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

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ENERGY CONSTRAINTS AND OPTIMAL DEVELOPMENT OF THE POLISH ECONOMY[1]

We began our considerations concerning the future of the Polish national economy i.e. the next 20 years with looking for these elements of the economy which seemed to change most slowly and were the most difficult to modify. Next, on the basis of model studies the conclusions on the impact of structural variants of those elements in the future on development of the economy were drawn. Beside the area of agricultural land or the number of population, the basic elements include natural resources and their output, especially power resources and production.

The model presented in this paper is constructed as an instrument of inference on a possible development of the economy, conditioned by the assumed scenario for the future of fuel and power production. Of course such a production depends to a large extent on other elements of the future economic development, including the ones we wish to predict. We break the vicious circle of interdependence in hopefully its weakest point where the constraints imposed by natural resources and high costs of their production make them impede the economic development.

The core of the model which enables us to transform the scenarios of fuel and power production up to 2000 into forecasts of other economic characteristics, is a system of equations called the input-output model. A criterion function is then added. The

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function allows for a choice of such a production programme which is optimal from its point of view. We shall consider three main groups of criteria:

1. Maximization of the net material product (NMP)[2] (final product)

$$\sum q_i \longrightarrow \max.$$

This is the simplest function which enables to maintain the linear character of the whole and solve it by means of linear programming methods.

2. Maximization of NMP utility function

$$\sum W_i q_i \longrightarrow \max,$$

where the weights W_i reflect the "utility" of NMP originating in the branch "i". This is a better approach, howéver, it is more difficult because of the problem of proper weight selection w_i in such a way as to reflect social preferences.

3. Minimization of the function of losses resulting from the failure in achieving some production goals

$$\sum w_i (q_i - q_i*)^2 .$$

In this case - beside the problem of weight selection w_i reflecting social preferences or losses we face the problem of determining the paths q_i* of desired growth of NMP elements q_i. Then our model is transformed into the optimal control model. Writing down the loss function alternatively as

$$\sum w_i |q_i - q_i*|,$$

we can keep the solution technique in a class of linear programming methods in their wide sense, while its original version makes us pass to the class of nonlinear programming techniques.

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[2] Generally speaking we may think about NMP as of national income minus the value of services.

Proper choice of constraints on production capacities forms the next problem to be solved. In the case of a model with the loss function the demand for production capacities is an element of the solution. In the case of the utility function and NMP maximization, the capacities must be given a priori. It is the submodel of the development of production capacities which makes the system dynamic. This problem requires careful investigation. A certain group of social limitations and preferences, absent in the standard input-output model, is imposed. These are the requirements concerning the structure of NMP, the admissible imported part of the final product, or finally the "minimum existence" requirements in the form of the minimum consumption and accumulation. The last external condition is the "budget constraint" requiring some excess of exports over imports, necessary for repaying foreign debts. The form of these limitations is subject to evolution according to the actual state and complexity of the model. Further details are given in the next part of the paper.

The model constructed in this way can have a double use. Assuming the most likely variant of assumptions of changes in product-consumption limitations, social preferences etc. we obtain a forecast of the national economy development and the information about the necessary imports etc.

On the other hand, when we change these assumptions according to the variants of the economic policy, we can compare the effects of various policies and evaluate their advantages and disadvantages in comparison with others, choosing this one which can bring the most desirable results.

The scheme of interrelationships between the model elements is presented in Fig. 1.

The below presented version of the model is a subsequent version among those which were being verified in 1982. The versions have been evaluated on the basis of differences of the solution generated by the model from the actual state of the economy in 1980, since the model in the part concerning input-output equations uses the last balance constructed for 1980. The input-output table published in statistical yearbooks cannot be used directly in our calculations mainly due to the way it presents imports. Imports are assigned to a given branch on the basis of similarity of goods (e.g. import of coal - to the

