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W-5 - ECONOMETRIC MODEL
OF THE POLISH NATIONAL ECONOMY**1. Introduction

The research aimed at the W-5 model construction in its present shape and on its utilization in simulation analyses and forecasting (till 1990) has been led since the mid-1983. There were elaborated: a) the concept of the new simulation-forecasting version of the model (see W. Welfe (1983, 1985a))¹, b) the final model structure obtained as a result of long-lasting searches for "the best" specification of the model equations (see G. J u s z c z a k, W. W e l f e. (1985 b)) and next, c) the model validation and first results of forecasting and simulation analyses regarding new 5-year plan 1986-1990 period. In the applications there were used the results and experiences from the application of the smaller, W7S model, which constituted the initial point for the construction of important elements of the W-5 model blocks generating the production factors supply and production flows.

The W-5 model is the first large model of a new generation. It takes into account not only the sources of economic growth and its disruptions but, parallel, allows to analyze economic dis-

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¹ That idea has been presented to the International Conference: ESEM - Pisa 1983.

equilibria. It contains, besides clear definition of market and institutional adjustment mechanisms of unbalanced growth, full range of possibilities for the Central Planner to influence the rates of growth modifications and to undertake measures aimed at approaching the equilibrium state. In this way it has not only scientific but also great potential practical importance. It is expressed in the possibilities of varying the paths of development and the ways of balancing economic processes. It has been manifested in its utilization for scenarios analysis concerning the alternatives of the Polish economic development in the years 1986-1990. It should be underlined that, contrary to typical "plan-preceding" undertakings, analyzes based on the model have the advantage consisting in the fact that obtained alternative solutions take into account full range of consequences resulting from simultaneous and dynamic feedbacks.

2. Structure and Characteristics of the Model

The W-5 model is a simulation type and forecasting model with more than 1000 equations, among those more than 400 are stochastic ones. There are no more than 60 exogenous variables (except the dummies). They embrace strictly exogenous variables (characteristics of international trade, weather conditions and demographic phenomena) as well as variables being the instruments of economic policy. The data for the model cover annual time series for the years 1960-1982, expressed e.g. in constant prices of 1982. They were taken from data bases created by the IEiS Uł within the framework of ministerial Project R.III.9. Regression equations parameters were estimated by OLS on the basis of annual data for 1960-1982.

The model covers not only real processes - of production and distribution of the NMP but, what is its individual feature, also financial processes together with subsystem generating the movement of prices. It was divided into 15 blocks of equations which encompass (variables symbols are given in brackets):

- 1) employment (N), the time worked (H), shifts worked (WZ);

- 2) investment outlays (J), investments put into operation (I);
- 3) fixed assets (K), scrappings (DK), depreciation (A);
- 4) capacity output in terms of potential net output (XK), degree of its utilization (WKK);
- 5) net output (X), gross output (Q) and sales, deflators;
- 6) the distributed national income (XG);
- 7) market deliveries (SH), retail sales (CH), household purchases (C), deflators;
- 8) stocks of inventories (R), stocks increase (OR), deflators;
- 9) exports (E), imports (M), deflators;
- 10) money incomes (YB), expenditures (VY), of households and non-socialized sector;
- 11) wages (Z), wage bill (F), pensions and other incomes; personal income (Y), savings (OZ), deflators;
- 12) financial accumulation of enterprises (AF), other non-material costs (AFD);
- 13) state budget: incomes (BY), expenditures (BC);
- 14) balance of payments;
- 15) prices (P).

The degree of the model disaggregation is not especially deep (it is lower than in the I-0 Tables). It embraces in the sphere of material production (X) sectors and branches (H): agriculture (R) divided into plant, animal and other production, forestry (L), industry (Q) divided into groups and of branches encompassing: mining and power (QE), raw material industries (QM), i.e. metallurgy, chemical and mineral industry, electro-engineering (QE), light industry (QL) and food-processing industry (QR) and other branches (QI); the next: transport and communication (T), trade (H) and other sectors (I). In the sphere of non-material services (O) housing and communal services (Z) were distinguished.

