Working Paper

MODELING AN ALTERNATIVE SOCIO-
ECONOMIC MECHANISM

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ABSTRACT

In some centrally planned economies, experiments with different economic mechanisms have been carried out for many years. This tendency has encouraged decentralized decision-making, indirectly influenced by the use of certain policy instruments on a central level. Up until the present time, changes in the economic mechanism have been based on a 'trial and error' approach, which does not allow the realizability of the proposed changes to be demonstrated.

In this paper changes in the economic mechanism are analyzed and a comparison is made between these changes and the conditions in existence before the economic reform. Conclusions are based on the results of the models used to simulate such changes. Thus, some proposals for altering both the implementation conditions of the economic mechanism and the directions in modeling the national economy are specified.

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INTRODUCTION

One approach to the analysis of socioeconomic change is to create scenarios representing different behavioral patterns within the socioeconomic system. These scenarios are based on preliminarily chosen goals and they can contribute towards the improvement of not only the analytical techniques but also the preliminary goals.

Analyses of the economic mechanisms existing in some centrally planned economies at the beginning of their experimental periods, which are based on the approach described above, are given in Mihailov (1973, 1974). Despite the theoretical nature of the models used in these analyses, the conclusions drawn about the economic mechanism have been proven in practice.

In this paper, an analysis of changes in the economic mechanism is based on the use of a set of models implemented on the computer. The main components of this set, after some modifications, have been solved at IIASA. They consist in an optimization input-output model, based on the input-output model developed by Nyhus (1977), and an equilibrium model designed by Mihailov, Assa, and Por (1980), based on the general version developed for the Swedish economy by Bergman (Bergman and Por 1980).

Because of the initial difficulties encountered in obtaining complete data, the models were built in a highly aggregated form for eight sectors, in two of which as well as on the international market competition was accounted for. For the same two sectors local optimization was performed in the equilibrium model, and this proved to be sufficient to describe the interdependency of all the sectors. Thus, the solution procedure can be used in the general case of competition and local optimization.

Despite the constraints imposed on the models' solutions, the conclusions turned out to be the same as when theoretical models are used. This indicates the effectiveness of the proposed approach for analyzing changes in the economic mechanism.

THE ECONOMIC MECHANISM EXISTING BEFORE THE REFORM

Adequacy of the Models

Optimization of economic development using an input-output model for forecasting (Nyhus 1977) is the most appropriate means of analyzing the functioning of the economic mechanism in existtence before the reform:

$$X = AX + Y \quad , \tag{1}$$

where

X = total production volume;
A = coefficient matrix;
Y = final consumption; consisting of

$$Y = G + C + K + Z - M + \Delta K \quad , \tag{2}$$

where

G = public consumption;
C = household consumption;
K = capital investments;
Z = exports;
M = imports;
ΔK = capital stock.

Some components of final consumption can be forecasted using a demand function, for example household consumption:

$$C_i = f(W, P_1^D, P_2^D, \ldots, P_n^D, \Delta W, t) \quad , \tag{3}$$

where

W = household income (wages);
P_i^D = domestic prices for commodity i;
t = time.

For exports:

$$Z_i = f(FD, P_i^{WE}, P_i^D) \quad , \tag{4}$$

where

FD = foreign demand;
P_i^{WE} = international market prices for commodity i.

The demand for capital can be defined by:

$$K = r\bar{X} \quad , \qquad \bar{X} = \sum_i k_i X_{t-1} \quad , \tag{5}$$

where

r = coefficient;
$\bar{X}$ = output;
k_i = distribution lag.

The separate sectors can be described in terms of price equations summing the input-output table by columns:

$$P_j = \sum_{i=1}^{n} a_{ij} P_i^D X_j + W_j + \Pi_j \qquad (j = 1, \ldots, n) \quad , \tag{6}$$

where

P_j = price of commodity j;

$\sum_{i=1}^{n} a_{ij} P_i^D X_j$ = material costs (a_{ij} = input coefficients);

W_j = wages ($W_j = \sum_{i=1} w_{ij} X_j$; w_{ij} = labor coefficients);

Π_j = profit included in the price.

Thus, the interrelationships between the most important elements of the economic system become clear and a balance between these elements can then be achieved.

The Optimization Problem

The problem of how to optimize national economic development has not yet been solved in practice. Our scheme for solving this problem is based on input-output and current planning methods (Figure 1).

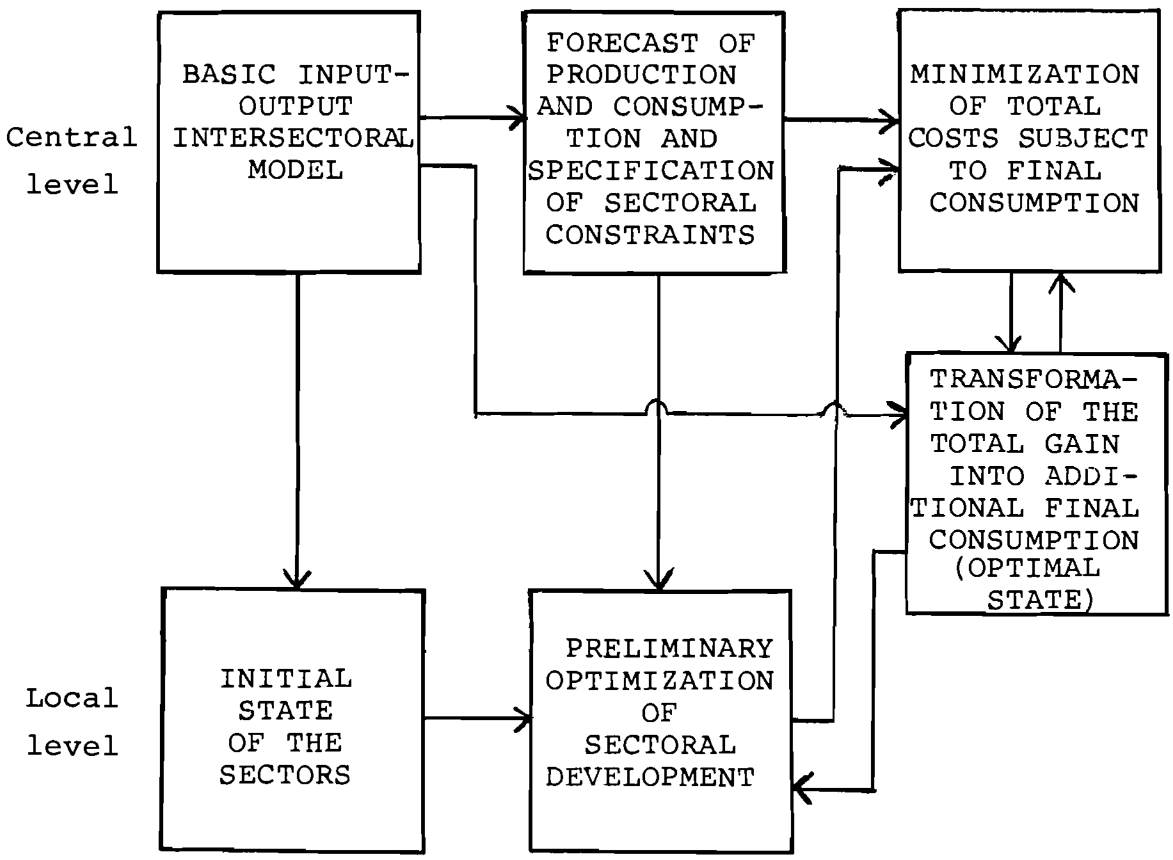

Figure 1. An input-output system of optimization models.

