IUI Conference Reports, 1978:1.

This makes the model truly dynamic in the sense that growth is endogenously determined subject to a technology constraint. The micro model is combined with traditional Leontief input-output and Keynesian aggregate demand systems. Thus, price determination and income generation are combined in a theoretical (albeit numerical) model. The overall macro structure of the model system (excluding the monetary side) is shown in Diagram 7. The internal planning decision process of one individual firm is pictured in Diagram 8.

The model project requires substantial data base work at the micro level. The regular planning survey of the Federation of Swedish Industries has been designed according to the format of the model, and the model is currently loaded with data from the 30 to 40 largest Swedish companies. The idea is to design a measurement system around decision units and to use the high quality data that exist at the firm level. Such data are seldom used efficiently in support of macro analysis, and this is the primary purpose of the model project. Direct observation of the units of measurement allows the use of very simple and efficient estimation techniques at the micro level. Some of this has been done and much is under way, but much more data work has yet to be undertaken before the model has a sufficient empirical footing.

A complete description of the model as it stood in Autumn 1977 is found in Eliasson (ed), A Micro-to-Macro Model of the Swedish Economy, Proceedings of a joint IUI-IBM symposium in Stockholm, IUI Conference Reports, 1978:1. The representation of the individual firm in the model rests heavily on experience from an extensive study on planning and decision methods in some 60 U S and European firms reported on in Eliasson, Business Economic Planning (John Wiley & Sons, 1976). Also see Eliasson, Competition and Market Processes in a Simulation Model of the Swedish Economy, AER 1977:1 and (same author) "Relative Price Change and Industrial Structure", and Albrecht, "Production Frontiers of