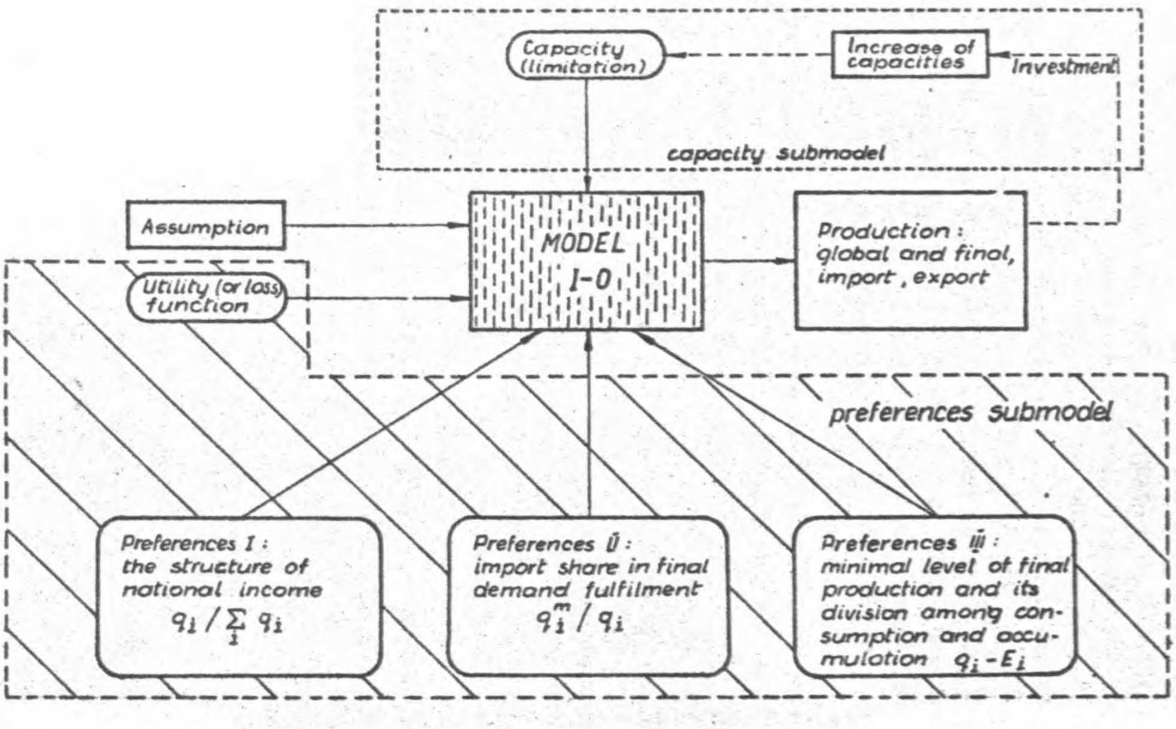
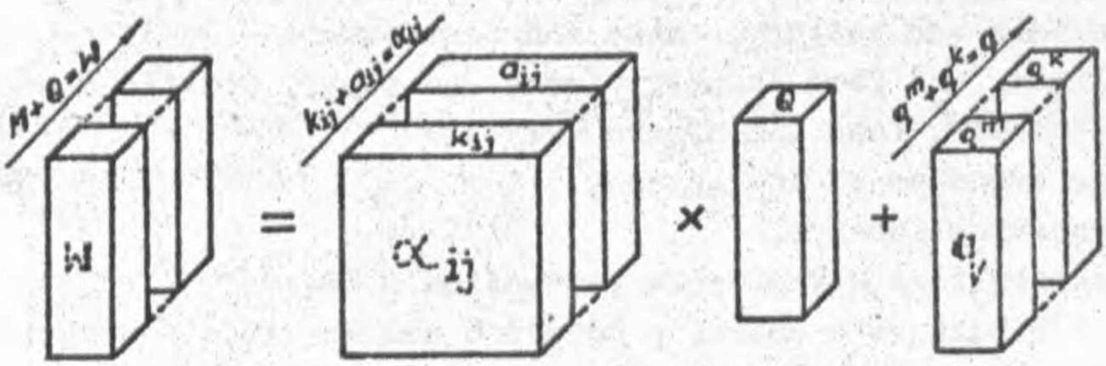


Fig. 1. Relationships of model elements



Q - *total domestic product*

M - *import*

q^k - *domestic final product*

q^m - *imported final product*

a_{ij} - *domestic inputs coefficient*

k_{ij} - *import inputs coefficient*

Fig. 2. Composition of input-output model

mining industry, import of fertilizers - to the chemical industry). This does not provide us with any information on the volume of utilization of imported goods in the production process of a given branch. Using some extraneous information we divide the input-output model into two parts - flows and consumption of domestic goods, and flows and utilization of imported goods (Fig. 2).