It can be assumed that a central-level forecast of national economic development, see equations (1) and (6), will form the basis for specifying sectoral constraints. Sectoral optimization can then be performed on a local level and the influence of the local optima on the central-level relationships may be analyzed.

The most appropriate model for optimizing the development of individual sectors is a mixed-integer-type model, which minimizes production and social costs, (Mihailov and Assa 1980).

$$\sum_{i=1}^{m} [c_i x_i + \sum_{k=1}^{T_i} (p_{ik} + s_{ik}) z_{ik}] \to \min \quad , \qquad (9)$$

where

$c_i x_i$ = current production costs for commodity i (i = 1,2,...,m);

T_i = possible technological alternatives for commodity i;

p_{ik} = production costs for commodity i using alternative k;

s_{ik} = social and other costs for commodity i using alternative k;

$z_{ik} = \{^0_1$;

$\sum_{k=1}^{T_i} z_{ik} \leq 1$ = zero-one constraints.

The model includes four main constraints.

A mixed-integer constraint on production volume:

$$X^{min} \leq \sum_{i=1}^{m} (x_i + \sum_{k=1}^{T_i} z_{ik} A_{ik}) \leq X^{max} \quad , \qquad (10)$$

where A_{ik} represents the production capacity for commodity i using alternative k.

A capital investment constraint:

$$K^{min} \leq \sum_{i=1}^{m} \sum_{k=1}^{T_i} z_{ik} f_{ik} \leq K^{max} \quad , \qquad (11)$$

where f_{ik} represents capital investments required to produce commodity i by alternative k.

A labor constraint (wages):

$$W^{min} \leq \sum_{i=1}^{m} \sum_{k=1}^{T_i} z_{ik} w_{ik} \leq W^{max} \quad , \tag{12}$$

where w_{ik} represents wages for producing commodity i by alternative k.

Other primary-resource constraints:

$$U^{min} \leq \sum_{i=1}^{m} \sum_{k=1}^{T_i} z_{ik} u_{ik} \leq U^{max} \quad , \tag{13}$$

where u_{ik} represents the use of other resources for producing commodity i by alternative k.

The local optimization model was used to analyze two sectors only with regard to substitution of input resources and input factors (labor and capital), substitution of domestic for imported goods, and substitution of alternatives giving rise to pollution for those with lower pollution levels.

An analysis of the influence of local optimization on the interdependencies at the central level indicated that when the production volumes are balanced (using technological coefficients that are modified as a result of local optimization) direct and indirect costs as well as the efficiency levels must be changed according to some exogenous final consumption. This fact shows that local optimization does not reduce the need for global optimization, which requires that not only the best local-level alternative but all possible alternatives have to be examined on a central level. Global optimization and the derivation of new price levels for the planning year should be carried out simultaneously.

The global objective function is the maximization of final consumption for some future period t:

$$\sum_{t=1}^{n} Y_i^t = \sum_{t=1}^{n} \sum_{i=1}^{n} a_i b_i x_j^t \to \max \quad , \tag{14}$$

where a_i represents an assortment coefficient for commodity i (i = 1,2,...,n), and b_i denotes the per-capita consumption of commodity i.

The model cannot be solved directly because the volume and structure of final consumption are subject to forecasting and are linked to a single level of wages and volume of intermediate products. For this reason, the objective function can be transformed into minimum direct and indirect production costs subject to the volume and structure of final consumption and employment (Figure 1).

$$\sum_{i=1}^{n} \sum_{k=1}^{T_i} S_{ik} X_{ik} \to \min \quad , \tag{15}$$

where S_{ik} represents the direct and indirect production costs for producing commodity i using alternative k.

The model includes the following additional constraints. A constraint on the volume and structure of final consumption:

$$Y_i^t = \sum_{i=1}^{n} \sum_{k=1}^{T_i} a_i F_{ik}^t \quad , \tag{16}$$

where F_{ik} represents total volume of final consumption of commodity i produced by alternative k.

A constraint on the substitution of final products:

$$Y_i^t = \sum_{i=1}^{n} \sum_{k=1}^{T_i} (\gamma_{i,\bar{i}} Y_{\bar{i}} + \bar{\gamma}_{i,\bar{i}}) \quad , \tag{17}$$

where γ_i represents a coefficient substituting commodity i for $\bar{i}$.

Constraints on employment (on wages):

$$\sum_{i=1}^{n} \sum_{k=1}^{T_i} X_{ik}^t = \sum_{i=1}^{n} \sum_{k=1}^{T_i} w_i N_{ik}^t = \sum_{i=1}^{n} \sum_{k=1}^{T_i} W_{ik}^t \quad . \tag{18}$$

It is obvious that the problem of comparing different technological alternatives (in terms of production costs) is also a problem of comparing certain types of prices (since production costs are partially a result of the price levels of resources used). This problem was solved in a theoretical way by Bulgarian Academician Evgeny Mateev, who proved that only those prices consisting in profit proportional to wages can be compared because current material costs can be measured in past production time, i.e. past wage expenditures (Mateev 1963).

Thus, if direct and indirect production costs are included in the price equations

$$P_j^D = \sum_{i=1}^{n} a_{ij}X_j + W_j + \Pi_j \quad ,$$
$$\sum_{i=1}^{n} a_{ij}X_j + W_j = S \quad , \tag{19}$$

and if profit as a percentage of wages is

$$\Pi_j = \lambda W_j = \Omega S_j \quad ,$$

we derive the following type of price:

$$P_j^D = S_j + \Omega S_j = (1 + \lambda)S_j' \quad ; \tag{20}$$

i.e. prices are proportional to production costs, they can be derived as a function of them:

$$P_j^D(t) = f[S_j'(t)] \, , \tag{21}$$

and they will not make production costs and efficiency levels lopsided in a comparison of different technological alternatives.

In this approach the gain realized through the minimized cost is transformed into additional final consumption, which is subject to forecasting:

$$\left(\sum_{i=1}^{n} a_{ij}P_i^D X_j^{t_o} + W_j^{t_o}\right) - \left(\sum_{i=1}^{n} a_{ij}P_i^D X_j^{*t} + W_j^{*t}\right) = \Delta \sum_{i=1}^{n} Y_i \quad , \qquad (22)$$

where t_o, t represent base and subsequent years and * denotes the optimal state of the economy.

This is an indirect way of maximizing final consumption that is adequate for planning and describes the dynamics of economic development. Static models do not allow us to optimize the 'consumption-accumulation' fraction over a long period).

