WORKING PAPER

STRATEGY SELECTION FOR FIRM DEVELOPMENT IN A REGION

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PREFACE

The research reported herein was performed under the auspices of the Technology, Economy, and Society (TES) Program at IIASA. At the same time, the authors have incorporated in this new research area some results obtained in 1985 from the Regional Issues Project.

This paper reports on establishing a preliminary (first version), conceptual, and instrumental solution to the complicated problem of strategic choices for companies, taking into account their probable technology/production capabilities and the strategic behavior of other competing companies. The model developed is used also to account for the requirements imposed on structural changes by social (e.g., employment) and natural habitat (e.g., pollution) balances for the region and/or company.

The system-based evaluation of company and/or region capabilities allow policymakers to examine the factors of long-run sustainable choices in addition to more immediate values of profitability.

The research work is carried out by IIASA in collaboration with All-Union Research Institute for System Studies (USSR). The second final computerized version of this model is to be completed by the end of 1986,

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1. The Main Problems

The systems approach requires the integrity of three units: the problem-orientation principle (the predominant characteristic), the wide interaction of scientific methods, and advances in the empirical base of research subjects and methods. The last point must be particularly emphasized. New information technology enables the integration of information flows that are generated at different levels of the socioeconomic system. This produces a wide spectrum of large-scale and long-term consequences. In particular, sociological information systems form a technological basis for greater public participation in decision making.

All the above methodological considerations are of value to research of regional problems. Nowadays, regional development faces many obstacles generated primarily by a lack of understanding of the nature of regional systems. These include a specific institutional context, since the basic part of a region's economic base is, in fact, removed from the regional prerogative and managed by large industrial firms or, in countries with planned economies, by the respective central and sectoral authorities.

A straightforward solution to problems of regional development is impossible unless this aspect is managed. The setting up of a regional economic base should be considered as an area suited to coordination based on information exchange and close cooperation between industrial firms and local and central authorities.

The major problem here is the compatibility of regional authorities and their responsibilities. This implies that the management of regional development cannot be reduced to a direct allocation of resources, since there are many other influences. Thus, the core of the proposed solution is the coordination of management activities:

- Between companies in a region.
- Between companies and local authorities.

The development of regional information systems and services is evidently a *sine qua non* of this activity.

The focus of strategic regional analysis on spatial interaction between industrial firms implies a wider use of economic criteria. The resulting model should be an instrument for in-depth efficiency analyses. This can be provided, in our opinion, only by optimization techniques.

An efficiency-analysis approach is necessitated also by the historical context of regional strategic analyses. In many countries, including the USSR, production intensification is today the basis of national socioeconomic development. Under these conditions, regional planning and management should focus upon the territorial aspects of economic intensification, such as the restriction of new industrial construction, increased replacement investment, and improved efficiency of the existing industrial assets. Various aspects of institutional support and implementation of such a strategy have been developed and used in the USSR and other socialist countries, such as the GDR.

All these principles were embodied into the structure of the proposed model, which should be further developed along four lines:

(1) Labor market analysis.

(2) Ecology analysis, or, in a wider sense, the calculation of externalities.

(3) The redistribution effects of development of the regional economic base, including the so-called complex social standard of living.

(4) Resources for regional strategy implementation.

Here we shall concentrate upon the first of these problems, labor market analysis; the three other questions will be only slightly touched upon.

An introductory remark is necessary. We have just mentioned that the regional economic base is a set of large industrial firms located in the region. A firm is but a specialized institution fitted to solve mostly economic problems (economic in a wide sense of the term, i.e., including problems that are technological, managerial, etc.). It is unlikely that a firm will be an adequate tool for solving many other problems – social, ecological, cultural, etc. These can be solved only by interaction between various specialized institutions – industrial firms, national and local authorities, public organizations, and the like. Close cooperation and partnership between all of these are therefore a necessary condition for a well-balanced regional development.

Development of a regional economic base increases pressure on local labor markets. To include in the model constraints to regulate the workforce to an upper limit (to involve a workforce that is less than or equal to the available manpower of the region) and a lower limit (the employment in the region should exceed a given high share of all the labor stock) is, of course, only a formal way to solve this critical problem. It seems to be impossible (except when enormous subsidies or compensations are involved) to provide full regional employment based only on the spontaneous decision-making of large, profit-seeking firms. The only way to alleviate the acuteness of the problems is, many experts believe, to reduce the

number of weekly working hours, as discussed by Dr. Moeller from the Institute for Applied Systems Analysis and Prognosis in Hannover, FRG, in his paper *Finding Strategic Labour Market Policies for Lower Saxony via Systems Analysis* (Moeller, 1985). One essential reservation is that this could not be ordered by state law – it is only possible to convince trade unions and enterprise associations that a quicker reduction in working time is the only way to avoid severe unemployment problems.

