STRUCTURAL CHANGE AND EXTERNAL SHOCKS: SOME SIMULATIONS USING A MODEL OF THE SWEDISH ECONOMY

Lars Bergman

September 1983
CP-83-48

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

FOREWORD

This Collaborative Paper is one of a series embodying the outcome of a workshop and conference on Economic Structural Change: Analytical Issues, held at IIASA in July and August 1983. The conference and workshop formed part of the continuing IIASA program on Patterns of Economic Structural Change and Industrial Adjustment.

Structural change was interpreted very broadly: the topics covered included the nature and causes of changes in different sectors of the world economy, the relationship between international markets and national economies, and issues of organization and incentives in large economic systems.

There is a general consensus that important economic structural changes are occurring in the world economy. There are, however, several alternative approaches to measuring these changes, to modeling the process, and to devising appropriate responses in terms of policy measures and institutional redesign. Other interesting questions concern the role of the international economic system in transmitting such changes, and the merits of alternative modes of economic organization in responding to structural change. All of these issues were addressed by participants in the workshop and conference, and will be the focus of the continuation of the research program's work.

Geoffrey Heal
Anatoli Smyshlyaev
Ernő Zalai

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1. PURPOSE AND SCOPE OF THE PAPER

During the 1970s the industrialized economies experienced a significant drop in labor productivity growth rates as well as two-digit rates of inflation. Together with other phenomena such as the emergence of the so-called Newly Industrialized Countries, these events have been interpreted as signs of a major shift in the pattern of economic development in the early industrialized world.

Economists trying to identify the major forces behind this process, for instance Lindbeck (1983), tend to point to several different factors of which some have been operating for a long time. The abruptness of the change in economic trends, however, to a large extent is assigned to the "shocks" in the form of dramatic increases in the prices of oil and other raw materials, as well as to the ensuing recession, experienced in the beginning of the 1970s.

The purpose of this paper is two-fold. The first is to analyze the impact on a national economy of the type of "shocks" experienced in the 1970s within the framework of a computable general equilibrium model implemented on Swedish data. The second purpose is to compare the computed impact of the oil price "shock" with the corresponding impact of the most recent

* Stockholm School of Economics, Stockholm, Sweden.

shock, the increase of real interest rates. The underlying issue is obvious: were the raw materials price increases a major factor behind the bad economic performance in the 1970s, and if so, is it likely that the upward shift in real interest rates will have equally detrimental effects?

The choice of method for this analysis has some implications which should be pointed out already at the outset. Thus, as the model essentially is designed as a neoclassical general equilibrium model, goods and factor prices are assumed to be flexible enough to clear all goods and factor markets in each period. Moreover, it does not contain financial markets. This means that the analysis, at best, can shed some light on the direct impact of changes in external prices and interest rates on real variables, while indirect effects, induced by malfunctioning goods and factor markets, real effects of higher inflation rates and various policy reactions, are disregarded.

To some extent this obviously limits the value of the analysis. On the other hand the partial nature of the analysis provides an opportunity to evaluate the relative importance of direct and indirect effects of the type of external shocks experienced by the industrial national economies during the last decade.

2. THE MODEL: BASIC STRUCTURE*

2.1. General Remarks

The model is a simulation model, designed to project the development of a national economy, subdivided into a number of sectors, over time. It is based on the "small open economy" notion. That is, prices of tradeables are determined on international markets and are not affected by the actions of the domestic agents. In the same spirit it is assumed that the domestic investors (in physical capital) can borrow as much as they wish at an internationally determined real interest rate. Producers are assumed to maximize profits under given technological constraints, while consumers, aggregated into a single household sector, are assumed to maximize utility under a budget constraint.

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* This section only gives a rather brief description of the model. A complete presentation is given in Bergman and Por (forthcoming).

The prices of nontradeables, as well as the real wage rate, are assumed to be determined by the interplay of supply and demand factors on domestic markets, all of which are assumed to be competitive. The model only determines relative prices, and the numeraire of the price system is the price (in domestic currency units) of imported manufactured goods. The supply of labor is exogenously determined.

There are seven producing sectors, numbered from 0 to 6, in the model economy and there is no joint production and thus a one-to-one correspondence between domestically produced goods and domestic production sectors. In the description of the model production sectors are denoted with index j and goods with index i. The production sectors are defined in Table 1. It should be noted that the output of public services is exogenously determined, and that the capital goods sector (Sector 7) is just a book-keeping sector which defines the aggregated capital good as a fixed proportions composite of the other goods.

Table 1. Production sector definitions.