Hence, the optimal state of the economy can be expressed by the volume of production, resources, and consumption, as well as the level of prices, wages, employment, and capital investment:

$$X_j^*,\ X_i^*,\ Y_i^*,\ P_i^{*D}, W_j^*,\ N^*, \text{ and } K^* \quad . \qquad (23)$$

The Problem of Economic Stimuli and Incentives

Economic stimuli are directed towards increasing sectoral efficiency (reducing expenditures) in comparison with the base year:

$$\left(\sum_{i=1}^{m} a_{ij}P_i^D X_j^{t_o} + W_j^{t_o}\right) - \left(\sum_{i=1}^{m} a_{ij}P_i^D X_j^{t} + W_j^{t}\right) = \Delta C_j \quad , \qquad (24)$$

where ΔC_j represents total gain in sector j. The increase in wages is dependent on the increase in total gain:

$$w = \frac{\Delta C_j}{\Delta W_j} \quad , \qquad (25)$$

where w is a coefficient.

The problem of creating stimuli and incentives should be analyzed separately at the development and fulfillment stages of the plan (Figure 2). At the development stage, by using a given coefficient w, the increase in wages W_j can be determined by

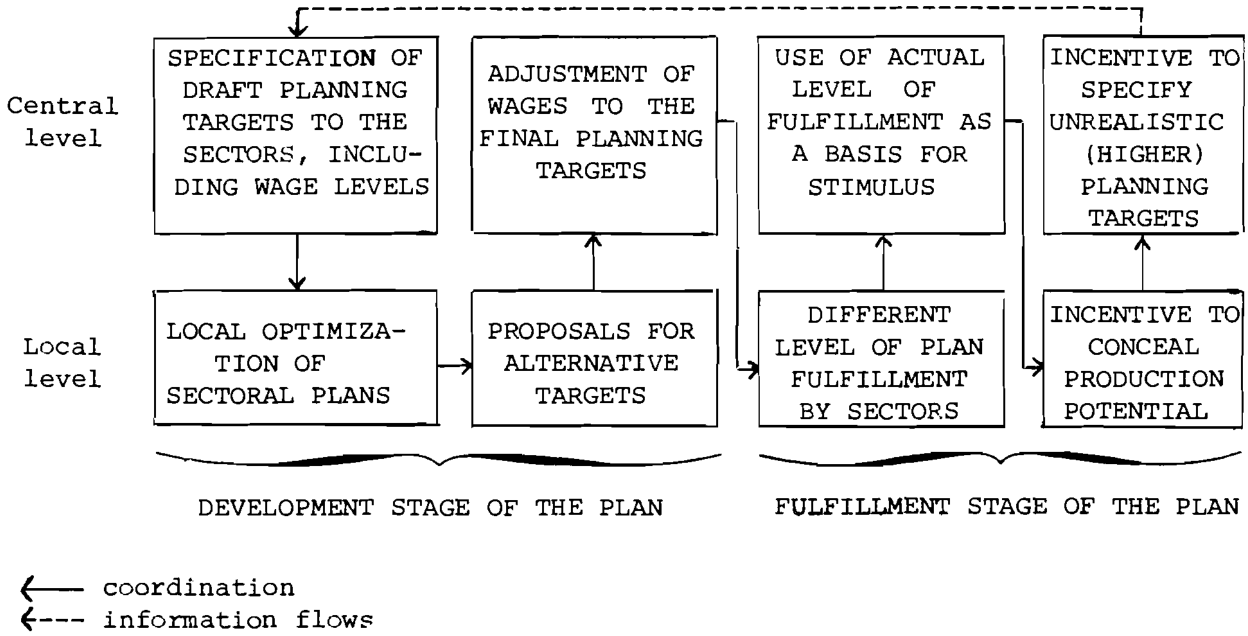

Figure 2. Stimuli and incentives in the planning procedure.

local optimization (9) and (10)-(13). However, as shown in Figure 2, after each iteration all the indicators presented in (23) will be changed by the central level*; this demonstrates that the level of these indicators, which are subject to local optimization, does not depend on the sector.† Labor resources must also be changed by the central level; this implies that the coefficient w should also be changed. Hence, there is no basis for assessing sectoral efficiency. Therefore, the final value of w has to be derived from the prescribed planning targets.

At the stage of plan fulfillment, different possibilities for fulfilling the production targets exist for different sectors:

$$\Delta C_j' < 100\% \quad , \qquad \Delta C_j = 100\% \quad , \qquad \text{and} \qquad \Delta C_j'' > 100\% \quad .$$

In this situation, nonfulfillment of the plan by one sector causes nonfulfillment by the users of that sector. The users can

*Central level here and below implies one coordinating planning body at the national level.

†Sector here and below also implies an enterprise.

justify their position by claiming that fulfillment could not be achieved because of factors outside their control. This forces the central level to reduce the coefficient values for those sectors that have not fulfilled the plan by 100 percent:

$$\text{from } w' = \frac{\Delta C_j'}{\Delta C_j} \quad \text{to} \quad w = \Delta C_j \ , \tag{26}$$

and for the sectors that have greatly exceeded plan fulfillment to a fulfillment level of 100 percent plus a minimum above 100 percent (in order to compensate for the losses from (26)):

$$\text{from } w' = \frac{\Delta C_j''}{\Delta C_j} \quad \text{to} \quad w = \Delta C_j + \min \Delta C_j \ . \tag{27}$$

In both these cases, the real fulfillment level serves as a basis for developing the plan for the next period.

This mechanism for estimating sectoral efficiency creates incentives for the sectors to conceal their production potential in order to fulfill the plan easily. Thus, the information passing from the local to the central level becomes unrealistic, which in turn forces the central level to prescribe very high (often unrealistic) planning targets even at the initial stage of the planning procedure (Figure 2).

From our examination of the models mentioned above and the efficiency assessment mechanism employed previously, we have reached three main conclusions. It has become evident that sectoral optimization is ineffective both for planning and for providing a stimulus for sectoral efficiency, since the sectors have an incentive to conceal their production potential both at the development and fulfillment stages of the plan. In this respect, the convergence achieved between central and local levels in some theoretical models is merely a formal convergence. The responsibility for negative results always lies with the central level because of the unrealistic feedback it utilizes and its inability to develop a balanced plan for all varieties of products, which total approximately tens of millions. Furthermore, in reality the economic mechanism is completely centralized, since decentralization leads to negative results for the economy because of the monopolistic position of the producers.

THE ECONOMIC MECHANISM CURRENTLY IN EXISTENCE

New Principles Proposed

In the mid 1960s, another economic mechanism was proposed as a replacement for the existing one. This new mechanism combined centralized and decentralized approaches to management along the following lines. Local-level decisionmakers should be independent in defining their production structure and volume given certain constraints. Price levels should be reasonably flexible. Sectoral income and credit should be used to increase production. However, in cases where sectoral income is insufficient, subsidies should be used to finance the increase. In addition, taxation imposed on sectoral income should be standardized to ensure equal production opportunities. The use of this measure, together with other policy instruments, would serve as long-term economic stimuli. Wages would also be standardized in accordance with sectoral income. These proposals for economic management reform were implemented, but local-level independence in decisionmaking was soon curtailed. The reasons for this restriction become evident in later sections.

