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THE STRUCTURE AND USE OF THE LONG-TERM ECONOMETRIC MODEL W8-D OF THE POLISH ECONOMY

1. Introduction

The new econometric model W8-D of the Polish economy was built with the intention to meet the needs of long term macroeconomic analyses. Its simulation version aims to support the work on the long term strategy of economic and social development of the country.

It was based on an earlier one sectoral model W8 of the Polish economy (R. Courbis, W. Welfe, eds. [1999]). The model was developed within the system of national accounts. It generates the GDP and its key components – consumption and investments, allowing for net exports. The final demand is confronted with the supply of goods and services as well as the capacity output, which allows analysis of fluctuations in the rate of capacity utilisation. Further, changes in the capacities are linked to investment activities. The model makes it possible also to evaluate the demand for labour force and, by setting it against supply, to estimate the rate of unemployment.

The model in its long-term version was extended in order to study the impact of technical progress on capacity output represented by the changes in total factor productivity – TFP. The changes in TFP were simultaneously related to the increase in a) domestic and foreign R&D stock and b) human capital stock. The endogenisation of technical progress followed the lines advocated by the endogenous theory of growth (W. Welfe et at. [2001]). It was executed by means of respective extension of production function and introducing equations explaining the dynamics of R&D and human capital.

The model is closed using equations explaining prices and wages, and the basic elements of the financial flows such as incomes, expenditures and savings of households, of enterprises and the government budget, as well as money and capital resources and their use.

The basic equations of the model (for example production function, consumer and investment demand functions, price and wages equations) are stochastic. Consequently, their parameters have to be estimated using time series of sufficient length. The series referred to the annual data that initially covered the years 1960–1993 for the real sector. They were extended up to the year 1998. The equations were respectively reestimated which helped to obtain more reliable estimates of producers and investors responses to marker signals for the transition period. We frequently had to allow for the changes of economic regimes also for the periods prior to the ‘90s.

Below, in section 2 we present the results of parameters’ estimation for selected major stochastic equations. Their specification rests on the extensive macromodelling experiences described in the world literature of the subject[1]. We tested many alternative hypotheses regarding likely regime or parameter changes, especially for the period of transition. More detailed information about the economic background and results of estimation can be found in our previous studies[2].

After transforming the estimation results of stochastic equations’ parameters we obtained equations of the simulation model. Having attached relevant identities that close the model, the model’s solution was arrived at. The short description of the properties of the simulation version of the model, the multiplier analysis is described in section 3. The presentation of the first results of the long-term economic policy simulations is postponed to section 4.

2. Structure of the long-term econometric model W8-D of the Polish economy

2.1. Introduction

The concept to estimate parameters of the model W8 equations using time series covering the years 1960–1993 may have looked risky as the sample covered several economic regimes, from the centrally planned, command type

[1]Particularly useful turned out to be the monograph devoted to the history of modern macroeconometric modelling: R. G. Bodkin et al. [1991] and the monograph by J. H. Dreze et al. [1990]; see also J. D.Whitley [1994].

[2]See W. Welfe, A. Welfe, W. Florczak [1996b]. Let us notice that the consumer demand, wages and government budget equations were proposed by A. Welfe. Specification of the other equations was based on W. Welfe’s concepts, put into life by W. Florczak. See also W. Welfe [2001].

economy through its decentralised version of the '80s to the transforming economy starting from 1990.

Yet, there are many premises that allow to believe that parameters of numerous equations were constant in time. This concerns the equations describing the technology (production and employment functions) and preferences of particular economic agents (for example, the consumer demand function), and the hypotheses are easily verifiable. On the other hand, the marked turning points in time allow segmentation of the sample (most frequently by relevant changes in the parameters), when changes in the behaviour (for example of the producers) or in the economic policy (e.g. regarding imports rationing) are to be accounted for.

The specification of model equations uses the hypotheses based on the underlying economic theory. We had to take into account the particular mechanisms referring mainly to producers (state-owned companies) and financial institutions, that initially governed in the period of a centrally planned economy and then were substituted for the new ones in the period of transition to market economy[3].

The model was broken down into five groups of equations. The first group explains the final demand and supply of goods and services. The second block explains production process and the third describes how the technical progress was endogenised. The next block defines the disequilibria in the commodity and labour markets. The last block presents financial flows as well as wages and prices. In each of the blocks the stochastic equations were distinguished, whose parameters were estimated using time series data. Then, the potential (unobservable) values of variables, being components of the simulation version of the model, were identified and their realisations calculated.

Equations of the blocks covering the real sector, are largely non-linear, for the case of simplification power or exponential functions, or their combinations, were assumed. Dynamisation of these equations was quite limited, considering the fact that they describe annual changes, i.e. being of limited inertia. Therefore, basically one year lags were assumed. The expectations were allowed for in the traditional manner, generally by assuming the adaptive expectations. Attempts to extend the dynamic specification, also by taking into account models with error correction, were successful in only few cases. This can be justified by observing that the sample was to small to allow for changes in economic regimes, i.e. for estimation of two or three long-run parameters.

Parameters of single equations were estimated using non-linear LS. Reestimation of parameters using methods that ensure consistency of estimators and are based on estimation of parameters of the whole system (3SLS, ML), is anticipated at the next stage of the research. Alternative hypotheses concerning equations' specification were verified using standard tests.

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[3]Wishing to keep our exposition concise we present its abbreviated form, referring the reader to more comprehensive justifications in our papers: see W. Welfe [1993], W. Welfe, A. Welfe [1996], and W. Welfe (ed.) [1997].

2.2. Equations explaining final demand

The first block includes equations explaining the *final demand*. They cover consumer demand (CD_t) that depends on real personal income and the public demand (GD_t) depending on the real current expenditures of the government budget. Next equations concern the investment demand (JAD_t) depending on the expected increase in or the actual level of output, on the rate of capacity utilisation, on relative prices and user costs, as well as the demand concerning the increase in inventories (DRD_t). The above components make up the domestic final demand (XGD_t). Then equations were defined that explain the foreign demand (export (ED_t)) that depends on the world exports and relative export prices, as well as the demand for imported goods (MD_t) that depends on GDP and relative import prices. Effectively, this allows to arrive at the final demand for domestic products (XD_t), i.e. for GDP.

As the starting point for estimation of parameters of the above demand functions were assumed equations explaining realized personal consumption, public consumption, investments, increase in inventories, export and import. To avoid biases in the periods of shortage relevant disequilibrium indicators were applied, or dummy variables being their substitutes. This is equivalent to the assumption that the supply of consumer and investment goods is equal to the domestic demand adjusted for the excess demand represented by the simple functions of indicators. We shall show the specification of consumer and investment demand in some detail.

The *consumer demand* (CD_t) is mainly dependent on the real personal income (Y_t) adjusted for net consumer borrowing $(YDIS_t)$. It was assumed that households behaviour was driven by the long term expectations (*life cycle hypothesis*), hence the dynamic specification of this relationship.

Since 1990 the changes of real interest rates on deposits started to oscillate. Hence, this variable was introduced; the parameter standing with this variable had to be calibrated, however.