Number	Sector
0	Petroleum refining
1	Electricity production
2	Import-competing industries (food, textiles, etc.)
3	Export-oriented energy-intensive industries (paper and pulp, iron and steel, etc.)
4	Other export-oriented industries (mainly manufacturing)
5	Low-trade industries, trade and private services
6	Public services
7	Capital goods

2.2. Technological Constraints and Producer Behavior

The model is rather elaborate on the supply side. Thus, there is a distinction between the substitutability of capital, labor, oil, and electricity *ex ante* and the corresponding substitutability *ex post*. Moreover, in each production sector different vintages of production units are distinguished, reflecting the "putty-clay" nature of technology as well as the impact of embodied technological change.

The basic restrictions on technology are given by *ex ante* sectoral linearly homogenous production functions, shifting over time due to technological progress. On the *ex ante* stage, labor, capital, oil, and electricity are substitutable factors of production, while other intermediate inputs, and sector-specific complementary imports in the energy sectors, are required in fixed proportion to output. With this much structure, and the assumption about profit maximizing behavior, the technological restrictions *ex ante* can be fully represented by a set of sectoral *ex ante* cost functions of the following type*:

$$H_j = H_j^*(W_j, Q_j, P_0^D, P_1^D; \nu) + \sum_{i=2}^{5} P_i^D a_{ij} + P_j^C b_j \qquad (1)$$

$$j = 0,1,\ldots,6$$

where H_j is the *ex ante* unit production cost, W_j the wage rate of labor employed in sector j, Q_j the user cost of capital in sector j, P_i^D for $i = 0,1,\ldots,5$ the domestic market prices of intermediate inputs, and P_j^C is the price, in the domestic currency unit, of complementary imports to sector j. The fixed coefficients a_{ij} and b_j are usual input-output coefficients (note that $b_j = 0$ for $j \geq 2$), while $H_j^*(\cdot)$ can be denoted the *ex ante* net unit cost function. It gives the minimum cost for the substitutable inputs labor, capital, oil, and electricity per unit of output. The time index ν indicates that the net unit cost function shifts over time.

*For simplicity, time indices are omitted where possible.

The sectoral wage rates W_j are defined by

$$W_j = \omega_j W \quad , \qquad j = 0,1,\ldots,6 \qquad (2)$$

where ω_j is a sector-specific constant and W an index for the overall real wage level. Strictly speaking the homogeneity of labor in the model implies that all ω_j's should be equal in equilibrium. By giving other values to these parameters, however, labor market distortions and the heterogeneity of labor can roughly be taken into account.

The user cost of capital in sector j is defined by

$$Q_j = P_7(\delta_j + R^W) \quad , \qquad j = 0,1,\ldots,6 \qquad (3)$$

where δ_j is an exogenously determined rate of capital depreciation and R^W the exogenously determined world market real interest rate. As the aggregated capital good is defined as a convex combination of other goods, it holds that

$$P_7 = \sum_{i=2}^{5} P_i^D a_{i,7} \quad \text{where} \quad \sum_{i=2}^{5} a_{i,7} = 1 \qquad (4)$$

The *ex ante* unit cost function is crucial in at least two ways. First it is the basis for the technological design and investment decisions. Second, once the technological design and investment decisions are made, it defines the *ex post* profit functions, i.e., the technological constraints on production decisions. More precisely the relation between the *ex ante* unit cost functions and the *ex post* profit functions are the following.

At a given point in time, say t, producers know the *ex ante* production function, and they hold certain expectations about the future development of goods and factor prices. To simplify the exposition, it is assumed that all producers have static expectations, i.e., that they expect current relative prices to prevail in the future as well. By evaluating the *ex ante* unit cost function at these prices and applying Shepherd's lemma, the cost minimizing input coefficients in the new vintage of production units can be determined. Thus, the energy input coefficients in the production units, which are designed in period t, and taken into operation in period t+1, $a_{t+1,ij}$, become

$$\frac{\partial H_i^*(\cdot)}{\partial P_i^D} = a_{t+1,ij} \quad , \qquad \begin{array}{l} i = 0,1 \\ j = 0,1,\ldots,6 \end{array} \qquad (5)$$

and the corresponding capital input coefficients become

$$\frac{\partial H_j^*(\cdot)}{\partial Q_j} = k_{t+1,j} \quad , \qquad j = 0,1,\ldots,6 \qquad (6)$$

In the same way the cost minimizing labor input coefficients can be determined, but as these variables are not needed in the further exposition we directly define a measure of the expected rate of return on real investments in excess over the world market real interest rate in period t. This measure is denoted $\tilde{R}_j(t)$ and defined by

$$\tilde{R}_j(t) = \frac{P_j(t) - H_j(t)}{P_7(t)k_{t+1,j}} \quad , \qquad j = 0,1,\ldots,6 \qquad (7)$$

where P_j is the producers' price of the goods produced by sector j, and the notation $H_j(t)$ indicates that the *ex ante* cost function is evaluated in time period t. It should be noted that if all future prices are well anticipated, and markets competitive, $\tilde{R}_j(t)$ should be equal to zero.

