A C T A U N I V E R S I T A T I S L O D Z I E N S I S

FOLIA OECONOMICA 54,1986

Władysław Welfe*

MODEL W-5 OF THE POLISH ECONOMY: GENERAL ASSUMPTIONS AND THE FIRST EMPIRICAL RESULTS

1. Introduction

The idea to treat the disequilibria as "normal" but disagreeable states of the economy is becoming widespread[1]. It has an increasing impact on the econometric macro-modelling, especially of the socialist economies. One of the most important tasks is to study empirically both the potentials and supplies of commodities (and labour) on the one hand and the demand for products and production factors on the other hand, with prices (if endogenous) being typically explained in the inflationary framework. The above approach does not necessarily assume a balanced growth (i.e. the existence of equilibrating mechanisms - quantitative adjustments other than prices). It may assume the prevailing states of disequilibria in certain markets or blocks of equations[2]. The model W-5 of the Polish economy which is described in

*Prof. Dr., Head, Institute of Econometrics and Statistics, University of Łódź.

[1] The analysis by J. K o r n a i (1980) of a centralized, command type economy prevailing during a certain historical period in socialist countries, which produced chronic shortages in commodity markets, excess demand for labour and capacities (investments) formed the theoretical basis for many empirical short and medium-term analyses. On the other hand, M. K a l e c k i (1963) in his theory of growth of the socialist economies has formulated the ideas of barriers of growth being the source of disequilibria (in foreign trade, balance of labour force and material balances, first of all of raw materials and energy). Let us note, that prices are assumed to adjust too slowly (after a long time lag) and thus do not play any significant equilibrating role.

[2] The model that contains the description of supplies, demand and either an equilibrating mechanism or the explanation of excess demand (supply) we used to call a c o m p l e t e model. See W. W e l f e 1976, 1978.

this paper has the above characteristics[3]. Its structure was shaped in 1982 along with the first results of estimations based on the 1961-1979 sample. It is still under testing. We shall concentrate on the description of the main assumptions being used and the first results obtained.

2. The predecessors: W-3 models of the Polish economy

As the model W-5 borrows heavily from its predecessors, especially from the demand and supply versions of the earlier W-3 model of the Polish economy, let us briefly characterize both of them[4].

The demand-oriented version was constructed in the early seventies to describe the mechanisms characteristic for the optimistic period of "accelerated", fairly balanced growth of the Polish economy. It assumed that the capacities at that period were not fully utilized, that their higher utilization as well as an increment of capacities might be easily obtained in short periods of time to meet the rising demand. This was based on the assumption that domestic resources and readily obtainable cheap foreign credits would help to eliminate the existing bottlenecks and guarantee steady inflow of imported raw materials and spare parts, and especially new technologies from developed market economies finding no constraints on the import side. This gave us the right to believe that both the intermediate and final demand would be fully satisfied, disregarding how it was decided. We

---

[3] The first model of the Polish economy (and possibly of a socialist economy) which explicitly specified supplies, requirements and excess demand (supply) was the W-1 model constructed in 1971 (W e l f e 1973). It has never been operationally used because of the constraints on the software side (nonlinearities) as well as the unsatisfactory knowledge about the observable disequilibria symptoms (indicators). The importance of that type of econometric studies has been emphasized in several papers (W e l f e 1976, 1978) and in the late 70ties during the economic crisis the idea of constructing a model of that class for Poland was raised once again (C z e r w i ń s k i, W e l f e 1982; K l e i n 1982; W e l f e 1982).

[4] The more comprehensive description of the versions of the W-3 model can be found in C z y ż e w s k i, D ę b s k i, W e l f e 1976; W e l f e 1980.

have in mind the individual households decisions with regard to the personal consumption, collective type decisions made by the government with respect to the investment allocation as well as the allocation of central budget to the services sector, and also the decisions by trade organizations with regard to exports. The above assumptions explain why a demand oriented type of W-3 model was built. It contained first of all demand equations which explain the behaviour of households, the decisions being made by industrial organizations with regard to investment outlays corrected at the top level - by the central planner, the increase of inventories and foreign demand (exports). A system of equations was constructed next that transformed the final demand to the demand for gross output and net output at the industry level. Then, assuming that the primary factors are available in excess, we tried to generate the required employment and eventually to compare it with the existing labour force (the active population in private agriculture was treated as a reservoir of potential supplies of employees towards manufacturing industries). The foreign trade equations were based on similar assumptions. Assuming that the foreign demand will be met, the export equations were specified as generating demand. Similary the import equations described the domestic complementary demand either for raw materials and semi-finished products or for investment goods or for consumers' goods. For many years there has been no real constraint with regard to the imports except for goods satisfying final demand[5].

In the middle of the 70's it became obvious that the demand determined model was not able to describe in an adequate way the development of the Polish economy. The main reason was, that several constraints arose which were not given before. They became very severe in the late 70's. The major constraint came from the import side. That was due to the restricted availability of foreign credits in convertible currencies, and to their increased expenditure on purchases of foodstuffs. In the same period, Poland started to repay its foreign debt. Originally, the constraints hit the import of consumer goods (except for foodstuffs). Then

---

[5] For a more detailed description see W e l f e 1980, 1981.

they affected with a certain delay the import of investment goods, which was in line with the policy of freezing and then declining the investment levels. At the very end the restrictions were imposed on the purchase of the raw materials, semi-finished products (chemicals etc.) and spare parts. These have been most severe and caused, in the first line, a decrease of inventories and afterwards less than proportional decline of industrial activities (as some substitution in their use took place). The above constraints jointly with the energy restrictions had a far reaching negative effect as the constraints spread all over the production sector "producing" new bottlenecks. As a feedback exists between the industries producing energy, raw materials and manufacturing industries, especially machinery and machine parts which can be called bottleneck multiplier - the final negative impact was higher than that directly imposed by the initial constraints.

The above description indicates that to be able to forecast and simulate the developments on a macroscale - the supply side of the economy had to be modelled. A supply-oriented version of the W-3 model was constructed at the end of the 70's[6] and it proved efficient in explaining economic crises during that period and forecasting the decline of the activities until 1982 and the prediction of the recovery in 1982/1983. This model is consequently supply-determined as it generates the net and gross output from the production functions, then allocates the output among final users by means of supply equations being approximations of balance identities. Imports were constrained by total exports and the assumed balance of trade, directly intervening in the production functions.

3. The model W-5 and the economic disequilibria

Having a supply-determined model only it occurred not feasible to perform serious studies with regard to the deep disequilibria, which were plaguing the national economy. To make progress - the

---

[6] Its operational version, obtained after introducing some simplifying assumptions, is recently used in performing forecasts and simulations. See J u s z c z a k, W e l f e 1982 and L u b e r a, P o t a r g o w i c z, W e l f e 1982.

simultaneous analysis of the demand side was indispensable. That led us to the construction of the W-5 model of the Polish economy.

Let us characterize the above mentioned problem of analysing disequilibria in the production sector in some more detail. They may be of a complex nature. In many industries, we can observe idle capacities because of the constraints on the supply side mostly due to shortages in energy and material supplies. In some other industries, mostly those producing investment goods we can notice that unutilized capacities are due to the "classical" factors, i.e. demand constraints. Let us take an example from the electro-engineering industry. The underutilization of the capacities in this industry is only partly due to the restrictions in supplies of raw materials and semi-finished imported products. It is mainly due to deep cuts in investment outlays not compensated by a respective increase of exports, i.e. demand for machinery and equipment. The exports cannot simply expand as quickly as the domestic investments have been declining. In this case we had a mixture of factors that caused a decline of activities in the electro-engineering industry. This was characteristic also for other branches of the national economy. Thus, we arrive at the conclusion that to describe the changes in the disequilibria we need both supply and demand equations.