The disaggregation of the model is as follows. First, energy limitations refer to three branches concerning fuel and power industry:

1) coal and briquettes (QFW),

2) fuels (excluding coal and briquettes) and processed products (QFP),

3) electric and steam energy (QFE);

other industries are:

4) metallurgic industry (basic metals and non-ferrous metals, QME),

5) electro-engineering industry (metal, machinery, transport equipment, electronic and electrical engineering - QEM),

6) chemical and mineral industry (chemical industry, building materials and pottery, china and earthenware - QCH),

7) light and food industry (wood and paper, textile and clothing, footwear, food and others - QPO);

the other branches of the economy:

8) construction - B,

9) agriculture - vegetable production - RR,

10) agriculture - animal production and services for agriculture - RH,

11) forestry - L,

12) transport and communication - T,

13) trade - H,

14) other sectors - PO.

The below presented version of the model is not the final one. The model has not reflected the interrelationships between subsequent periods yet (it is a static model). This means that the increment of production capacities caused by previous investment outlays, is not incorporated in the model. At present, the limitations of production capacities in the model have an exogenous character. This requires careful forecasting of production capacities of sectors in particular periods. Some chosen variants of such forecasts are discussed in the further part of the paper.

The following notation is introduced:

Q_i - total domestic product of the i-th branch (calculated columnwise)

$\check{Q}_i$ - the i-th type products for distribution (calculated rowwise)

M_i - imports of goods of kind produced by the i-th branch

q_{ij} - the flow of the i-th type products to the j-th branch

q_i - final i-th type products

q_i^k - final domestic i-th type products (i.e. for final users)

q_i^m - imported i-th type products for final users

z_i - unbalanced sum in the i-th row

K_j - correction term which introduces correction because of including to the total production of the j-th sector the products belonging to another branch.

Let us introduce the following definitions. The coefficient

$$\alpha_{ij} = \frac{q_{ij}}{Q_j}, \tag{1}$$

is called the input-output coefficient. It is a sum of domestic inputs coefficients

$$a_{ij} = \frac{q^k_{ij}}{Q_j}, \tag{2}$$

and import inputs coefficients

$$k_{ij} = \frac{q^m_{ij}}{Q_j} . \tag{3}$$

It is necessary to differentiate between Q_i and $\tilde{Q}_i$ in our paper because reports distinguish between total production calculated by means of the product method $\tilde{Q}_i$ and the enterprise method Q_i.

$$\tilde{Q}_i = Q_i + K_i. \tag{4}$$

This is also taken into account in input-output balances. The rows present total production using the product method, while the columns the production calculated by the enterprise method.

According to the above definition the input-output coefficient is a sum of unit domestic and import inputs

$$\alpha_{ij} = a_{ij} + k_{ij}. \tag{5}$$

The main goal of our model is to look for such variants of economic plans which are characterized (under certain assumptions) by a maximum final product.

$$\sum_{i=1}^{14} q_i \longrightarrow \max. \tag{6}$$

The conditions to be fulfilled have the following form:

A. The balance of domestic commodity flows.

These are the balance equations of production. We should stress that some unbalance, which results from including in the total production of the j-th sector–the products belonging to another branch (K_i) and correction (z_i), is incorporated into technical-financial coefficient a_{ii}, i.e. if

$$Q_i = \sum_{i=1}^{14} a_{ij} Q_j + q_i^k + ERROR_i$$

the elimination of the error is reduced to the following equation:

$$\left(1 - \frac{ERROR_i}{Q_i} - a_{ii}\right) Q_i - \sum_{\substack{j=1 \\ j \neq i}}^{14} a_{ij}Q_j = q_i^k \quad i \in \left\{1, 2, \ldots, 14\right\}. \tag{7'}$$