Specific classifications of products flows directed to the groups of final users (K) were accepted. They refer to the households (7 groups of expenditures), investments (3 kinds), stocks of inventories and foreign sector (5 groups according to the SITC classification).

The model generates information concerning the above blocks

in both constant (1982) and current prices and in US dollars as for the foreign trade.

The feature that distinguishes the W-5 model from among the others consists in the fact that its basic blocks can generate information about not only the resources and flows being realized in the economic processes but also about potential values of respective variables, being unobservables. It concerns the capacity output and its utilization and especially demand and supply and additionally excess demand. As for consumer goods it allows to estimate the excess demand for distinguished groups of these goods as well as their global level (forced savings).

We should underline here that the W-5 model is the first large model for socialist economy which explicitly poses and tries to solve the above problems and in this way it stimulates the development of the economic theory and applied econometric model building². In particular, it was proved that traditional understanding of demand function (for consumer goods as well as for investment goods and materials both domestic and imported) in disequilibrium conditions is not sufficient. The proposal was made to generalize the notion of demand function. The effective demand - besides its notional value (being in accordance with equilibrium conditions) - should contain additional elements resulting from: a) forced substitution (intergroup transfers), b) postponement in its fulfilling (intertemporal transfers), c) anticipation of changes in intensity of disequilibria or prices. The budget constraint should be redefined to include additional sources of demand financing (mostly forced savings). Parallel, there was formulated a specific concept of disequilibrium indicators for estimating the excess demand. The difference between the effective demand function and that of excess demand (both variables are unobservable) yields the equation explaining the expenditures (realizations) being observable. It enables the

² There have to be notice interesting attempts to apply the disequilibrium econometrics framework to small macromodels accentuating the short-term adjustments mostly of the central planner, neglecting, however, the production process. See R. P o r t e s, R. E. Q u a n d t, D. W i n t e r, S. Y e o (1983).

estimation of the parameters of this equation and next the separation of the effective and excess demand³.

On the other hand, to obtain correct characteristics of capacity output and its utilization it proved to be necessary to analyse from the very beginning the basic hypothesis concerning the construction of the production function. Its results seem especially important. A clear distinction has to be drawn between the long-term concept of the production function (two-factor one), generating capacity output and short- and medium-term adjustments in the output levels reflected in the degree of capacity output utilization. These adjustments mostly due to the constraints in the supplies of the production factors, have been mostly interpreted, in the flavour of M. Kalecki's theory of growth barriers. And thus, in the investment processes modelling (decisive factor for the increase of machinery equipment determined capacities) consumption barrier was taken into account, while in the case of production function itself, employment barrier (directly and indirectly by introduction of characteristics of machinery equipment utilization in the form of numbers of shifts) and foreign trade one (imports of raw materials and fuel constraints⁴). The last one was taken into account by introduction to the production function of a special disequilibrium indicator expressing the degree of shortage of imported raw materials against their industrial demand. As a result we were able to estimate jointly the adjusted production function parameters including those showing the impact of the capacity output utilization and next to generate not only the expected output (offer) but also (unobservable) capacity output and the degree of its utilization. Let us notice that potential, working time has been generated for this purpose. Production offer (in terms of gross output by industries) obtained in the way presented above can be compared with demand for dome-

³ As for demand for consumer goods this problem has found its widest presentation in the series of studies, by A. W e l f e (1984, 1985, in print). We used here also some suggestions of J. K o r n a i (1982).

⁴ The W7S model contains also explicite barriers in the materialtechnical supplies of commodities of domestic origin, resulting from the three above mentioned barriers affecting directly and indirectly capacities of supplying industry.

stic products (by industries) generated by the model to define the degree of economy imbalances at the producers level.

It should be added that for the adequate presentation of the effects resulting from technical progress - what is especially important for long-term analysis - two indicators were constructed to measure the effects of embodied technical progress. The first one is based on the assumption that those effects are quasi-proportional to the rate of growth of fixed assets, the second - that they depend on imported technology⁵. It allowed for presentation - better than in earlier versions of our models - of decrease of the rate of embodied technical progress in the period of economic crisis and its increase after the economic development acceleration began.