Therefore, the first characteristic feature of the model W-5 is that it combines the two versions of the previous W-3 model in one. On the one hand, we have a system of equations generating supply. Supply is broadly understood: we mean by it generation of primary production factors, productive capacities, and the production itself (being import-constrained), and the allocation of the produced commodities among the final users. On the other hand, the model generates demand, i.e. the final demand of households, government, investors, exports and its transmission to the production level and then the demand for imports and also the required employment. Having defined such a system the following question must be answered. Should this system be closed, i.e. equilibrated or not? A system is equilibrated if we assume that supply equals demand[7].

---

[7] See W e l f e 1976, 1978.

Let us take a simple example. We shall assume that for the description of the consumer market the supply and demand functions have been defined. The supplies of consumer goods at the retail level (CS) depend on the production (QS), imports (M) and prices (PC). We thus have

$CS = s(QS, M, PC)$ supply.

The consumers' demand (CD) is determined by real income (Y) and prices (PC). Then

$CD = d(Y, PC)$ demand.

If we assume that $CD = CS = C$, where C means consumers' real expenditure, we can have many options. The classical option is of course the assumption that the prices clear the market and so PC will be endogenized by solving for PC the market system. Then, we might drop either the supply which is being done typically, or demand. The rationale behind the first solution is a belief that changes in supply will follow those in demand (at a given price level). Sometimes another option might seem more realistic. If the factors determining the expected supply are strong enough and the prices are kept constant the adjustments in the demand can be achieved via the income changes. Or to put this in yet another way - if the planner would like to satisfy the consumer demand, given the total supply of consumer goods and unchanged prices, he would have to adjust the nominal incomes (YP) in such a way that $CD = CS$. The precondition is that the planner is able to control the wages or incomes. However, the adjustment of wages downwards is hardly feasible and as the Polish experience shows, it is also difficult to control the rates of wage increases. In all the last 5 or 6 years, we faced a situation that the plans with regard to the pay-roll were overfulfilled[8].

The other most appealing possibility for the planners would be to assume that supply equation vanishes and from the supply equation either domestic production (QS) or imported supplies (M) will be determined. Then it must be assumed that there are no con-

---

- [8] It can be claimed that a skilled planner will be able to evaluate the likely level of the overestimation of the plan and calculate it in his forecast.

straints either in the foreign trade or with regard to the domestic production, i.e.either idle capacities must be available or their increase feasible. This solution uses the framework of a typical material balances technique.

Assuming this or that type of equilibrium or balancedness, we are going in fact to resign from an explicit determination of either supply or demand function. However, the above assumption does not seem realistic enough. The opposite might be typically true, i.e. that demand does not equal supply CS ≠ CD. In this case the system is left open.

One of the features of the model W-5 is that in two broad commodity markets the assumption has been made that the equation systems are open. We have the consumer goods market where both demand and supply are determined, but not equalized. The other block of the model where the subsystem is left open is the production measured at the producers' level. The factual production of 13 industries is being generated from the constrained production functions, while the demand for products of the above industries is obtained from transformation of the final demand. For the sample period, which covers 20 years one can expect that the estimates of both supply and demand should be very close to each other, provided suitable disequilibria indicators were used. But any simulation excercise that does not assume this type of balance will show the likely difference between supply and demand. If the user likes to perform simulations aimed at reaching the balance he might either solve the system with respect to chosen variables determining demand and/or supply (being residual), or use optimal control techniques to arrive at solutions close to balance.

4. General characteristics of the model W-5

The model W-5 is large and this is partly due to the fact that many blocks appear twice explaining demand and supply. Let us present now the general characteristics of the model. As it stands now it has more than 800 equations, among them more than a half being stochastic (the details are shown in Appendix 1).

In fact there are fewer behavioural equations than stochastic ones because in some cases the stochastic equations are simply

approximations of identities. The reason is that because of data deficiencies not all the components of an identity (the balance) are known or expressed in the same units.

There are more than 160 exogenous variables but among them less than 50 are strictly exogenous, the others are dummies which have been introduced to impose the shocks in parameters. Very often they can be regarded as reflections of the central planner's interventions, that took place in the past. For instance, if the prices for alcoholic beverages had been increased for about 50 or 70%, this change would be extremely difficult to explain by means of accumulated costs of alcohol fabrication or by accumulated excess demand. Dummy stays for a decision, that has behind it the above mentioned rationale. The variables which are strictly exogenous characterize either the impact of changes of the world economy or of the weather conditions. On the other hand, the variables being exogenous and at the same time representing the economic policy measures have been traditionally the government consumption (which will be endogenized in the near future), then variables determining the allocation of total investment and among the main spheres and industries and also the number of shifts worked in the industry being one of the most important indicators of the utilization of capacities. Some financial variables have been treated as exogenous too. They represent the government policy with regard to taxation and other financial measures (subsidies etc.). The prices are generally endogenized but many possibilities of intervention have been offered in the form of dummies introduced into the price equations.

5. The structure of the model

The structure of the model can be decribed by indicating what blocks of activities were distinguished and what is the aggregation level. Let us stress that the model has been enlarged as compared with the W-3 model. Typically, the models constructed for the socialist economies cover the real processes but not the financial ones, except for wages and incomes. We tried to enlarge the model W-5 by including the blocks explaining the financial processes, i.e. the incomes and expenditure of socialized firms,

of the state budget, and balances of payments, investment financing and money flows. The level of disaggregation is similar as in the W-3 models - the productive sector is divided into 11 industries, there are specific classifications of commodities and activities for final users etc.[9]

The first block deals with employment, and it generates hours worked and both demand by industries and total supplies of labour force. The second block describes investment and investment process. It generates the demand for investments by industries being mainly determined by the expected net output (increase). This is corrected taking into account the constraints with regard to the total investments, i.e. proportionally to the ratio of total required investments to those assumed by the government; the latter being related to the desired level of total consumption expressing the policy of protecting the attained levels of the living standards. Then, the supply of investment goods is determined: the buildings and constructions depend on the activity levels of the building industry, whereas the supplies of machinery and equipment are assumed to meet the demand (domestic investment and exports). This ensures the global balance between supply and demand for investment goods. The investment outlays (by industries) are transformed within an investment process characterized by specific lags into investments put into operation (gross capital formation). At the very end of this process, we will have a block showing the formation of fixed assets, taking into account the initial volume plus gross capital formation minus estimated scrappings (Fig. 1).

The next block characterizes the generation of output. The detailed description of the production functions will be given further on. Now, let us note that the block generates the capacity output, the supply, which is typically equal to the actual output, sales of output, and the demand for output by industries. Because we are using both net and gross output the equations are defined for both of these indicators (Fig. 2).

The consumer is described in a separate block. The domestic production and imports determine the supplies of consumer goods to the wholesale trade (adjusted for exports), which in turn

[9] See Tab. 1.

