

**System analysis of real and monetary flows in
a planned economy ¹⁾**

by

**ZBIGNIEW CZERWIŃSKI
WITOLD JUREK
EMIL PANEK**

Academy of Economics
Poznań, Poland

An outline of a planning procedure and the very first results of its application to midium-term planning at the central level of national economy are presented in the paper. The aim of the procedure is to find consistent trajectories of both **real and monetary flows** in a centrally planned economy. This feature distinguishes the procedure among a number of procedures based on mathematical models, elaborated lately in countries of centrally planned economies that deal with real flows rather than with monetary flows. Although a number of variables representing monetary flows appear in those models, they do not contain the full financial balance of subsystems of the economy (see, eg. K. Cichocki, A. Stachurski, W. Wojciechowski [1], N. Łapińska-Sobczak, Ł. Tomaszewicz, W. Welfe [8], W. Misiąg [9]).

1. Basic ideas of the model

The model being the base of the planning procedure consists of several blocks. The most important are

(a) block of input-output equations describing real flows (of goods and services), and

(b) block of equations describing monetary flows between subsystems of the economy.

Some monetary flows reflect real flows (although they have opposite directions), while the others are independent of real ones. The block of input-output

¹⁾ This research has been supported by programs MR.I.30 and CPBP 02.15. Results of the research have been reported in [11] — [13].

equations, similar to those of many models of national economy, is adapted to the specific character of Polish economy. ²⁾

Products, activities, spheres of activities and subsystems (with activities assigned to them) are the basic concepts of the model.

Products are meant either as individual goods, measured in physical units or as aggregates, measured in monetary units, taking for granted a given system of prices of goods composing the aggregates. In up-till-now computations based on the model two so-called strategic products, measured in physical units, are distinguished: coal (millions of tons) and electric energy (tera-watt-hours).

National economy is meant as system consisting of **subsystems**. To every subsystem some (at least one) economic **activities** are assigned:

- (a) production,
- (b) trade,
- (c) investment,
- (d) consumption.

The activities (a)-(d) are associated with both real and monetary flows. There are, however, activities associated only with monetary flows. They are called

- (e) purely monetary activities.

As a separate economic activity

- (f) increase of reserves

in distinguished.

Activities belong to various spheres of social life. Production belongs to production sphere, divided into sectors. It is assumed in the model that the output of every productive sector consists of one product (individual or aggregate) although the same product can be produced in different subsystems. Investment activity aimed at the increase of capital stock is also assigned to production sphere. This activity is called productive investment.

To non-productive sphere of the economy both consumption activities and investment activities (non-productive investment) are assigned. The non-productive sphere is divided into

- (a) administration,
- (b) defence,
- (c) environment protection,
- (d) health protection,
- (e) education and culture,
- (f) science,
- (g) housing.

The last activity is understood as consisting of distribution of new apartments and maintenance of existing houses (house construction is the activity of house construction sector).

²⁾ Cf. e.g., [2] — [7], [10].

Partition of the economy into subsystems and assignment of activities to the distinguished subsystems corresponds to the organizational structure of the Polish economy (with some simplifications).

Altogether 15 subsystems are distinguished

1. SINE state industrial enterprises (and co-operatives),
2. MINE municipal industrial enterprises,
3. POIE private-owned industrial enterprises,
4. STFA state farms (and co-operative farms),
5. POFA private-owned farms,
6. HOTR home trade,
7. HCOP housing co-operatives,
8. STBU state budget (and centralized funds),
9. REBU regional budget ³⁾,
10. NFHO non-farm households,
11. FAHO farm households,
12. FOTR foreign trade,
13. BANK bank,
14. RFOR rouble foreign market,
15. DFOR dollar foreign market.

Table 1

Subsystems															
Activities	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Production	+	+	+	+	+										
Current consumption	+	+	+	+	+	+						+			
Productive investment	+	+	+	+	+										
Non-productive investment						+	+	+	+	+	+	+			
Individual consumption										+	+				
Collective consumption							+	+	+						
Trade (domestic, foreign)						+						+		+	+
Monetary activities	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Increase of reserves						+									

In Table 1 the sign of plus (+) identifies activities assigned to particular subsystems. One can notice that two foreign markets (rouble and dollar) are also treated as subsystems, though they represent the environment of the economy.

³⁾ During the first experimental computations both subsystems STBU and REBU were put together and called BUDGET.