The endogenization of price changes which took place in the second half of the seventies was an important achievement of the W-class models. Special systems of price equations with wholesale price equations as their core (gross-output deflators at the level of industries) have been constructed. They were and still are constructed according to the so called cost formula, i.e. expressing only cost push factors. Many tries have been made to verify the hypothesis that the changes of the disequilibrium intensity (demand pressures) provoke, respectively, upward price tendencies - but they have not given positive results, what is not against the practice. Only large scale price increases (e.g. of foodstuffs in 1982) or of alcoholic beverages and luxuries could be explained by a tendency to diminish the inflationary gap (they are represented in the model by dummies).

Possibilities of inflationary processes investigation are, in general, broadly offered by the W-5 model. The inflationary loop was introduced explicitly. It consists in the fact that growing living costs of the households cause, less than proportional, growth of nominal wages what results in the increase of labour costs (partly compensated by the increase of labour productivity) and brings an increase of production costs (if not

⁵ Broad discussion with many alternatives is included in doctoral dissertation of G. J u s z c z a k (1985).

compensated by savings of energy and materials). These cost pressures finally lead to the producers price increase and of the wholesale and retail prices and of living costs of the households. Centrum interference by means of limiting the price growth in an administrative way is of short-term meaning only. It is associated with the increase of subsidies, etc. After some time it is followed by "compensatory" price increases.

The model offers a wide range of possibilities of conducting analyses of inflation sources both from the demand side (incomes and wages) and supply side (supplies of consumer goods to the household sector, etc), policy simulations aimed at restraining inflation by means of "softening" its sources. We should mention here the consequences of changes of proportions in production and use of investment goods versus consumer goods, the impact of balance of payments changes (e.g. the increase or decline of net exports), the results of acceleration of hampering of budget expenditures for social or military aims (and the role of the budget deficit), etc. These last possibilities result from the enlarging of the W-5 model by financial sector of the economy.

The above characteristics of the specific properties of the W-5 model does not give full range of the possibilities of this application for enriching the economic analyses concerning the alternatives of economic development in the 5-15 year horizon. Therefore we shall extend it by having a look at economic mechanisms described by the model, trying to indicate the role of the Central Planner in shaping the growth path and modifying the economic policies in order to balance the economic activities.

3. The Mechanisms of the Economic Growth and Balancing the Economy

Following M. Kalecki we shall consider as the basic ones the relationships occurring in the investment and production processes, i.e. between investment outlays and expected output, characterizing efficiency of the investment process and concerning the use of the machinery equipment constrained capacities (blocks of

investment, fixed assets and output). There is a "supply acceleration" rule defined in the model. It consists in the following feedback. The investment outlays materialize themselves as the increase of machinery equipment after the time needed for accomplishment of investment process. Given the degree of capacity utilization, it involves the production increase also in the sector producing investment goods, which is additionally accelerated due to the technical progress. The national income growth achieved this way involves - given the investment (NMP rate) especially "productive" investment (NMP rate) - further increase of investment outlays (also in the investment goods sector). This autonomous growth process may be of cyclical character, if e.g. concentration of outlays for new, starting investment projects takes place in the first years of the 5-year plan (what has not been confirmed in Poland). It may be accelerated (delayed) by regulatory activities aimed at a) the change of investment share in the national income and next the share of production investments, b) the changes in the length of investment cycle, c) the change of the degree of utilization of machinery equipment depending, among the others, on barriers in production process.

To describe properly the phenomena characteristic for the economic crisis we were forced to include broadly in the model the growth barriers concerning not only labour force supply, but also foreign trade barriers (mainly imports of fuel and raw materials) beginning with the second half of the 1970s. The model offers the possibilities of an analysis of expected results of measures aimed at enlarging (or limiting) labour force supply, mainly by means of social policy decisions. Foreign trade barriers are presented in the model by making total imports dependent on exports and assumed (exogenous) balance of trade (by groups of countries). The above barriers explain the decline of capacity output utilization and production itself in the years of the economic crisis. In scenario analysis alternative assumptions with regard to foreign trade constraints allowed us to differentiate the forecasts concerning expected increase of the utilization of the fixed capital (growing old) in the 1980s. The possibilities of relaxation (or tightening) of supply constraints are additio-

nally given by introducing characteristics of material costs share (by industries) to the model. They depend, first of all, on the foreign trade constraints and institutional settings which are introduced into the model by means of changes of the respective equations parameters.