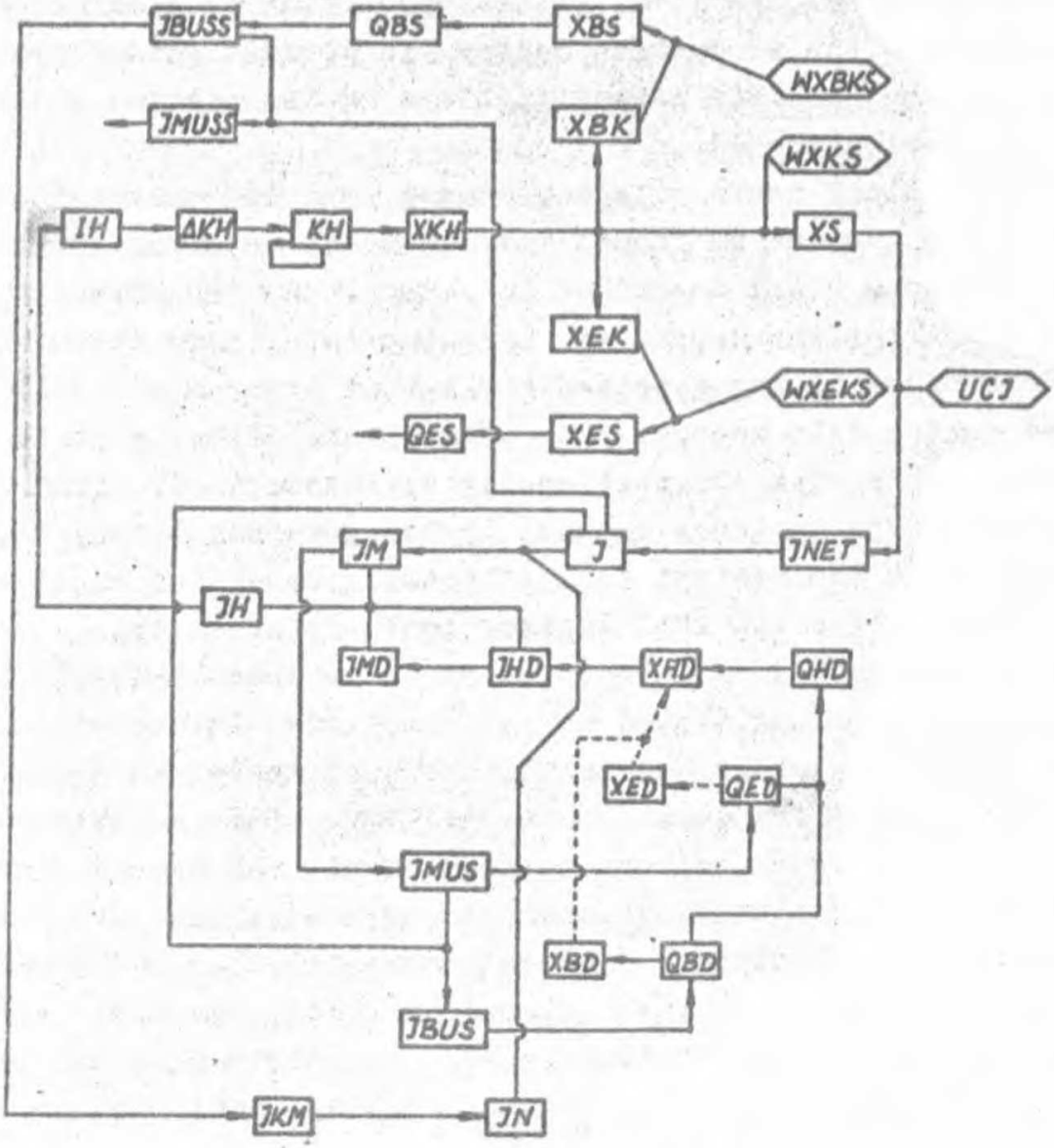

Fig. 1. Investment outlays-production

determine the sales at the level of the retail trade - with a distinction made between the socialized and the private trade. At the very end supplies to households are shaped. On the other hand, the consumer demand is generated in a traditional way (personal income and relative prices being the main explanatory variables). Both supply and demand are either left unbalanced or adjusted using general or specific instruments (prices, additional supplies etc.) (Fig. 4).

The inventory levels and changes are the ingredients of a separate block of the model. They depend on activity levels and

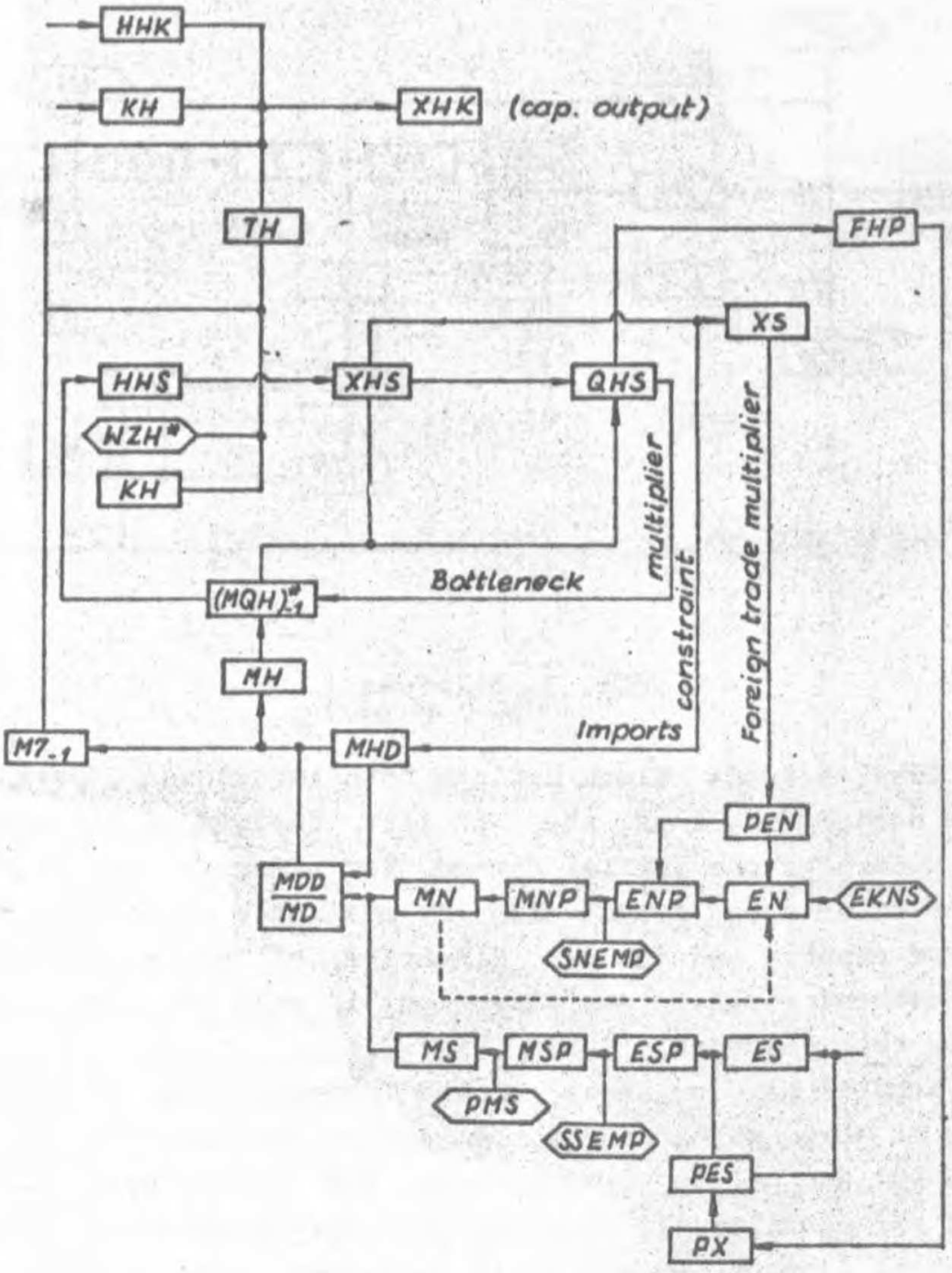

Fig. 2. Production sector

also on changes in demand-supply relationships. Unfortunately, they do not intervene much in the rest of the economy because of great difficulties, first of all, in measurements, and secondly, in utilizing that type of information. Therefore, for the time being this block is mostly post-recursive.