On the basis of the variables $\tilde{R}_j(t)$, sectoral gross investments are determined by means of investment functions defined later on in the exposition. Now it is assumed that once an investment is made in a given sector, the capital goods in question are tied to that sector. It is also assumed that energy input coefficients cannot be varied *ex post*. That is, all the $a_{t+1,ij}$ are variables in period t and constants from period t+1 and so on. These added restrictions together with the *ex ante* production functions define the *ex post* production functions of vintage t. By definition the *ex post* production functions can be written as functions of the input of labor only, and they exhibit decreasing returns to scale in that factor.

The *ex post* production functions differ across vintages for two reasons. First, these functions reflect the technological progress only up to the period in which the vintage in question was designed. Second, the fixed energy input coefficients are most likely to differ across different vintages of production units in a given sector. Moreover, the *ex post* production functions shift over time due to exogenously determined depreciation of the fixed capital stock.

On the basis of the *ex post* production functions and the profit maximization assumption, a set of profit functions, $\pi_{\nu j}(\cdot)$, one for each vintage of production units in each sector, can be derived and written

$$\pi_{\nu j} = \pi_{\nu j}(P^*_{\nu j}, W_j; t) \quad , \qquad \begin{array}{l} \nu = 0,1,\ldots,t \\ j = 0,1,\ldots,6 \end{array} \tag{8}$$

where thus $\pi_{\nu j}$ is the gross profit in production units of vintage ν in sector j, and

$$P^*_{\nu j} = P_j - \sum_{i=0}^{1} P^D_i a_{\nu ij} - \sum_{i=2}^{6} P^D_i a_{ij} - P^C_j b_j \tag{9}$$

$$j = 0,1,\ldots,6$$

Having defined the profit functions, the derivation of the output supply and input demand functions is quite straightforward. Thus, by Hotelling's lemma the supply of output from production units of vintage ν in sector j in period t, $X_{\nu j}(t)$, becomes

$$\frac{\partial \pi_{\nu j}(\cdot)}{\partial P^*_{\nu j}} = X_{\nu j}(t) \quad , \qquad \begin{array}{l} \nu = 0,1,\ldots,t \\ j = 0,1,\ldots,6 \end{array} \tag{10}$$

and by adding over vintages, the total supply of output from sector j in that period, $X_j(t)$, is determined. That is

$$\sum_{\nu=0}^{t} X_{\nu j}(t) = X_j(t) \quad , \qquad j = 0,1,\ldots,6 \tag{11}$$

The supply of output from each traded sector, i.e., j = 0,1,...,5, is assumed to be a composite made up of goods for domestic use and goods for export. The prices of exports are exogenously determined by world market conditions, while the prices of domestically sold goods are endogenously determined by the interplay of supply and demand factors on domestic markets. It is assumed that the demand for inputs is independent of the composition of output, and that there is a constant, scale-independent elasticity of transformation between the two types of output. Under these conditions it holds that

$$P_i = \chi_i(P_i^N, P_i^Z) \quad , \qquad i = 0,1,\ldots,5 \qquad (12)$$

where P_i is the producer unit revenue of composite output i, P_i^N is the price of the goods with the classification i sold on the domestic market, P_i^Z the export price of goods with the classification i and $\chi_i(\cdot)$ is the unit revenue function. Observe there are several types of goods with the classification i. This feature of the model will be further discussed in subsection 2.3.

On the basis of equation (12) and Shephard's lemma, the supply of domestically produced goods on domestic markets in period t, $N_i(t)$, is given by

$$N_i(t) = \frac{\partial \chi_i(\cdot)}{\partial P_i^N} X_i(t) \quad , \qquad i = 0,1,\ldots,5 \qquad (13)$$

$$N_6(t) = X_6(t) \qquad (14)$$

while the supply of exports is given by

$$Z_i(t) = \frac{\partial \chi_i(\cdot)}{\partial P_i^Z} X_i(t) \qquad i = 0,1,\ldots,5 \qquad (15)$$

By Hotellings's lemma and the structure of technology, the demand for labor, $L_j(t)$, intermediate inputs, $X_{ij}(t)$, and complementary imports, $M_j^C(t)$, by sector j in period t becomes

$$\frac{\partial \pi_{\nu j}(\cdot)}{\partial W_j} = - L_{\nu j}(t) \quad , \qquad \begin{array}{l} \nu = 0,1,\ldots,t \\ j = 0,1,\ldots,6 \end{array} \qquad (16)$$

$$\sum_{\nu=0}^{t} L_{\nu j}(t) = L_j(t) \quad , \qquad j = 0,1,\ldots,6 \qquad (17)$$

$$X_{ij}(t) = \begin{cases} \sum_{\nu=0}^{t} a_{\nu ij} \; X_{\nu j}(t) & \text{when} \quad i = 0,1 \\ a_{ij} \; X_j(t) & \text{when} \quad i = 2,3,\ldots,6 \end{cases} \qquad (18)$$

$$j = 0,1,\ldots,7$$

$$M_j^C(t) = b_j \; X_j(t) \quad , \qquad j = 0,1 \qquad (19)$$

which completes the derivation of the model's output supply and input demand functions.