2. Blocks of the model

The model may be used to verify the feasibility of given trajectories describing the growth of the economy (e.g. the planned one) or to find a set of such trajectories (when the plan is being prepared). Examples of both types of research are reported in [5], [6].

Regardless of the type of research the trajectories of variables describing the economy are subject to the following groups of constraints, forming consecutive blocks of the model.

(i) **Real balances** are of the form

$$\begin{aligned} \text{CHANGES IN RESERVES} &= (\text{IMPORT} + \text{GROSS OUTPUT}) \\ &- (\text{INTERMEDIATE FLOWS} + \text{FINAL CONSUMPTION} + \\ &\text{INVESTMENT} + \text{EXPORT}) \end{aligned}$$

and state that for any period (year) changes in reserves of any product are equal to the difference between gross domestic output increased by import consumption of the product by all the activities (including investment and exports to both foreign markets). The balances assume a given structure of all final activities: consumption, investment (productive and non-productive), export, import.

Levels of productive activities (gross output) are constrained by production capacity, available labour force, and levels of investment activities in the past. These constraints are called **technological** ones.

(ii) **Monetary balances** take the following form

$$\text{INITIAL RESERVE} + \text{REVENUES} = \text{EXPENDITURES} + \text{FINAL RESERVE.}$$

For every subsystem and period (year) the balance of all monetary flows **to** and **out** of the subsystems have to cover the cost of all their activities. It does not mean that the economy is in a state of monetary equilibrium (understood as a state desired from an „external” point of view or from the points of view of particular subsystems). Monetary balance of a subsystem can be assured at the cost of purely monetary flows, such as subsidies and credits, that create deficits or surpluses in other subsystems, undesirable by them or by the central planner.

(iii) Equations of the third block specify monetary flows between subsystems. As already mentioned they may be divided into two groups: those reflecting the real ones and the purely monetary flows. The equations of this block are called **institutional** ones, as they result from the law in force and organization of the economy.

Both types of equations of the third block may be written in the following general form.