The Model System Based on the Proposed Mechanism

Under the proposed mechanism, the same types of model as (1)-(8) are used, but prices are based on a different method of assessing profit, depending on the value of the sector's capital stock. Sectoral behavior can then be described by a profit-maximization model that includes the policy instruments mentioned above:

$$\sum_{i=1}^{m} \{P_j + S_j - [a_{ij} P_i^D X_j + W_j + T_j + c_j + \sum_{k=1}^{T_i} (p_{ik} + s_{ik}) z_{ik}]\} = \Pi_j \rightarrow \max \quad , \qquad (28)$$

where

P_j = price of commodity j constrained such that $\bar{P}_j > P_j > \underline{P}_j$;

S_j = subsidy based on the production volume: $S_j = \Psi X_j$ (Ψ = coefficient);

W_j = wages, depending on profit Π and the coefficient w: $W_j = w\Pi_j$;

T_j = taxes on profit (or on income), determined by the coefficient β: $T_j = \beta\Pi_j$;

c_j = payment of interest on credit: $c_j = hK_j$ (for the remaining notation, see (9)).

The solution of the model is subject to (10) and (11).

The proposed economic mechanism is analyzed on the central and local levels and at the stages of plan development and fulfillment.

Analysis at the Stage of Plan Development

If, on the basis of forecasting, the central authorities prescribe the use of standard policy instruments

$$\bar{P}_j,\ \underline{P}_j,\ \bar{X}_j,\ \underline{X}_j,\ \Psi,\ w,\ \beta,\ \text{and } h \tag{29}$$

for all sectors, equilibrium in the economy may be achieved by local optimization (28), when the variables are defined by their marginal values:

$$\bar{\bar{P}}_j + S_j = \sum_{i=1}^{n} a_{ij} P_i^D \bar{\bar{X}}_j + \bar{\bar{W}}_j + T_j + c_j + \Pi_j \quad , \tag{30}$$

where $^{=}$ denotes marginal value.

On the other hand, only (1)-(8) and (14)-(18) can be used by the central level for global optimization (if real prices, which consist in profit proportional to capital stock, are introduced into these equations, then the result is an unbalanced global optimum; see (19)-(21)). Nevertheless, we can call this solution conditionally optimal:

$$P_j^* = \sum_{i=1}^{n} a_{ij} P_i^D X_j^* + W_j^* + \Pi_j^* \quad . \tag{31}$$

The analysis shows that a fundamental discrepancy between the results of the local (30) and the central (31) levels always exists. The main reason for the difference is that indirect economic and social expenditures are not considered and the values of the policy instruments in the base year do not account for future change. This difference can often have negative consequences: a high percentage of unemployment, unjustified wage differentials among the sectors, etc. Hence, a problem arises when the sum of the local optima does not correspond to the global optimum. The central authorities then have two possibilities for action: either the planning targets for the local level can be changed directly or the value of the policy instruments can be adjusted to the specific situation of the sector. The first possibility contravenes the requirements of the reform. The second requires that certain techniques be used by the central authorities in order for them to be able to forecast the state of the economy resulting from the changed value of the policy instruments, otherwise the differences will always occur, for example, in wages:

$$w\Pi_j \lesseqgtr \sum_{i=1}^{m} w_{ij} X_j^* \quad , \tag{32}$$

and in capital investment:

$$hK_j \lesseqgtr P_j^* - (\sum_{i=1}^{m} a_{ij} P_i^D X_j^* + W_j^*) \quad , \qquad \text{etc.} \tag{33}$$

Because of the lack of forecasting techniques for determining the influence of certain instruments on economic development, the central level is forced to change the value of the policy instruments according to the level of planning targets for the optimal state (31). However, the lack of uniformity in natural and production conditions requires that the instruments be differentiated by sector. For example, the new coefficient value for wages will be:

$$w = \frac{\sum_{i=1}^{m} w_{ij} X_j^*}{\sum_{i=1}^{m} \Pi_j^*} \quad , \qquad \text{etc. for the remaining instruments.} \qquad (34)$$

Hence, the sectors are not subject to equal conditions with equal opportunities. This implies that the sectoral contributions to the development of the plan are not assessed on an objective basis. Local autonomy in the elaboration of the plan is not permitted, because changes by one sector to its planning targets lead to an imbalance in the targets of all other sectors. This was the main reason why the degree of economic independence that was allowed when the new reform was initially implemented was soon removed.

Analysis at the Stage of Plan Fulfillment

The planning targets prescribed and the variety of policy instruments used currently create the same disparity of opportunities among the sectors for plan fulfillment as those produced by the economic mechanism existing before the reform. Thus, the central level must currently modify the policy instruments, including the coefficients for estimating sectoral efficiency, which will destroy the role of the instruments as long-term stimuli.

From the analysis, it can be concluded that the use of the models described above does not allow sectoral economic autonomy. In addition, the policy instruments cannot contribute towards developing and fulfilling the plan, because they reflect the centrally designed and obligatorily prescribed plan. Furthermore, local-level incentives to conceal real production potential exist in much the same way as they did under the economic mechanism employed before the reform, even though the policy instruments described above are now used. The main feature of the new economic mechanism is shown in Figure 3.