2.3. Final Demand for Goods

The demand for goods in the model economy can be subdivided into two categories, intermediate and final demand. As the determination of intermediate demand was discussed above, it remains to specify the final demand functions. Before that, however, a few words should be said about the definition of "goods" in this model.

It has already been stressed that there are several types of goods with the same classification in the model. The situation can be clarified by means of Table 2.

In the non-traded, public sector there is obviously no distinction between P_i, P_i^N, and P_i^D. Another way of saying this is that P_i^M and P_i^Z are not defined for $i = 6$. In the private sectors, however, all the prices defined in Table 2 appear in the model and may differ from each other. Adopting the so-called

Table 2. Types of goods denoted with a given index i in the model.

Type of good	Quantity	Price*	Price determination
Composite output from sector j = i	X_i	P_i	Endogenous
Exports produced by sector j = i	Z_i	P_i^Z	Exogenous
Non-traded goods produced by sector j = i	N_i	P_i^N	Endogenous
Imported goods	M_i	P_i^M	Exogenous
Domestically used composite goods	**	P_i^D	Endogenous

*In the domestic currency unit.
**Does not explicitly appear in the model.

Armington assumption (see Armington [1969]) it is assumed that domestically produced goods for domestic use (N_i) are relatively close substitutes to imports with the same classification (M_i). Thus, in the model, domestic agents are assumed to demand a composite of imported and domestically produced, non-exported goods with the classification i, and the composite is defined by means of a "production" function aggregating goods from the two sources of supply.

This function is assumed to be homothetic and to apply to all domestic users of the goods in question. Consequently, the minimum unit cost of the composite good is solely a function of P_i^M and P_i^N. Thus the price of the composite good, P_i^D, can be defined by the unit cost function of that good, i.e., it holds that

$$P_i^D = \psi_i(P_i^M, P_i^N) \quad , \qquad i = 0,1,\ldots,5 \qquad (20)$$

where $\psi_i(\cdot)$ is the unit cost function of the composite good demanded by domestic agents. By Shepard's lemma, the demand for imports and domestically produced goods, respectively, is given by the partial derivatives of the function $\psi_i(\cdot)$.

From the assumption about exogenously determined export prices, it follows that export demand is completely elastic, and by the construction of the model, public sector demand for goods is treated as a kind of intermediate demand. As inventory changes are disregarded, two final demand categories, household consumption and gross investment, remain to be specified. In both cases the time-recursive nature of the model has led to simplifying assumptions.

All consuming units are aggregated into one single household sector, which is assumed to maximize utility subject to a budget constraint. Thus the maximum consumption expenditures by the household sector in period t, E(t), is given by

$$E(t) = [1 - s(t)] \sum_{j=0}^{6} \left\{ \sum_{\nu=0}^{t} \pi_{\nu j}(t) + W_j L_j(t) \right\} , \qquad (21)$$

where s(t) is an exogenously determined variable, indicating domestic saving and net taxation as a share of total factor income.

In a full-blown, Arrow-Debreu type of multiperiod general equilibrium model, s(t) would be endogenously determined by the wealth constraint of the households and the demand for public services. In this model, however, there is no mechanism assuring that current absorption levels are compatible with the economy's wealth constraint. Instead s(t) is a variable which can be used for defining alternative macroeconomic adjustment patterns.

Given the definition of E(t) and an assumption about the utility function of the household sector, the household demand functions can easily be determined. For the time being, these functions simply are written as

$$C_i = C_i(P_0^D, \ldots, P_5^D, P_6, E) \quad , \qquad i = 0,1,\ldots,6 \qquad (22)$$

In contrast to the other structural equations of the model, the investment functions are not derived as solutions to optimization problems faced by the agents of the model economy. The reason for this is that in the case of investment, these optimization problems would involve relationships between current investment decisions and future goods and factor prices, i.e., relationships which cannot be incorporated in this model. Instead, the sectoral investment functions are specified as functions of the expected rates of excess profit in accordance with

$$I_j(t) = \begin{cases} (\delta_j + g)k_{t+1,j}\, X_j(t) \left(\dfrac{R^W(t) + \tilde{R}_i(t)}{\bar{R}(t)}\right)^{\rho_j} & \text{when } R^W(t) + \tilde{R}_j(t) \geq 0 \\ 0 & \text{when } R^W(t) + \tilde{R}_j(t) < 0 \end{cases}$$

$$j = 0,1,\ldots,6 \qquad (23)$$

where $I_j(t)$ are the sectoral investment volumes, while g and ρ_j are exogenously given constants, and $\bar{R}(t)$ is an exogenously determined long-run rate of return requirement.