$$\text{MONETARY FLOWS} = f(\text{REAL FLOWS})$$

or

$$\text{MONETARY FLOWS} = g(\text{MONETARY FLOWS, OTHER VARIABLES}).$$

Outline of planning procedure

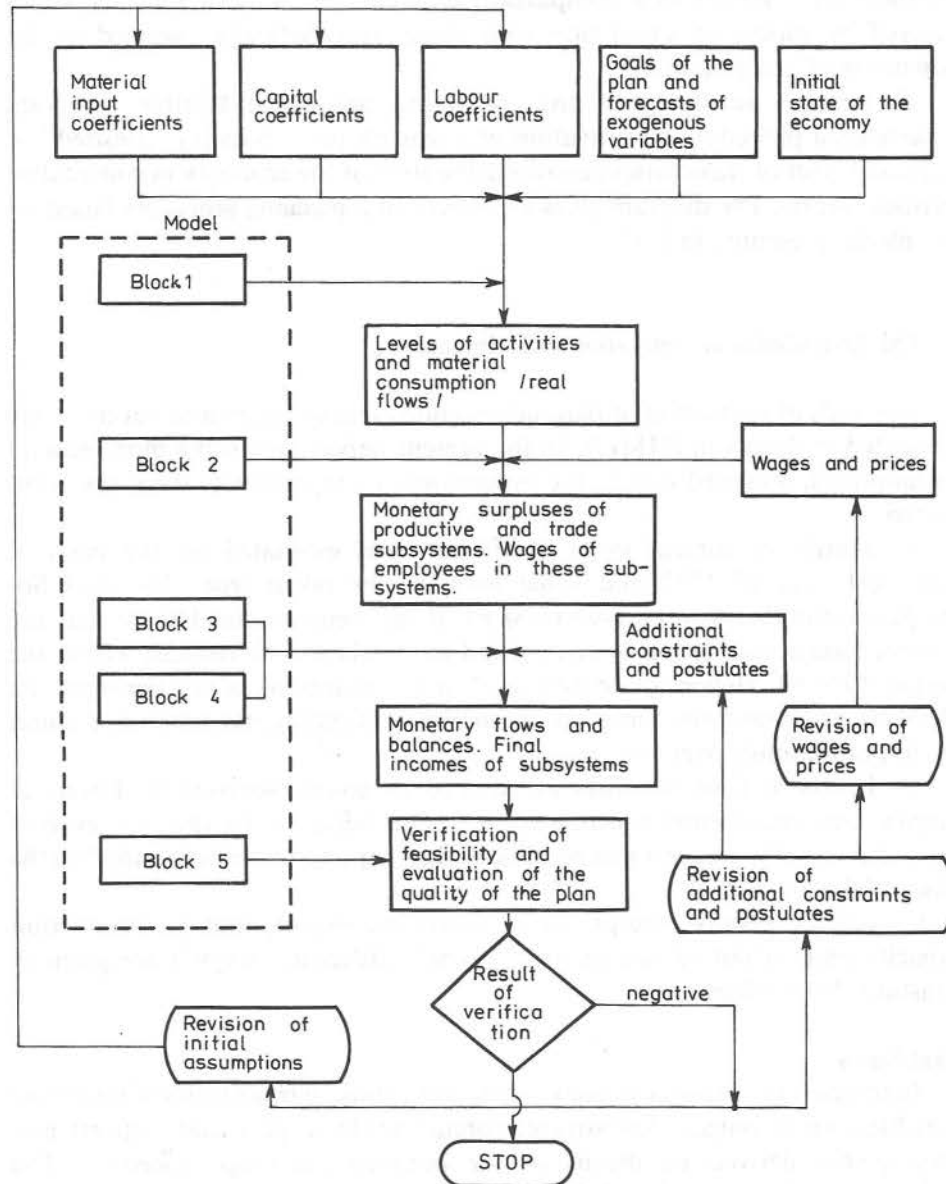


Diagram 1
Outline of planning procedure

(iv) Equations of the fourth block are called **behavioural**, as they describe consumers' behaviour on the market, especially consumers' reaction to wages, prices and the level of supplies of consumer goods.

(v) The fifth block consists of equations, on the basis of which feasibility (and quality) of a set of trajectories derived by the planning procedure may be verified. Verification is meant as a comparison of the trajectories of some variables derived by means of simulation with those hypothetically assumed at the beginning of computations.

Trajectories satisfying all the constraints are called feasible. Diagram 1 sketches a procedure of derivation of a feasible (and, possibly, „desired” or „optimal”) set of trajectories describing the state of the economy in consecutive periods (years). The diagram gives an outline of a **planning procedure** based on the model presented in [13].

3. The first results of simulation experiments

Methods of estimation of parameters and values of exogenous variables are presented in details in [11]-[13]. In the present paper, only some more general assumptions, accepted during the processing of the statistical data, are mentioned.

— Matrix of current input coefficients was estimated on the basis of statistical data of 1982 and some assumptions taken from National Socio-Economic Plan for 1986-90 (NSEP). It has been assumed there that the intermediate consumption of energy and materials will be reduced within the period 1986-90. Hence the matrix used in computations is not constant. Its elements representing intermediate consumption of energy and materials per unit of output diminish over time.

— Levels of final activities are treated as given exogenously. Levels of output, investment, employment, export, import adjust to the assumed levels of final activities. Wherever it was possible the assumptions were determined on the basis of the the NSEP.

— All the results (except for employment, export, import, production capacity and output of two sectors: „Coal”, „Electric energy”) are given in constant, 1982 prices.

Real flows

In this part of the paper we make some comments on trajectories of four basic variables: gross output, investment, foreign trade (export and import) and employment derived by means of the outlined planning procedure. The trajectories are presented in Table 2.⁴⁾

The trajectories of **gross output** reveal several characteristic features.

— Generally, gross output is almost constant over time (e.g. „fuel”, „electric

⁴⁾ Table 2 contains only „total” quantities of the variables mentioned above. The quantities are not divided into sectors of origination or destination.

Table 2
Planned trajectories of selected aggregate variables

Variables	Years				
	1986	1987	1988	1989	1990
1. Gross output (billion zł)	12223.0	12516.4	12847.5	12902.7	13513.2
2. Investment (billion zł)	901.1	706.5	1147.3	967.9	955.6
3. Export (billion zł)	1430.1	1358.7	1314.9	1422.6	1348.7
4. Import (billion zł)	982.5	942.0	1009.6	979.1	998.0
5. Employment (10 ⁶ persons)	14.3	14.4	14.5	14.6	14.6

energy", „chemicals") or even slightly diminishes (eg. „metallurgy", „machinery", socialized sector of agriculture).