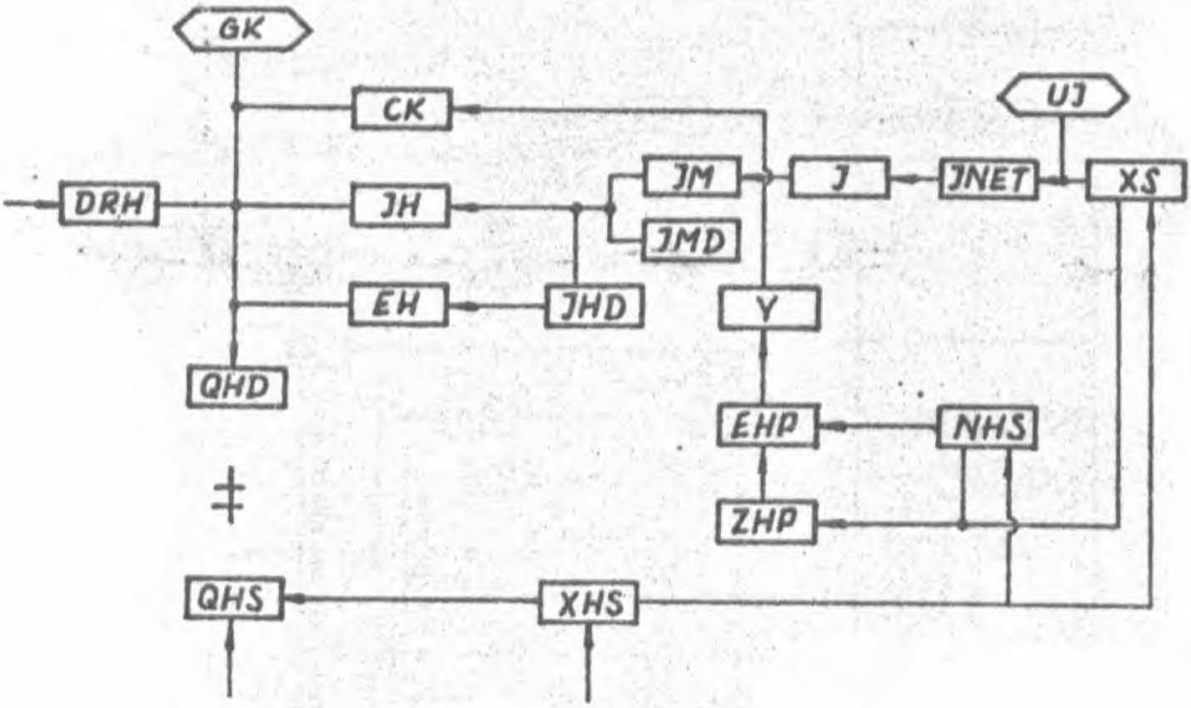

Fig. 3. Balances

The foreign trade block defines both import and export equations as demand functions. The specific feature of the model is that it generates the initial demand for imports and then compares the total money demand with the available money fund determined from exports and the net financing of foreign operations. This adjustment works in one direction, it cuts the demand if it is higher than disposable funds (Fig. 2, 3).

The traditional component of the financial side of the model consists of wages which depend on labour productivity, the rate of inflation and policy interventions, and total wage bills are obtained via identity. It also contains the formation of personal income which depends on wage bills, pensions and earnings from the private sector (mostly agriculture). The new feature is that we tried to incorporate in the model the elements of the so called balance of money receipts and expenditures of the households and the private sector used in the planning and controlling of money flows by the National Bank. This balance is rather more or less devoted to the characteristics of the money flows than to analysis of the consumer behaviour.

Several elements of the financial accumulation of the enterprises (gross surplus) are given in the model and they are put into a complex framework with the block covering the state budget.

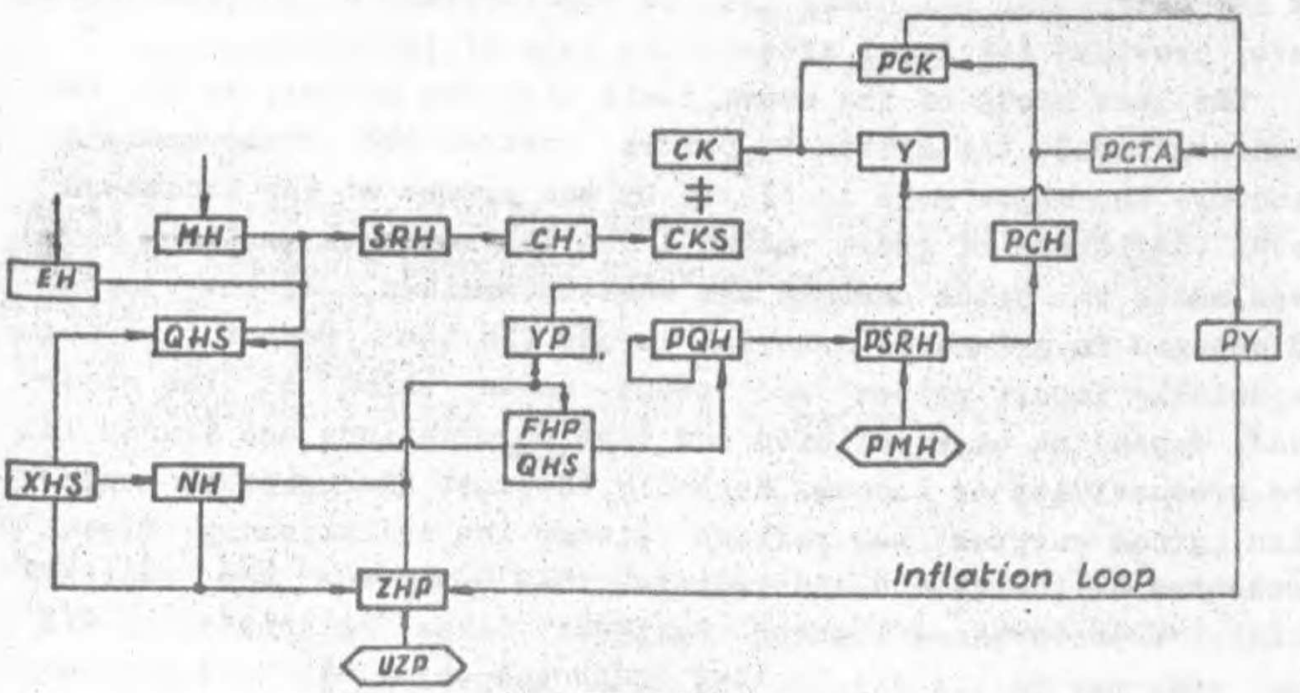

Fig. 4. Market

The state budget includes revenues and expenditure explained in the model by relating the items to the levels of activities generating revenues and to the level of activities financed from the budget respectively. The only problem which is to be solved is the incorporation of the banks financial operations in the model. This will help closing the system of financial flows.

The balance of payments was incorporated into the model in a rough way as the data were published fairly late with no sufficient detail. The model generates the total debt, the expected payments (including interest rate) and also total receipts and expenditure from foreign trade, including financial transfers.

Thus, we can say the financial side was largely developed in the model in comparison with its predecessors and other comparable models. Nevertheless, taking into account that the economic reform in Poland tends towards a broad use of the financial instruments in the economic policy - we have to determine how to link the financial sector with the real sector - introducing in the latter respective financial indicators as explanatory variables. Such an example dealing with the activation of private savings for instance, can be easily indicated. The interest rate which has been increased several times during the last few years,

is an instrument which may lead to the increase of propensity to save, provided its level exceeds the rate of inflation.

The last block of the model deals with the prices. As it has been mentioned, the system of prices covers the whole national economy. The major role is played by the prices at the producers' level (deflators of gross output). The following assumptions have been made: the price changes are cost-determined, i.e. they depend on changes in prices of material inputs (in the recent period especially import prices) and labour costs which on the other hand, depend on wage policies and wage negotiations and trends in the productivity of labour. Secondly, the unit financial accumulation (gross surplus) may reflect either the inflationary, fiscal pressures or the demand constraints that express the central planner's preferences via the indirect taxes or subsidies. The last case may be illustrated by the increases in alcohol or cigarette prices which are determined not according to the cost increases but are prompted by the actions aiming at diminishing demand. The specification of those equations is not satisfactory enough at the moment as it mostly observes the principle of cost push rather than equilibrating considerations.