The interpretation of these investment functions is quite straightforward. The terms in front of the parentheses define the sectoral investments required when all sectors of the economy grow at the annual rate g. Under conditions of balanced growth, there will be no excess profits and $R^W(t)$ will coincide with $\bar{R}(t)$. Thus the value of the last parenthesis will be unity. However, if the economy is not on a balanced growth path, positive excess profits will be expected in some sectors and negative in others. In accordance with the investment functions above, the former group of sectors will grow faster than g and the latter slower than g. Total gross investment becomes

$$I(t) = \sum_{j=0}^{6} I_j(t) \quad , \qquad (24)$$

which, by definition, equals the "production" of the aggregated capital good, i.e., $X_7(t)$.

2.4. Equilibrium Conditions

Having derived the structural equations of the model, it remains to specify the equilibrium conditions for the goods markets as well as for the labor market. Within the model economy, there are three groups of goods markets: the markets for domestically produced goods, the markets for imports (other than complementary imports), and the markets for complementary imports. On the basis of equations (1), (11), (13), (14), (18), and (22), and use of equation (20), the equilibrium conditions for the first group of markets becomes:

$$\frac{\partial \chi_i(\cdot)}{\partial P_i^N} X_i(t) = \frac{\partial \psi_i(\cdot)}{\partial P_i^N} \left[\sum_{j=0}^{7} X_{ij}(t) + C_i(t) \right] \qquad i = 0,1,\ldots,5 \tag{25}$$

$$X_6(t) = C_6(t) \tag{26}$$

$$X_7(t) = I(t) \tag{27}$$

where $C_6(t)$ is the exogenously determined consumption of public services.

In the same way, and noting that the supply of imports is assumed to be completely elastic, the equilibrium conditions for the imported goods becomes

$$M_i(t) = \frac{\partial \psi_i(\cdot)}{\partial P_i^M} \left[\sum_{j=0}^{7} X_{ij}(t) + C_i(t) \right] , \qquad i = 0,1,\ldots,5 \tag{28}$$

$$M_j^C(t) = b_j \; X_j(t) \quad , \qquad j = 0,1 \tag{29}$$

On the basis of equations (16) and (17), and the assumption about exogenously determined labor supply, L(t), the labor market equilibrium condition becomes

$$L(t) = \sum_{j=0}^{7} L_j(t) \tag{30}$$

Thus, given the values of L(t), $C_6(t)$, $P_i^M(t)$, $P_i^Z(t)$, $P_j^C(t)$ and $R^W(t)$, the model endogenously determines the equilibrium domestic pattern of resource allocation and relative goods prices, as well as the equilibrium real wage rate. Moreover, the current account deficit (or surplus), D(t), which does not directly affect the allocation of resources, is determined by

$$\sum_{i=0}^{5} P_i^Z(t) \frac{\partial \chi_i(\cdot)}{\partial P_i^Z} X_i(t) - \sum_{i=0}^{5} P_i^M(t)\ M_i(t)$$

$$- \sum_{j=0}^{1} P_j^C(t)\ M_j^C(t) = D(t) \tag{31}$$

Finally, it should be mentioned that the model also contains a number of commodity tax parameters, but there is no explicit budget constraint for the public sector.

3. EMPIRICAL BASIS AND THE REFERENCE CASE

In order to implement the model presented in the preceding section, it is necessary to specify the functions $H_j^*(\cdot)$, $\chi_j(\cdot)$, $\psi_i(\cdot)$ and $C_i(\cdot)$, and all the parameters of the model have to be estimated. It is beyond the scope of this paper to go into details of the implementation process. Only a brief account can be given here. In general, however, the model's data base is constructed on the basis of available econometric results.

The *ex ante* unit cost functions $H_j^*(\cdot)$ are derived from a nested Cobb-Douglas-CES function. Thus there is a constant elasticity of substitution between a composite capital-labor input, defined by a Cobb-Douglas production function, and an oil-electricity input, defined by another CES function. Both sets of elasticity of substitution parameters were set equal to 0.75, a figure which seemed reasonable in view of results presented by Pindyck (1980) and the resulting *ex post* price elasticities.

The unit revenue functions $\chi_j(\cdot)$ were derived from a CET (see Powell and Gruen [1968]) type of transformation frontier. On the basis of available econometric estimates of export responses to relative price changes, the elasticity of transformation was set equal to unity in all sectors. In much the same way, the functions $\psi_i(\cdot)$ were derived from a CES definition of the composite good demanded by domestic agents, and the elasticities of substitution, which can be interpreted as import demand price elasticities, were determined on the basis of estimated import demand functions. The numbers thus derived ranged from 3.0 for sector 2 to 1.5 for sector 5.