Conversely, in countries with planned economies there is a tight labor market. This prevents the development of more flexible ways of unemployment based on differentiating the length of the work day, work week, and work year for women with small children, for pensioners, for students, and so on. Some results have been achieved by planning work places and information exchange between industries and local authorities in regional systems within the USSR and Czechoslovakia. In particular, the regional register of population, connected with the national one, may become a useful tool for solving this problem. The balance between new industrial construction and improvement of existing jobs is a key problem to be dealt with by both central and local authorities.

A set of well-known demographic and migration models can be used to predict the national and regional manpower constraints. In particular, the Markovian-type models of interregional migration, developed at IIASA by Rogers and his colleagues (Rogers, 1981), are useful for regions and countries with a stable network of settlements and stabilizing demographic processes. The efficiency of this approach has been proved by a Swedish case-study in South-Western Skane. Soviet experience of microanalytical socioeconomic prediction based on regional sociological enquiries can also be used. We refer here primarily to new techniques of socioeconomic data processing that have been developed at the All-Union Institute for Systems Studies and referred to generally as "determination analysis".

Determination analysis is a tool to evaluate regularities and to form typologies using stable local relations between particular values of qualitative variables. It provides a clear interpretation of results at each step of the analysis and a verification of the significance of each variable while generating typologies. It also enables one to observe "the density of packing" of groups within typologies, so increasing the reliability of the results (Chesnokow, 1982).

This new technique was successfully used for processing the data of many sociological enquiries, including those carried out by the All-Union Institute in 1979, 1980, and 1982 in a cluster of towns and villages of the Krasnoyarsk region in Siberia.

Determination analysis can be of significant value in processing microlevel data about preferences and behavior of firms, households, local representatives, etc., collected in sociological and expert enquiries.

Externalities, redistribution effects, and resource provision for regional development should also be investigated. The basic hypotheses that may by discussed are as follows:

(1) For externalities: the well-known concept that it is only the direct compensation of negative externalities (and, conversely, subsidies for positive externalities) that may lead to a Pareto-optimal economic state.

(2) For distributive effects: seeking a trade-off between tendencies of interregional equalization and the stability of distributional shares of all the regions can be considered as the fundamental purpose of regional strategic choice.

(3) For resource provision: the system of interrelated territorial funds – national, regional, and local – should be developed and supported as a necessary tool for the corresponding budget formation.

The concise presentation of the above theses can be made with the help of the seven lists that foliow.

List 1. The systems methodology approach integrates three elements:

(1) Problem orientation to give the subject.

(2) Scientific tools to give the method.

(3) Integrating information flows from macro- and micro-levels to give the empirical (information) basis.

List 2. Theory: Region in the Socioeconomic System. A polyhierarchical structure of this system is postulated, including:

(1) A set of industrial firms that forms the economic base of regions.

(2) A set of local authorities.

(3) A cluster of central functional and programming institutions.

List 3. Theory: Regional Strategy should be Focused on the Analysis of the Economic Base. The economic base is the key element of regional structure and the core of regional strategic planning and management. This implies that:

(1) Efficiency analyses of spatial interaction between firms are necessary for regional strategic planning. They require a wide use of optimization techniques.

(2) The coordination between firms is the main tool of regional strategic management.

List 4. Problems to be discussed:

(1) Labor market structure.

(2) Ecology and externalities.

(3) Intra- and inter-regional distribution of income and wealth; complex social standard of living.

(4) Resources for regional strategy implementation.

List 5. Regional strategy approach to labor-use problems:

(1) Use of nationwide predictions of demographic change and migration.

(2) Integrated analysis of employment and education.

(3) Regional programming systems of work places.

(4) Development of flexible employment systems for women, pensioners, students, etc.

List 6. Determination analysis (DA) of socioeconomic data:

(1) DA is a new method for multidimensional calculation of conditional frequencies.

(2) DA can be used for analysis of data from both sociological and expert enquiries.

(3) DA strengthens the possibilities of processing information generated at the microlevel of regional systems.

List 7. Problems for the future:

(1) Do regional externalities require a system of direct compensations and subsidies?

(2) Distribution – a trade-off between regional equalization and stabilization should be achieved.

(3) Resources for regional strategy can be accumulated through a system of funds – national, regional, and local.

As has been remarked, optimization methods and the corresponding techniques are very suitable for finding strategies for firm development within a region.

This approach allows us to account for the most important factors that determine regional policy, both in its objective and in its constraints. The most important factors of the system include labor resources, employment and migration, ecology and living conditions, interaction between regions, and interaction of firms within the region. These considerations are described in the model for selection of a firm's development strategy. This example illustrates well the possibility of using optimization methods for forming the elements of regional development.