6. The production function

The problem of constructing the production functions, mentioned above, is the most crucial if we wish to explain the economic crises which hit the Polish economy during the late seventies and at the beginning of the eighties, as well as to explain the future path of recovery. The question is how to adjust the production functions so as to be able to explain the underutilization of capacities which was being estimated for mining and manufacturing industries at 40% in 1982.

We mostly used the Cobb-Douglas type of production functions. The typical specification of the production function is that the net output (X) is a log-log function of fixed assets (K), employment (N) and technical progress (T). It defines in fact the capacity output. It may be understood in a different way according to whether the production is constrained by the existing machinery equipment (potential capital) or by available labour input (poten-

tial hours worked HS or potential employment). In the first case we have (disregarding the specific form of the function):

- capital-constrained capacity (net) output XK:

$$XK = f(K, HK, T, e), \tag{1}$$

where: HK - the number of hours worked, sufficient to utilize fully the available machinery and equipment, i.e. HK = h(K); e - - disturbance term.

In the second case:

- labour-constrained capacity (net) output XN:

$$XN = f(K * WZ, HS, T, e), \tag{2}$$

where WZ - the average number of shifts being a proxy for a coefficient of adjustment of the time being worked by machinery and equipment to the available working time of the employees - HS.

As there are not available statistical data about the capacity output or utilization of capacities in Poland (the same is mostly true for other socialist countries) we had to develop the concepts of measurement of the above mentioned indicators ourselves.

The main idea was to extend the notion of production function to cover the potential output constrained by all other production factors, especially material and energy inputs MQ, equal to factual production in the case when the potential output is less than demanded. It thus means we have to specify explicitly the above mentioned constraints. First of all, let us notice that the constraints in material inputs affect the time being worked. If there was no substitution between these two factors - the decline in hours worked could exhaust the effects of material input decrease. We have for the time being worked (H):

$$H = h(N, T, MQ^*_{-1}, e), \tag{3}$$

where: MQ^* - stands for an indicator of input constraints to be explained below, T - represents a declining time trend in the average number of hours worked per employee, and for the potential amount of working time (HS):

$$HS = h(N, T, e). \tag{4}$$

This is,however, not the case, as workers are not necessarily fired and are offered temporary extra jobs within factories (this was the common experience during the 1981/1982 crisis). Secondly the statistics of time worked are typically biased - hours not worked are not fully reported. There is another reason which is not less important. If there are constraints in spare parts or raw materials coming from imports and if the substitute-ability is not very high then the efficiency of use of materials declines. This means that to obtain the same output an increase in the inputs is needed, which are either of inferior quality or of inferior efficiency. That is what we have really observed in the industry starting from 1979[10]. That gives an additional argument towards introducing material inputs as a special variable into the equation system. In fact the constraints on input, especially on import side reflect two items: the physical decline of output due to the import constraints, secondly the decline in efficiency of material use.

Let us analyse in some more detail how the indicator of shortages in material inputs can be constructed. Several authors have been arguing that the problem can be solved by a simple extension of the list of explanatory variables of the production function, i.e. by means of adding a variable being proxy for material input. In this way energy was introduced as an explanatory variable, to allow for energy constraints in the 70's. In our case it should be rather the raw materials being in short supply, especially those imported from the hard currency areas. The results will be misleading as there were constrained possibilities of substitution for either domestic or produced elsewhere materials. Let us illustrate this point.Suppose we have a Cobb-Douglas type production function and if there are no returns to scale, then the sum of elasticities with regard to fixed capital (K), employment (H) and imports (M) should be close to 1. We would expect that the elasticity with regard to imports would be between 0.1-0.3 (the other two adding up to 0.7-0.9).This would mean that any addition of imported raw materials by 10% would add to the annual output

---

[10] The gross output still increased but the net output started decreasing, i.e. material inputs (per unit) increased.

by 1-3%, which seems reasonable, if this is associated with the quality or efficiency increase of the imported materials against the domestic ones. This, however, does not explain the decline of the activities of the industry, which will be associated with a decline in imports of raw materials by say 10%. The Polish experience indicates that the decline of output might be proportional or slightly less than proportional to the decline in imports (elasticities are in fact 0.7-0.9). It is not very difficult to explain what went wrong. The assumption that the raw material imports are substitutes for the other factors of production holds true only within a small range of changes in other production factors. Otherwise, imports are complementary to the use of other factors. Their decreased level has now moved to the position of efficient constraint, whereas "normally" it never does. Thus the satisfactory specification will imply that the impact of input restrictions should be constrained to the periods when they really occur.It technically means to introduce a suitable defined dummy. Now we have to answer how to define the "disequilibrium indicator" associated with material inputs being in short supply. This can be done in several ways[11]. The main idea is that the above indicator should compare the available material input with the necessary (normative) input. Generally we can write for such an indicator MQ^*:

$$MQ^* = \left[\frac{MQ}{Q} : \left(\frac{MQ}{Q}\right)^*. U_1\right], \tag{5}$$

where: $U_1 = \begin{cases} 1 \text{ if } \frac{MQ}{Q} : \left(\frac{MQ}{Q}\right)^* < \lambda \\ 0 \text{ otherwise} \end{cases}$

and $0 < \lambda < 1$, λ close to 1

or

$$MQ^* = (\dot{MQ}\% - \dot{Q}\%) \cdot U_2, \tag{6}$$

where $U_2 = \begin{cases} 1 \text{ if } \dot{MQ}\% < \dot{Q}\% \\ 0 \text{ otherwise} \end{cases}$

[11] See W e l f e 1982.

where: MQ - total material input, $(MQ/Q)^*$ - normative unit material input, $\dot{MQ}\%$ - percentage rate of change of MQ, similarly for $\dot{Q}\%$.

Combining the results obtained so far we can write the following formula for the production function, explaining the real output (provided there is no demand constraint):

$$XS = f(K \cdot WZ, H, T, MQ^*_{-1}, e), \tag{7}$$

where the lag for $M\dot{Q}$ was introduced to take into account the fact that the impact of input constraints is not immediate (due to an inventory buffer).

According to our experience, the indicator given by(5) yields results that are more stable (in simulation exercises) than the indicator specified by (6), where the rates of growth of inputs versus the rates of growth of gross output were used.

On the other hand, we had to adjust also the gross output.The relationships linking net output and gross output need adjustment being reverse to that introduced in production functions. This relationship was originally simple as it was assumed that the marginal rates of gross output to net output are constant. The decline of efficiency of material inputs means that this rate increases, i.e. that the decrease of net output must not be accompanied by a decline of gross output. Hence, we have the following equation generating gross output:

$$QS = f(XS, MQ^*_{-1}, e). \tag{8}$$

It is not certain whether the elasticities of net output with regard to imports or other material inputs determined for the case of decreasing imports (or other inputs) will be similar for the reverse case of increasing imports (material inputs), i.e. whether we obtain increased efficiency of inputs associated with improved utilization of machinery equipment and labour force of the same size. There might be a lag in response to the increased supplies, as in the first line the inventories have to be rebuilt and the changes in the product mix may imply further increase of inventories.

7. The principal economic mechanisms described by the model

In the demand-oriented models the relationships between investment and output are characterized by the well-known acceleration principle, whereas in the supply-determined systems there is a feedback which might be called inverse accelerator type of relationship. It is as follows.The production of investment goods increases the capacities with some delay in time, among others of the industries producing machinery, equipment and of the building industry. That increases the output of those industries. Thus, we have a feedback which is long-term being completely different from the classical accelerator. In the model W-5 the relationships were specified in a slightly different way being, to some extent, a mixture of these two above mentioned mechanisms. This is shown in Fig. 1. In its upper part, the net output (supplies) by industries adds up to the NMP produced. Given the exogenous net investment share we obtain net investment and hence total investments and investments in the material product sector. This, compared with the required investments in MP sector, yields the implied corrections in demanded investment outlays by industries. The adjusted investment outlays materialize in the fixed capital formation (after allowing for appropriate lags) and thus increase the capacities of industries and consequently their output as well as total NMP. This loop is obviously different from the inverse accelerator as in this case the physical output of industries producing investment goods does not determine the total level of investment activities. It is assumed that this level is being determined from the top (by adjusting demand for investment outlays - according to the desired levels of personal consumption). It follows that if the supplies of buildings and construction projects are dependent on the activity level of building industry (and building materials) - the supplies of machinery equipment being residual adjust the total supplies to total(corrected) demand. The feedback runs through the entire national economy, being not constrained to the sector of investment goods production. It must be added that the supplies of buildings and construction projects influence the levels of investment activities in the housing sector. As they co-determine the investment levels

in MP sector their decline (increase) will be competitive with regard to investments in the productive sector.