The household demand functions $C_i(\cdot)$ were derived from a linear expenditure system estimated on 10 consumer commodity groups. Thus, the 10 consumer commodity groups, and the corresponding price indices, were defined as convex combinations of the seven types of composite goods explicitly treated in the model. Consequently, the model was extended with a matrix "transforming" the demand for the 10 consumer commodity groups into demand for composite goods.

The parameters ρ_j in the investment functions, however, are rather difficult to estimate, since the variables $\tilde{R}_j(t)$ cannot be observed. However, by assuming "static" expectations, i.e., that producers expect current prices to prevail also in the future, there is a rather close correlation between the sum $R^W(t) + \tilde{R}_j(t)$ and conventionally estimated current rates of return on capital. Thus, in this case, estimated investment functions can indicate reasonable values for the parameters ρ_j.

In Lindbeck (1983) a cross-country regression of gross investment on the profit rate and value added growth in the business sector is presented. The estimated elasticity of gross investment with respect to the profit variable is 0.23, but Lindbeck argues that, for several reasons, this estimate is on the low side. On the basis of this, and a number of test runs with the model, the numerical value of the parameters ρ_j was set equal to 0.5 in all sectors.

The parameters a_{ij} and b_j, i.e., the fixed input-output coefficients, were estimated on the basis of input-output data for 1975, and the exogenous variable s(t) was estimated on the basis of the national accounts and kept at the base-year value. However, for the purpose of the type of simulations presented here, some adjustments were made in the 1975 data. The reason why and the procedure are as follows.

It is quite likely that the impact of external shocks, such as world market oil price increases, depends on the initial state of the economy; an economy which is reasonably close to a balanced state is probably less vulnerable than one which has not adjusted to previous changes in external conditions. However, the model used here is not well suited for depicting an economy in disequilibrium. In 1975, however, there were a number of disequilibrium phenomena in the Swedish economy, and some of these were reflected in the input-output statistics. For example, the input-output statistics in conjunction with the capital stock statistics revealed quite significant differences across sectors in the rate of return on capital, and the current account was deteriorating. Moreover, we now know that the adjustment of oil input coefficients in the production system to the 1973/74 oil price increase had just begun in 1975.

In view of this a static long run equilibrium model (see Bergman (1982)), was used to compute a hypothetical equilibrium allocation of resources in the Swedish economy, designed to reflect the allocation after a complete adjustment to the 1973/74 oil price increase had been carried out. Thus, it was assumed that the observed 1975 oil input coefficients reflected the 1972 technology and the 1975 prices; that the higher cost of oil was completely balanced by lower profits; that the higher cost of oil imports had not led to any macroeconomic adjustments and thus only showed up in the current account. On the basis of these assumptions, an equilibrium allocation of resources and domestic absorption, characterized by such an allocation of capital that the rate of return on capital was the same in all sectors, was computed. This allocation of resources was then taken as the point of departure for a projection used as a reference case in the analysis.

The reference case projection extends over a six-year period and the model is explicitly solved for the initial year and every second year after that. The labor force is assumed to remain constant in man-hours, but an assumed rate of labor-augmenting technical progress makes the labor force measured in efficiency units grow by 0.75 percent per annum. In addition, there is embodied technical progress, i.e., shifts of the *ex ante* production functions, ranging from 3.5 percent per annum in the manufacturing sector (sector 4) to 1.5 percent per annum in the public sector. Moreover, it is assumed that world market prices remain constant in real terms, and that the internationally determined real rate of interest is 3.5 percent. Finally, it is assumed that the output of public services grows by 3.8 percent per annum. The projected development of some macroeconomic indicators are summarized in Table 3.

The reference case is, in what follows, used as a basis for comparisons, i.e., the impact of various external shocks is evaluated in terms of deviations from the reference case projection. This projection is not intended to exactly replicate the actual development of the Swedish economy after 1975; yet it includes some features which were typical of Swedish economic development during that period. For instance, a relatively slow growth of GDP, and public-sector growth in excess of the GDP growth rate; relatively rapid growth of real wages and the share of wages in the national income; slow growth of gross investments and a gradual deterioration of the current account. Thus, in terms of the model, the adopted values of the exogenous variables s(t) (in equation 21) and $C_6(t)$ (consumption of public services) do not seem to be compatible with balanced growth.

Table 3. Macroeconomic development in the reference case. Annual rates of change (percent per year) over a six-year period.

Private consumption*	2.2
Public consumption*	3.8
Gross investments*	1.5
Export*	1.8
Import*	2.6
Gross domestic product (GDP)*	2.4
Gross domestic (factor) income (GDI)**	2.8
Real wages per man-hour	2.9

*In constant base-year prices.
**In terms of the numeraire good.