2. Model for Selecting Strategies for Development of Firms within a Region

2.1. Formulation of the problem and initial premises

An important trend in modern regional investigations is to develop methods of strategic regional policy realization in different regions. This involves the problem of generating the regional economy on the basis of industrial authorities and under market conditions – according to decisions made by some of the firms.

The problem will be considered as follows:

(1) In some regions of the study, several firms are active. Other regions are considered as a unit without being divided into firms.

(2) Every firm can produce some goods, any of which can be one of the three types (mass, specific, new) according to the firm's capacity restrictions.

(3) There are some areas of consumption with a fixed market capacity and fixed prices for each good.

(4) There are assumed measures of stimulation (or limitation) for some productions. The activity of each firm in the market can be increased to a determined value.

(5) Considered as being needed for studies of the long term are the possible variants in firm specialization, the use of different innovations, progressive technologies, etc., and the production costs and investments and their distribution for each variation. Transport costs between the regions and also sales and consumer-service costs are assumed.

(6) Production and sale costs are nonlinear.

(7) Labor, ecological, and other restrictions are taken into consideration.

(8) Restrictions of profitability (to cover investment) and of the activity of several firms in the markets are also considered.

The model follows the simple criterion that a scalar optimization problem is under consideration.

In the model some assumptions are accepted:

(1) The characteristics of the real situation are aggregated. Thus, the number of regions, markets, firms in a region, variants of strategy, and goods is assumed to be about ten. Under these conditions firms in one region are considered disaggregative (for other regions it is assumed that only one firm produces all the goods).

(2) It is assumed that development strategies for a firm and all the data can be *a priori* (or by interactive process) formed by representative experts. This data comprises (for every variant) the following:

(i) Data on goods specialization and modification for the period under consideration. In this case, experts determine, of course, not the value of production, but the possibility of production.

(ii) The effect of different methods of production in the various scenarios (including new technologies) and different restrictions of production capacity.

(iii) The volume of investments and present-value costs of production, transportation, and sale for the period under consideration (or use a calculation method depending on production structure and production volume).

(iv) Possible influence on the environment, influence coefficients for different ingredients, and weight coefficients for individual influences.

(v) Normative values of employment for professional groups and as a whole, with assumed upper and lower limits.

(vi) Forecast of production demand and prices in the markets.

(vii) Use of economic characteristics, such as discount rate and the dynamic, marginal period of investment, covering possible volumes of subsidies, duties, etc.

(3) It is assumed that production restrictions for specific and new goods are known for all firms and regions, but those for mass goods only for the firms of a given region.

(4) It is assumed that all goods delivered to the markets are sold and demand is satisfied.

(5) The criterion for selecting of the most efficient variant (including specialization, innovations, etc.) is the minimum total costs of production, transportation, and sale according to forecasted demand of goods in all markets.

(6) A linear approximation is adopted for functions of production, transportation, and sale costs, including a part that is independent of the strategy variant.

Some of these assumptions can be easily eliminated, relaxed, or introduced in different ways. The formal model of development of the regional economic base involves optimization models widely used in planning. In particular, it is based on the Soviet experience of solving problems in economic sectors and intersector problems of production allocation and transport development.

The differences between existing models and our model involve the following factors:

(1) Variations that involve different goods production and specialization.

(2) Large-scale innovations (new technologies).

(3) The possibility of goods production using three modifications (new, mass, specific).

(4) Social restrictions (employment, environmental protection, and others).

(5) The expediency of economic stimulation (or, otherwise, restrictions) to produce different goods with the help of subsidies, taxes, etc.

(6) Specific costs of realization and consumer service for each region and market.

Accordingly, the vectors that describe the variations available to a firm's strategy have a complex structure. Together with integer variables that characterize goods production or nonproduction by the firms, vectors include the

number of technologies used, feasible capacity, investment, and other variables.

The formal model is adequate for problems of development of interconnected economy sectors in the region under conditions of economic independence and increasing firms' responsibility. Use of this model can provide the necessary information and control of firm's activity by central and local authorities.

The model is based on principles of system analysis, namely:

(1) Necessary coordination between the micro- (including firms) and macro-level parameters of the socioeconomic system.

(2) Efficiency analysis as the main tool of regional strategic planning, in particular to determine the optimization model.

(3) Use of coordination between firms as a main tool of strategic regional management.

The most important part of the model is the analysis of labor resources. Here, the following are assumed:

(1) Wide use of national demographic and migration forecasts.

(2) Integration of employment and education analyses (including professional training and retraining).

(3) Elaboration of long-term regional development programs of employment.

(4) Combination of national regulation of the length of the working day, week, and year with flexible forms of employment for working women, pensioners, and youth.

2.2. Basic designations

a, volume of production capacity.

$C, \bar{C}, \tilde{C}$, the production, transportation, and sale costs, respectively.

C_e, C_z, lump-sum and present-value (operating) components of the cost.

d, D, actual and admissible influence on the environment.