We had also to allow for the excess demand, that appeared before 90's with different intensity, by introducing as the explanatory variable a disequilibrium indicator (II_t), based on the relations between the major determinants of demand (real incomes) and supply (see A. Welfe [1984]). It occured not sufficient enough to explains the excess demand in the worst years 1981–1982 and 1989–1990 for which respective dummies (U_t) were introduced. Considering that the anticipated demand resulting from the expected rate of inflation appeared sporadically and rather on local markets, the introduction of this variable was given up.

In effect the following equation explaining personal consumption (C_t) was obtained:

$$\underset{}{\Delta \ln C_t} = \underset{(3.2)}{0.366} - \underset{(2.2)}{0.168}(\ln C_{t-1} - \ln YDIS_{t-1}) + \underset{(6.5)}{0.409}\Delta YDIS_t - \underset{(2.9)}{0.0285}YDIS_{t-1} +$$
$$- \underset{(.)}{0.2}(1 + RKFR_t /(PC_t / PC_{t-1})(1 - U6090_t) - \underset{(2.2)}{0.0191}I1_t + \qquad (1)$$
$$- \underset{(4.2)}{0.0743}U8182_t + \underset{(2.4)}{0.0453}U83_t - \underset{(3.3)}{0.592}U89_t - \underset{(6.5)}{0.141}U90_t$$

$\overline{R}^2 = 0.903 \quad DW = 2.2 \qquad \overline{R}_L^2 = 0.997 \quad DW_L = 2.3$

where:

$RKFR_t$ – nominal interest rate,

PC_t – consumption deflator,

L – levels; absolute values of t-statistics in brackets.

The estimated short-term elasticity with respect to real incomes equals to 0.4, but the long-term elasticity is equal to 0.83. The excess demand was ca 6–8% of the volume of supply in the worst years – 1981–1982. The consumer demand (CD_t) was obtained by ignoring the excess demand.

The demand for *investment goods* was decomposed into three elements, with reference to the timing of the investment process and motivation (including financing). So the demand for investments in machinery and equipment – JV_t was distinguished (mainly enterprise sector), and in buildings, structures and other facilities – JJT_t. In the last case we distinguished private ($JJTF_t$) and public investments treated as exogenous (for the case of simplification it was assumed that they are represented by the investment outlays from the central budget in the real terms ($BCJP_t / PJJTF_t$)).

Specification of the investment outlays' equations concerns periods when mechanisms in the investment decision processes showed quite considerable variations. It was assumed anyway that throughout the period the accelerator rule was in use, reflected in relating the size of an investment project to the expected (planned) increase in the production capacity. This justifies assuming the increase in or the level of GDP (X_t) and the lagged investments as the explanatory variables (See comprehensive argumentation in: W. Welfe [1992] and W. Welfe and A. Welfe [1996]).

It was also taken into account that in the case of high rate of utilisation of the existing production capacities (WKZ_t), investors were inclined to invest promptly, whereas in the case of low rate – to slow down the rate of growth of investments.

In addition, for the economy in transition a hypothesis was formulated that investment decisions of enterprises were also affected by the profitability of investment projects. An approximation of the relative user cost KUI_{it} was assumed being the product of the real interest rate: $(1+RKFR_t)(PJV_{it}/PJV_{t-1})$ divided by the ratio of *GDP* deflator (PX_t) to investment deflator (PJ_{it}): (PX_t/PJ_t), where $i=V_t, ITF$ [4].

The introduction of variables approximating profitability stresses non-linearity, hence, it was decided to choose non-linear specifications.

We shall show in some detail the equation explaining *investment outlays on machinery and equipment* (JV_t) only. Beside the explanatory variables mentioned, a variable was introduced that expresses the effects of replacement of labour with machines, defined as the ratio of average wages (WBP_t) to the deflator of investment goods (PJV_t). A relatively more expensive labour forces – according to this hypothesis – substitution, that is, an additional investments increase.

Also, we had to take into account that in some periods the above relationships were disturbed. This concerns the policy of accelerated growth in the early 1970s (dummy $U7275_t$).

Direct estimation of seven parameters turned out to be practically impossible (to few degrees of freedom and collinearity of variables). Hence, by using search procedures, we obtained estimates of parameters standing with the rate of capacity utilisation. Ultimately we have:

$$\begin{aligned}\ln JV_t = {} & \underset{(0.2)}{0.326} + \underset{(6.1)}{0.634}\ln JV_{t-1} + \underset{(15)}{0.276}\ln X_t + \underset{(5.7)}{0.304}\ln(WBP_t/PJV_t) + \\ & +\underset{(\cdot)}{0.4}\ln WKZ_{t-1} - \underset{(1.5)}{0.187}\cdot\ln KUIV_t * (1-U6091_t) + \underset{(4.2)}{0.219}U7275_t + \\ & - \underset{(3.6)}{0.323}U82,\end{aligned} \tag{2}$$

$\overline{R}^2 = 0.984 \quad DW = 1.5 \qquad \overline{R}_L^2 = 0.978 \quad DW_L = 1.3$

The short term elasticity of investments with respect to the level in GDP amounts to 0.3, and the long term is 0.75. This gives approximate estimate of marginal capital-output ratio. In the short-term an 1% increase in user costs yields a 0.2% decline in investments, whereas in long-run a 0.5% decline, showing that investments are highly sensitive to changes in real interest rates. The effect of replacement of labour with the machines is considerable (long term elasticity exceeds 0.8).

The specification of the investment demand for structures, buildings or other types of investments in the enterprise sector $(JJTF_t)$ is similar to that presented above.

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[4]This specification is close to that assumed in the neo-classical approach to the investment function. See D. W. Jorgenson [1967]; also W. Welfe, A. Welfe [1996].

Final demand for domestic products (XD_t) was obtained by adding up components of the final domestic demand (XGD_t) and the foreign demand (ED_t), and subtracting the demand for imports (MD_t):

$$XD_t = XGD_t + ED_t - MD_t \tag{3}$$

where

$$XGD_t = CD_t + GD_t + JAD_t + DRD_t .$$

2.3. Equations explaining production process

The second block of the model provides a description of the process of generation of production factors and, above all, of the potential output. Fixed capital was analysed in two variants: with machinery and equipment only (baseline variant), or total, including also buildings and structures. Gross fixed capital formation, i.e. new investments put into operation depend on the investment outlays spent before. Lag distributions are considerably different for buildings and machinery. The former were described using the polynomial lag distribution (second degree polynomial was assumed with maximum 6 year lag). For machinery and equipment the hypergeometric distribution proved a sufficiently accurate approximation.

The supply of labour force depends on the number of working age population and fluctuations in its economic activity that are on the other hand linked to the ratio of social benefits to wages and the level of wealth.

The technical production function linking outlays of the factors of production with the output, i.e. GDP (X_t) is of the essential importance. The Cobb-Douglas type production function was used because of its well known properties. Its initial form refers to the combination of the long term relationship generating potential output and the characteristics of its utilisation (see W. Welfe [1992]). Broadly speaking, it can be written as follows:

$$X_t = B(KM_t^a N_t^{1-a}) A_t (WKZ_t^n WN_t^m) e^{e_t} \tag{4}$$

where:

KM_t – fixed capital (machinery and equipment),

N_t – employment,

A_t – total factor productivity (TFP),

WKZ_t – rate of shifts utilisation,

WN_t – rate of working time utilisation,

e_t – disturbance term.