4. SOME SIMULATION RESULTS

4.1. The Impact of Oil Price Increases

In the first step of the analysis, the impact of changes in world market prices was simulated. Thus, in one simulation the world market price of oil was assumed to increase by 100 percent in the second year and to remain at that level throughout the simulation period. In another simulation a 10 percent drop in the export price of a major export good, the output of the basic materials industries in sector 3, was assumed. This could be interpreted as the result of a global reduction of the demand for energy intensive goods, induced by the oil price increase.

Although the numbers are somewhat arbitrarily chosen, these simulations both represent external "shocks", generally regarded as important factors behind Sweden's bleak economic development in the 1970s. It should be noted that by international standards the per capita consumption of energy is high in Sweden, and in 1975 imported oil accounted for about 70 percent of the energy supply. Moreover, about 25 percent of Sweden's export originated in the industries here assigned to sector 3. The simulated macroeconomic impact in year 2 of these shocks is summarized in Table 4.

Largely these figures speak for themselves. Yet a few comments should be made. To begin with it should be noted that the assumed wage flexibility prevents unemployment, and consequently there is hardly any impact on GDP in constant prices. Thus the real income losses and structural changes resulting from the external shocks essentially reflect changes in relative prices*. Yet, the real income losses are significant in both cases.

In terms of aggregated real income losses, the two shocks have roughly the same macroeconomic impact, but they seem to induce quite different adjustment patterns. Thus, while wages are squeezed more than profits in the case of the oil price increase,

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*In Bergman and Mäler (1983), it is shown that if export demand is less than completely elastic, an oil price increase induces additional terms of trade, and thus real income, losses through reductions of export prices.

Table 4. Immediate macroeconomic impact of selected external shocks (percentage deviation from the reference case values)

	100% increase in world market price of oil	10% decrease in world market basic material prices (exports from sector 3)
Private consumption*	-4.4	-1.3
Public consumption*	±0[a]	±0[a]
Gross investments*	-1.5	-3.1
Export*	+3.7	±0
Import*	-4.9	-3.7
GDP*	-0.3	±0
GDI**	-3.6	-3.2
Real wages per man-hour**	-4.5	-2.9

[a]By assumption

*In constant base-year prices.
**In terms of the numeraire good.

the opposite holds when sector 3 export prices are assumed to drop. Moreover, in the case of the oil price increase, an increase in the relative price of the commodity bundle demanded by households tends to squeeze real private consumption more than aggregated real income. Again the opposite holds in the case of the export price reduction. In both cases, however, the adjustment mechanism operating in the model seems to differ considerably from the one that actually operated in the Swedish economy.

In the real Swedish economy, there was a considerable lag between the 1973/74 oil price increase and the adjustment of real wages. In fact real wages increased considerably in the years immediately after the oil price increase. The wage adjustment lag was made possible, to a large extent, by an expansion of the public sector and measures preventing a fall in the disposable income of the household sector. Consequently, net export rather than domestic absorption was held back. In the model simulation, on the other hand, the immediate real wage adjustment brought about a net export expansion large enough to restore labor market equilibrium in spite of the reduction in domestic absorption.

It can be argued that unexpected changes in world market conditions that call for rapid reductions in household consumption levels and real wage rates are particularly difficult to handle in a modern welfare state like Sweden. If this is so, the model results suggest that a 100 percent increase in oil prices produced a good deal more adjustment problems than a 10 percent drop in sector 3 export prices.

Before turning to the next simulation, a few additional results should be mentioned. Thus, looking at the simulated development over the entire six-year period, one should expect the larger drop in gross investments to lead to a relatively larger reduction in the GDP growth rate in the case of falling sector 3 export prices. Although this effect turned out to be unimportant (GDP less than 1 percent lower than in the reference case), the output level of sector 3 was more than 8 percent lower than in the reference case at the end of the simulation period.

The case with the oil price increase not surprisingly implies a slower growth of oil consumption, 1.3 percent per annum as compared to 3.0 percent per annum. However, in spite of this considerable cut in oil consumption growth, less than half of the adjustment to the higher oil price level was completed at the end of the sixth year. In the relatively energy-intensive sector 3, for example, the doubling of oil prices induced a 35 percent reduction of oil input coefficients in new vintages of production units. By the end of the simulation period, i.e., four years after the oil price increase, the incorporation of these production units had reduced the average oil input coefficient of sector 3 by 1/3 of that, or 13 percent.

4.2. The Impact of Higher Real Interest Rates

The next step in the analysis is to compare the computed impact of an oil price increase, the main external "shock" experienced in the 1970s, and the corresponding impact of an increase in internationally determined real interest rates, i.e., the type of external "shock" experienced at the beginning of the 1980s. The model simulation carried out was based on the assumption that the internationally determined real interest rate increases from 3.5 percent to 5.0 percent two years after the initial point in time, and remains at that level throughout the simulation period. However, the long-run rate of return requirements, i.e., the variable $\overline{R}(t)$ in the investment functions (equation 23), remain unaffected. The main results are summarized in Table 5.

