SYSTEMS RESEARCH INSTITUTE
POLISH ACADEMY OF SCIENCES

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS

CONTRACTED STUDY AGREEMENT REG / POL / 1

"CONCEPTS AND TOOLS FOR STRATEGIC REGIONAL SOCIO-ECONOMIC CHANGE POLICY"

STUDY REPORT

PART 1

BACKGROUND METHODOLOGIES

COORDINATOR, IIASA: A. KOCHETKOV
COORDINATOR, SRI PAS: A. STRASZAK

ZTS / ZPZC / ZTSW 1-36/85

WARSAW 1986

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Consisting of 3 Parts

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IV. INVESTMENTS AND CREDITS AS CONTROL TOOLS IN A CENTRALLY PLANNED ECONOMY

by Krzysztof Cichocki and Waldemar Wojciechowski

Editor's note: This chapter forms a whole together with subsequent chapters: V and VI. In fact, most of the problems taken up in the two other chapters are introduced in this one. Thus, e.g. Chapter V highlights some of the methodological questions related to the model outlined in Chapter IV, while Chapter VI gives a description of the banking system, some of whose features are also taken into account in the model of Chapter IV.

IV.1. Introduction

A model of national economy is presented, designed as a decision aiding tool for the Central Planner and the National Bank Director (for brevity they will be refered to as "the Center"). The national economy is divided into branches - groups of enterprises producing homogeneous goods - which are subject to current financial regulations in Poland.

The Center has institutional and executive power of influencing the activity of branches in such a way that their functioning yields provisions for a realization of desires of the Center. The Center expresses its desires by specification of, for instance, a rate of growth of a consumption path or a rate of decrease of the foreign debt trajectory. It controls the branches with the help of such instruments as taxes and credits for financing investments. It also determines other financial parameters which stimulate the activity of branches of the economy.

It is argued in this chapter that the actual tax policy, operative in the cost of production and the cost of capital can efficiently stimulate the financing of the investment. For discussion of these problems see also Chirinko and Eisner (1983), and Gerard and Van den Berghe (1985). Investments are one of the major controls in the presented model. Part of them is the object of decisions made within branches, and it contributes to the promotion of production and services consistently with the branches choice.

However, another part of investments is directly controlled by the Center and is planned to be used for a restructuration of the national economy. Consistently with the present practice these investments are favoured by the Center. Means, bank credit and raw materials are assured by the Government and it is required that the Center investments be completed on time. It is assumed that the Center investments are exogeneous in the model. They are independent of enterprises investments but they limit the total level of these investments.

The investments and credits for their financing are one of the major forces of promoting structural changes and technological progress. However, we argue that some economic and organizational progress can be imbedded in the investigations of the full utilization of production capacities based on the material coefficients matrix.

IV.2. The two-level structure of controlling the national economy

The model formulated in the paper reflects the structure of the Polish economy. The existing relations between variables which characterize the economic system, the mechanism of its functioning and limitations are described in some detail.

It is assumed that the Polish economy consists of a finite number of branches: m-1 production branches which produce a homogeneous good and one branch financed from the government budget (it includes science and culture, education, administration and the army). The branches function consistently with the valid regulations and aim at achievement of their objectives. These objectives are: simultaneous maximization of the profit and of the revenue.

The Center is trying to control the activity of the branches with the help of parameters. Given the parameters, the branches have the freedom of maximizing their own objectives.
Among the most important parameters are:
exogeneously determined - investments of the Center V^C_{tj}, financi subsidies Do_{tj}, a rate of the income tax τ_{tj}, and the controls of the Center problem - investment credits in the Polis and in foreign currencies Po_{tj}, which are granted by the bank, the rate of the turnover tax σ_{tj}, the share of the amortization

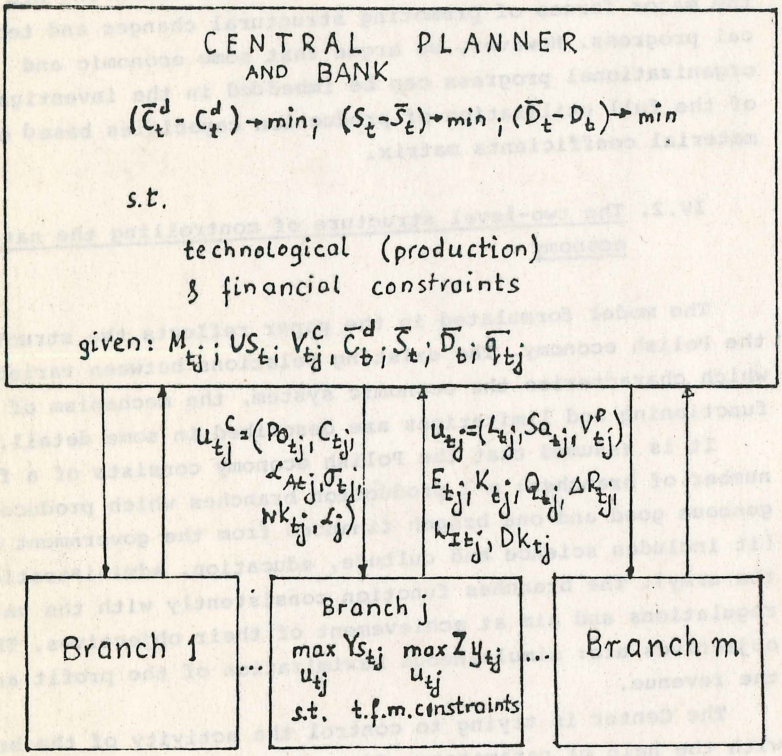
CENTRAL PLANNER
AND BANK
$(\bar{C}_t^d - C_t^d) \to \min$; $(S_t - \bar{S}_t) \to \min$; $(\bar{D}_t - D_t) \to \min$
s.t.
technological (production)
& financial constraints
given: M_{tj}; US_t; V_{tj}^c, $\bar{C}_{tj}^d$; $\bar{S}_t$; $\bar{D}_t$; $\bar{q}_{tj}$
$u_{tj}^c = (Po_{tj}, C_{tj}, \mathcal{L}_{At}, \sigma_{tj}, Wk_{tj}, \mathcal{L}_j)$
$u_{tj} = (L_{tj}, Sa_{tj}, V_{tj}^p, E_{tj}, K_{tj}, Q_{tj}, \Delta R_{tj}, W_{Itj}, Dk_{tj})$
Branch 1
Branch j
$\max_{u_{tj}} Ys_{tj}$ $\max_{u_{tj}} Zy_{tj}$
s.t. t.f.m.constraints
Branch m