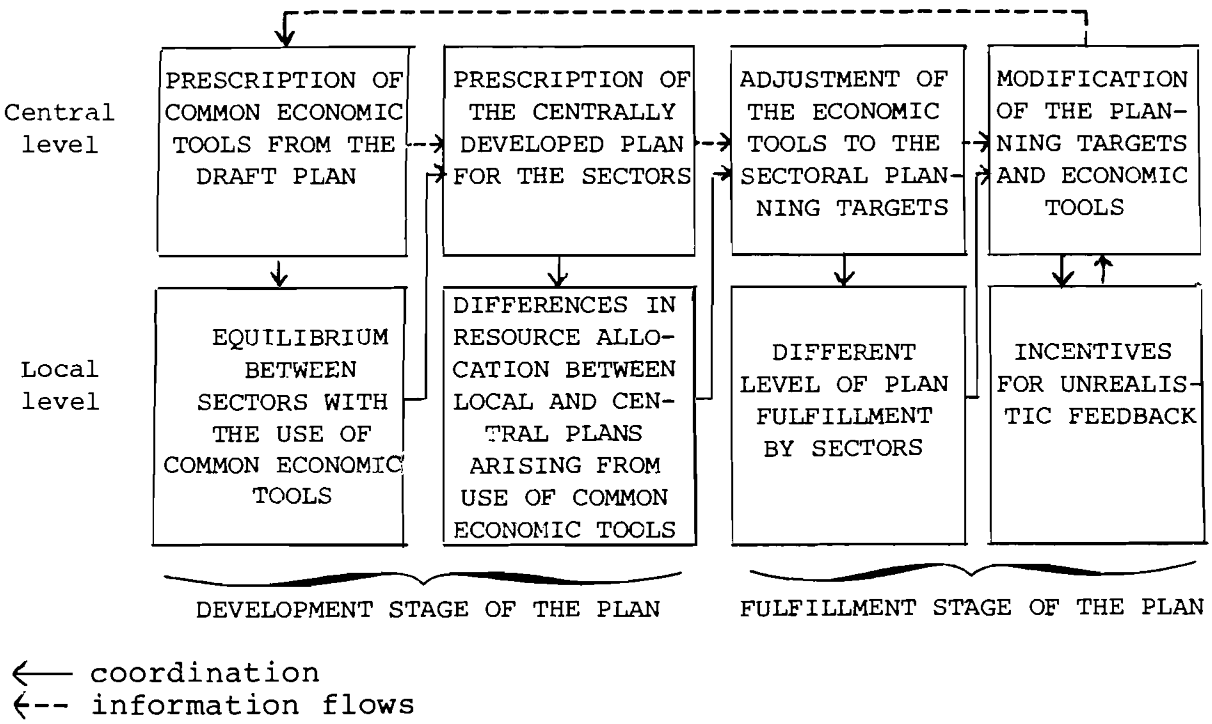

Figure 3. Stimuli and incentives following the reform.

CHANGES REQUIRED

The Alternative Planning Mechanism

The alternative planning mechanism ensures that the sectors have real independence to define their production structure and volume, prices, and production factors (resources, labor, and capital). The central authorities can indirectly influence sectoral incentives.

The state of the national economy under conditions of sectoral economic independence can be described in terms of an equilibrium model. (See the lower half of Figure 4, denoted by block II.) In the analysis given in the preceding sections, it has been shown that this state is not optimal from the point of view of some global criterion. The global optimization procedure was shown in Figure 1 and in (1) - (8) and (14) - (18). (See the upper half of Figure 4, denoted by block I, in which the local level is not based on real sectoral participation in the planning procedure, but merely expresses a sectoral view of the national economy.)

The analysis shows that indirect regulation of the economy can be achieved only if the appropriate models are used. Some models developed at IIASA have been designed with this purpose in mind.

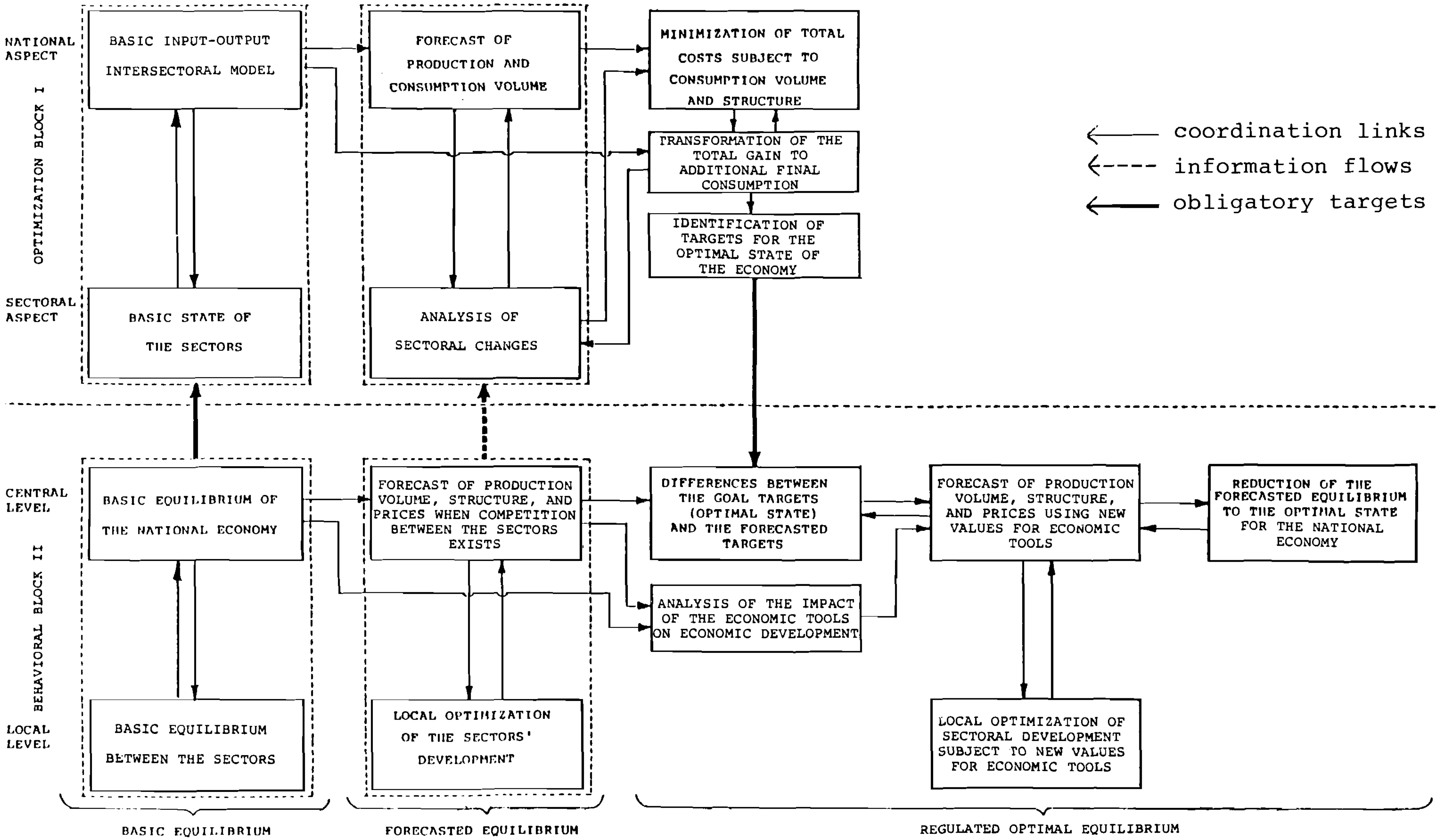

Figure 4. Regulated optimization based on a multi-level equilibrium system of models for economic development. (The term 'regulated optimization' is used to imply that the optimal state of the sectors and of the national economy is achieved by indirectly influencing the behavior of the producers).

Equilibrium in the Base Year

To express the development of the economy over time, the initial state of the economy should be described, when all components of the economy are known. However, in practice centrally planned economies do not yet have market equilibrium prices. Therefore, sectoral competition is not included in the equilibrium of the base year, and market prices only indicate the requirements for expanding production (competition will be included in the analysis for subsequent years).

Although the physical structure of production is the same for the base year in blocks I ('optimization' block) and II ('behavioral' block), the economic and financial interdependencies, and hence the equilibrium conditions, differ significantly. In I, the procedures of which were described in (1)-(8) and (14)-(18), prices in the base year are derived from market prices, whereas in II prices are derived after extracting the profit share. This profit is transpormed into sectoral captial stock.

Although the prices of the products for personal consumption in block I are based on the balance between supply and demand, the difference between price levels and production costs (i.e. taxes) goes towards the budget and serves as nondistributed capital investment. This also allows the sectors producing commodities for personal consumption to be optimized according to their production costs.