Diagram 7. Macro delivery and income determination structure of Swedish model

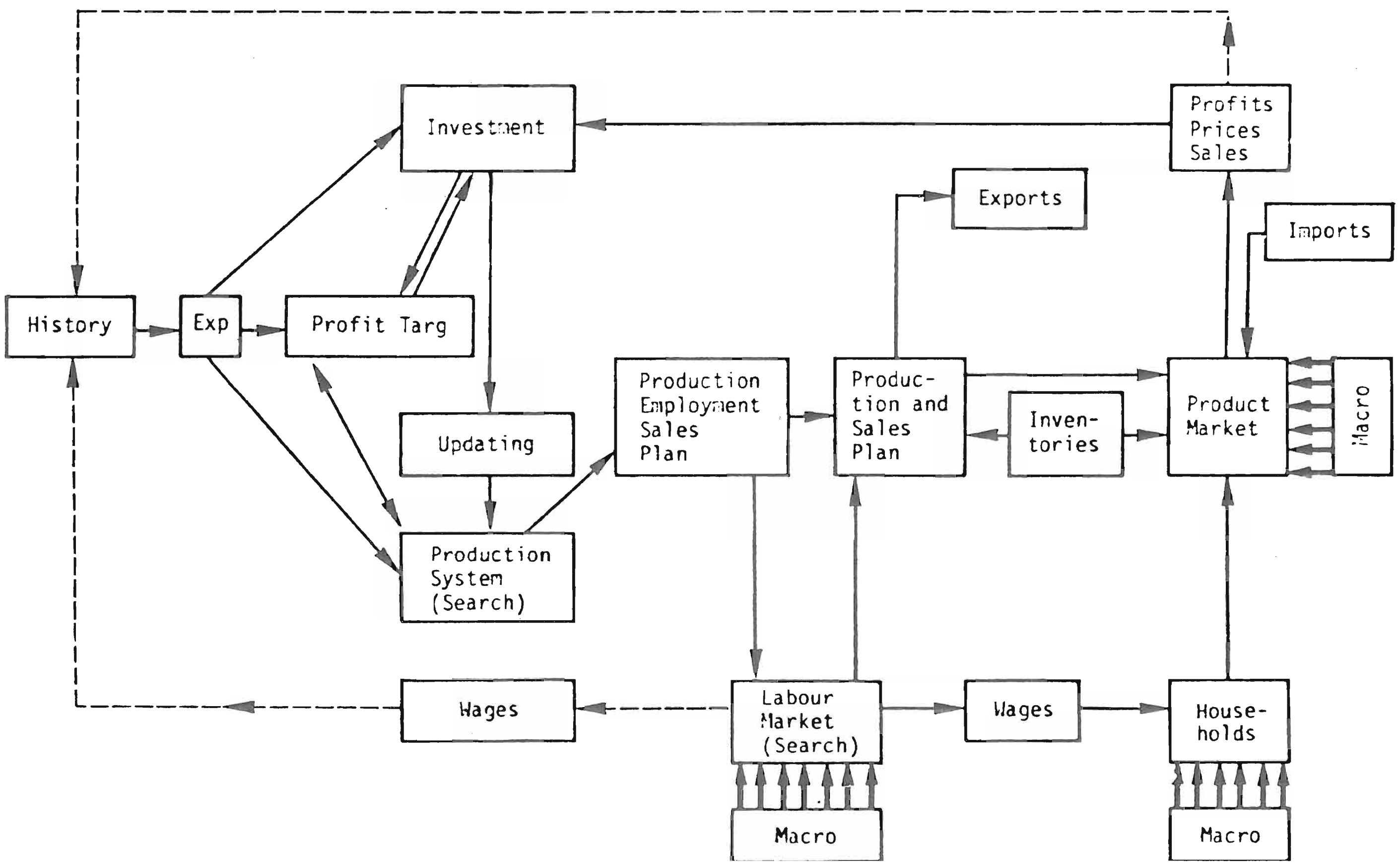


Sectors with individual firms (markets)
1. RAW = Raw material production
2. IMED = Intermediate goods production
3. DUR = Durable household and investment goods production
4. NDUR = Consumer, nondurable goods production

Macro symbols
Z = Private service production
G(OV) = Government output

Other symbols
TRANS = Government transfer payments to firms and households
U = Unemployed

Diagram 8. Business Decision System (One Firm)



Individual Firms in Swedish Manufacturing 1975 and 1976", both in Carlsson-Eliasson-Nadiri (eds), The Importance of Technology and the Permanence of Structure in Industrial Growth, IUI Conference Reports, 1978:2. Some recent illustration of the empirical potential of the model is found in Eliasson, "Experiments with Fiscal Policy Parameters on a Micro-to-Macro Model of the Swedish Economy", in Haveman and Hollenbeck (eds), Microeconomic Simulation Models for Public Policy Analysis, forthcoming 1980 from Academic Press.

Until recently, most analytical work on the model has been concerned with sensitivity analysis aimed at ascertaining the properties of the entire economic system. Even though positive experiences for the economy generate normal short-term or medium-term effects, as in conventional macro models, reversals take place sooner or later. We have consistently found that if shocks, positive or negative, are large and sudden enough, they disturb the market signalling system and lead to erroneous decisions which cause lasting damage in the form of lost growth. This has helped to clarify the restrictive nature of traditional equilibrium assumptions.

Part of the reason for these growth effects is the long transmission times of price disturbances around us that upset the relative price structure and makes it difficult for individual firms to interpret price and wage signals in the markets. A brief period with high prices and profits easily changes into wage drift and a cost crisis that may take years to correct itself if the initial disturbance was strong enough, and firms grew cautious and investments were hurt. The model has exhibited good performance in tracking price transmission through the economy and also longer term growth rates.

Some of the less palatable conclusions that have emerged from model analysis can be traced to the initial positioning of the economy, emphasizing the importance of high quality measurement for a proper understanding of economic phenomena. Further applied work consists in ascertaining the empirical basis for the behavior of the entire system, especially at the micro and market levels. Much empirical analysis of the life histories of individual firms remains, and some of this work will take place in the context of a separate study of the macro effects of corporate income taxation. An estimation project on the positioning and shifting of individual firm production frontiers is being planned, partly to make the model empirically useful as an instrument to analyze the efficiency and stability properties of the Swedish economy.