Figure IV.1.

fund which is kept by a branch α_{Atj}, the coefficient wk_{tj} betwee the relative increase of the revenue and the increase of the wage fund, and the rate of taxes, which a branch has to pay on extra wage fund. (They are very progressive and can be characterized by a parameter α_j).

The Center tries to attain the goals of two kinds:

- it tries to achieve some growth paths which are selected jointly by the Bank and by the Central Planner and are designed to satisfy the needs of individual persons and to ensure given production and development programs. The Center is interested in real growth rates and not in nominal values. It expresses the implicit desire of maximization of individual and public consumption C_t, maximization of national income D_t and minimization of the foreign debt S_t.
- its activity is largely motivated by a sound principle of profitability. For instance the bank selects only reliable creditors, i.e. such branches which have credit worthiness.

It is assumed in the model that the branches make decisions independently one from another. Balancing of production, raw materials and labor force takes place at the upper level. In section IV.4 financial mechanism of a branch is described with the help of mathematical formulas. The lower level problem of a branch is a multicriterion optimization problem. Each branch maximizes simultaneously its profit and its revenue given financial regulations and parameters from the Center level. The solution yields a vector of control variables u_{tj} which are: the j-th branch investments V^p_{tj}, the wage fund sa_{tj}, the employment level L_{tj} $t=0,\ldots,T$. Additionally, the export E_{tj} of production and investment goods as well as the production Q_{tj} and the fixed assets K_{tj} in the j-th branch are derived from equations IV .45, IV.20-24.

The above values of E_{tj}, Sa_{tj}, V^p_{tj}, K_{tj}, L_{tj}, Q_{tj} and the credit repayments Dk_{tj}, are reported by the j-th branch, $j=1,\ldots,m$, as a result of its activity to the Center. These values are functions of the parameters of the Center, together with the whole financial mechanism are used by the Bank and by the Central Planner in order to motivate the branches to act consistently with their desires. In the Figure IV.1 the two-level structure of an interactive control of the economy is depicted.

IV.3. The upper level problem

The concern of the Center is in the achievement of given development paths which in the view of the Central Planner and the Bank are desired by the society and at the same time ensure sufficient production program and development of the national economy.

The desired trajectories of consumption $\bar{C}_t^d$, of national income $\bar{D}_t$ and of the foreign debt of the Polish economy $\bar{S}_t$ appear in the objective as follows

$$\min |C_t^d - C_t^d| , \tag{IV.1}$$

$$\min |D_t - D_t| , \tag{IV.2}$$

$$\min |S_t - S_t| , \quad t=0,\ldots,T, \tag{IV.3}$$

where T is the terminal time of the investigated period and C_t^d, D_t and S_t are defined further on by expressions (IV.16), (IV.15) and (IV.13) respectively.

The production and financial balances have to be satisfied in the upper level problem.

The production balance assumes the form

$$Q_t + G_tQ_t + \bar{B}_tV_t + M_t = A_tQ_t + B_tV_t + E_t + C_t + \Delta R_t, \quad t=0,\ldots,T \tag{IV.4}$$

where the variables Q_t, V_t, M_t, E_t, C_t, ΔR_t are vectors of m elements, and m is the number of branches in the economy.

The left hand side of the equation (IV.4) denotes an amount of production and imports, for production G_iQ_t, for investment $\bar{B}_tV_t$ and for consumption M_t purposes which is to be divided among branches. The right hand side presents a division of the product between intermediate production A_tQ_t, investments B_tV_t, export E_t, total consumption C_t and the supplies and reserves ΔR_t.

It is assumed that the Leontief matrix A_t changes over time and encompasses an anticipated decrease of material coefficients.

B_t is a changing over time total capital coefficient matrix, $\bar{B}_t$ is a matrix of imported capital coefficients and G_t is a matrix of imported material coefficients.