An analysis of blocks I and II was made on a similar methodological basis with respect to the same number and type of sectors (energy and agriculture) and the problems to be solved within those sectors.

The following notations are used for describing all further procedures (the notations used in Bergman and Por 1980 are retained):

Sectors:

0 = electricity (from the energy sector),
1 = conventional fuel (from the energy sector),
2 = unconventional fuel (from agricultural residues),
3 = agriculture,
⋮

n
n+1 = housing sector,
n+2 = public sector,
n+3 = capital goods sector.

Exogenous variables:

- G = public consumption
- N = total labor,
- K = total capital stock,
- I = total net investment,
- D = surplus (deficit) on the current account,
- P_i^E = world market price for exported commodity i ($i = 1,2,\ldots,n$),
- P_i^I = world market price for imported commodity i ($i = 0,1,\ldots,n$),
- $\bar{P}_i$ = world market price for complementary imports* of commodity i ($i = 1,2$).

Endogenous variables:

- X_j = gross output in sector j ($j = 0,1,\ldots,n+3$),
- K_j = capital stock in sector j ($j = 0,1,\ldots,n+2$),
- N_j = employment in sector j ($j = 0,1,\ldots,n+2$),
- $\bar{M}_j$ = input of complementary imports in sector j ($j = 1,2$),
- C_i = household consumption of commodity i ($i = 0,1,\ldots,n+1$),
- Z_i, M_i = exports and imports of commodity i ($i = 0,1,\ldots,n$),
- P_i, P_i^D = domestic production costs and domestic price of commodity i ($i = 0,1,\ldots,n+3$),
- W, W_j = total wages in the economy and wage rate in sector j ($j = 0,1,\ldots,n+2$),
- R, R_j = rate of return on capital in the economy and in sector j ($j = 0,1,\ldots,n+2$),
- Q_j = 'user cost' of capital in sector j ($j = 0,1,\ldots,n+2$),

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*The term 'complementary imports' refers to the import of commodities that cannot be (or at least are not) produced within the country.

V = exchange rate (domestic currency per unit of foreign currency),

O = household consumption expenditures,

Y = real gross national product,

C = total real household consumption,

Z, M = total real exports and imports,

Π_j = total profit in sector j (j = 0,1,...,n+2).

Parameters:

a_{ij} = input of commodity i (i = 2,3,...,n) per unit of output in sector j (j = 2,3,...,n+2),

$\bar{b}_{ij}$ = input of complementary imports of commodity i (i = 1,2) per unit of output in sector j (j = 1,2),

ρ_j, γ_j = substitution coefficients in the production function of sector j (j = 0,1,...,n+2),

δ_j = annual rate of depreciation in sector j (j = 0,1,...,n+2),

σ_j = annual rate of change in world market trade in commodity i (i = 1,2,...,n),

ω_j = index of wage rate in sector j (j = 0,1,...,n+2),

β_j = index of the rate of return on capital in sector j (j = 0,1,...,n+2),

η_i, η_{ij} = expenditure and price elasticity parameters in household demand for commodity i (i = 0,1,...,n+1),

ε_i, μ_i = price elasticity parameters in export and import demand for commodity i (i = 0,1,...,n),

A_j, B_i = constants in production for household demand,

Z_i^0, M_i^0 = constants in import and export functions,

λ = annual rate of technological change in sector j (j = 0,1,2,...,n+2),

α_j, a_j, b_j, c_j, d_j = distribution parameters in the production of sector j (j = 0,1,...,n+2).

Decision variables:

S_j = subsidy for sector j (j = 0,1,...,n+2),

T_j = fuel tax parameter for sector j (j = 0,...,n+2),

θ_i = indirect tax on commodity i (i = 0,1,...,n+2),

ϕ_i = import duty on commodity i (i = 0,1,...,n),

E_j = export premium on commodity j (j = 0,1,...,n+2),
F_j = tax on profit in sector j (j = 0,1,...,n+2),
Ω_j = payment of interest in sector j (j = 0,1,...,n+2).

The equilibrium of the economy in the base year is described in block II by (35)-(44) below. The initial profit level in sector j, including payments derived from taxes and subsidies (decision variables), is:

$$\Pi_j = P_j X_j + S_j + E_j - \phi_j - F_j - \theta_j - T_{1j} P_1^D X_{1j} \qquad (35)$$

$$- T_{2j} P_2^D X_{2j} - W_j N_j - Q_j K_j \qquad (j = 0,1,\dots,n+2) .$$

Equilibrium conditions for the commodity markets:

$$X_1 = \sum_{j=0}^{n+2} X_{1j} + C_1 + Z_1 - M_1 \quad . \qquad (36)$$

$$X_2 = \sum_{j=0}^{n+2} X_{2j} + C_2 - M_2 \quad , \qquad (37)$$

$$X_i = \sum_{j=0}^{n+3} a_{ij} X_j + C_i + Z_i - M_i \qquad (i = 3,\dots,n) \quad , \qquad (38)$$

$$X_{n+1} = C_{n+1} \quad , \qquad (39)$$

$$X_{n+2} = G \quad , \qquad (40$$

$$X_{n+3} = I + \sum_{j=0}^{n+2} \delta_j K_j \quad . \qquad (41)$$

Equilibrium conditions for the factor markets are:

$$\sum_{j=0}^{n+2} K_j = K \quad , \qquad (42)$$

$$\sum_{j=0}^{n+2} N_j = N \quad . \tag{43}$$

The current account balance is:

$$\sum_{i=3}^{n} \frac{P_i}{V} Z_i - \sum_{i=0}^{n} P_i^I M_i + E_i - \phi_i - \bar{P}_1 \bar{M}_1 - \bar{P}_2 \bar{M}_2 = D \quad . \tag{44}$$

Forecast of Economic Development

The economic development* forecast obtained from block II is based on four assumptions. First, it is assumed that world-market conditions are exogenously given. In addition, the sectors act independently of the central level in local decisionmaking and the policy instruments prescribed for them take on the same values as in the base year. Finally, local optimization is carried out in the energy and agricultural sectors, and their influence on the national economy is assessed. This calls for an impact analysis of competition between the two sectors and between them and the international market (fuel is produced by the agricultural--as biogas--and energy sectors). An examination of the technological alternatives for their substitution possibilities with respect to capital, labor, and other resources including imports and for their environmental impacts, is also required.

The forecasting procedure is described below:

1. A variety of functions are used (for k possible alternatives, k = 1,...,n).

Import function:

$$m_{ik} = \frac{M_{ik}}{X_{ik} - Z_{ik}} = \frac{M_{ik}^0}{X_{ik}^0 - Z_{ik}^0} \left(\frac{P_{ik}}{(1 + \phi_i) V P_{ik}^I} \right)^{\mu_{ik}} \tag{45}$$

$$(i = 0, 1, \ldots, n) \quad .$$

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*For a general description of the problem, see Johansen (1974).