In the branches in which the above mentioned unbalance does not occur or is insignificant, the classical input-output equation was assumed, i.e.

$$\left(1 - a_{ii}\right)Q_i - \sum_{\substack{j=1 \\ j \neq i}}^{14} a_{ij}Q_j = q_i^k \; i \in \left\{1, 2, \ldots, 14\right\}. \tag{7''}$$

In general this equation can be written as

$$\left(W_i - a_{ii}\right)Q_i - \sum_{\substack{j=1 \\ j \neq i}}^{14} a_{ij}Q_j = q_i^k \; i = 1, 2, \ldots, 14, \tag{8}$$

where:

$$W_i = 1 - \frac{ERROR_i}{Q_i} .$$

B. The balance of imported commodity flows.

$$\sum_{j=1}^{14} k_{ij}Q_j + q_i^m = M_i \quad i = 1, 2, \ldots, 14. \tag{9}$$

C. Proportions between final imports $\left(q_i^m\right)$ and final domestic product $\left(q_i^k\right)$.

$$q_i^m/q_i^k \leqslant \varepsilon_i \quad i = 1, 2, \ldots, 14. \tag{10}$$

Each of the above inequalities should be interpreted as follows. For each złoty of final domestic product of the i-th type no more than ε_i złotys of the i-th type product can be imported for final use. It should be added that q_i^m contains not only the consumption of imported goods but also imports for investment purposes, increment of stock and the so called re-export. Thus, the parameter ε_i should be determined on the level not lower than this one resulting from planned values of these categories in relation to planned volume of final domestic production in this sector.

D. The "minimum existence" requirement.

Conditions (11) result from the classical balance of final product, i.e. from the equation $q_i = C_i + A_i + E_i$ or, $q_i - E_i = C_i + A_i$.

$$q_i - E_i \geqslant \underline{C}_i + \underline{A}_i \quad i = 1, 2, \ldots, 14. \tag{11}$$

The aim of the above system of inequalities is the protection against generating an unacceptable variant of the economic plan. It is an open question what use can be made of the excess of the left hand side (11) over the assumed right hand side. This can be used both for additional exports and for the additional (in relation to the assumed level) consumption or/and accumulation.

E. Requirements concerning the structure of final products.

The system of inequalities (12) was derived first of all to protect the solution generated by the model against socially inacceptable structure of the final product. Each inequality (12) can be treated as a kind of completion of the corresponding inequality (11). It means, if inequality (11) is the so called lower bound for the final product q_i, inequality (12) is the so called "liquidated" upper bound for this product. It should be expected that the role of constraints (12) will be the larger, the larger will be the excess, mentioned above in point D, over the minimum consumption and accumulation.

$$q_i / \sum_{l=1}^{14} q_l \leqslant \beta_i \quad i = 1, 2, \ldots, 14. \tag{12}$$

The parameter $\beta_i (\beta_i \in (0, 1))$ denotes a maximum admissible share of final production of the i-th branch in the total final production. Let us note that β_i should be chosen as

$$\sum_{i=1}^{14} \beta i \geqslant 1.$$

The structure of the final product will be of course closer to the structure of β_i the closer $\sum \beta_i$ will be to unity. However, $\sum \beta_i > 1$ should be left as a margin not only for numerical reasons. It also reflects the fact that we can be pretty sure what individual share β_i can still be accepted, but our confidence decreases when the entire set of the shares (the structure of final product) is concerned. It should be mentioned that restrictions (12) are very tricky. Actually, in any acceptable solution the sum of these shares equals to one. Has any particular product had this share too high - some of the others should have this share very low. This may activate other groups of restrictions (10, 11, 13″). As a result only few restrictions (12) work as the binding constraints.