The initial demand for investment outlays by industries is determined in the model taking into account the expectations about the gross and net output demand. These requirements for the investment outlays are further adjusted according to the rules described above. The total adjusted requirements for investment outlays in MP sector generate the requirements for machinery and equipment and thus for the production of the electro-engineering industry. The requirements for buildings and construction projects are residual. They again influence the gross output of the building industry and co-determine the total requirements for the gross output by industries. As they further on co-determine the requirements for investment outlays, the loop is being closed. We have thus the feedback of an accelerator type which is however modified according to the general policies of allocation of the distributed national income.

The components of the production sector are highly interdependent (see Fig. 2). These feedbacks are realized with appropriate lags. If we start with the fixed capital, taking into account the hours worked, and arrive - using the production function - at net and gross output of separate industries, then (with one year lag) the scarcities in supplies of the products of these industries being inputs in other industries create new constraints captured by the production functions. If the loop is closed then we have a feedback called a bottleneck multiplier. On the other hand, the source of shortages can be the import constraints. They can have a far reaching impact. If they cause a decline in output and this diminishes exports, then given the foreign trade prices and expected balance of trade - the imports are affected again. This feedback will be called an import bottleneck multiplier.

The model contains also some minor feedbacks linking prices. It has been assumed that export prices to the non-socialist countries depend on the propensity to export. The export prices of commodities sold to the socialist countries are assumed to be affected by the domestic inflationary pressures. These price increments co-determine the earnings from exports and thus imports. The imports may indirectly influence the exports and thus the changes in export prices.

The interrelationships in the processes of distribution of the NMP, i.e. in the process of balancing output and demand are shown in Fig. 3. The output (supply) determines employment, co-determines wages and personal incomes and thus influences the consumer demand. It also determines the investment outlays and, thus, the adjusted requirements for investment goods. Therefore, the two main components of the final demand are influenced by total supply (by industries) which does not imply that they must equal each other.

Figure 4 shows relationships in the markets of consumer goods and illustrates the inflationary process. The starting point is the production. It determines market supplies, retail sales and supplies of consumer goods directly to the consumer. This is compared with the demand, which is determined by real income and relative prices. No assumption has been made so far that the prices clear the markets. No feedback of the multiplier type is to be found in the model because we had cut off the possibilities of adjusting the production of the consumer goods to the changes in the consumer demand.

There is an inflationary type of feedback in the model. The increase of labour costs characterized by the ratio of the wage bill to the total output produces pressures on the costs side towards an increase of the producers' prices. The producers' prices then determine the retail prices. At the very end they determine the living cost index. This again introduces pressures towards the wage increases. As the average wages are constitutive elements of the wage bill (their increase may be, however, compensated by the increase of productivity of labour), thus we have a typical inflationary feedback in the model. This latest interrelationship occurred especially strongly in the last 3 years during the social unrest.

8. Final remarks

The model attempts to capture the latest economic developments characteristic for the Polish economy, which may have more general significance. They are characterized by an economic crisis of unique depth and tendencies to recover slowly. The description

of the above phenomena proved to be very uncertain, because all the changes introduced in the model to deal with them are basically determined using only a few observations. These are the observations of the last 5 years if we begin with 1977. The model has been originally estimated using the last observation from 1979. Just now we try to re-estimate the model using the up-dated information for 1980-1981.Our experience with the supply-oriented model shows, however, that the year 1982 may be of a decisive value for the estimation of parameters for the period of the crisis and for the future projections. As we were not able to increase the sample size for the moment, then instead of using more statistical observations we were trying to put as much as judgement possible into the model specification. Therefore, our model is not purely econometric because the values of many parameters are based on extraneous information. It seems, however, observing the practice of those who are utilizing the models in developed countries, that the application of as much as possible extraneous information helps to arrive at more accurate prediction and simulation results.

Appendix 1

General description of the model W-5

Number of endogenous variables =	
= number of equations	839
among them - stochastic	408
- identities	431
- number of exogenous variables	141
Data used for estimation:	1961-1979
Methods of estimation:	OLS

Blocks of equations distinguished:

1. HOURS WORKED (HP), EMPLOYMENT (N), LABOUR PRODUCTIVITY, SHIFTS WORKED (WZ)
2. INVESTMENT OUTLAYS, DEMAND (J...D), CORRECTED (J), SUPPLY (J...SS), DEFLATORS (PJ)

3. FIXED ASSETS - GROSS CAPITAL FORMATION (I), FIXED ASSETS (K), ADJUSTMENTS (DK...I), NET FIXED CAPITAL FORMATION (DK)
4. CAPACITY OUTPUT - GROSS (QK), NET (XK), UTILIZATION (WXK), POTENTIAL HOURS WORKED (HP...K)
5. GROSS OUTPUT (Q), NET OUTPUT (X) - DEMAND, GROSS OUTPUT SUPPLY (QS), DEFLATORS (PQ), NET OUTPUT SUPPLY (XS), DEFLATORS (PX), INDUSTRIAL SALES (QQS)
6. NATIONAL INCOME DISTRIBUTED (XG, XGS) DEFLATORS (PXG)
7. WHOLESALE SALES: PROCUREMENT SALES (SSC), MARKET SUPPLIES (SR...S), DOMESTIC AND IMPORTED; DEFLATORS (PSR); RETAIL SALES (CH), DEFLATORS (PCH), SUPPLIES TO THE HOUSEHOLDS (C...S); CONSUMERS' DEMAND (C), DEFLATORS (PC)
8. INVENTORY INVESTMENT (DR) and STOCKS (R), DEFLATORS (PDR)
9. FOREIGN TRADE: IMPORTS DEMAND (M...D),CORRECTED (M),DEFLATORS (PM); EXPORTS (E), DEFLATORS (PE), BALANCE OF TRADE (SEM)
10. MONEY INCOMES AND EXPENDITURES OF HOUSEHOLDS AND NON-SOCIALIZED SECTOR; MONEY INCOMES (Y...PP), EXPENDITURES (C...PP), MONEY SUPPLY (BOPP)
11. WAGES AND PERSONAL INCOMES AND SAVINGS - AVERAGE WAGES (ZP), WAGE BILLS (FP), PERSONAL INCOME (Y), DEFLATORS (PY), SAVINGS - STOCKS (OL), INCREASE (POL), FINANCIAL EXPENDITURE (SBY), INVESTMENT EXPENDITURE (JKMLP)
12. FINANCIAL ACCUMULATION - PRIMARY FACTOR INCOMES (YU, V), FINANCIAL ACCUMULATION (GROSS SURPLUS) (AF)
13. STATE BUDGET - INCOME (BY), EXPENDITURE (BB)
14. BALANCE OF PAYMENTS - EXPORTS (E...), IMPORTS (M...), CAPITAL FLOWS AND DEBT (BD)
15. PRICES (P) (other than indicated in previous blocks)

Note: First letters of the respective symbols are given. For prices two symbols are indicated, the first P means price. Letter D at the end of a symbol indicates demand, letter S - supply. Letter P standing at the end of a symbol stands for valuation in current prices.

The disaggregation level.