There are 5 agriculture activities: 3 in the socialized sector of agriculture (state — owned and collective farms): field crops, livestock, agricultural services, and 2 in the non-socialized sector (private forms): field crops, livestock. Coefficients of material inputs and capital-output ratios in the socialized agriculture estimated on the basis of available statistical data are approximately 1.4 times greater than those in private farms. This is the reason why agricultural activities in the socialized sector have been forced out by the corresponding activities of private farms. An increase in agricultural output was attained by intensification of activities of private farms.

— To derive the trajectories of all variables we had to assume some production capacities of sectors in the initial year. It turned out that assumed capacity of the house construction sector is too small to assure within the period of 1986-90 the number of apartments postulated by the NSEP. (If this number is assumed as a target, the system of balance equations has no feasible solution). This may constitute the evidence for the necessity of structural changes within the house building industry.⁵⁾

Total **investment**, necessary to reach the planned levels of production and final activities, amounts to 4.7 · 10¹² zlotys in 1982 prices, what approximately

⁵⁾ The solutions, i.e. trajectories of variables, reported further on were derived with the initial production capacity of house construction artificially enlarged.

makes 7.5 .10¹² zlotys in 1985 prices. This value is lower than that appearing in the NSEP.

The trajectories of **exports** to both foreign markets (in domestic, 1982 prices) slightly decrease (the NSEP assumed 6.7% and 3.3% average yearly rates of growth of exports to the rouble and dollar markets, respectively), whereas the trajectories of **imports** from both regions are more or less constant over time (in the NSEP they are assumed to grow at 3.9% and 3.7% average yearly rates of growth for the rouble and dollar markets, respectively). While forecasting sectoral labour-output ratios, another optimistic **assumption** was accepted that these ratios will decrease within the period 1986–90 with the rate observed in the seventies. Despite of it, the trajectories do not reveal any reserve of **labour force**.

Monetary surpluses and deficits of subsystems

Three subsystems attain the greatest surpluses: industrial enterprises (state and private-owned) and domestic trade. Total value of monetary surpluses in 1990 is almost by 20% higher than in 1986, but the growth is somewhat irregular.

The surpluses of the state budget due to the foreign trade reach within 1986–90 approximately 14 billion roubles, and 3 billion US dollars measured in constant, 1982, prices. These surpluses, increased by incomes gained at home market, are insufficient (because of disadvantageous rates of exchange) to cover cost of current activity of subsystem „foreign trade” measured in zlotys. Thus, „foreign trade” is a deficit subsystem of the economy.

Table 3
Monetary surpluses of selected subsystems (billion zlotys)

Subsystems	Years				
	1986	1987	1988	1989	1990
1. State industrial enterprises	3039.1	2714.5	3329.7	2965.2	3512.5
2. Municipal enterprises	43.9	45.8	55.0	56.4	65.9
3. Private enterprises	212.7	203.4	248.1	243.2	280.4
4. State and co-operative farms	35.8	46.6	100.0	105.9	128.5
5. Private farms	51.5	38.0	18.8	14.3	13.3
6. Domestic trade	602.5	644.3	647.3	683.5	696.8
7. Foreign trade	-103.1	-82.7	-96.0	-77.8	-58.7

Foreign debt (in dollar market) reached 29.3 billion \$ in 1985. In an „optimistic” scenario (7% interest rate, 10% rate of growth of transfers), the debt reaches 34 billion US dollars, while in a „pessimistic” scenario (10% interest rate, 5% rate of growth of transfers the debt reaches 44 billion US dollars in 1990.

Monetary flows

In simulation experiments a number of trajectories of real flows were derived. They do not differ significantly one from another. Conversely, various scenarios of monetary flows corresponding to a given scenario of real flows differ substantially. This results, partly, from the model itself, the monetary part of which is subject to only a few weak constraints. Therefore, additional const-