The modelling of the distribution and utilization of the NMP and national income is closely related to the needs of analyses of imbalances occurring in the national economy and its particular sectors as well as the policies of restoring the equilibria. The model allows to generate supply a) directly - of consumer goods (deliveries for the market supply of domestic and imported commodities, retail sales, etc.) and investment goods and b) indirectly for exports and material-technical use. On the other hand, the model allows to generate directly final demand, especially for consumer goods, mostly that of the households, investment demand, foreign demand and demand for imported commodities. It allows, only indirectly, for the computation of demand for raw materials, materials and energy. Total demand for products by industries is obtained using either the input-output approach (including the use of bridge matrices) or its stochastic approximations. The demand for labour is generated using equations derived from the production functions. The demand for fixed assets is not directly specified⁶.

The possibilities of balancing demand and supply appear in the model in almost all the phases of production process while the number of autonomous, especially of market clearing (price) mechanisms of adjustment is limited. It is assumed that the sensitivity to the changes of relative prices is shown mainly by the households (demand responses) and production units as for the changes of prices of imported commodities in relation to domestic ones. As a result, the model generates the values of variables showing directly the degree of balance tensions (mainly the excess demand): a) by the direct comparison of demand and supply on the

⁶ The respective equations were used to obtain the equations explaining the requirements for investment outlays. The latter can be regarded as reduced forms of equations explaining demand for investment outlays in terms of fixed assets increase and demand for fixed assets in terms of expected output.

consumer goods market and also as for forced savings and of total demand and supply by industries as for the production level, b) indirectly by means of specific disequilibrium indicators - in exports and material supplies. It should be underlined that the Central Planner's measures aimed at restoring the equilibria have been partly endogenized. It takes place in the case of investment goods when it is assumed that initial demand of economic organizations for investment outlays is being modified according to the policy targets (e.g. protecting of the consumption levels during the economic crisis). Similarly, the demand for imported goods (by commodity groups) is being adjusted respectively to the financial possibilities defined by the Central Planner. In the model there are also other possibilities available to include Central Planner's interventions. It concerns both influencing the production process efficiency and the relaxation of employment barrier. It is worth mentioning that the model explains the tensions in the labour market. The possibilities of their relaxation and, generally speaking, of ensuring full employment is typically linked with social policies (changes in retirement age, granting new social benefits for young mothers, etc.) including the changes in the length of working time (working days per week and hours per day).

As for financial processes we should pay attention to the fact that wage increases being the main source of personal income increase, were related mostly to the growth of living costs and to some extent to the labour productivity growth but also to the increase of tensions in the labour market. The possibility of Central Planner interference were assumed in the model. However, we are sceptical as for the feasibility of their utilization, especially in the case of the wages freeze. We have already discussed the inflationary loop and generation of prices above. It is worth indicating that the model creates, however moderate, but interesting possibilities of the analysis of consequences of financial and monetary policies. We have in mind the government budget as well as the banking policy in both controlling the investment activity and forcing of current efficiency of economic organizations and also pro- or antiinfla-

tionary measures. We tried here to include the realities of the economic reform.

4. Utilization of the Model for Forecasting of Economic Processes and Economic Policy Simulations

The simulation model W-5 and earlier the simulation model W7S, which constituted the starting point for establishing blocks generating supply, became a basis for systematic forecasting and formulating alternatives of the Polish economy development for the years of new, 5-year plan 1986-1990 (see W. J u s z c z a k, W. W e l f e (1984, 1985a), W. W e l f e (1985b)). First attempts were made to extend the forecasting horizon until the year 1999. It should be stressed that having accepted the econometric model as a basis, the results of the forecasting exercises are internally consistent and fulfill balance conditions in the sense that all macroeconomic categories in the model constitute the sum of elements of particular aggregates. They take also into account interrelationships, particularly the feedbacks, existing in the national economy, and described by the model. It enables treating the results of the simulations based on the alternative scenarios as alternative variants of the likely future economic development.