The matrices $\bar{B}_t$ and G_t represent the propensity of the economy to import for investment and production purposes respectively.

The total investment V_{tj} is defined as a sum of the centrally financed investments V^C_{tj} and the branch investments V^P_{tj}

$$V_{tj} = V^C_{tj} + V^P_{tj}, \quad j=1,\ldots,m, \quad t=0,\ldots,T \tag{IV.5}$$

The investments in the year t+1 result from decisions made at time t and prior to time t. In order to account for earlier commitments it is assumed that the centrally financed investment in the j-th branch, at time t are not below the level planned at the year t.

The investments planned to be committed in the year t result from investment decisions made prior to time t and are determined by the matrix $ZAA^C_{t-1,j}(n,1)$. It describes the funds anticipated for continuation of investments which are to be committed in the year t (t-1+1) and whose completion is anticipated for the year t-1+n

$$V^C_{tj} \geq \sum_{n=1}^{N^C_{t-1,j}-1} ZAA^C_{t-1,j}(n,1) \tag{IV.6}$$

The value $N^C_{t-1,j}$ is the maximum length of continuation of the centrally financed investments in the j-th branch measured at time t-1. The method of construction of the above investment matrix and examples of investment which are to be committed in the sectors of the Polish economy over the period 1986-1990 are briefly described in chapter VI and more thoroughly in Cichocki and Wojciechowski (1984) and Wojciechowski (1985).

Additionally it is assumed that the flows of investment goods produced by the metal-machine and the construction sectors do not exceed production capacities in these sectors.

$$\sum_{j=1}^{m} b_{3j} V_{tj} \leq f(K_{t-1,3}, L_{t,3}) \tag{IV.7}$$

$$\sum_{j=1}^{m} b_{10j} V_{tj} \leq f(K_{t-1,10}, L_{t,10}), \quad t=0,\ldots,T \tag{IV.8}$$

where the indices 3 and 10 correspond to the investing sectors

of the metal machine industry and the construction sector.

In the expressions (IV.1-8), the values $\bar{C}^d_t$, $\bar{D}_t$, $\bar{S}_t$, G_t, $\bar{B}_t$, B_t, A_t, V^C_{tj}, M_T are determined exogeneously. The values C_{tj}, D_t, S_t, Q_{tj}, V^P_{tj}, E_{tj}, ΔR_t are computed, given parameter values of the Center, some of which are in turn calculated based on information from the lower level.

The lower bound on consumption $\underline{C}_{tj}$, called the subsistence level is also exogeneous. The consumption computed from the model should not be below the subsistence level

$$C_{tj} \geq \underline{C}_{tj}, \quad j=1,\ldots,m, \quad t=0,\ldots,T \qquad \text{(IV.9)}$$

The second group of constraints concerns financial conditions. Some of them represent flows of money, the others describe reserves (the states) of monetary funds.

The state of the bank accounts in Polish currency at time t+1 is defined by $\overline{BANK}(1)_{t+1}$

$$\overline{BANK}(1)_{t+1} = \overline{BANK}(1)_t + BANK(1)_t + \overline{FROZ}(1)_t + \sum_{j=1}^{m} (Dk(1)_{tj} - Po(1)_{tj} - V^C_{tj}(1)), \quad t=0,\ldots,T \qquad \text{(IV.10a)}$$

The state of the bank accounts in foreign currencies

$$\overline{BANK}(2)_{t+1} = \overline{BANK}(2)_t + BANK(2)_t + \sum_{j=1}^{m} (DK(2)_{tj} - Po(2)_{tj} - V^C_{tj}(2) - Dz^t_t)), \quad t=0,\ldots,T \qquad \text{(IV.10b)}$$

The bank accounts are the sum of accounts in the following banks: The Polish National BANK (NBP), The Bank for Food Economy (BGZ) and The Trading BANK SA (BH SA) in Warsaw. The banking system is described in Chapter VI of this part of the Report.

$BANK(1)_t$ represents sums of Polish money (flow at time t) that are either paid to the bank (e.g. tax liabilities) or have to be paid by the bank to cover some wages and other expenses in branches of the economy

$$BANK(1)_t = \sum_{j=1}^{m} (Podo_{tj} + Podd_{tj} + F_{tj} + PFAZ_{tj} + (1-\alpha_{Atj})A_{tj} - Do(1)_{tj} - Sa'_{tj}) + Os(1)_t, \quad t=0,\ldots,T \qquad (IV.11a)$$

The money flow in foreign currencies is defined as:

$$BANK(2)_t = Os(2)_t - Z_t - \sum_{j=1}^{m} Do(2)_{tj}, \quad t=0,\ldots,T \qquad (IV.11b)$$

The j-th branch pays to the bank the turnover tax, $Podo_{tj}$, the income tax, $Podd_{tj}$, the wage fund tax F_{tj}, the progressive tax paid on the extra growth of the wage fund PFAZ, and a part of a verified amortization fund $(1-\alpha_{Atj}).A_{tj}$, $0<\alpha_{Atj}<1$. $Do(1)_{tj}$ denotes subsidies, in Polish zloty, granted by the bank to the j-th branch, Sa'_{tj} is the wage fund of the j-th branch which is financed from the central budget and $Os(1)_t$ is the balance of savings of individual citizens at time t. $Os(2)_t$ and $Do(2)_{tj}$ denote the balance of savings and the subsidies of the j-th branch, in foreign currency at time t. The trade balance with abroad Z_t is defined as a difference between import and export

$$Z_t = \sum_{j=1}^{m} [M_{tj} + (G_t Q_t)_j + (\bar{B}_t V_t)_j - E_{tj}], \quad t=0,\ldots,T. \qquad (IV.12)$$

Positive Z_t increases the foreign debt.