F. Production capacity of particular sectors.

These capacities can be introduced in two ways: either in the form of a typical upper bound (13′) or in the form of constraints imposed on total production structure, i.e. (13″). However, in the latter case the limiting sectors should still have capacity constraints of the type (13′). In special cases (13′) and (13″) can be treated as substitutions, e.g. in the case when a sensible reliable forecast of production capacities in a given sector is missing, or in the case of sectors in which production volumes are derivatives of the production volumes of other sectors, as it is the case in such sectors as trade and transportation and communication.

$$Q_i \leqslant \bar{Q}_i \quad i \in \left\{1, 2, \dots, 14\right\}. \qquad (13')$$

$$Q_i / \sum_{l=1}^{14} Q_l \leqslant \varkappa_i \quad i \in \left\{1, 2, \dots, 14\right\}. \qquad (13'')$$

The parameter $\varkappa_i$ should satisfy similar conditions as β_i in (12). In the future, with properly specified submodel generating the dynamics of capacity, version (13') will be preferable.

G. Foreign trade balance (budgetary constraint).

The constraint represents the postulate of achieving at least a given surplus of exports over imports:

$$\sum_{i=1}^{14} E_i - \sum_{i=1}^{14} M_i \geqslant \Omega \qquad (14)$$

If the excess is negative, then (14) can be rewritten as

$$\sum_{i=1}^{14} M_i - \sum_{i=1}^{14} E_i \geqslant -\Omega$$

H. Final production balance.

The final production balance in the following categories: consumption, accumulation and exports, is taken into account in (11). In the categories of final imports and final domestic production this balance is presented in the form of equations-definitions (15):

$$q_i = q_i^k + q_i^m \quad i = 1, 2, \dots, 14 \qquad (15)$$

The system of equations and inequalities (8)-(15) completed with non-negativity conditions (16) and criterion function (6) forms a classical linear programming problem:

$$\sum_{i=1}^{14} q_i \longrightarrow \max$$

$$\left.\begin{aligned}&(w_i - a_{ii})Q_i - \sum_{\substack{j=1\\j\neq i}}^{14} a_{ij}Q_j = q_i^k\\&\sum_{j=1}^{14} k_{ij}Q_j + q_i^m = M_i\\&q_i^m/q_i^k \leqslant \varepsilon_i\\&q_i - E_i \geqslant \underline{C}_i + \underline{A}_i\end{aligned}\right\} \quad i = 1,2, \ldots, 14.$$

$$q_i/\sum_{l=1}^{14} q_l \leqslant \beta_i \qquad i = 1, 2, \ldots, 14,$$

$$\left.\begin{aligned}&Q_i \leqslant \bar{Q}_i\\&Q_i/\sum_{l=1}^{14} Q_l \leqslant \varkappa_i\end{aligned}\right\} \quad i \in \{1, 2, \ldots, 14\},$$

$$\sum_{i=1}^{14} E_i - \sum_{i=1}^{14} M_i > \Omega,$$

$$q_i = q_i^k + q_i^m .$$

$$\left.\begin{aligned}&Q_i \geqslant 0,\ q_i \geqslant 0,\ q_i^k \geqslant 0,\\&q_i^m \geqslant 0,\ E_i \geqslant 0,\ M_i \geqslant 0, \qquad i = 1, 2, \ldots, 14.\end{aligned}\right\} \qquad (16)$$

In its present version it has 99 constraints and 84 decision variables.

Initial forecasts generated by the model

We shall start with the assumptions about the parameters of (6)-(16) These assumptions will be discussed subsequently according to constraints of the above presented model.

A. Balance of flows of domestic commodities

The basis for constructing these equations are the unit input coefficients a_{ij}. For the year 1980 the matrix $[a_{ij}]$ has been used. There are slight differences only in power industry and other four branches where the coefficients a_{ii} have been corrected due to unbalance errors (cf. (7')). The most significant proved to be the correction made for metallurgy where the coefficient a_{ii} calculated according to the classical definition (cf. (2)) was overestimated by about 70%. The corrected version of coefficient matrix $[a_{ij}]$ was used to generate the solutions for 1990 and 2000.