The first our forecast concerning the period 1986-1990 was available before the official "Variants of the Concept of the National Social - Economic Plan for 1986-1990" were published (W. J u s z c z a k, W. W e l f e (1985a)). The next one including also the results of simulation analysis concerning several alternatives of future development was ready in the end of summer 1985. Results of those forecasts and analyses compared to the plan variants will be summarized below.

The assumptions concerning the factors defining the possibilities and barriers of growth (investment outlays, foreign trade balance, import of raw materials and fuel) do not differ significantly from the third Plan Variant. It was accepted that the

positive trade balance with non-socialist countries will not surpass 1.7 billion of US \$ in 1990, while for the socialist countries declining negative trade balance will remain. The increase of, first of all, raw materials and fuel imports was assumed. Net investment outlays are to grow at an annual rate of 7%, what should ensure the beginning of the restructurization process in the industry by the end of the 80-ties. On the other hand, the employment stagnation should have been assumed in the sphere of material production.

As a result of forecast we obtained results (the rates of growth of the NMP, of personal consumption, etc.) closer to the second (lower) variant of the Plan proposal. This is mostly due to the less optimistic way of defining - in our forecast - the production factors efficiency increase, especially with regard to the savings of the energy, raw materials and materials. Tendencies observed in the recent years show continuous growth of material costs content in the gross output; prevailing import barriers will still make the reversal of the above trends difficult.

Forecasted annual rate of growth of the NMP will amount to 3.6%. It will be achieved under stabilized employment - being the result of the production potential increase by 2.3%, resp. embodied technical progress as well as raw material import increase by 8%; average weather conditions in agriculture were assumed. It will mean a very slow increase of the degree of utilization of production potential, unless accelerated scrapping of old equipment takes place within the framework of restructurization policy.

All over the forecasting period the tensions in material and material-commodity balances should be expected. Preliminary estimates show that the degree of satisfaction of demand for the domestic production will increase but will not exceed 93% as for the products of industry in 1990, except for foodstuff industry products - 98%, what is the result of investment priorities for this industry and expected price increases limiting consumer demand for food. The deterioration (further shortages) may take place with respect to the building industry products what would

indicate real threat to the suggested programmes of the housing development.

The forecast says that the foreign trade will be developing at higher rates than the production - exports by 6.3%, imports by 6% (these values are between the second and the third plan variant). The turnover with socialist countries will grow at higher rates according to the agreements concluded (7% in imports with socialist countries against 4.3% with non-socialist countries).

The increase of market deliveries by 4.4% will be the consequence of the above rates of growth of output and imports. This, taking into account the necessities of restoring the stocks of inventories, especially in trade organizations, will diminish the increase of offer for households to 2.5% (annually and consequently the personal consumption). The possibilities of further supply increase largely depend on the scale of minimizing the losses in the process of storing and processing of agricultural products and increase of quality and efficiency of industrial production and in the long-term on the reorientation on market production. The latter is expected to be the result of structural changes which may take place as a result of changes in investment policies towards respective changes of the industrial allocation of investment outlays.

We foresee, an average annual wages increase by 10.5% that of personal income by 11% what involves average rate of inflation of about 9.1% remaining at stabilized levels. It does not seem to be realistic the Plan assumption that the inflation rate can be reduced to the level of 6-7% by the end of the 80-ties. Taking into account slow increase of the market offer, market tensions, (decreasing from year to year) are expected to take place during 2-3 years of the new, 5-year plan period. Still in 1988 the excess demand for non-food commodities may be at the level of 4-6% according to the preliminary estimates. Analogously, global financial - market situation will be only slowly stabilized what results from limited efficiency of the policy aimed at hampering the wages growth, and the continuation of the policy of repressing the price increase, although not at the scale foreseen by the plan project.