The foreign credits granted by time t, Dz_t, are repaid at consecutive time instants t, t+1,..., $t+T_R$ in the amounts Dz_t^t, $Dz_t^{t+1},\ldots,Dz_t^{t+T_R}$. The value Dz_t^t is a repayment of the foreign credit due at time t and granted by time t. It is assumed that the values Dz_t^{t+i}, $1<i<T_R$ include the interests on credits, which depend on the time. T_R denotes the time period in which the credits, granted by time t, must be repaid.
If the foreign trade balance Z_t is positive, the deficit has to be covered from new credits, which can be obtained at time t, with a new repayment period and new interest rates. This fact changes the repayment strategy.

The investigation of the foreign trade and of foreign credits is not the major objective of the paper and therefore we will not study it further. For the sake of simplicity of presentation we will assume that no credits are granted at

time t, thus implicitly assuming that $Z_t<0$. Then, the foreign debt of the economy at time t is equal to the repayments of the foreign credits

$$S_t = \sum_{z=1}^{p} \sum_{i=0}^{T_{R(z)}} Dz_t^{t+i} \qquad \text{(IV.13)}$$

where p is a number of credit categories.

$FROZ(1)_t$ denotes the state of the development fund which is worked out at the branch by enterprises. The definition of $FROZ(1)_t$ is given by (IV.39) and the mechanism of its formation illustrates the Figure IV.2.

$Dk(1)_{tj}$ and $Dk(2)_{tj}$ denote credit liabilities of the j-th branch in Polish and in foreign currencies respectively which are to be paid to the bank at time t. Prolongation of the crediting period and postponement of the time of credit repayment yields additional interest, thus increasing Dk_{tj}, which depends on the amount of credits and the length of its repayment.

$Po(1)_{tj}$ and $Po(2)_{tj}$ represent credits granted by the bank to the j-th branch at time t.

The bank collects interest on granted credits. It grants credits (investment, turnover, payment and other ones) to branches based on the solvency and worthiness of enterprises. For instance, it is required for investment credits that the percentage of the enterprise own fund amount to at least 70% of the value of investment, the length of credit repayment is not longer than 5 years and a special measure of investment effectiveness is satisfied (some details are given in the paper by Cichocki and Wojciechowski (1984)).

It is assumed in the model that the total foreign debt of the economy, S_t, does not exceed a number US_t, given by the Center

$$S_t < US_t, \qquad t=0,\ldots,T \qquad \text{(IV.14)}$$

The national income is defined as

$$D_t = \sum_{j=1}^{m} (V_{tj} + C_{tj} + \Delta R_{tj}), \qquad \text{(IV.15)}$$