When constructing the production function two measures were used alternately: of fixed capital covering only machinery and equipment (KM_t) – baseline version, shown above and total fixed assets (K_t) – auxiliary version.

Total factor productivity (A_t) represents the impact of technical progress embodied in additions to fixed capital stock and human capital, as well as disembodied technical progress described in the next section.

The characteristics of utilisation of the productive fixed capital and the working time of the employed were:

– rate of utilisation of shifts *WKZ*, defined as the ratio of the number of shifts in industry (WZN_t) [5] to its historically maximum value $WZN_t^{\max} = 1.53$, that is $WKZ_t = WZN_t / 1.53$,

– rate of the working time utilisation (WN_t), defined as the ratio of the time worked per one employee during the year (NH_t) to the nominal working time per one employee (NHN_t) [6]: $WN_t = NH_t / NHN_t$. Because of lacking data about the number of shifts and utilisation of the working time of the machines it was assumed that the changes in them are proportional to the changes in the number of shifts and the utilisation of the working time of the employed.

Parameters of the production function were not directly estimated on the basis of equation (4). It was assumed that the economies of scale at the level of the national economy could be ignored which consequently allowed to define the functions of productivity of fixed capital $(WXKM_t)$ and of the productivity of labour (WXN_t), and thus to reduce the strongly correlated variables representing fixed capital and employment to the capital-labour ratio $(TUM_t = KM_t \cdot WKZ_t / N_t)$.

In the process of estimation of the parameters of equations explaining productivity of fixed capital and labour productivity we had to use the decomposition of TFP – shown here in general terms as A_t^K and A_t^L – into the variables measuring the R&D expenditures as well as the human capital per employee.

Results of estimations of the parameters of the *productivity functions* are as follows:

for the productivity of machines and equipment $WXKM = X_t / KM_t$:

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[5] For the years 1992–1993, when the information about the rate of shifts stopped to be published, the data were estimated, by extrapolating the series for the ‘90s. The following values of the rate were obtained 1992 - 1.13, 1993 - 1.12.

[6] For the years 1960–1978 data were available only on the industry. As the rates of working time utilisation in the economy were in the next years on average higher by 2.5% than in industry, so the rates for the whole economy in the years 1960–1978 were obtained by increasing industrial rates respectirely.

$$\Delta \ln WXKM_t = -0.501 \Delta \ln TUM_t + \Delta \ln A_t^K + 1.075 \Delta \ln WKZ_t +$$
$$(4.8) \qquad\qquad (4.8)$$

$$+ 0.558 \Delta \ln WN_t - 0.0901 U7982_t + 0.0448 U8384_t - 0.107 U90_t$$
$$(1.6) \qquad (4.8) \qquad (3.4) \qquad (3.4)$$

$$\overline{R}^2 = 0.849 \quad DW = 2.0 \qquad \overline{R}_L^2 = 0.997 \quad DW_L = 1.6 \tag{5}$$

and for the labour productivity $WXN_t = X_t / N_t$:

$$\Delta \ln WXN = 0.495 \Delta \ln TUM_t + \Delta \ln A_t^L + 0.518 \Delta \ln WN_t +$$
$$(5.0) \qquad\qquad (1.7)$$
$$- 0.0911 U7981_t + 0.0444 U8384_t - 0.111 U90_t \tag{6}$$
$$(7.5) \qquad (2.9) \qquad (4.1)$$

$$\overline{R}^2 = 0.857 \quad DW = 2.0 \qquad \overline{R}_L^2 = 0.973 \quad DW_L = 2.1$$

Estimates of elasticities with respect to fixed capital are rather high $(\hat{a} = 0.5)$, for both the productivity of machines, and productivity of labour.

2.4. Total factor productivity and the impact of r&d capital and human capital

The total factor productivity changes treated as a representation of the technical and organisational progress can be generally decomposed in three factors (W. Welfe [2001]). The first shows the impact of technical progress embodied in additions to fixed capital (A^K), next embodied in labour (A_t^N) and the last representing the influence of an increase in general knowledge (A_t^W).

Using the production function (4) we can thus postulate that:

$$A_t = A_t^W (A_t^K)^a (A_t^N)^{1-a} \tag{7}$$

Different approaches were represented in the literature as to the ways the above components should be associated with primary production factors. (R. J. Barro [1991], N. Mankiw et al. [1992]; P. M. Romer [1990]). We represent the view that all the above components must be represented in the production function, using (7) as otherwise the estimates of parameters in equations explaining particular TFP components only, might be biased.

The impact of an increase in general level of knowledge is mainly represented by exponential time trend. In our computations its impact occured negligible.

The impact of technical progress embodied in fixed capital, A_t^K might be represented either by patent activities or by real cumulated expenditures on R&D, i.e R&D real capital, following Coe and Helpman [1995]. The transfers from abroad play here significant role, especially in smaller countries. Having at our disposal the data on domestic and foreign R&D expenditures we used the second approach. The results of estimation were following:
for the productivity of machinery equipment:

$$0.5\Delta \ln A_t^K = \underset{(0.5)}{0.076}\Delta \ln BIRKS_t + \underset{(1.4)}{0.0838}\Delta(M7_t / JV_t \ln BIRMS_t), \tag{8}$$

for the productivity of labour:

$$0.5\Delta \ln A_t^K = \underset{(0.5)}{0.0705}\Delta \ln BIRKS_t + \underset{(1.7)}{0.0904}\Delta(M7_t / JV_t \ln BIRMS_t), \tag{9}$$

where:
$BIRKS_t$ – cumulated R&D real expenditures in Poland,
$BIRMS_t$ – cumulated R&D real expenditures in 6 major OECD countries weighted by their imports share in Polish foreign trade,
$M7_t$ – imports of SITC group 7, (mainly machinery equipment),
JV_t – domestic investments of machinery equipment.

The above parameter estimates being far from significant are close to those obtained by Coe-Helpman [1995]. Hence, we did not calibrate them.

Human capital (H_t) was estimated for Poland using the data on employment decomposed into three segments taking into account the education level (basic, middle and high, i.e. university level). The weights were represented by the ratio of average wages in 1996 in these groups $(WBP_{i,96})$ to the average wage of employees with basic education $(WBP_{0,96})$. Hence, we have for total human capital:

$$H_t = \sum_{i=0}^{2} (WBP_{t,96} / WBP_{0.96}) N_{it}, \tag{10}$$

where:
N_{it} – employment with educational level i.

and human capital per person (h_t):

$$h_t = \sum_{i=0}^{2} (WBP_{i,96} / WBP_{0,96})(N_{it} / N_t). \quad (11)$$

As the quality of labour was identified with the human capital per emplayee i.e. $A_n^N = h_t$, the elasticity of GDP with respect to h_t was, following (7), equal $1-a$, that is roughly 0.5 for both productivity of machines and labour[7].