Capital-labor input function:

$$F_{jk} = K_{jk}^{\alpha_{jk}} N_{jk}^{1-\alpha_{jk}} e^{\lambda_{jk}t} \qquad (j = 0,1,\dots,n+2) \quad . \qquad (46)$$

Composite input function:

$$H_{jk} = \{c_{jk}X_{1jk}^{\gamma_{jk}} + d_{jk}X_{2jk}^{\gamma_{jk}}\}^{\frac{1}{\gamma_{jk}}} \qquad (47)$$

$$(j = 0,1,\dots,n+2) \quad .$$

Gross output function:

$$X_{jk} = A_{jk} \{a_{jk}F_{jk}^{\rho_{jk}} + b_{jk}H_{jk}^{\rho_{jk}}\}^{\frac{1}{\rho_{jk}}} \qquad (48)$$

$$(j = 0,1,\dots,n+2) \quad .$$

Export function:

$$Z_{ik} = Z_{ik}^{0} \left(\frac{P_{ik}}{VP_{ik}^{E}}\right)^{\varepsilon_{ik}} e^{\sigma_{ik}t} \qquad (i = 3,\dots,n) \quad . \qquad (49)$$

Household consumption function:

$$C_{ik} = B_{ik}O^{\eta_{ik}} (T_{1ck}P_{1k}^{D})^{\eta_{1i}} (T_{2ck}P_{2k}^{D})^{\eta_{2i}} P_{3k}^{D^{\eta_{3i}}},\dots, \qquad (50)$$

$$P_{n+1,k}^{D^{\eta_{n+1,i}}} \qquad (i = 0,1,\dots,n+2) \quad .$$

2. The above functions allow us to derive more realistic future conditions for equilibrium using equations of the same form as (35)-(44) , for the alternatives $k = 1,\dots,n$.

3. The factor-market equations (42) and (43) can be solved as a function of factor-market prices W_j and Q_j, after which the price system should be normalized:

$$\sum_{j=0}^{n+2} P_{jk}X_{jk} + S_{jk} + \sum_{j=0}^{n} VP^{I}_{jk}M_{jk} - \theta_{ik} + V\bar{P}_{1k}\bar{M}_{1k}$$

$$+ V\bar{P}_{2k}\bar{M}_{2k} - VP^{E}_{ik}Z_{ik} + E_{jk} \qquad (51)$$

$$= \sum_{j=0}^{n+2} X_{jk} + \sum_{j=0}^{n} M_{jk} - \sum_{j=0}^{n} Z_{jk}$$

$$+ \bar{M}_{1k} + \bar{M}_{2k} \quad .$$

4. On giving initial values for W, R, and V, we can derive P^*, P, and P^D, where

$$P^*_j = (1 - \theta)P_j - \sum_{i=2}^{n} P^D_i a_{ij} - V\bar{P}_j\bar{b}_{ij} \qquad (52)$$

$$(j = 0,1,\ldots,n+2) \quad .$$

P^*_j can then be inserted into the profit function (35), which is to be maximized with respect to the sectors under analysis only (the energy, j = 0,1, and agricultural sectors, j = 2,3).

Maximization of profit Π^*_j is subject to constraints on the policy-instrument coefficients (s, ε, ϕ, f, p, t, and q = const.):

$$S_j = sX_j \quad , \qquad E_j = \varepsilon Z_i \quad , \qquad \theta_j = \phi X_j \quad ,$$

$$F_j = f\Pi_j \quad , \qquad P_j = pX_j \quad , \qquad T_j = tX_j \quad , \qquad (53)$$

$$Q_j = P_{n+3}(\delta_j + R_j + q_j) \quad ,$$

to production and demand function constraints (45)-(50), where different alternatives are included, and to constraints on factor combinations (54)-(57), where on the left-hand side of the equations, different technological and market alternatives are included and on the right-hand side, the policy instruments are represented:

$$a_{jk}(1 - \alpha_{jk}) \left(\frac{A_j F_{jk}}{X_{jk}}\right)^{\rho_{jk}} = \frac{W_j N_j}{P_j^* X_j + sX_j + \varepsilon Z_j} \qquad (j = 0,1,2,3) \quad , \tag{54}$$

$$A_{jk}\alpha_{jk} \left(\frac{A_j F_{jk}}{X_{jk}}\right)^{\rho_{jk}} = \frac{Q_j K_j}{P_j^* X_j} = \frac{P_{n+3}(\delta_j + R_j + q_j)}{P_j^* X_j + sX_j + \varepsilon Z_j} \tag{55}$$

$$(j = 0,1,2,3) \quad ,$$

$$b_{jk}c_{jk} \left(\frac{A_j H_{jk}}{X_{jk}}\right)^{\rho_{jk}} \frac{X_{1jk}}{X_{jk}}^{\gamma_{jk}} = \frac{T_{1j} P_1^D X_{1j}}{P_j^* X_j + sX_j + \varepsilon Z_j} \qquad (j = 0,1,2,3) \quad , \tag{56}$$

$$b_{jk}d_{jk} \left(\frac{A_j H_{jk}}{X_{jk}}\right)^{\rho_{jk}} \frac{X_{2jk}}{X_{jk}}^{\gamma_{jk}} = \frac{T_{2j} P_2^D X_{2j}}{P_j^* X_j + sX_j + \varepsilon Z_j} \qquad (j = 0,1,2,3) \quad . \tag{57}$$

Maximization of profit, subject to the above conditions, leads to the choice of the optimal alternative, which at the same time influences the distribution and substitution coefficients, i.e. the development of all sectors.

By fixing the profit function equal to zero, we can derive commodity prices as a function of factor prices, and by substituting P_j^* in (52), the unknown P_j and P_j^D can be derived.

5. Production volume X_j, production costs P, and prices P_j^D are employed to derive the values of N_j and K_j and the difference in their initial states ΔN and ΔK. W and R can then be adjusted.

6. Equilibrium between production volume, prices, production costs, wages, and the interest level makes it possible to redistribute the total fuel production volume (produced in sectors 1 and 2) among these sectors on the basis of the optimal fuel to electricity ratio in the energy sector and the optimal fuel to agricultural production ratio in the agricultural sector, subject to a minimum fuel price level (which implies competition between these two sectors):

$$\Pi_{j1} = (P_{j0}X_{j0} + P_{j1}X_{j1}) - (P_{i0} + P_{i1}) \rightarrow \max \quad , \qquad (58)$$

subject to $P_{j1}X_{j1} \rightarrow \min$;

$$\Pi_{j2} = (P_{j1}X_{j1} + P_{j2}X_{j2}) - (P_{i1} + P_{i2}) \rightarrow \max \quad , \qquad (59)$$

subject to $P_{j1}X_{j1} \rightarrow \min$.

The redistribution of fuel, subject to competition, will affect the other sectors by stimulating a lowering in the price for this product.

Thus, the forecast for the national economy can be represented by indicators expressing the final state in relation to the optimal state (23):

$$\hat{X}_j, \ \hat{X}_i, \ \hat{Y}_i, \ \hat{P}^D_i, \ \hat{W}_j, \ \hat{N}_j, \text{ and } \hat{K}_j \quad . \tag{60}$$

The solution of the models* was performed using the algorithm presented in Figure 5.