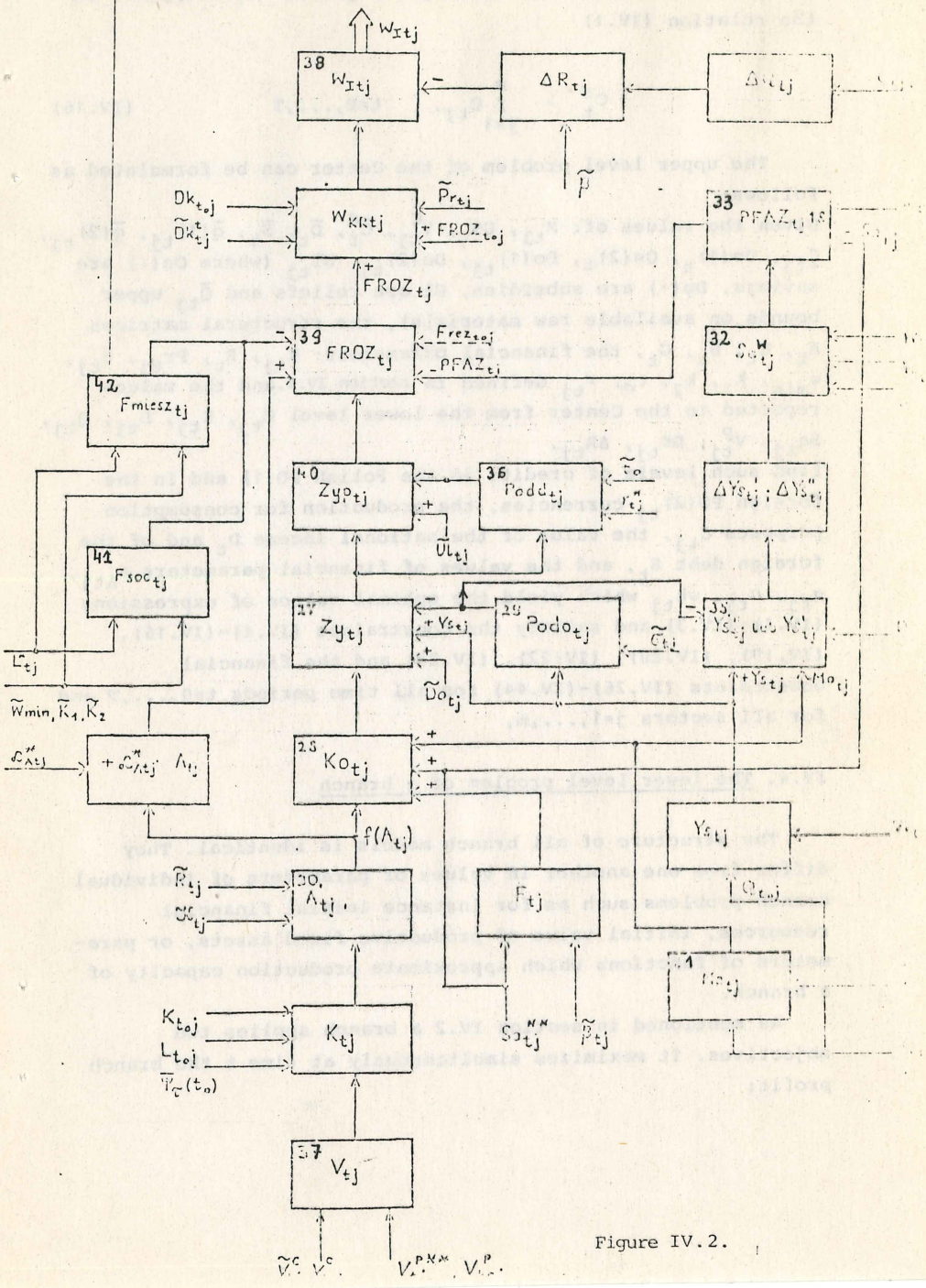
38 W_{Itj}
ΔR_{tj}
ΔY_{tj}
$\tilde{p}$
Dk_{toj}
$\tilde{Dk}^{t}_{tj}$
W_{KRtj}
$\tilde{P}_{rtj}$
$+ FROZ_{toj}$
$FROZ_{tj}$
33 $PFAZ_{tj}$
39 $FROZ_{tj}$
$Frez_{toj}$
$-PFAZ_{tj}$
32 S^{W}_{tj}
42 $Fmiesz_{tj}$
40 Zyp_{tj}
36 $Podd_{tj}$
$\tilde{Do}$
$\tilde{Y}^{n}_{tj}$
$\Delta Ys'_{tj}; \Delta Ys''_{tj}$
$\tilde{Ul}_{tj}$
41 $Fsoc_{tj}$
37 Zy_{tj}
29 $Podo_{tj}$
$\tilde{Ge}_{tj}$
35 Ys'_{tj} lub Ys''_{tj}
$+Ys_{tj}$
Mo_{tj}
$\tilde{L}_{tj}$
$\tilde{W}min, \tilde{K}_1, \tilde{K}_2$
$\tilde{Do}_{tj}$
$\tilde{\alpha}^{n}_{Atj}$
$+\tilde{\alpha}^{n}_{Atj} A_{tj}$
28 Ko_{tj}
$f(A_{tj})$
Ys_{tj}
$\tilde{R}_{tj}$
$\tilde{Sc}_{tj}$
30 A_{tj}
F_{tj}
Qe_{tj}
31 Mo_{tj}
K_{toj}
L_{toj}
K_{tj}
$\tilde{Sa}^{NN}_{tj}$
$\tilde{P}_{tj}$
$\tilde{V}_{c}(t_o)$
37 V_{tj}
$\tilde{V}^{c}$ V^{c}
$V^{P,NN}$ V^{P}

Figure IV.2.

where $\Delta R_{tj} = R_{tj} - R_{t-1,j}$ is the increase of the reserves. The global production of consumption goods, which appears in the relation (IV.1)

$$C_t^d = \sum_{j=1}^{m} C_{tj}, \qquad t=0,\ldots,T \tag{IV.16}$$

The upper level problem of the Center can be formulated as follows:

Given the values of: M_{tj}, US_t, V^C_{tj}, $\bar{C}^d_t$, $\bar{D}_t$, $\bar{S}_t$, $\bar{q}(1)_{tj}$, $\bar{q}(2)_{tj}$, $\underline{C}_{tj}$, $Os(1)_t$, $Os(2)_t$, $Do(1)_{tj}$, $Do(2)_{tj}$, Ul_{tj} (where $Os(\cdot)$ are savings, $Do(\cdot)$ are subsidies, Ul are reliefs and $\bar{Q}_{tj}$ upper bounds on available raw materials), the structural matrices A_t, B_t, $\bar{B}_t$, G_t, the financial parameters: K_{tj}, R_t, Pr_{tj}, β_{tj}, w_{min}, k_1, k_2, t_o, r_{tj} defined in section IV.4, and the values reported to the Center from the lower level E_{tj}, K_{tj}, L_{tj}, Q_{tj}, Sa_{tj}, V^P_{tj}, Dk_{tj}, ΔR_{tj},

find such levels of credits in the Polish PO(1) and in the foreign $PO(2)_{tj}$ currencies, the production for consumption purposes C_{tj}, the value of the national income D_t and of the foreign debt S_t, and the values of financial parameters α_{Atj}, α_{tj}, σ_{tj}, wk_{tj} which yield the optimal values of expressions (IV.1)-(IV.3) and satisfy the constraints (IV.4)-(IV.16), (IV.19), (IV.20), (IV:22), (IV.23) and the financial constraints (IV.26)-(IV.44) for all time periods t=0,...,T and for all sectors j=1,...,m,