In order to illustrate the possibility of external dynamization it was assumed that energy consumption of the economy till 1985 would be kept on the 1980 level and then it would decrease by 1.7% annually (mainly due to technical improvements in energy utilization, since we should not expect a significant decrease of energy consumption by replacing the energy-consuming technological process by less energy-consuming processes). This causes a change in the coefficients a_{ij} for the rows of power sectors (i.e. rows QFW, OFP, QFE) according to the following scheme:

$$a_{ij}^{1990} = (0.983)^5 a_{ij}^{1980} \quad \text{and} \quad a_{ij}^{2000} = (0.983)^{15} a_{ij}^{1980}$$

Of course the changes of unit input coefficients a_{ij} need not include all sectors to the same degree. It is also possible to take into account single changes of coefficients for a chosen period connected e.g. with the expected change of technology. For instance, transition from the wet technology of cement production to dry production technology diminishes, among others, electric energy consumption which is reflected by diminishing the coefficient $a_{QFE,QCH}$.

B. Balance of imported commodity flows.

For the years 1990 and 2000 three first rows of matrix k_{ij} (i.e. for QFW, QFP and QFE) were changed according to the assumption of an annual decrease of energy consumption in the whole economy by 1.7% beginning from the year 1985.

Such an approach is true when we treat the whole supply imports as complementary and proportional to the domestic production.

Naturally, if a domestic substitute is found, the size of a particular flow (or a group of flows) may decrease or even disappear which should be reflected by an appropriate decrease of the coefficient (or a group of coefficients) k_{ij}. In the variants for the years 1990 and 2000 the coefficients k_{ij} for power sectors are determined on the basis of the dependence:

$$k_{ij}^{1990} = (0.983)^5 k_{ij}^{1980} \quad \text{and} \quad k_{ij}^{2000} = (0.983)^{15} k_{ij}^{1980}$$

C. Proportions between final imports $\left(q_i^n\right)$ and final domestic product.

For both variants (i.e. for the years 1990 and 2000) the assumed level of the maximum share of final imports in final domestic product was by about 50% higher than that reported in 1980.

The parameter ε_i was determined on the basis of the formula:

$$\varepsilon_i = q_i^m / q_i^k \; 1.5,$$

where q_i^m and q_i^k are the values of final imports and final domestic product in the i-th branch reported for 1980, respectively.

D. The minimum existence levels of consumption and accumulation.

We assumed that the level of consumption and accumulation, starting from 1980, would reveal, first, a downward trend (up to 1983-1984) and then it would increase to achieve in 1990 the 1980 level. In subsequent years 1990-2000 a 1% annual growth rate of consumption and accumulation was assumed, i.e.

$$\underline{C}_i - \underline{A}_{i\ 2000} = 1.01^{10}\ C_i + A_{i\ 1980}.$$

The following variants for the minimum level of consumption and accumulation were taken (Tab. 1).

Table 1

The minimum assumed for accumulation and consumption

Year	QFW	QFP	QFE	QME	QEM	QCH	QPO
1990	3 557	31 618	22 344	6 670	441 667	102 336	750 370
2000	3 929	34 925	24 681	7 368	487 875	113 043	828 875
Year	B	BR	RH	L	T	H	PO
1990	422 015	6 815	53 962	1 229	92 444	259 012	39 075
2000	466 167	7 528	59 608	1 358	91 069	286 110	43 163

In bill. zł, 1980 prices.

E. Requirements referring to the final product structure.

In all variants of 1990 and 2000 a "loosened"by 50% structure reported for 1980 was assumed, i.e.

$$\beta_i = \left(q_i^{80} / \sum_{l=1}^{14} q_l^{80} \right) 1.5.$$

Table 2

The shares of final product in 1980

Sector	QFW	QFP	QFE	QME	QEM	QCH	QPO
β_i	0.04	0.04	0.02	0.035	0.3	0.1	0.35
Sector	B	BR	RH	L	T	H	PO
β_i	0.25	0.05	0.05	0.01	0.1	0.15	0.025