Scenarios analysis of the variants of the economic development until 1990 assume the possibilities of the acceleration of growth by means of old machinery equipment elimination as the initial point (elimination of 5% of fixed assets in industry and building). As it has been mentioned before, the three variants of Plan Project assume the possibility of acceleration of growth by means of extensive savings of energy and materials resulting from improved technologies and industrial organization. Our assumptions accentuate the role of technical progress in this respect. The results of simulation showed that if the stocks of raw materials resulting from their savings thanks to old equipment elimination were utilized for the enlarging of consumer goods production, then it would enable a reallocation of imports towards the increase of imports of fuels and materials. Gived additional exports intensification in 1987-1990, obtained results are encouraging. In relation to the baseline forecast, average annual rate of growth of the national income would increase by 0.7%, i.e. to 4.3% while the personal consumption by 0.4% to 2.9%. The rate of inflation would decline by 0.5% to 8.7%.

The results of the next simulation excercises are not less interesting. The relaxation of external barriers by granting additional loans of 3 billion US \$ (in 1986-88) was assumed. This experiment which can be treated as a warning forecast gave surprising results. The use of the loans under other conditions unchanged would result in the restoration of economic and industrial structure from the end of 1970s and would bring the deterioration of the economic situation after 1988, i.e. when the additional supplies from import are over. Positive results were obtained after extending the simulation scenario by additional assumptions. They consist mainly in assuming the changes in the economy structure towards developing the exporting industries to ensure additional growth of exports in 1988-1990 and after. To provoke these changes there were assumed: the increase of the annual rate of growth of investment outlays to 8% and the changes in the imports allocation in favour of the imports of fuels, raw materials and materials at expense of consumer goods imports. As a result strong "push" was obtained as for the foreign trade in the first years after having received additional possibilities

of imports financing. Additional annual export increase as compared with the baseline forecast amounted to 3%, i.e. the rate of growth increased to 9.1%, while imports by 3.7%, i.e. to 9.7%. Additional increase of national income would be quite stable and by 1.5% higher (i.e. annual rate of growth would be 5.1%) while the personal consumption by 1.1% (i.e. to 3.5%) with limiting the annual rate of inflation by 2%, i.e. to 7.2%.

The above variants of simulation analyses do not exclude each other showing the possibility of obtaining better results than it has been presented. They, of course, do not exhaust the possibilities of improvements as for the economic policy.

However, they seem to be interesting enough, from the economic policy point of view, to advise systematic preparation of similar scenarios simulated on the basis of the econometric macromodels, under the condition that these tools of macro-economic analysis, still underestimated in our practice, are systematically updated and actualized.