IV.4. The lower level problem of a branch

The structure of all branch models is identical. They differ from one another in values of parameters of individual branch problems such as for instance initial financial resources, initial value of productive fixed assets, or parameters of functions which approximate production capacity of a branch.

As mentioned in section IV.2 a branch applies two objectives. It maximizes simultaneously at time t the branch profit:

$$\max_{u_{tj}} Zy_{tj} , \quad t=0,\ldots,T, \quad j=1,\ldots,m \tag{IV.17}$$

and the revenue (production sold by the branch)

$$\max_{u_{tj}} Ys'_{tj} , \quad T=0,\ldots,T, \quad j=1,\ldots,m \tag{IV.18}$$

where the control vector u_{tj} is defined as $u_{tj}=(Sa_{tj},V^p_{tj},L_{tj})$. Sa_{tj} denotes the wage fund, V^p_{tj} - the investments an L_{tj} - the employment of the j-th branch at time t.

Maximization of the profit implies maximization of the development fund (IV.39), which is the major source of financing the branch investment. (The liabilities and the repayment of investment credits also burden the development fund). Thus, the bank is interested in the profit maximization of the branches.

Maximization of the branch net revenue directly maximizes the wage fund of the branch. At fixed prices, increased revenue also contributes to the growth of the national income. The above controls u_{tj} have to satisfy a number of conditions which result from limited production capacities, scarcity of raw materials and financial funds and from financial regulations.

The production capacities of the j-th branch Y_{tj} are approximated by a two-factor production function of the CES type:

$$Y_{tj} = f_{CES}(K^B_{t-1,j}, L_{tj}), \quad t=0,\ldots,T \tag{IV.19}$$

It depends on the gross value of the fixed assets in the preceding year $K^B_{t-1,j}$, on the employment L_{tj}, and on the technological progress.

Utilization of the production capacities is described with the help of expression

$$Q_{tj} = m_{tj} Y_{tj} ,$$

$$0 < m_{tj} < 1 , \quad t=0,\ldots,T , \quad j=1,\ldots,m, \tag{IV.20}$$

where m_{tj} can assume alternative values which result from

various assumptions about the economical and organisational progress; Q_{tj} denotes production.

The rate of utilization of production capacities depends on the material input-output coefficients which determine the intermediate production.

The material production rate in the case of our model is a vector of m elements (each element corresponds to one branch) and shows how many intermediate production goods are needed in order to utilize fully the production capacity.

In real production, some intermediate goods are in abundance and there is a scarcity of the other production goods. A scarcity of intermediate goods lowers the utilization of the production capacity and thus the value of m_{tj}.

The organizational and economic progress should increase the value of m_{tj} and contribute to the increase of production.

In a separate paper we study a method of improvement of the utilization of production capacity. The method ensures first intermediate goods necessary for continuation of production at a given level and then is allocating the overproduction in such a way that the branch objectives are maximized.

The employment in the j-th branch is constrained by a increasing function which depends on the difference between the average wage in the branch w_{tj} and the average wage in the economy W_{t-1}

$$L_{tj} \leq g(w_{tj}-W_{t-1}) \quad , \quad t=0,\ldots,T \tag{IV.21}$$

where $w_{tj} = Sa_{tj}/L_{tj}$.
The fixed assets are calculated from the difference equations

$$K^B_{t+1,j} = (1-\underline{l}_{tj})K^B_{tj} + \sum_{i=0}^{N_j-1} \psi^t_j(i)(V^C_{t-i,j} + V^P_{t-i,j})$$

$$\text{for} \quad t \geq N_j \tag{IV.22a}$$

$$K^B_{t+1,j} = (1-\underline{l}_{tj})K^B_{tj} + \sum_{i=1}^{t} \psi^t_j(i)(V^C_{t-i,j} + V^P_{t-i,j}) + \Delta_{tj}$$

$$\text{for} \quad t < N_j \tag{IV.22b}$$

where

$$\Delta_{tj} = \sum_{i=t+1}^{N_j-1} \psi_j^t(i)\bar{V}_{t-i,j} \quad , \quad i=0,\ldots,T \qquad \text{(IV.22c)}$$

given the initial value

$$K_{oj} = \bar{K}_{oj} \; . \qquad \text{(IV.23)}$$

For every sector $j=1,\ldots,m$, N_j is the average investment delay, $\psi_j^t(i)$ denotes coefficients of lagged investments and represent the effect of current ($i=0$) and lagged ($i=1,\ldots,N_j-1$) investments on fixed assets formation, $0 < \psi_j(i) < 1^*$; $\underline{l}_{tj}$ is the liquidation rate of fixed assets, $\bar{V}_{t-i,j}$ denotes the central and branch investments together, committed prior to the investigated period $(0,T)$, i.e. for $t-i<0$.