F. Production capacity of particular sectors.

For the sectors QME, QEM, QCH, QPO, B, T, H, PO we had not got satisfactory forecasts for the years 1990 and 2000. Therefore, in order to limit the production capacity of these sectors inequalities (13″) were used. The parameter $\varkappa_i$ was assumed at the level realized for 1980, i.e.

$$\varkappa_i = Q_i^{80} / \sum_{l=1}^{14} Q_l^{80}$$

Table 3

The shares of selected production capacities in 1980

Sector	QME	QEM	QCH	QPO	B	T	H	PO
$\varkappa_1$	0.0595	0.185	0.0756	0.2401	0.0927	0.0689	0.0562	0.0163

For other sectors inequality (13′) was used. This required that forecasts of production capacities of three sectors had to be generated.

For sectors RR, RH, and L a 2% annual rate of growth starting from 1985 was assumed. For both agricultural sectors, the year 1985 was assumed at the level of the best year of 1976-1980, i.e. RR_{1978} and RH_{1979}, while for L-the 1980 level, i.e. L_{1980}. Table 4 presents production capacity estimated in this way.

Table 4

Production capacities assumed for agriculture and forrestry

Year	RR	RH	L
1985	446 593	409 588	31 266
1990	493 075	452 218	34 520
2000	601 055	551 252	42 079

In bill. zł, 1980 prices.

The basis for forecasts for the sectors QFW, QFP and QFE were the data presented by K. Kopecki in "Jutro energetyczne Polski" ("Tomorrow of the Polish Energetics"), Wiedza Powszechna, Warsaw 1981. From these data the so-called "strong"variant of the national economy development was selected. Such an approach needs some justification in the case of heavy economic crises. We shall present it below.

Estimates according to the strong variant for 1990 are generally the same as those made by J. Danielewski ("Życie Gospodarcze", No. 35, vol. XXXVII, 19 Sept. 1982, p. 4) except for brown coal (the table presented in the article shows a different approach to sources and consumption of energy). The summary of the assumptions is shown in Tab. 5.

Table 5

Per cent increase of energy resources (in %)

Source of energy	1980-1985	1985-1990	1990-1995	1995-2000
Coal and briquettes (QFW)	83.3	13.6	20.4	6.4
Liguid and gas fuels (QFP)	29.3	18.8	19.0	17.3
Electric and heat power (QFE)	12.5	31.5	30.9	34.4

On the basis of Tab. 5 the forecasts of production capacities in sectors QFW, QFP and QFE have been made (Tab. 6).

Table 6

Production capacities assumed for coal, fuels and electric energy

Year	QFW	QFP	QFE
1990	280 424	205 932	134 013
2000	359 240	287 454	235 770

In bill. zł, 1980 prices.

G. Foreign trade balance.

It is assumed for the years 1985-2000 that the annual balance will be positive and equal to US $ 3.5 bill. i.e. about 210 000 bill. złotys (in the base year 1980 US $ 1 = 60 zł). Thus, in subsequent variants Ω = 210 000 (in bill. złotys, 1980 prices). In both 1990 and 2000 variants condition (14) was used.

As an illustration of the pilot model experiments we shall present a comparison of four variants of solution (A, B, C, and D, Tab. 7).

Except for the parameters a_{ij} (balance of domestic commodity flows (8)) and k_{ij} (balance of imported commodity flows(9)) all the remaining parameters of the model are constant for the variants A, B, C, and D. The presented variants are characterized by different assumptions concerning the presence or absence of a downward trend in energy consumption in our economy and possible reasons for this decrease. Therefore,

Table 7

Comparison of forecasts for global products of branches of the national economy at various assumptions of energy consumption (1980 = 100)