The human capital was further endogenised by relating its increase – after allowing for its depreciation – to the number of graduates and further students of particular educational level, the number of people in schooling age and educational costs being dependent on goverment and household expenditures, (see. W. Florczak et al. [2001] and fig. 2).

2.5. Potential output and employment

Estimation of parameters of the productivity of fixed capital and labour productivity functions allowed determination of the technical (potential) productivity of machines and labour productivity functions, assuming the full utilisation of particular production factors and then potential output (GDP).

The following variants were distinguished:

A. The potential GDP corresponding to the *full utilisation of machinery and equipment* $(XKMT)$, was obtained from the following identity:

$$XKMT_t = WXKMT_t \cdot KM_t, \quad (12)$$

where $WXKMT_t$ is technical productivity of machinery and equipment derived from (5), assuming full utilisation of the machines, i.e. of the number of shifts $(WKZ_t = 1)$ and of the nominal working time, except for vacations $(WN_t = 1 - NHUQ_t / NHNQ_t)$, where $NHUQ_t$ = number of hours off per one person employed in industry and $NHUQ_t$ – nominal working time per one person employed in industry.

B. Potential GDP corresponding to the *full utilisation of the working time of employed* $(XNMT_t)$ equals to:

$$XNMT_t = WXNMT_t \cdot N_t, \quad (13)$$

7 Inserting h_t into (5) and (6) and rearranging respectively we arrived at TUM_t / h_t in (5), (6) and WXN_t / h_t in (6), which made it possible to skip in the estimation process h_t as additional explanatory variable.

where $WXNMT_t$ is technical productivity of labour estimated with the assumption that the nominal working time of the employed was fully utilised (except for vacations), analogously to the previous case, i.e.: for $WN_t = 1 - NHUQ_t / NHNQ_t$.

To obtain the potential GDP that assumes *full employment* (and full utilisation of the employees' working time) it is enough to substitute in (13): $N_t = NS_t$, i.e for labour supply or eather labour supply adjusted for the rate of narural unemoloyment.

C. To identify the potential production $(XKMAT_t)$ that might have been obtained if the constraints in the supply of raw materials, materials and fuels had been eliminated (for the periods before 1990 specific procedure was applied).

To identify volumes of the effective output (X_t) the generalised minimum condition was employed, according to which GDP is generated from a nonlinear combination of four output indicators: potential demand XD_t (3), potential output $XKMT_t$ (12), $XNMT_t$ (13) and $XKMAT_t$ namely:

$$X_t = (XD_t^{-r} + XKMT_t^{-r} + XNMT_t^{-r} + XKMAT_t^{-r})^{-1/r}. \tag{14}$$

Estimation of parameter r, whose inversion is called *mismatch parameter*, stabilised at the level of 58 and the average mismatch was $1/r = 0.017$. The last value is close to those obtained for West European countries. (See J. Dreze et al. [1990]).

Using the estimate of parameter r, we can easily find the elasticities of effective GDP with respect to the particular categories of potential output, since we have:

$$E_{X,XZ} = (\partial X_t / \partial XZ_t) \cdot XZ_t / X_t = (XZ_t)^{-r} / X_t^{-r}, \tag{15}$$

where $XZ_t = XD_t, XK_t, XN_t, XA_t$, and $XK_t = XKMT_t$, $XN_t = XNMT_o$, $XA_t = XKMAT_t$, and also:

$$E_{X,XD} + E_{X,XK} + E_{X,XN} + E_{X,XA} = 1. \tag{16}$$

Moreover, it can be shown that the rate of growth of GDP is equal to the average value of the weighted rates of growth for particular categories of production, where the above defined elasticities are the weights:

$$\overset{\circ}{X}_t = \overset{\circ}{XD}_t \cdot E_{X,XD} + \overset{\circ}{XKMT}_t \cdot E_{X,XK} + \overset{\circ}{XNMT}_t \cdot E_{X,XN} + \overset{\circ}{XKMAT}_t \cdot E_{X,XA}. \tag{17}$$

This allows to interpret elasticities in a special way as the shares of these enterprises that were particularly constrained (by demand, capacity, labour, etc.). The elasticities can be also interpreted as characteristics of the role (share) of particular growth determining factors.

The employment function was obtained by inverting the production function. To identify the potential or effective demand for employed a simpler procedure was applied, namely, appropriately identified volumes of GDP were divided by the labour productivity obtained from the labour productivity function (with capital-labour ratio TUM_t).

The effective demand for employed (ND_t) was obtained by dividing the previously calculated potential GDP corresponding to the demand for domestic goods (XD_t) by the labour productivity function (WXN_t) (6):

$$ND_t = XD_t / WXN_t \,. \tag{18}$$

On the other hand, the potential demand for employment corresponding to *full utilisation of the capacites* was arrived at taking estimation of $XKMT_t$ (12) as the starting point:

$$NK_t = XKMT_t / WXN_t \,. \tag{19}$$

In an alternative variant it was additionally taken into account that the adjustment processes take place, amongst others, that enterprises decide to retain employees in periods of output decline (recession), because of the prospective high costs of training newly employed workers in the periods of recovery, etc., which leads to labour hoarding.

It was also considered that in the period of centrally planned economy, i.e. to the year 1990, dominated situation characterised by the tensions on the labour market, i.e. excess demand for employees. This variable was represented in the model by a function of the ratio of the number of vacancies registered to the number of job – seekers used as the disequilibrium indicator.

The equation generating the efective number of employed, i.e. total employment (N_t) that corresponds to the generalised minimum principle has the following form:

$$N_t = (ND_t^{-n} + NK_t^{-n} + NS_t^{-n})^{-1/n} \tag{20}$$

where:

NS_t – supply of labour force.

The rate of unemployment is obtained as a residual value from the following identity:

$$U_t = 1 - N_t / NS_t \tag{21}$$

An alternative could be to explain the rate of unenployment in terms of the rate of capacity utilisation and other factors and use the identity (21) to determine the supply of labour.

2.6. Equations explaining prices, wages and financial flows

The last block of equations describes prices, wages and financial flows. The equation explaining prices in the production sector (GDP deflator) is of the key importance. Equations explaining prices of *final goods* and (to some extent) the foreign exchange rate relate these prices to the producer and imports prices. Accordingly, equations explaining transaction prices in foreign trade allow for world trade prices.

The basic price equation depicts the way the *producer prices* are generated, i.e. the prices of goods that comprise GDP (PX_t). As the starting point was assumed the familiar I–O identity representing the decomposition of prices into unit costs and mark-up (expressing i.a. the effects of market tensions) and further decomposition of unit costs into the components – unit costs of imported materials, unit depreciation, labour unit costs plus additional charges, costs of debt service (plus other financial costs) and rates of indirect taxation (mainly VAT).