Thus, production in the model depends on the branch investments V^P_{tj} and on the branch employment L_{tj}.
It is assumed that the fixed assets do not decrease over time

$$(1-\underline{l}_{t+1})K^B_{t+1,j} > (1-\underline{l}_t=K^B_{tj} \quad , \quad t=0,\ldots,T \; . \qquad \text{(IV.24)}$$

Additionally, the funds for investments financed by the branch, V^P_{tj}, should be at least sufficient for continuation of investments committed prior to time t. The funds required for continuation of these investments can be determined analogously as in (IV.6) by the matrix $\mathrm{ZAA}^P_{t-1,j}(n,1)$

$$V^P_{tj} > \sum_{n=1}^{N^P_{t-1,j}-1} \mathrm{ZAA}^P_{t-1}(n,1), \quad t=0,\ldots,T \qquad \text{(IV.25)}$$

However, in case of investment suspension the above relation

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*There exist practical situations, in the Polish economy, when this coefficient is greater than 1. It can happen when the investments are resumed, after a suspension time, and the financial records are not being changed.

can be violated.

The conditions (IV.24) express the tendency, articulated in the official economic plan 1986-1990, to restrain the decapitalization process of fixed assets. The conditions (IV.24), (IV.25) restrain the investment levels from below. The revenue (the value of the sold production) maximized in the j-th branch, is proportional to the production given by expression (IV.20)

$$Ys_{tj} = \kappa_{tj} Q_{tj}, \qquad \text{(IV.26)}$$

where κ_{tj} is an exogeneously determined parameter which symbolizes an aggregate branch price.

The profit, which is maximized, is defined consistently with the operating regulations

$$Zy_{tj} = Ys_{tj} - Ko_{tj} + Do_{tj} - Podo_{tj} + Sal_{tj}, \qquad \text{(IV.27)}$$

where Ko_{tj} represents the own costs of production of the j-th branch

$$Ko_{tj} = A_{tj} + Ma_{tj} + Sa_{tj} + F_{tj}, \qquad \text{(IV.28)}$$

The subsidies from the Bank Do_{tj} are determined at the upper level.

The turnover tax $Podo_{tj}$ is defined as a part of the revenue

$$Podo_{tj} = \sigma_{tj} \cdot Ys_{tj}, \qquad \text{(IV.29)}$$

where parameters σ_{tj}, t=0,...,T are elements of the control vector of the upper level problem, with the help of which the Center stimulates financial policy of branches, Sal_{tj} denotes the balance of extraordinary benefits and losses in the j-th branch.

The costs of production Ko_{tj} and the turnover tax $Podo_{tj}$, as presented below, are calculated basing on economic and financial gains of the branch and on the parameters with the

help of which the bank controls the branch activity.
The value of the amortization fund is approximated as a proportion of fixed assets

$$A_{tj} = \xi_{tj} \cdot K_{tj} , \quad t=0,\ldots,T \tag{IV.30}$$

where ξ_{tj} is given by the Center. Thus, A_{tj} implicitly depends on the branch investments.
The material costs of production Ma_{tj} are computed from the equation

$$Ma_{tj} = \sum_{i=1}^{m} a_{tij} Q_{tj} + (G_t Q_t)_j \tag{IV.31}$$

where the coefficients a_{tij} are elements of the material coefficient Leontief matrix A_t.

The wage fund of the j-th branch, Sa_{tj}, is the control variable which satisfies the relations given below.

The branch wage fund at time t, which is not subject to a progressive tax on extra increase of the wage fund ($PFAZ_{tj}$) is denoted by Sa^w_{tj} and defined as follows

$$Sa^w_{tj} = Sa_{t-1;j} + wk_{tj} \frac{\Delta Ys''_{tj}}{Ys_{t-1,j}} \tag{IV.32}$$

The increase of the wage fund at time t depends on the relative increase of the net revenue Ys''_{tj}, multiplied by a correction coefficient wk_{tj} and an additional term which highly depends on taxes. The progressive tax on wages, the $PFAZ_{tj}$ is paid to the bank out of the development fund. It is defined as

$$PFAZ_{tj} = \begin{cases} 0 & \text{if} \quad Sa_{tj} < Sa^w_{tj} \\ (Sa_{tj} - Sa^w_{tj})^{\alpha_j} & \text{if} \quad Sa_{tj} > Sa^w_{tj} \end{cases} \tag{IV.33}$$

The parameters wk_{tj} and α_j are elements of the control vector of the Center.
The net revenue is calculated as follows

$$Ys''_{tj} = Ys'_{tj} - Ma_{tj} , \tag{IV.34}$$

$$Ys'_{tj} = Ys_{tj} - Podo_{tj} - Do_{tj} . \tag{IV.35}$$

The income tax $Podd_{tj}$ assumes the form

$$Podd_{tj} = r_{tj}(Zy_{tj} + Kn_{tj}) + \bar{W}_{tj} \qquad (IV.36)$$

r_{tj} is a parameter given exogeneously by the Center. With the help of r_{tj} the Center influences financial activity of branches. Kn_{tj} denotes unjustified costs and losses and is exogeneous in the branch model. The value of F_{tj} denotes the wage tax which changes over time with a constant rate.