Sector	Variant A 1990	Variant A 2000	Variant B 1990	Variant B 2000	Variant C 1990	Variant C 2000	Variant D 1990	Variant D 2000	Production capacities 1990	Production capacities 2000
QFW	192x	232x	197x	262x	197x	262x	192x	232x	208	267
QFP	154	214	154	214	154	214	154	214	154	214
QFE	148	215x	148	250x	148	250x	148	215x	148	260
QME	139	172	139	175	139	175	139	172	-	-
QEM	141	176	142	178	142	178	141	176	-	-
QCH	139	172	139	175	139	175	139	172	-	-
QPO	129x	157x	129x	157x	129x	157x	129x	157x	-	-
B	137	170	138	173	138	173	137	170	-	-
RR	124	151	124	151	124	151	124	151	124	151
RH	122	149	122	149	122	149	122	149	122	149
L	110	135	110	135	110	135	110	135	110	135
T	138	171	138	174	138	174	138	171	-	-
H	140	174	140	177	140	177	140	174	-	-
PO	137	170	138	173	138	173	137	170		
Q_i	136	169	136	172	136	172	136	169	x	x
q_i	138	174	138	174	138	174	138	174	x	x

x - denotes production capacities not fully utilized.

- the variant A assumes the energy consumption decrease by 1.7% per year, starting from 1985, both in domestic (a_{ij}) and imported (k_{ij}) energy sources,
- the variant B (pessimistic) does not allow for changes in energy consumption (a_{ij} and k_{ij} remain at the 1980 level),
- the variant C assumes 1.7% average annual decrease of energy consumption only in imported energy sources (k_{ij}); a_{ij} remains at the 1980 level,
- the variant D assumes 1.7% average annual decrease of energy consumption only in domestic energy sources (a_{ij}); k_{ij} remains at the 1980 level,

- x - denotes production capacities not fully utilized (see Q_i or x_i cf.(13') and (13").

From the above comparison it is apparent that under our assumptions about 70% increase of gross production can be expected. It is not a high rate for an almost 20 year period of development. However, it should be noted that there is an opinion that up to 1990 the main goal of the economy will be to restore equilibrium, to overcome bottle-necks and to achieve a financial surplus in foreign trade. In power industry, the main limiting role is played by liquid fuel industry with coal being the next. In other sectors a significant constraint is the assumed level of agricultural production and the share of particular industrial branches in the gross output. If the production technology of the national economy in 2000 is to remind the 1980 technology (by technology we mean unitary raw material consumption) then the comparison of variants A, C, D with B points out that the decrease of energy consumption by 1.7% annually does not provide a sufficient prerequisite for a significant growth of the economy. Thus, in the future investigations more attention should be paid to the assumptions concerning technological changes. The problem of model dynamization should also be solved through proper transformation of current annual investment outlays into the future capacity increase.

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OGRANICZENIE ENERGETYCZNE A OPTYMALNY ROZWÓJ GOSPODARKI POLSKI

Przy konstrukcji prezentowanego modelu za główne ograniczenie rozwoju gospodarczego przyjmuje się zasoby paliwowo-energetyczne. Dalszymi ograniczeniami są możliwości produkcyjne, importowe, a także znaczna sztywność struktury produkcji uwarunkowana strukturą kapitału. Opis powiązań pomiędzy działami gospodarki narodowej ma postać modelu input-output wyróżniającego 14 działów, w tym 3 energetyczne.

Centralną część modelu stanowi układ warunków wychodzący z klasycznego systemu równań input-output $Q = AQ + q$. Układ ten uzupełniony jest warunkami dotyczącymi struktury dochodu narodowego brutto $q_i/\sum_i q_i \leqslant \beta_i$, zdolności produkcyjnych wybranych

działów, dochodu narodowego tworzonego w poszczególnych działach oraz salda handlu zagranicznego (wypłacalność wierzycielom zagranicznym).

Klasyczny model $Q = AQ + q$ został zmodyfikowany do postaci $Q + M = \alpha Q + q$ z powodu charakteru dostępnej informacji statystycznej (M - import).

Model stanowi punkt wyjścia dla analizy stanu i możliwości gospodarki w okresie bieżącym i okresach przyszłych. Programowanie rozwoju gospodarki narodowej odbywa się poprzez wariantowanie zdolności produkcyjnych, struktury dochodu narodowego (β_1), struktury przepływów międzygałęziowych (α_1).