Table 4
Selected monetary flows

Monetary flows	Years				
	1986	1987	1988	1989	1990
1. State subsidies to municipal enterprises	52.4	56.8	55.6	61.0	73.1
2. State subsidies to socialized agriculture	8.7	10.6	11.4	7.7	0
3. State subsidies to foreign trade	231.7	195.3	224.0	186.8	204.0
4. Social services (except for private farmers)	800.7	850.3	1028.1	1045.1	1200.0
5. Social services to private farmers	765.2	795.6	822.8	850.9	880.0
6. Household payments to housing co-operatives	493.7	226.7	509.7	296.5	409.9
7. Budget subsidies to housing co-operatives	804.2	512.9	723.3	464.0	704.6
8. Balance of credits of private farmers	-480.7	-29.7	-525.0	-65.0	-107.9
9. Balance of credits of housing co-operatives	622.0	169.8	468.3	50.4	319.3
10. Increase in savings of non-farm population	299.7	590.1	510.1	692.4	805.8

rains, reflecting monetary policy of the state are to be imposed in simulation experiments. The trajectories of monetary variables turned out to be very sensitive to them. Hence, many alternative trajectories of monetary flows could not be recognized as realistic and recommended, and only general conclusion concerning monetary flows within the period 1986–90 could be drawn on the basis of the experiments.

(i) **Subsidies and social services** financed by the state budget are presented in Table 4 (rows 1–5). Because of small surpluses of sectors: agriculture (both socialized and private), and municipal enterprises, and of a deficit of foreign trade, the subsystems mentioned in the table are heavily subsidized within the five-year period 1986–90.

In Table 4 (row 7) the budget subsidies for housing co-operatives are shown. It is worth noticing, that in some other scenarios housing co-operatives are financed by state industrial enterprises. Thus, experiments reveal two possible ways of subsidizing the housing co-operatives: either by the state budget or by the state enterprises.

Social services are approximately equal to the planned ones.

(ii) **Credits.** Debt of private farmers increases within the period 1986–90 (cf. Table 4, row 8), their funds (plus subsidies) being insufficient to invest with the intensity necessary to keep the agricultural production at the level corresponding to the solution of the real balance equations. Balances of credits for other subsystems (state industrial enterprises, private enterprises, domestic trade, housing co-operatives) are equal to or less than zero.

(iii) **Financing of housing co-operatives.** The cooperatives are financed by state budget and households. A part of personal incomes is allocated to co-operatives (Cf. Table 4, row. 6). The figures in the 7th row correspond to the scenario of state subsidies in which budget expenditures equalize incomes.

(iv) **Savings.** Savings of non-farm population increase rather fast (cf. Table 4, row. 10). Savings of farm population do not change within the period 1986–90. All the surpluses of private farmers are devoted to intensify their investment activity.

4. Concluding remarks

When studying the NSEP one can notice that the real side of the plan (output, production and consumption of a materials) is not sufficiently connected with the monetary side of the plan (income and expenditures of population, enterprises, state budget). It seems that this practice is one of many causes of tensions in the economy. The planning procedure based on the model opens the possibility of consistent planning of both sides of the economy: real and monetary, what is of great importance. Neither the model nor preliminary simulation experiments presented in the paper can be considered as a „final

product" directly applicable to planning. The model needs some corrections, initial information should be more extensive and reliable, and methods of estimation of model parameters should be improved. Despite of these shortcomings we present the up-to-now results in belief that procedures based on the model linking together real and monetary flows may substantially improve the quality of mid-term plans of the Polish economy.