The blocks representing primary factors of production, production and its allocation are grouped according to the industrial subdivision into (generally denoted by H)

- agriculture (R)

- forestry (L)
- mining and manufacturing (Q)
  among them:
  - fuel and power industry (QF)
  - metallurgic, chemical and mineral industry (QM)
  - electro-engineering industry (QE)
  - light industry (QL)
  - food industry (QR)
- building industry (B)
- transportation and communication (T)
- trade (H)
- others (PO)

and in non-material services sector:
- housing and communal services are distinguished (KM).

The specific groupings for different final users include (denoted by K):
- the consumption - of foodstuffs, alcoholic beverages, tobacco, textiles and apparel, other nondurables, durables, services
- the investment - buildings and construction projects, machinery equipment, others
- inventory increase - in trade channels, others fabricated: work in progress, raw materials and materials
- foreign trade - SITC classification is used to distinguish agricultural products and foodstuffs, other raw materials, fuel and energy, machinery, equipment, others.

Appendix 2

The list of symbols used to define the variables mentioned in the paper

AF	- financial accumulation of enterprises
AFO*	- other non-material expenditure of enterprises
C	- personal consumption
CH	- retail sales in socialized trade
CTA	- sales in catering trade
DR	- inventory changes

E - exports
ED - total exports
EHS* - total world exports
EN - exports to non-socialist countries
ES - exports to socialist countries
EKNS* - total exports of non-socialist countries
F - wage bill, socialized sector
H - hours worked
G* - consumption of material goods, non-material services sector
I - investments put into operation (gross capital formation)
J - investment outlays
JBUS - investment outlays, construction projects
JKM - investment outlays, residential and communal construction
JM - investment outlays in material production sector
JMUS - investment outlays, machinery and equipment
JN - investment outlays, non-material services sector
JNET - net investment outlays
K - fixed assets, end of year
LM* - urban population
M - imports
MD - total imports
MN - imports from non-socialist countries
MS - imports from socialist countries
MSRWP* - total imports of CMEA countries
M7 - imports of machinery and equipment
MQ - imports (use) of raw materials, semi-finished products and energy
N - employment
O - savings, stock end of year
PC - prices of consumer goods, index
PCH - retail prices in socialized trade, index
PCTA - retail prices in catering trade, index
PEN* - export prices to non-socialist countries, deflator
PES* - export prices to socialist countries, deflator
PMN* - imports from non-socialist countries, deflator
PMS* - imports from socialist countries, deflator
PQ - gross output deflator

PSR - market supplies of consumer goods, deflator
PX - net material product, deflator
PY - deflator of personal incomes
Q - gross output
QB - gross output of building industry
QE - gross output of electro-engineering industry
R - inventories, end of year
SG - difference between national income produced and distributed and losses
SNEMP* - balance of trade with non-socialist countries
SSEMP* - balance of trade with socialist countries
SR - market supplies of consumer goods
t - time
T* - technical progress indicator
WZ - number of shifts
WXBKS - capacity utilization rate in building industry
WXKKS - capacity utilization rate
WXEKS - capacity utilization rate in electro-engineering industry
X - net material product (net output)
XB - net output originating in building industry
XE - net output originating in electro-engineering industry
XG - national income distributed
Y - real personal incomes
Z - average wages

Notes:

* - denotes an exogenous variable
D - added after the symbol denotes demand
H - added after the symbol indicates the branch of industry
K - added after the symbol defining final users' purchases indicates the particular commodity group
K - added after the symbol defining hours worked, employment and output - denotes a variable, the values of which were adjusted to the full capacity utilization level
P - added after the symbol indicates that the variable has been expressed in current prices, otherwise - in constant prices
S - added after the symbol denotes supply
U - added before the symbol denotes a dummy variable. Variables

shown in circles are exogenous. All variables indicating values are expressed in billions of złotys. Constant prices of January 1, 1977 were used.

Appendix 3

Typical specification of equations in the simulation version of the W-5 model

Demand	Supply
1. Employment (N), hours worked (H):	
$NH = a_0 + a_1 XH * UND + a_2 (XHS/NH)_{-1} + a_3 DNS$	$NH = b_0 + b_1 XHS * UNS + b_2 (XHS/NH)_{-1} + b_3 DNS$
$HH = c_0 + c_1 NH + c_2 MQH^*_{-1}$	NS exogenous, $UNS = 1 - UND$
2. Investment outlays (J):	
$JMHD = a_0 + a_1 JMHD_{-1} + a_2 XH + a_3 UJMH$	$JNET = XGS - CXG - G - DR$
$JMD = \sum_H JMHD$, $JKM = c_0 + c_1 JKM_{-1} + c_2 DJBUSS + c_3 LM$	$J = b_0 + b_1 JNET$, $JM = J - JN$
	$JMH = f_0 + f_1 (JM/JMD)$
$JN = d_0 + d_1 JKM$, $JD = JMD + JN$	$JBUSS = g_0 + g_1 QBS$
$JNETD = e_0 + e_1 JD$	$JMUSS = J - JBUSS$
3. Fixed assets (K), gross capital formation (I), corrections (DK...I):	
	$KH = KH_{-1} + IH - \delta KH_{-1} + DKHI$
	$IH = b_0 + b_1 \sum_{i=0}^{T} j_1 JH_{-i} + b_2 UIH$
	$DKHI * c_0 + c_1 IH + c_2 UDK$

4. Capacity output (X...K):

$$HHS = a_0 + a_1 NH$$

$$\ln XHK = b_0 + b_1 \ln(KH * WZH^{max}) + (1 - b_1)[\ln HHS + \ln(WZH^{max}/WZH)] + b_2 t + b_3 \ln M7$$

$$WXHKS = XHS/XHK$$

5. Gross output (Q) and net output (X):

$$QH = a_0 + a_1 QL + a_2 CK + a_3 JK + a_4 EH$$

where: $L \neq H$

$$\ln XHS = b_0 + b_1 \ln(KH * WZH) + (1 - b_1) \ln HH + b_2 t + b_3 \ln M7 + b_4 \left(\ln \left[\frac{MQ}{Q} : \left(\frac{MQ}{Q} \right)^*_{-1} \right] \right) * U_{1,-1}$$

$$XH = c_0 + c_1 QH + c_2 MQ^*_{-1}$$

$$QHS = d_0 + d_1 XHS + d_2 MQ^*_{-1}$$

$$QHP = QHS * PQH$$

$$XHP = FHP + AFHP + AFOHP$$

6. Net material product (X) and national income distributed (XG):

$$X = \sum_H XH, \quad XG = CX + G + JNETD + DR$$

$$XS = \sum_H XHS \qquad XGS = XS - SG$$

$$SGD = X - XG$$

$$SG = b_0 + b_1 XS + b_2 (ED - MD)$$

$$XP = \sum_H XHP$$

$$XP = \sum_H XHP$$

Notices: MQ^* and $\left[\frac{MQ}{Q} : \left(\frac{MQ}{Q} \right)^* \right] * U_1$ are explained in the text, pp. 111-112

7. Sales - wholesale (SR), retail (CH), personal consumption (C):

$$CKD = a_0 + a_1 CKD_{-1} + a_2 Y + a_3 PCK/PY$$

$$SRHP = SRH * PSRH$$

$CX = \sum_{k} CKD$ (except services)

$CKP = CKD * PCK$

$SRH = b_0 + b_1 QHS + b_2 (EH-MH)$

$CHK = c_0 + \sum_{H} c_{1H} SRH$

$CHKP = CHK * PCHK$

$CKS = d_0 + d_1 CHK + d_2 CTAK$

$CXS = \sum_{K} CKS$ (excluding services) $CXC = CXS + UCX$

8. Inventory investment (DR) and stocks (R):

$RK = a_0 + a_1 CKD + a_2 RK_{-1} + a_3 QHS$

$DRK = RK - RK_{-1}$ (quasi balance)