Data on particular cost components are typically not available, with some exeptions like, for example, data on direct taxes ($BYVP_t / X_t$) and labour costs, which in many excercises forced the researchers to constrain the price decomposition into labour costs and broadly understood markup. We were searching, however, for suitable approximations of particular cost components. Unit labour cost can be approximated by estimating the wage bill as the product of average wage (WBP_t) and the number of employees (NZ_t) divided then by the GDP (X_t), and allowing for the charges due to social benefits. Unit costs of the use of imported raw materials could be approximated by the product of the imports of intermediate commodities-output ratio (MZ_t / X_t) and the transaction import prices (PM_t), combined with charges being due to custom duties $(BYCP_t)$, border tax and indirect taxes (VAT), unobservable in the sample period. Changes in the debt service can be described by the variable being a product of the interest rate on loans $(RKFR_t)$ and the debt level $(BZNGP_{t-1})$ per one unit of production (these effects proved significant for the 1990s only). Finally, market tensions after 1990 can be represented by the rate of utilisation of capacities (WKZ_t). This equation was partly dynamised to allow for the lagged impact of the changes in unit costs onto the prices.

In effect, the specification of the price equation concerns two components – markup and unit costs (KIP_t):

$$\begin{aligned}\ln PX = & -\underset{(5.5)}{0.223} + \underset{(68)}{1.179}\,[a_t \ln(AFZSP_t / X_t KIP_t) U6090_t + \\ & + a_t \ln WKZ(1 - U6090_t) + (1 - a_t)\ln(0.45 KIP_t + 0.55 KIP_{t-1})] + \\ & + \underset{(5.9)}{0.372} U6071_t - \underset{(4.9)}{0.333} U7276_t + \underset{(8.4)}{0.677} U8082_t\end{aligned} \qquad (22)$$

$R^2 = 0.999 \quad DW = 1.9 \qquad \overline{R}_L^2 = 0.997 \quad DW_L = 1.1$

where:

$AFZSP_t / X_t KIP_t$ – surplus (markup) total costs ratio,

a_t – lagged markup share in value added.

Unit costs are obtained from the following identity:

$$\begin{aligned}KIP_t = & BYVP_t / X + PM_t[1 + BYCP_t / MP_t + \\ & + BYVP_t / X_t(1 - U6090_t)]MZ_t / X_t + AMKKP_t KKP_t / X_t + \\ & + [WBP_t(1 + AFKP_t)NZ_t / X_t] + RKFR_t BZNGP_{t-1} / X_t,\end{aligned} \qquad (23)$$

where:

$AMKKP_t$ – rate of depreciation,

KKP_t – fixed capital,

MP_t – imports.

Price equations for particular groups of final users have the form of bridge equations being approximations of weighted averages of GDP deflators (PX_t), import deflators (PM_t) and, possibly, rates of indirect taxes. These are deflators of personal consumption (PC_t), public consumption (PG_t), investment outlays on machinery and equipment (PJV_t) and other investment outlays $(PJJT_t)$. Deflators of incomes from labour (PYW_t) and of total disposable (personal) incomes (PY_t) were obtained using the bridge equations linking these variables with the deflator of personal consumption (PC_t).

Basically, successive model equations describe financial flows by institutional sectors, with agriculture and small industry being left outside households and treated as a components of the enterprise sector.

The specification of the equation explaining *average wages* (WBP_t) assumes as its starting point the results of the earlier analyses obtained by A.Welfe [1990], [1993] and it is based on a generalisation of the equation representing augmented Phillips curve. According to these results, although the rate of growth of nominal average wages was dependent on the rate of inflation, the social pressures were insufficient to force an increase in wages proportional to the increase in retail prices of consumer goods. Consequently, explanation of real wages was abandoned, taking nominal wages as the endogenous variable. In this context one of the key explanatory variables remains the deflator of personal consumption PC_t. It should be noted here that between 1990–1994 wages in the public enterprise sector were indexed because of the growing cost of living. This increase was controlled through a progressive tax on the supra standard wages that was imposed if the prescribed norm – in terms of the elasticies of wages with respect to prices – was overridden. However, apart from 1990, these norms remained at a fixed level (0.8), therefore omitting them should not bias the estimate of the parameter standing with the prices.

The rate of growth of wages depends in the long-run on the rate of growth of labour productivity. Let us add that in the period prior to 1990s, when the rates of inflation were relatively low, there was a tendency to interrelate the rates of wages' growth and of the productivity of labour (or rather the rates of growth of the wage bill and of the volume of output) initially administratively and then by the fiscal measures. This system punished the state-owned companies with the progressive tax, should the rates of growth of the wage bill exceed the prescribed fraction of the rate of growth of production. Typically, this relationship only took place when the productivity of labour grew. In the case when the productivity of labour (generally) declined this relationship was partially or completely suspended[8].

In periods of market tensions an additional pressure was exerted on wages to grow, resulting from the stronger position of employees than the companies seeking new workers. The rate of growth of wages was ascending together with the growing scale of tensions on the labour market. So, this response can be described using a generalised Phillips curve. The relation of the number of vacancies to the number of job seekers was assumed as the disequilibrium indicator. After 1990 massive unemployment appeared. The effects of the changes in the rate of unemployment were, however, initially not directly estimable. Hence, we first tried to calibrate the rate standing with the rate of unemployment (U_t) but then estimated it directly, calibrating the parameter standing with the consumption deflator at the level 0.95, close to the previously obtained results.

[8] See, A. Welfe [1990].

The estimates of the parameters of the equation explaining the average wages, constructed according to the above rules, are as follows:

$$\ln(WBP_t / WBP_{t-1}) = 0.95 \ln(PYW_t / PYW_{t-1}) + 0.586 \ln[(X_t / N_t)/(X_{t-1} / N_{t-1})]U1_t +$$
$$(.) \qquad\qquad (3.4)$$

$$+1.278 \ln(LB_t - LZ_t)/NU_t]U2_t + 0.379.1/U_t \cdot (1 - U6089_t)$$
$$(2.0) \qquad\qquad (2.2)$$

$$+0.0954\, U75_t - 0.264\, U82_t + 0.146\, U89_t - 0.206\, U90_t +$$
$$(2.8) \qquad (7.5) \qquad (4.4) \qquad (4.0)$$

$$\overline{R}^2 = 0.991 \quad DW = 2.3 \qquad\qquad \overline{R}_L^2 = 0.999 \quad DW_L = 2.3 \qquad (29)$$

where:

$U1_t$ – 1 for years, when $(X_t / N_t)/(X_{t-1} / N_{t-1}) > 1$,

$U2_t$ – 1 for years, when $(LB_t - LZ_t)/NU_t > 0$.

NU_t – number of employees in the public enterprise sector.

Real average wages (WB_t) are obtained from the identity: $WB_t = WBP_t / PYW_t$

Nominal incomes of households (YP_t) were obtained by referring to the changes in the wage bill. *Real incomes* of households are obtained from the identity: $Y_t = YP_t / PY_t$, whereas real *disposable incomes* $(YDIS_t)$ after allowing for net real consumer borrowing.

3. Long-term simulation model

3.1. Introduction

Estimation results of stochastic equations' parameters as presented in the previous section allowed obtaining potential values of the basic macro variables Then, allowing for the relevant identities, we determined the set of equations that was included in the *simulation version* of the model. This version makes it possible to generate both the potential demand, potential production and effective output. The same applies to employment.

Below, we are presenting the formal structure of the simulation version of the model. Next were distinguished the basic feedbacks, with the emphasis put on the demand oriented model version.