Needless to say the computed impact of this external shock is dramatic, perhaps dramatic to the point where the numerical values of the rate of profit elasticities in the investment

Table 5. Immediate macroeconomic impact of selected external shocks (percentage deviation from reference case values)

	100% increase in world market price of oil	Increase of real interest rates from 3.5% to 5%
Private consumption*	-4.4	- 1.4
Public consumption*	$\pm 0^a$	$\pm 0^a$
Gross investments*	-1.5	-17.7
Export*	+3.7	+ 6.9
Import*	-4.9	- 8.4
GDP*	-0.3	- 0.4
GDI**	-3.6	- 5.4
Real wages per man-hour**	-4.5	- 4.5

[a]By assumption.

*In constant base-year prices.
**In terms of the numeraire good.

functions should be seriously questioned. Also it is perhaps unrealistic to assign the same real interest sensitivity to private and public real investments. However, the precise pattern of the computed impact obviously depends very much on the specification of the model. Thus there is reason to briefly point out some features of the model which are particularly important here.

The assumed increase in world market interest rates, *ceteris paribus*, increases the user cost of capital and thus squeezes the expected profit rates which determine sectoral gross investments. This reduces the demand for capital goods, and in the end the demand for labor. In order to maintain labor market equilibrium, real wages start to fall. This, in conjunction with the reduced domestic demand for goods, tends to bring about a switch of domestic supply from domestic to international markets as well as a switch in domestic demand from imported to domestically produced goods. But the lower prices of domestic output tend to depress profit expectations even more, thus inducing additional cuts in gross investments and another round of adjustments. These mechanisms are all quite reasonable, but, as mentioned above, the model might overstate their speed and power.

By coincidence the adjustment of the real wage in terms of the numeraire good is the same in both simulations underlying the results presented in Table 5. In the case of the real rate of interest increase, however, the prices of consumer goods fall whereas the opposite holds in the case with the oil price increase. Consequently, real wages in terms of consumer goods, which are close to what is commonly meant by "real wage", are considerably less affected by the former type of external shock.

The sharp drop in gross investments resulting from the real rate of interest increase of course has an impact on the rate of GDP growth over the entire simulation period. Thus, while GDP grows by 2.4 percent per annum in the reference case, it only grows by 2.0 percent per annum in the case of the real rate of interest increase. This is clearly a significant reduction, but yet not the end of economic growth.

5. CONCLUDING REMARKS

For obvious reasons the results obtained in this type of model simulation should not be stretched into definite conclusions about the real world. Yet a few observations can be made.

One striking result is that both the short- and long-run impact on constant price GDP of the assumed oil price shock is very small. Thus the remarkable drop in real GDP growth experienced in Sweden and most industrialized countries after the 1973/74 oil price increase clearly is not reproduced by the model. This can be interpreted in two, not mutually exclusive, ways. One is that other exogenous factors than those dealt with in this paper have led to a slow-down of economic growth. The other possible interpretation is that the smooth adjustment of relative prices taking place in the model economy does not have a counterpart in the real world.

The latter interpretation can actually be given a good deal of support by means of additional simulations with the same model. Thus, if the labor market equilibrium condition is dropped, and the real wage rate exogenously fixed at the reference case values, a 100 percent oil price increase leads to both unemployment and a significant reduction in constant price GDP. Moreover, there is a drop in investments and a sharp deterioration of the current account. In other words, the behavior of the model economy becomes quite similar to the behavior of the real Swedish economy during the mid-1970s.

This suggests that the type and magnitude of the impact of external shocks, in the form of significant unanticipated changes in internationally determined prices, to a large extent depends on the flexibility of the domestic factor prices. In turn this suggests that the change in domestic factor prices needed to restore equilibrium after a given external shock could serve as an index by which different external shocks could be compared.

On the basis of the computed impact on the real wage in terms of consumer goods, the results of the model simulations indicate that a 100 percent oil price increase (above the 1974 level) is "worse" than a 1.5 percentage points temporary increase in real interest rates. Whether this means that the real interest increases experienced at the beginning of the 1980s will be less detrimental to economic growth than the oil price increases of the 1970s is an open question. The results do suggest, however, that there is a considerable need for flexibility in the domestic resource allocation mechanisms in an economy faced with significant changes in exogenously determined relative prices and real interest rates.

ACKNOWLEDGEMENTS

The author is grateful to the International Institute for Applied Systems Analysis for providing office facilities and secretarial support, the Energy Research and Development Commission, Stockholm, Sweden for financial support, and to Claes Thimrén, Stockholm School of Economics, for research assistance.

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