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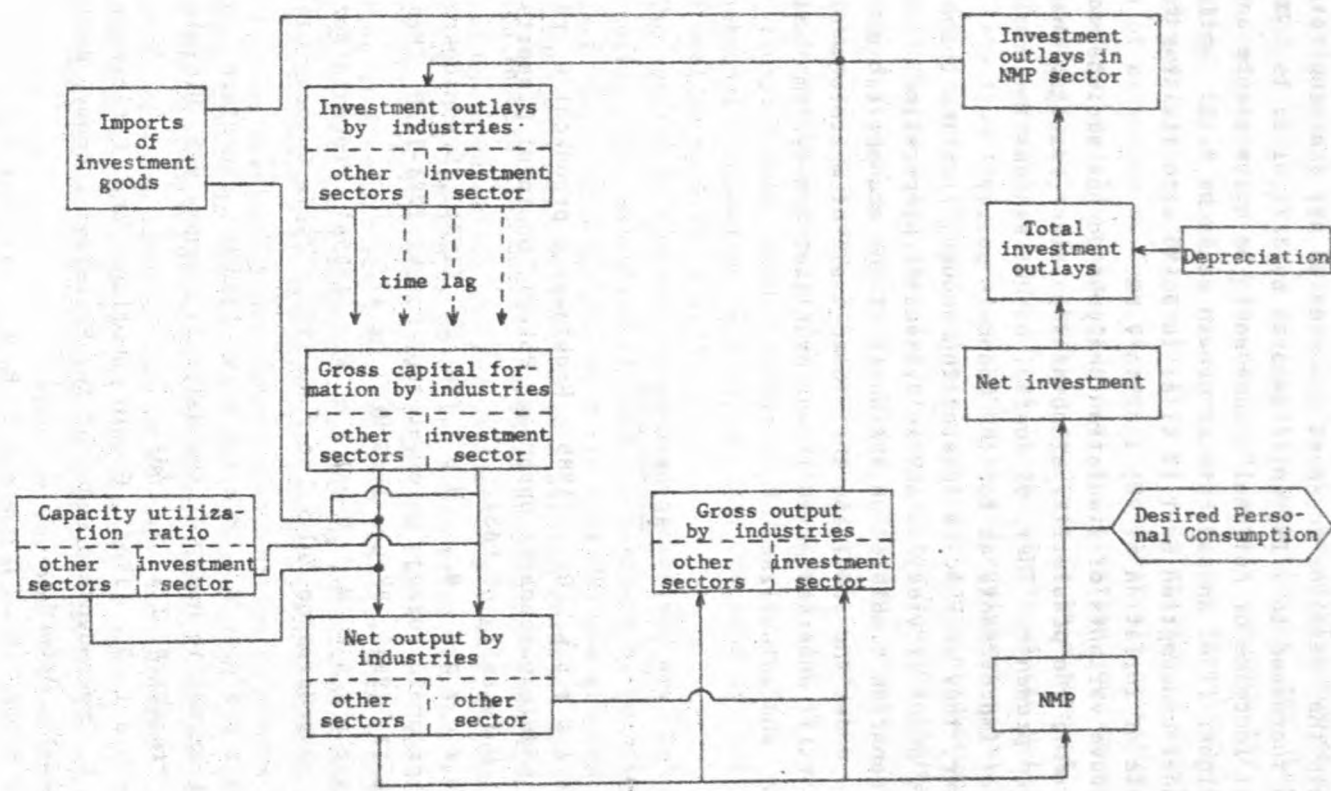