$DR = \sum_{K} DRK$

$DRH = b_0 + b_1 DQHS + b_2 RH_{-1}$

$RH = RH_{-1} + DRH$

$DRHP = DRH * PDRH$

9. Foreign trade - exports (E):

$EH = a_0 + a_1 EHS + a_2 PEHS + a_3 MQ^*_{-1}$

$ED = \sum_{H} EH$

$EHP = EH * PEH$

$EN = c_0 + c_1 EKNS + c_2 (PEN/PEKNS) + c_3 MQ^*_{-1}$

$ENP = EN * PEN$

$ES = ED - EN$

$ESP = ES * PES$

Imports (M):

$MHD = a_0 + a_1 QHS + a_2 JK + a_3 CK + a_4 (PMH/PQH)$

$MDD = \sum_{H} MHD$

$MSD = c_0 + c_1 XS + c_2 (PMS/PX) + c_3 MSD_{-1} + c_4 DMN$

$MND = MDD - MSD$

$MS = b_0 + b_1 ES + b_2 (ES_{-1} - MS_{-1})$

$MSP = MS * PMS$

$SSEMP = ESP - MSP$

$MNP = ENP - SNEMP$

$MN = MNP/PMN$

$MP = MSP + MNP$

$MD = MS + MN$

$MH = MHD * (MD/MDD)$

10. Money incomes (Y...) and expenditure (C...) of households and private sector (double PP at the end of the symbol):

$$YKPP = a_0 + a_1\,YKP + a_2 UYKP \qquad CKPP = b_0 + b_1 CKP$$

$$YPP = \sum_K YKPP \qquad CPP = \sum_K CKPP$$

11. Average wages (Z), wage bill (F), personal income (Y), saving (DO):

$$ZHP = a_0 + a_1(XHS/NH) + a_2 PY + a_3 UZHP \qquad FHP = ZHP * NH \qquad FP = \sum_H FHP$$

$$YP = b_0 + b_1 FP + b_2 f(FP) + b_3 UYP \qquad Y = YP/PY \qquad DOP = YP - CXSP$$

(other expenditures)

12. Financial accumulation (gross surplus) of enterprises (AF):

$$AFHP = a_0 + a_1 QHP + a_2 UAFH \qquad AFP = \sum_K AFHP$$

13. State budget - income (BY) and expenditure (BB):

$$BYHP = a_0 + a_1 XHP + a_2 UBYH \qquad BBKP = b_0 + b_1 QHP + b_2 GP$$

14. Prices (P):

$$PQH = \left(a_0 + a_1 PMH + \sum_{\substack{j=2 \\ J \neq H}}^{m} a_j PQJ_j\right) + XHP/QH \qquad PXH = XHP/XH \qquad PX = XP/X$$

$$PSRH = b_0 + b_1 PQH \qquad PCHK = k_0 + \sum_H k_{1H} PQH + k_2 UPCH$$

$$PCK = c_0 + c_1 PCHK + c_2 PCTA \qquad PY = d_0 + d_1 PCX \qquad PCX = CXP/CX$$

$$PJBUS = e_0 + e_1 PQB \qquad PJMUS = f_0 + f_1 PM7 + f_2 PQE$$

$$PJH = g_0 + g_1 PJBUS + g_2 PJMUS + g_3 UPJH \qquad PJ = JP/J$$

$$PEH = h_0 + h_1 PEHS + h_2 EH/XS$$

$$PES = i_0 + i_1 PES_{-1} + i_2 PX + i_3 (ES/MSRWP)$$

$$PEN = j_0 + j_1 PEHS + j_2 (EN/XS)$$

References

C z e r w i ń s k i Z., W e l f e W., 1982, Macroeconomic Modelling Based on Econometric and Simulation Models for the Polish Economy, Chapter 11, [in:] Advances in Econometrics, ed. W. H i l d e n b r a n d, Cambridge University Press.

C z y ż e w s k i B., D ę b s k i W., W e l f e W., 1976, Dynamic Simulations Based on Revised W-1 Model and the Model W-3, the Polish Economy, Pr. IEiS UŁ, no. 26.

J u s z c z a k W., W e l f e W., 1986, Forecasts of the Polish Economy 1983-1985 Based on the W3S79 Model. Paper presented at the IX Conference "Problems of Building and Estimation of Large Econometric Models", Łódź, published in this volume.

K a l e c k i M., 1963, Zarys teorii wzrostu gospodarki socjalistycznej (On the Theory of Growth of the Socialist Economy), PWN, Warszawa.

K l e i n L. R., 1982, Wykłady z ekonometrii(Lectures on Econometrics), PWE, Warszawa, Chapter 2, Modele gospodarki socjalistycznej (Models of the Socialist Economy) by W. Welfe.

K o r n a i J., 1980, Economics of Shortage, North Holland, Amsterdam.

L u b e r a M., P o t a r g o w i c z M., W e l f e W., 1986, Multipliers Analysis Based on the W3S79 Model. Paper presented at the IX Conference "Problems of Building and Estimation of Large Econometric Models", Łódź, published in this volume.

W e l f e W., 1973, A Medium-Term Econometric Model of the Polish Economy. Pr. IEiS UŁ, no. 8.

W e l f e W., 1976, The Unbalanced Econometric Macromodels Exemplified by the Model W-1, [in:] J. Ł o ś, M. Ł o ś (eds): Computing Equilibria How and Why, North Holland, Amsterdam, PWN, Warszawa.

W e l f e W., 1978, Disequilibria in Econometric Macromodels of Centrally Planned Economies. Proceedings of the Colloque Structures Economiques et Econométrie, Lyon.

W e l f e W., 1980, Ekonometričeskije modeli v processie planirovanija narodnogo khozjajstva PNR (in Russian). (Econometric Models in the Process of Planning of the National Economy), Pr. IEiS UŁ, no. 34,

W e l f e W., 1981, Models of the Socialist Economy, IHS Journal, vol. 5, Physica Verlag, Wien.

W e l f e W.,(ed.), 1982, Modele popytu konsumpcyjnego i równowagi rynkowej (Models of Consumer Demand and Market Equilibrium), vol. 3 of Ekonometryczne modele rynku - analiza - prognozy - symulacja. PWE, Warszawa 1982.

Władysław Welfe

MODEL GOSPODARKI POLSKI W-5: OGÓLNE ZAŁOŻENIA I PIERWSZE REZULTATY EMPIRYCZNE

Model gospodarki Polski W-5 służyć ma jako narzędzie analizy polskiego kryzysu, źródeł jego powstania, związanej z nim nierównowagi oraz scenariuszy odpowiadających alternatywnym drogom wychodzenia z kryzysu. Stanowi on w istocie znacznie rozbudowaną, podażowo zorientowaną wersję modelu W-3. W szczególności rozbudowane zostały znacznie funkcje produkcji oraz równania opisujące przepracowane roboczogodziny i dostawy dóbr konsumpcyjnych; określone zostały ponadto zdolności produkcyjne oraz stopień ich wykorzystania.

W modelu W-5 podjęto także próbę budowy systemu równań opisujących popyt finalny i pośredni, w sposób zbliżony do ujęcia zastosowanego wcześniej w popytowo zorientowanych wersjach modelu W-3. Dzięki temu uzyskano możliwość badania nierównowagi na poziomie producentów oraz gospodarstw domowych (konsumpcji indywidualnej).

Nowymi cechami modelu jest:

- jawne wprowadzenie priorytetów centralnego planisty dotyczących relacji konsumpcja-inwestycje, zmian alokacji nakładów inwestycyjnych oraz alternatyw dla bilansu płatniczego,
- włączenie do podmodelu sektora finansowego równań opisujących wpływy i wydatki budżetu państwa, finansowanie nakładów inwestycyjnych i główne elementy bilansu płatniczego.

Model W-5 zawiera ok. 840 równań, szacowany był na danych obejmujących lata 1961-1979 przy użyciu klasycznej MNK.