3.2. Formal structure of the model

Model W8-D, being a one sectoral model is characterised by an extensive description of the generation of potential output and of growth factors being endogenized. This enlarged the model to the average size of a macroeconometric model. The simulation model version W8-D encompasses 211 equations of which 79 are stochastic and 132 identities. This might be misleading, as some identities were obtained by transforming the stochastic equations (for example, the equation explaining the shift utilisation rate).

The number of strictly exogenous variables including time-trend, but without dummy variables, is 21. The basic list – apart from time – includes: a) 7 variables for demographic and social factors, b) 3 variables for external conditions – the world trade – total exports (EHS_t), world export prices $(PEHS_t)$ and GDP of 6 OECD countries, c) 5 economic policy variables: the rate of social benefits $(AFFP_t)$ rate of depreciation $(AMKKP_t)$ rate of the income tax on individuals $WNB_t)$ and the share of investment outlays in the government budget $(RELBCJP_t)$ effective rate of duties $(BYCCOEF_t)$. Other possible changes in taxation, administered prices, etc., can be introduced by adjusting the parameters of respective equations.

The small number of exogenous variables facilitates the forecasting process, but it also makes simulations with the model less arbitrary, because of the limited number of clearly defined assumptions.

The considerable number of dummy variables was introduced to the model in order to allow for the sample segmentation, especially where it was a priori justified – by separating the '90s from the previous years, but also by distinguishing subperiods characteristic of particular variables.

Model W8-D is a model with a large number of simultaneous and dynamic feedbacks. It only contains 22 pre-simultaneous equations. The simultaneous block includes 100 equations. The relationships within the block are decided by 9 feed back variables. They include variables entering feedbacks in the production sphere: that is, force employment (N_t), the rate of shift utilisation (WKZ_t), investment (*JA*) GDP (X_t) and these present in the inflationary feedback: GDP deflator (PX_t), investment deflator (*JV*) average gross wages $WBP_t)$ exchange rate $(WZLD_t)$ and indirect taves (*BYVB*).

The relatively large number of the post-simultaneous equations (89) results, amongst others, from the introduction of numerous identities that generate important macro characteristics in the form of relations (for example various macro values in relation to GDP).

The control solution that requires from 6 to 15 iterations for each year was obtained using Gauss-Seidel method incorporated into SIMPC simulation system. Calculations were made on computer PENTIUM COMPAQ XL-560. Solving time is ca 30 seconds.

3.3. Structure of the simulation model. Basic economic mechanisms

The structure of the simulation model W8/96 was designed in such a way as to reflect economic mechanisms typical of a centrally planned economy, to a higher or smaller degree characterised by shortages of products and production factors, and of an economy in the transition period towards a market economy. We mean here an economy where demand constraints are becoming typical, and an excess of production factors follows, and where market adjustments (concerning prices and wages) are starting to play an important role, reinforcing the quantitative adjustments. These mechanisms are reflected in the model in numerous feedbacks.

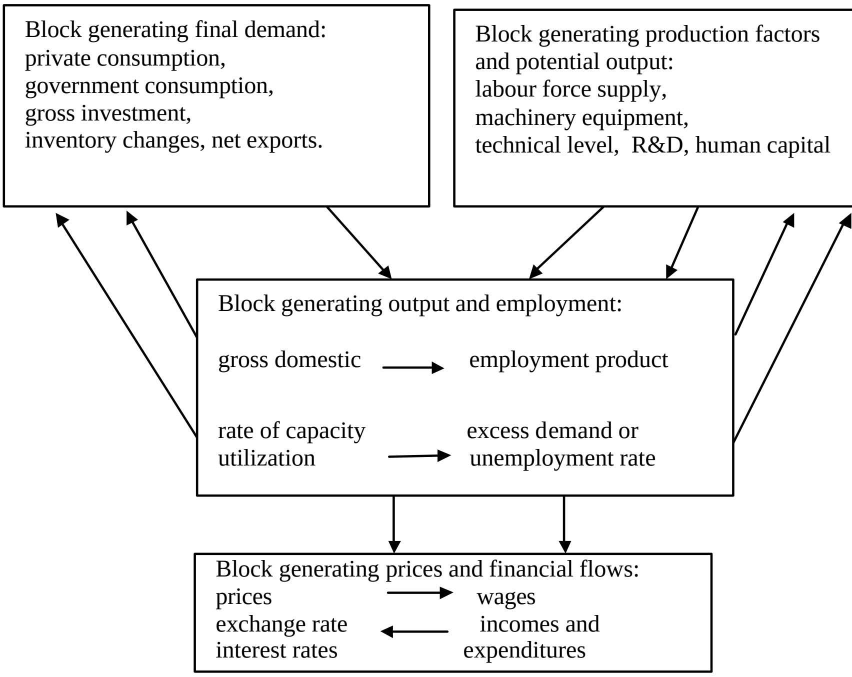
The most important are feedbacks that identify relationships in the production sector: a) between consumption, production and employment (the consumption multiplier), and b) between investments and production (the accelerator), c) and then the relationships between the production and financial sectors channeled, amongst others, trough the taxation system and the budget (fiscal multiplier), as well as d) the relationships between prices and wages (the inflationary spiral). The relationships between the production sector and the financial sector in transition economies are reflected most of all in the transformation of the quantitative indicators of disequilibria (excess demand, unemployment rates) into price and wage adjustments which, on the other hand, influence the intensity of quantitative adjustments (for example demand). The schematic relationships between particular blocks can be described as in Fig 1.

The economic mechanisms and the relations reflecting them are different in particular economic regimes. They are specific for the regime where the demand for production and production factors is being met, and the regime when supply is realised, which implies imperfection of the price-wage adjustments. In fact, both of the situations may be concurrent. Then the mechanisms characteristic of the demand and supply oriented models will co-exist in different, varying proportions[9].

[9] Especially, for the years prior to the 1990s the occurrence of mixed regimes should be assumed. See W. Welfe et al. [1996b].