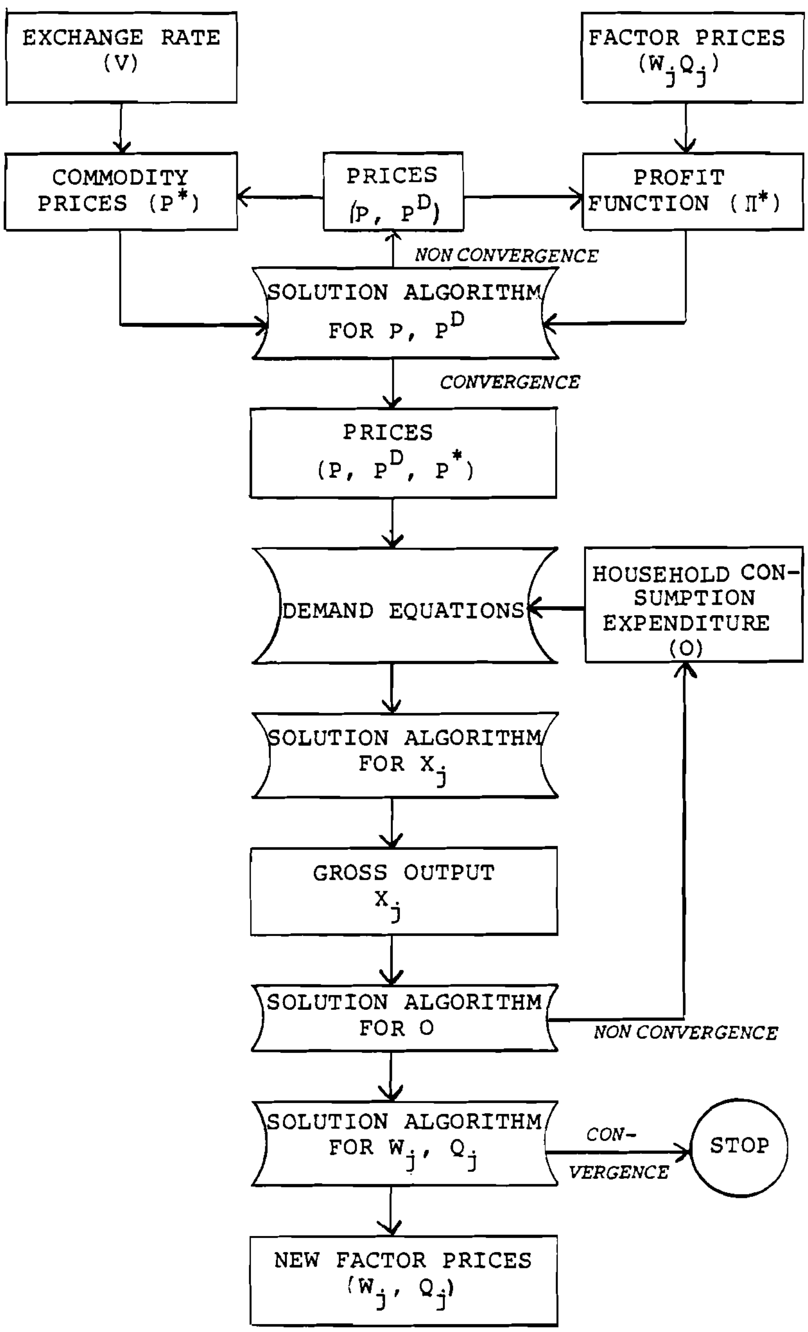

Figure 5. Solution algorithm of an equilibrium model (* denotes that the variable is subject to calculation).

*The solution algorithm was developed by Andras Por (Bergman and Por 1980).

Some of the results from the above forecast can serve as information for block I, at the stage of national economic forecasting.

Regulated Optimization* Equilibrium

The analysis shows that some differences always exist between the values of the indicators of the equilibrium forecast (60) and the desirable (optimal) state of the economy, which is a result of block I (23):

$$X_j^* - \hat{X}_j = \Delta X_j \quad ; \qquad P_i^{*D} - \hat{P}_i^D = \Delta P_i^D \quad ; \qquad \text{etc.} \qquad (61)$$

First, we examine these differences in order to clarify why they occur. Some analysis of expenditures, for example when environmental protection expenditures appear in block I, shows that environmental pollution in block II has not been taken into account when local optimization has been performed on a sectoral level. This conclusion indicates that the level of standards or penalties for environmental pollution have to be adjusted (with respect to the initial equilibrium in II).

Second, we attempt to identify the policy instruments to be directly employed. This analysis is especially necessary for our case since no basis exists for adjusting the type and value of these instruments. Some calculations that include sequential changes in the value of each instrument (without changing the others) and that are based on the solution procedure described above are required. By comparing the changed values of the indicators with their inital values, it is possible to determine the 'intensity' coefficients and thus the type, purpose, and extent of use of each policy instrument.

For example, if

$$l = \frac{\Delta X_j}{\Delta s} \quad , \qquad (62)$$

*For a definition of the term 'regulated optimization', see Figure 4.

where l is the intensity coefficient,

$$\Delta s = \frac{\Delta X_j}{l} \quad . \qquad (63)$$

Thus, changes in the type and value of the policy instruments used influence the conditions of sectoral incentives with respect to optimization and local autonomy, and at the same time these incentives serve as a means of achieving the optimal (desirable) state of the economy:

$$X_j^* - \hat{X}_j = 0 \quad ; \quad P_i^{*D} - \hat{P}_i^D = 0 \quad , \quad \text{etc.} \qquad (64)$$

CONCLUSIONS

Several conclusions can be drawn from the analysis given in the preceding sections.

First, an economic mechanism based on regulated optimization ensures a high level of sectoral incentives and responsibility because:

-- equal opportunities exist for all production units and employees;
-- real equilibrium of a large number of products can only be achieved by means of local-level decisionmaking;
-- the clearly defined functions of the central level, which differ from those at the sectoral level, and can be realized through aggregation, lead to a real sense of responsibility on the part of the center.

Second, although the conclusions about the economic mechanism are generally correct given the restricted conditions of the analysis (limited optimization factors, partial competition, etc.), the equilibrium system of models requires further improvement. Local optimization should be implemented for all sectors with respect to the substitution of all possible commodities and factors under conditions of sectoral competition and taking into account the spatial features. The models should be solved dynamically. Global optimization in block I should be based on a multiobjective optimization approach (Wierzbicki 1979), given a preliminary prescribed growth rate and certain spatial conditions (Anderson 1979). Demographic and migration models

(Kelley and Williamson 1979) should be included in the model system. Some of the proposed models and approaches can be used in market economies.

Third, improvement of the economic mechanism requires changes to be made in the implementation conditions as well as in the modeling of the national economy. These changes include the use of an equilibrium system of models, which is a necessary condition for using standard policy instruments and thus for the achievement of real economic autonomy on a local level. The two conditions mentioned above are essential to the implementation of regulated optimization for developing the economy.

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