References

Books and papers

- [1] CICHOCKI K., STACHURSKI A., WOJCIECHOWSKI W. Two-level model of the Polish economy: production and financial interrelations. Systems Research Institute, Polish Academy of Sciences, Warsaw 1985.
- [2] CZERWIŃSKI Z., JUREK W., PANEK E. Zastosowanie dynamicznego modelu Leontiefa w planowaniu (Application of the dynamic Leontief model in planning). *Ekonomista*, (1979) 6, (in Polish).
- [3] CZERWIŃSKI Z., JUREK W., PANEK E., ŚLEDZIŃSKI W. On the application of the dynamic Leontief Model in Planning. *Oeconomica Polona*, (1989) 4.
- [4] CZERWIŃSKI Z., JUREK W., PANEK E., ŚLEDZIŃSKI W. System of models for medium-term planning of national economy. In: *Dynamic Modelling and Control of National Economics* (J.M.L. Janssen, L.F. Pau, A. Straszak — eds.), Pergamon Press, Oxford 1981.
- [5] CZERWIŃSKI Z., GUZIK B., JUREK W., PANEK E., RUNKA H., ŚLEDZIŃSKI W. Modelowanie i planowanie wzrostu gospodarki narodowej (Modelling and planning of growth of the national economy). PWN, Warszawa 1982, (in Polish).
- [6] GUZIK B., JUREK W., PANEK E. An analysis of consistency of the three-year plan (1983–85) of the productive sphere of the Polish economy. *Control and Cybernetics* (1986) 3–4.
- [7] GUZIK B., JUREK W., PANEK E. Ekonomicheskii analiz wnutrienniogo soglasovannosti triechletnego plana rozwitia narodnogo PNR (1983–85). (Economic analysis of consistency of the three-year plan (1983–85) of development of national economy of Poland). Paper presented to the International Conference of Academies of Sciences of the socialistic countries „Problemy uwiązki choziaystwiennogo mekhanizma s celami i zadachami narodnokhoziaystwiennogo plana” (Problems of linkage of economic mechanism with objectives of national planning; in Russian), Warszawa, czerwiec 1986.
- [8] ŁAPIŃSKA-SOBCZAK N., TOMASZEWICZ Ł., WELFE W. Modelling of financial and monetary flows in Poland. Paper presented to the Colloque Internationale de l'Econometrie Appliquee, mimeo. Rome 1979.
- [9] MISIĄG W. Analiza skutków zmian cen urzędowych — model MCEN (An Analysis of Consequences of Changes of the Governmental Prices — the MCEN Model). *Przegląd Statystyczny*, (1987) 2, (in Polish).
- [10] PANEK E., JUREK W. Problemy planowogo rozwitia narodnogo khoziaystwa, na primierie PNR (Some problems of planned development of the national economy, the Polish case). In: *Ekonomicheskaiia dinamika, planirovanie, prognozirovanie, modelirovanie* (Economic dynamics, planning, forecasting, modelling). Charkov 1983 (in Russian).

Reports prepared at the Institute of Economic Cybernetics, Academy of Economics, Poznań, all in Polish

- [11] Koncepcja teoretyczna systemu modeli i służących do wyznaczania ścieżek wzrostu gospodarki narodowej (A theoretical concept of a model system serving for derivation of paths of growth of national economy); problem: MR.I.30, subject: 2.8.1985;
- [12] System modeli służących wyznaczaniu ścieżek wzrostu gospodarki narodowej — badania symulacyjne (A system of models serving for derivation of paths of growth of national economy — simulation tests); problem: M.R.I, subject: 2.8.1985;
- [13] Dynamiczny model przepływów rzeczowo-finansowych — koncepcja teoretyczna i wstępne obliczenia (A dynamic model of real-monetary flows — theoretical concept and preliminary computations), problem: CPBP 02.15/1.1.4.86, 1986.

Received, October 1987.

Analiza systemowa przepływów rzeczowych i pieniężnych w gospodarce planowej

W pracy naszkicowano procedurę planowania i pierwsze wyniki jej zastosowania do średniookresowego planowania na poziomie centralnym w gospodarce narodowej. Celem procedury jest znalezienie zgodnych trajektorii **przepływów rzeczowych i pieniężnych** w gospodarce z centralnym planowaniem. Ta cecha odróżnia podaną procedurę od innych procedur opartych na modelach matematycznych, które opracowano ostatnio w krajach z centralnym planowaniem i które opisują raczej przepływy rzeczowe, a nie pieniężne. Chociaż użyte tam modele zawierają znaczną liczbę zmiennych opisujących przepływy pieniężne, to jednak nie zawierają one pełnych bilansów finansowych poszczególnych działów gospodarki (patrz np. K. Cichocki, A. Stachurski, W. Wojciechowski [1], N. Łapińska-Sobczak, Ł. Tomaszewska, W. Welfe [8], W. Misiąg [9]).

Системный анализ вещественных и денежных потоков в плановом хозяйстве

В работе рассмотрена процедура планирования и первые результаты её использования для среднесрочного планирования на центральном уровне народного хозяйства. Целью процедуры является нахождение согласованных траекторий вещественных и денежных потоков в экономике с центральным планированием. Этот признак отличает данную процедуру от других процедур, основанных на математических моделях, которые были разработаны за последнее время в странах с центральным планированием и которые описывают в основном вещественные, а не денежные потоки. Хотя используемые в тех случаях модели содержат значительное число переменных, описывающих денежные потоки, однако они не требуют полного финансового баланса в отдельных отраслях экономики (см., например, К. Цихоцки, А. Стахурски, В. Войцеховски [1], М. Лапиньска-Собчак, Л. Томашевска, В. Вельфе [8], В. Мисэнг [9]).