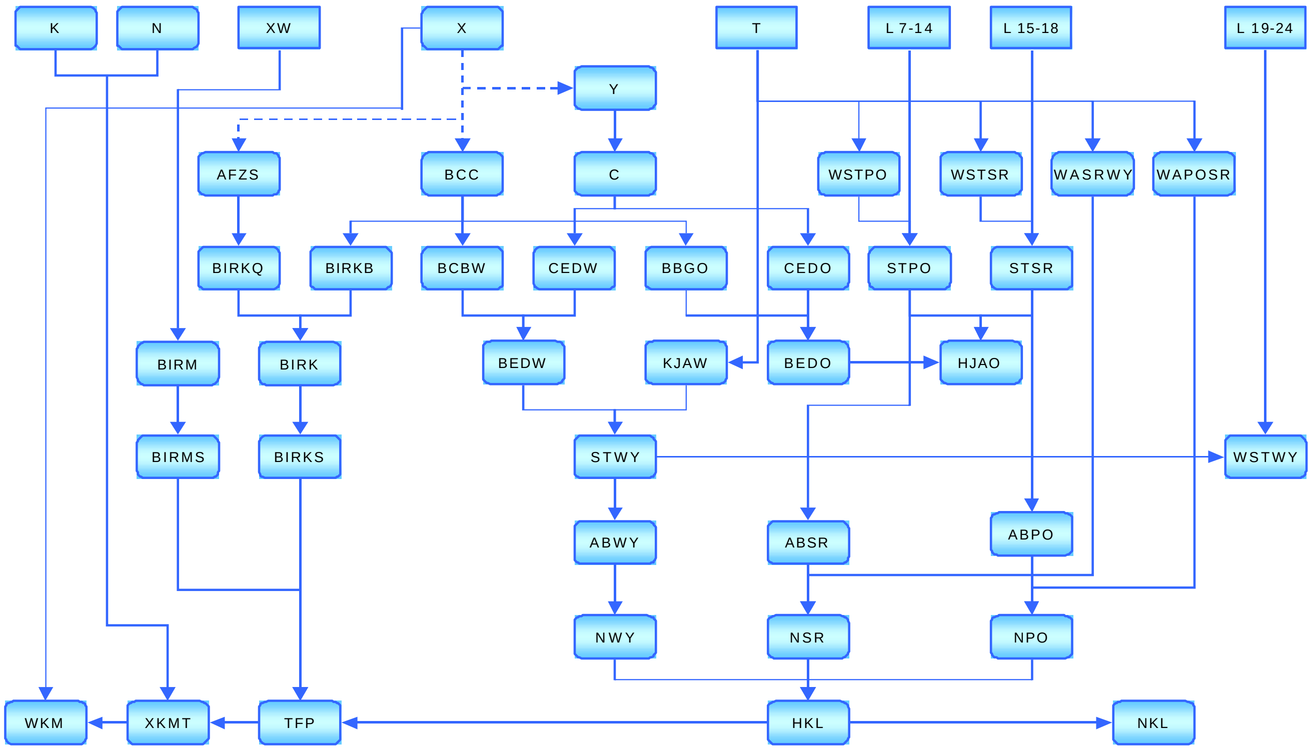
Figure 1

Structure of model W8



In the long term version of the model there are additional relationships introduced in the real sector in the process of generating potential GDP (see fig. 2). On the one hand, domestic R&D stock, being dependent on real domestic R&D expenditures and hence domestic GDP affects TFP increase and potential GDP growth. Similarly foreign R&D stock, being dependent on imports of machinery and on additions to foreign R&D affects domestic TFP and GDP. On the other hand, the human capital per employee being dependent on investment in human capital due to an increase of real expenditures on education, especially high education which positively changes the structure and educational level of graduates – affects the TFP and GDP. A new feedback would be established in the model if the potential GDP would equal the realized GDP, i.e. for a supply driven regime. The numerical characteristics of the above feedbacks are shown while presenting the results of multiplier analysis in W. Welfe et al. [2001].

Figure 2
Sources and impact of technical progress.



List of varinbles used in fig 2 (except for explained in the previous text)

AB_l	– graduate of school level i
BBGO	– budget real expenditures on education
BCBW	– budget real expenditures on universities
BCC	– budget total current real expenditures
BEDO	– total real expenditures on education
BEDW	– total real expenditures on universities
BIRK	– current domestic real expenditures on R&D
BIRKB	– current budget real expenditures on R&D
BIRKO	– current real expenditures on R&D of private sector
BIRM	– current foreign real expenditures on R&D
CEDO	– household real expenditures on education
CEDW	– household real expenditures on university education
HJAO	– real expenditures on education per student
HKL	– human capital per capita
L_j	– population at age j (j =7–14, 15–18, 19–24)
N_i	– employment of individuals with educational level i
NKL	– human capital
ST_i	– students in schools of level i
WA_{ij}	– ratio of students passing from schools of level i to schools of higher level j
WST_i	– ratio of students of schools of level i to pupils of respective age (scholarisation coefficient)
WKM	– rate of capacity utilisation
XW	– GDP of selected *OECD* countries.

4. Long-term forecasts and scenarios analyses up to the year 2025

4.1. The assumptions

The first applications of the W8-D model in the long-term forecasting were based on an extension of our medium-term forecasts (to 2010) which were prepared using the midium-term W8 model of the Polish economy (R. Courbis, W. Welfe (eds.) [1999]). The alternatives to the long-term path were elaborated taking into account the results of scenario analyses performed (up to the year 2020) by the Forecasting Committee of PAN [2000] and K. Barteczko, A. Bocian [2000] and the ideas developed in governement strategy up to 2025 [2000].

The forecast was based on the assumption, that in the first years of XXI century the recovery from stagnation of 2000–2001 will follow due to the changes in economic policy introduced by the new, leftist governement. The entrance in the EU structures is assumed before 2005, which will positively affect the domestic activities, as well as foster the foreign direct investment. The economic policy will be friendly against the long-term goals – the technical restructuring of industry, promotion of high-tech sectors and export industries, as well of services, especially in telecommunications. Hence, the import of foreign R&D will be promoted and expenditures on domestic R&D and education increased as percentage of GDP.

We distinguished two scenarios of the development of the Polish economy.

Optimistic scenario is based on the following assumptions: the improved foreign conditions will promote Polish exports and the inflow of foreign capital. Technical level of domestic production will improve due to technical reconstruction and the competitiveness of domestic products will increase, all due to the higher absorbtion of the R&D capital. It will be manifested in an increase of the rate of growth

of gross – investment initially by 4 p.p., and after 2010, by 2.2 p.p.,

of exports by 2 p.p.

and an increase by 50% of the elasticity of absorbtion of foreign R&D capital stock.

On the other hand, we decided to analyze a *pessimistic scenario.* It assumes, that the slowdown of the Polish economy, associated with financial turbulences will continue for a couple of years, the entrance to the UE will be postponed, less expenditures spent on R&D and education. In effect, the rates of growth will up to 2010 decline

in gross-investment by 2 p.p.,

in exports by 1 p.p.,

and in this period the expenditures on education will stagnate at the level of 6% GDP and on R&D will increase from 0.83%–to 0.95% GDP in 2010.

4.2. The simulation results

The results of our excercises are presented in table 3.1. They summarize the effects of our computations showing the five year rates of growth and deviations from the baseline forecast only (for details see W. Welfe (ed.) [2001]).

The rates of growth of GDP are forecast such that initially they will recover to 5% then reduce and after 2010 will increase again from 4% to roughly 5%. In optimistic scenario they will be initially raised to above 6% and after a decline to 5%, will increase again to 7%. The pessimistic scenario provides the rates exceeding 3% only.

Domestic final demand will show slightly lower rates of growth, with private consumption being in optimistic scenario up to 8% higher than in the forecast, and in pessimistic up to 15% lower, and with gross-investment being in optimistic scenario up to 90% higher than in the forecast, but in the pessimistic one up to 30% lower. The slower growth Vafter 2010 will be compensated by higher rates of growth of exports than that of imports – in the last decade the net exports will be positive, except for pessimistic scenario.