The profit Zy_{tj} can be uniquely determined by the: exogeneous parameters of the Center, its control variables and parameters, and by the branch controls the investments V^p_{tj} and the wage fund Sa_{tj}.

The value of the investment fund V^p_{tj} is limited from above by the financial resources of the j-th branch. The investments V^p_{tj} can be financed from the development fund $FROZ_{tj}$ (current and accumulated) and with the help of investment credits, granted by the bank.

$$V^p_{tj} < W_{Itj} + Po_{tj}\,, \qquad (IV.37)$$

$$W_{Itj} = \overline{FROZ}_{t-1,j} + (1+Pr)FROZ_{tj} - DK_{tj} - \Delta R_{tj} \qquad (IV.38)$$

The development fund is defined as

$$FROZ_{tj} = Zyp_{tj} - Fr_{tj} - PFAZ_{tj} - Fs_{tj} - Fm_{tj} + \alpha_{tj}A_{tj} - Fz_{tj}\,. \qquad (IV.39)$$

The verified profit

$$Zyp_{tj} = Zy_{tj} - Podd_{tj} - Ul_{tj} \qquad UIV.40)$$

where Ul_{tj} represent tax and financial reliefs granted by the Center. The social benefits fund Fs_{tj} and the housing fund Fm_{tj} depend on the employment L_{tj}.

The workers fund, Fz_{tj} is the source of bonuses, which are granted to the workers of the j-th branch and depends on the wage fund

$$Fs_{tj} = 0.5\, w_{tjmin} L_{tj} \qquad \text{(IV,41)}$$

$$Fm_{tj} = 0.25\, w_{tjmin} L_{tj} \qquad \text{(IV.42)}$$

$$Fz_{tj} = 0.085\, w_{tj} L_{tj}\,, \quad t=0,\ldots,T \qquad \text{(IV.43)}$$

where w_{tjmin} is the minimum wage, and w_{tj} - the average wage in the j-th branch.

The state of the accumulated development fund is formulated as

$$\overline{FROZ}_{t+1;j} = \overline{FROZ}_{tj} + (1+Pr_{tj})FROZ_{tj} + PO(1)_{tj} - DK(1)_{tj} - V^{p}_{tj}\,, \qquad \text{(IV.44)}$$

where Pr_{tj} denotes interest rate on $FROZ_{tj}$.

Export in the j-th branch depends on the branch production and on the financial situation of the branch. The maximum share of the production in export is determined by the parameter k which represents the growth rate of export. The minimum production Q_{jmin} is specified, below which no export results from production. The financial situation is characterized by the weighted relative total import and export in the preceding year.

$$E_{tj} = \left[\max(Q_j - Q_{jmin})\right]^{1/k} + \beta_1 Jm_{tj} + \beta_2 E_{t-1,j} \qquad \text{(IV.45)}$$

where β_1, β_2 are estimated constants and

$$Jm_{tj} = M_{tj} + (G_t Q_t)_j + (\bar{B}_t V_t)_j$$

The prices of exported and imported goods are not explicitly defined in the model. Therefore the terms of trade are not considered in the above equation. Also, the world market is not considered.

The scarcity of raw materials is assumed

$$\sum_{k=1}^{m} a_{tjk} Q_k < \bar{q}_{tj}(1) \qquad \text{(IV.46)}$$

and

$$\sum_{k=1}^{m} g_{tjk} Q_k < \bar{q}_{tj}(2) \quad , \qquad \text{(IV.47)}$$

where $j=1,\ldots,m$, $\bar{q}_{tj}(2)$ are the upper levels of the imported materials and components and $\bar{q}_{tj}(1)$ are the upper levels of home produced materials, both given exogeneously.

IV.5. Summary and conclusions

The presented model includes many relations, which describe the major objectives and regulation functions of the current Polish economy. However, some simplifications have been applied. Among the major ones is the assumption of an exogeneous quasi--price for aggregated goods produced by branches. This assumption results in a very strong conclusion that the branch decides for itself only about financing of its own investments and about its wage fund. Implicitly, it decides upon its labor and export. The homogeneity of branches, to which some regulations are applied as if they were enterprises is also a great simplification. However, this difficulty can be hardly overcome at this stage of research.

The complexity of the model results from considering multiple objectives of the joint coordinator, represented by the union of Polish banks and by the Central Planning Commission, and from selection of the branch objectives in such a way that they satisfy an individual employee by applying explicit maximization of the wages and implicitly contribute to the satisfaction of the objectives of the Center. The financial regulations and limitations with respect to raw materials, production capacities and home and foreign finances are adequatly described, thus creating a complex picture of the Polish economy. It has been argued that the production capacities of branches can be better utilized due to the introduction of the economic and organizational progress.

The simplifications mentioned above can be of benefit at the first stages of investigations. They can allow for thorough investigations of a mechanism of creation of the branch investments and for studying of an impact of the economic progress on utilization of production capacities.

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STUDY REPORT

PION III

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