Fig. 1. NMP growth and investment loop

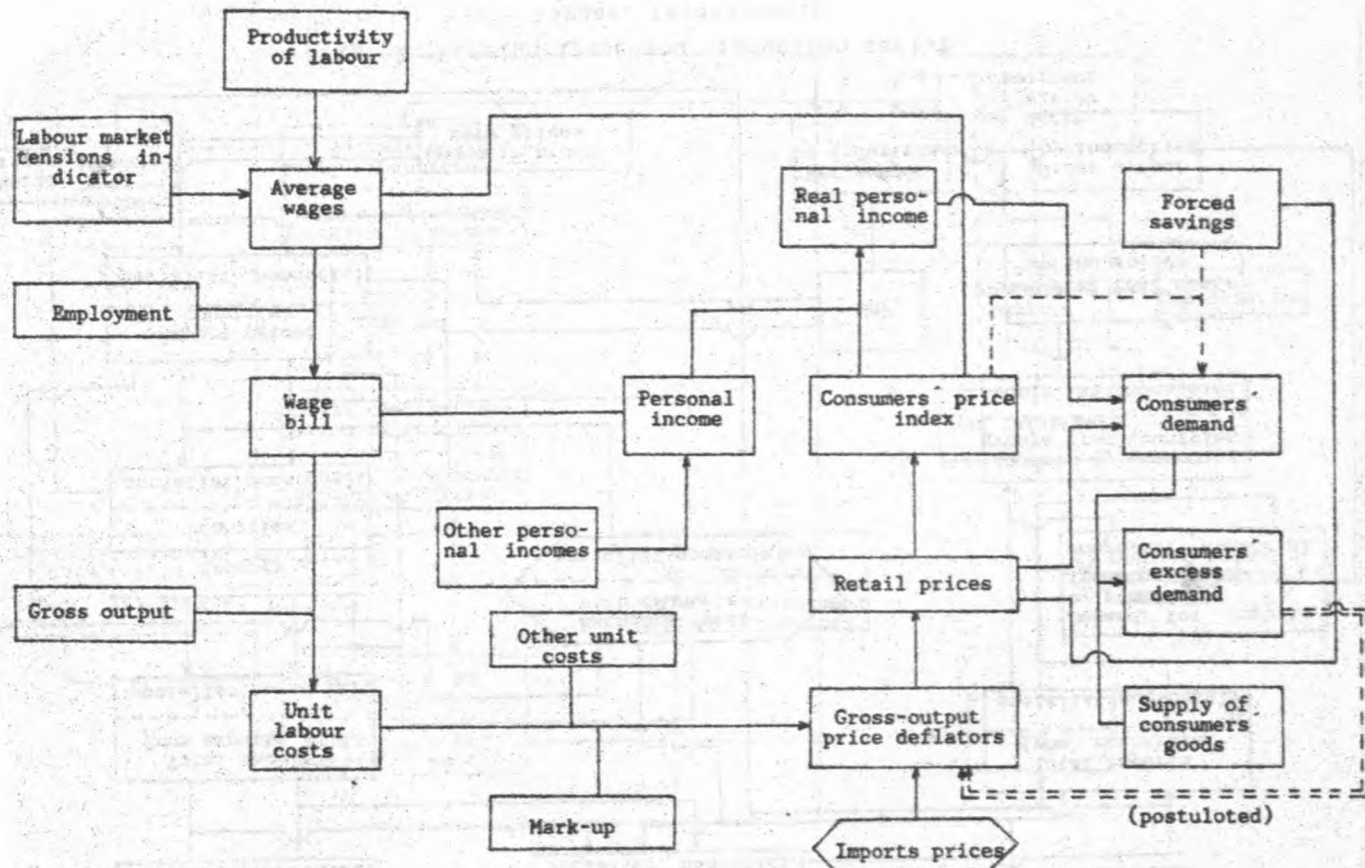


Fig. 3. Inflationary loop, consumers' goods market

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EKONOMETRYCZNY MODEL GOSPODARKI NARODOWEJ
POLSKI W-5

W nowej generacji modeli gospodarki Polski (W5 i W7) podjęto próbę integracji celów długookresowych i krótkookresowych adaptacji w zachowaniu podmiotów gospodarczych (przedsiębiorstwa, gospodarstwa domowe) oraz funkcji kontrolnych centralnego planisty przy zastosowaniu, w warunkach reformy gospodarczej, instrumentów polityki finansowej. Bezpośrednim zadaniem było objaśnienie kryzysu gospodarczego lat 1979-1982 i towarzyszących mu zjawisk nierównowagi gospodarczej, inflacji oraz prezentacja symulacji gospodarki ukazujących możliwości wyjścia z kryzysu i odbudowy gospodarki:

Nowy model ma charakter operacyjny, wyróżnia 13 działów i gałęzi oraz odpowiednie kategorie popytu finalnego wraz z operacjami instytucji finansowych. Model W-5 składa się z 1200 równań, opisuje popytową i podażową stronę gospodarki, generując wielkości nieobserwowalne (moce produkcyjne, nadwyżka popytu itp.),

akcentuje także istnienie barier wzrostu, zwłaszcza ograniczenie bilansu płatniczego oraz przedstawia spójne schematy alokacyjne.

W sektorze produkcji główną rolę odgrywają funkcje produkcji, wiążące długookresowe technologiczne funkcje produkcji z czynnikami objaśniającymi krótkookresowe zmiany w wykorzystaniu zdolności produkcyjnych. W schemacie alokacyjnym przyjęto, iż ceny nie są wystarczającym czynnikiem określającym ten proces.

Rola dostosowań rezerw i zapasów jest również ograniczona. Model definiuje popyt finalnych odbiorców określając nadwyżki popytu, wymuszone oszczędności itp. przez wprowadzenie odpowiednich indyktorów nierównowagi.

W modelu przedstawiono także spójny system równań cen oraz pętlę inflacyjną. Wykorzystano również informacje zawarte w tabelicach przepływów międzygałęziowych. Model stanowi narzędzie dla konstrukcji prognoz oraz scenariuszy symulacyjnych na okres 1986-1990.