The productive potential is forecasted to grow initially at higher rates (6%) than effective GDP, going down to ca 4%. It was initially mainly due to investment in fixed capital and after 2005 in ca 50–60%. In optimistic scenario the rates of growth of potential GDP vary between 5.4% and 6.5%, in the last decade growing slower than the effective GDP. Pessimistic scenario yields after 2005 2–2.5% increase in potential GDP only. The impact of the TFP increase varies between 40–50%.

The forecasted rates of growth are associated with declining rates of unemployment, going down to 6%, in optimistic scenario to 3%, whereas in pessimistic one staying at 9%. This will be accompanied by 2.5% rate of inflation (after 2005), slightly higher in optimistic scenario, but keeping close to 5% in pessimistic one.

4.3. Final remarks

The results of the analysis of the properties of the long-term model W8-D of the Polish economy are so far promising . They show that the transition of the Polish economy is far advanced. The model clearly reflects the effects of the market mechanisms operating in the 1990s. This allows us to believe that it can be used also in the long term forecasts of macro economic Poland’s development and to perform simulation analyses concerning alternative scenarios of the economic development of the country. The initial analyses gave the first quantitative insight into the likely patterns of growth. Assuming that the share of GFCF/GDP should not exceed 30% the other major growth factors will be the increase of TFP (40%–50% of GDP increase) due to the implementation of R&D stock, mainly from abroad, and the increase of human capital.

References

Barro R. J. [1991], *Economic Growth in a Cross-Section of Countries*, Quarterly Journal of Economics, 106, 407–443.

Barteczko K., A. F. Bocian [2000], *Modele i symulacja makroekonomiczna (Macroeconomic Models and Simulations)*, Wydawnictwo Uniwersytetu w Bialymstoku, Bialystok.

Bodkin R. G., L. R. Klein, K. Marwah (eds.) [1991], *A History of Macroeconometric Model-Building*, E. Elgar, Aldershot.

Coe D. T., E. Helpman [1995], *International R&D Spillovers*, European Economic Review, 39, 859–887.

Courbis R., W. Welfe (eds.) [1999], *Central and Eastern Europe on its Way to European Union. Simulation Studies Based on Macromodels*, P. Lang, Frankfurt am Main.

Davis C., W.Charemza (eds.) [1989], *Models of Disequilibrium and Shortage in Centrally Planned Economies*, Chapman and Hall, London.

Dreze J. H., C. Bean, J. P. Lambert, F. Metha, H. R. Sneessens (eds.) [1990], *Europe's Unemployment Problem*, MIT Press, Combridge.

Florczak W., L. Sabanty, W. Welfe [2001], *Human Capital Estimates for Poland*, in. W. Welfe (ed.), Macromodels'2000, Wydawnictwo Absolwent, Lódz, 96–112.

Jorgenson D. W. [1967], *The Theory of Investment Behavior*, in: R. Ferber (ed.) *Determinants of Investment Behavior*, Columbia University Press, New York.

Klein, L. R., A. Welfe, W. Welfe [1999], *Principles of Macroeconometric Modeling*, North-Holland, Elsevier, Amsterdam.

Lucas R. E. [1988], *On the Mechanisms of Economic Development*, Journal of Monetary Economics, 22, 3–42.

Mankiw N., D. Romer, D. N. Weil [1992], *A Contribution to the Empirics of Economic Growth*, Quarterly Journal of Economics, 107, 407–438.

Polska 2025. Dlugookresowa strategia rozwoju (Poland 2025. Long-term Strategy of Growth), [2000], Rzadowe Centrum Studiów Strategicznych, Warszawa.

Romer P. M. [1990], *Endogenous Technological Change*, Journal of Political Economy, 98, S71–S102

Strategia rozwoju Polski do roku 2000 (Strategy for the Development of Poland up to the year 2020) [2000], Komitet Prognoz "Polska 2000 plus" przy Prezydium PAN, Elipsa, Warszawa.

Welfe A. [1989], *Savings and Consumption in the Centrally Planned Economy: a Disequilibrium Approach*, in: C. Davis and W. Charemza (eds.), *Models of Disequilibrium and Shortage in Centrally Planned Economies*, Chapman and Hall, London.

Welfe A. [1990], *Ekonometryczny model plac przecietnych w sferze produkcji materialnej w polskiej gospodarce,* (Econometric Model of Average Wages in Enterprise Sector of the Polish Economy), *Przeglad Statystyczny*, 37, 1–2, 48–61.

Welfe A. [1993], *Inflacja i rynek,* (Inflation and Market), Warszawa, PWE.

Welfe W. [1989], *Macroeconomic Disequilibrium Models in Poland*, in: C. Davis and W.Charemza (eds.), *Models of Disequilibrium and Shortage in Centrally Planned Economies*, London, Chapman and Hall.

Welfe W. [1991], *Multisectoral Econometric Models of the Centrally Planned Economies and the Disequilibria*, *Economics of Planning*, 24, 203–226.

Welfe W. [1992], *Ekonometryczne modele gospodarki narodowej Polski*, (Econometric Models of the Polish National Economy), Warszawa, PWE.

Welfe W. [1993] *Topics in Macro-Modelling of East European Countries in the Period of Transition*, Economics of Planning, 26, 105–126.

Welfe W., A.Welfe [1996], *Ekonometria stosowana*, (Applied Econometrics), PWE, Warszawa.

Welfe W., A.Welfe, W. Florczak [1996a], *Makroekonomiczny minimodel gospodarki polskiej*, (Macroeconomic Minimodel of the Polish Economy), in: *Budowa i implementacja modeli makroekonomicznych*, Z prac Instytutu, 28, IRiSS, Warszawa, 25–37.

Welfe W., A. Welfe, W. Florczak [1996b], *Makroekonomiczny roczny model gospodarki narodowej Polski*, (Macroeconomic Annual Model of the Polish National Economy), Z prac Instytutu, 31, IRiSS, Warszawa

Welfe W. (ed.), [1996], *Sredniookresowy ekonometryczny model gospodarki narodowej Polski w warunkach transformacji*, (Medium-Term Econometric Model of the Polish Economy in the Period of Transition), Absolwent, Lódz.

Welfe W. (ed.), [1997], *Economies in Transition and the World Economy. Models, Forecasts and Scenarios*, P. Lang, Frankfurt am Main.

Welfe W. [1998], *Modeling Inflation in Poland*, Przeglad Statystyczny, 45, 309–329.

Welfe W., W. Florczak, A. Welfe [2000], *The Annual Macromodel of the Polish Economy (Model Version W8–98)*, in: W. Welfe, P. Wdowinski, (eds.) Macromodels'99, Absolwent, Lódz, 128–188.

Welfe W. [2000], *Empiryczne modele wzrostu gospodarczego* (Empirical Models of Economic Growth), Ekonomista, 4, 483–498.

Welfe W. [2001], *Czynniki wzrostu potencjalu gospodarczego Polski* (Factors of Growth of the Potential of the Polish Economy), Ekonomista, 2, 177–200.

Welfe W. (ed.), [2001], *Ekonometryczny model wzrostu gospodarczego*, (Econometric Model of Economic Growth), Wydawnictwo Uniwersytetu Lódzkiego, Lódz.

Whitley J. D. [1994], *A Course in Macroeconomic Modelling and Forecasting*, Harvester/Wheatsheaf, New York.