G, set of admissible values (for instance, G^n is the set of possible strategies for firm n).

i, index of the region.

j, index of goods.

k, index of strategy variant.

L, employment (number of workers).

n, index of the firm in the region considered.

P, goods price in the market.

r, index of the market.

s, index of goods modification (s =1, mass; s =2, specific; s =3, new).

t, index of time (year).

u, index of professional group.

X, volume of goods production (scaler or vector).

Z, demand for a good in a region.

γ, duties (subsidies) for goods sale on the market.

δ, subsidy (fine) for goods production.

ε, coefficient of goods modification and interchangeability.

ζ, value of goods demand.

η, identifier for selected strategy variation.

ϑ, index of poilution mode.

ν, contribution of the firm to the market.

T, marginal period.

T_{ok}, feasible period to cover investment.

φ, discount rate.

Ψ, weight coefficient for the significance of the ingredient.

In the objective function (1) the indexes $\overline{pr}$, $\overline{tr}$, and $\overline{sl}$ represent production, transportation, and sale, respectively.

Although according to the assumptions all transported goods are sold, the different designations are used in (1) for structural clarity.

When a value has upper and lower limits an asterisk marks the lower limit and a double asterisk the upper limit.

2.3. The objective function

Total costs of the period are minimized:

$$C = \sum_{t=1}^{t=T} \varphi(t) \left\{ \sum_{n=1}^{n=N} \sum_{k \in G^n} \left[C^t_{nk}(X^t_{\overline{pr}}) + \bar{C}^t_{nk}(X^t_{\overline{tr}}) + \tilde{C}^t_{nk}(X^t_{\overline{sl}}) \right] \eta_{nk} \right.$$

$$\left. + \sum_{t=2}^{t=I} \sum_{k \in G^i} \left[C^t_{ik}(X^t_{\overline{pr}}) + \bar{C}^t_{ik}(X^t_{\overline{tr}}) + C^t_{ik}(X^t_{\overline{sl}}) \right] \eta_{ik} \right\} \rightarrow \min \qquad (1)$$

2.4. Algorithm of the cost value calculation

The following equations are separately related to the firms of the first region ($n = 1,2, ..,N; i = 1$) and to the other regions ($i = 2, ..,I$).

Production costs in the first region:

$$C^t_{nk} = (C^{0,t}_{nk} \pm \delta^{0,t}_{nk}) + \sum_{j,s} (C^t_{njsk} \pm \delta^t_{njsk}) X^t_{njs}$$

Transportation costs from the first region:

$$\bar{C}^t_{nk} = \bar{C}^{0,t}_{nk} + \sum_{j,s,\tau} \bar{C}^t_{njs\tau} \cdot X^t_{nj s\tau} \tag{2}$$

Sale costs of goods from the first region:

$$\tilde{C}^t_{nk} = \tilde{C}^{0,t}_{nk} + \sum_{j,s,\tau} (\tilde{C}^t_{njs\tau} \pm \tilde{\gamma}^t_{njs\tau}) X^t_{njs\tau}$$

$$X^t_{njs} = \sum_{\tau} X^t_{njs\tau} \tag{3}$$

Production costs in other regions:

$$C^t_{ik} = C^{0,t}_{i,k} + \sum_{j,s} C^t_{ijsk} \cdot X^t_{ijs}$$

Transportation costs in other regions:

$$\bar{C}^t_{ik} = \bar{C}^{0,t}_{ik} + \sum_{j,s,\tau} \bar{C}^t_{ijs\tau} \cdot X^t_{ijs\tau} \tag{4}$$

Sale costs of goods from other regions:

$$\tilde{C}^t_{ik} = \tilde{C}^{0,t}_{ik} + \sum_{j,s,\tau} (\tilde{C}^t_{ijs\tau} \pm \tilde{\gamma}^t_{ijs\tau})\, X^t_{ijs\tau}$$

$$X^t_{ijs} = \sum_{\tau} X^t_{ijs\tau} \tag{5}$$

In the above formula, the upper index 0 means that the function is a component of the total cost that is independent of the production value. For instance, $\bar{C}^{0,t}_{nk}$ is independent of the transportation component of the total cost of transportation of firm n for strategy k for its development in t years.

Accordingly, $\bar{C}^t_{njs\tau}$ is the specific cost to firm n for transportation of goods j with modification s from the first region to market τ. Other components of the cost are interpreted analogously. Moreover, the two summands in parantheses are not interpreted as a sum to show the information structure of the corresponding parts of the costs.

2.5. The main bounding conditions of the model

(a) The production value cannot be more than the production capacity

$$X^t_{njs} \le \sum_k a^t_{njsk} \cdot \eta_{nk} \tag{6}$$

$$X^t_{ijs} \le \sum_k a^t_{ijsk} \cdot \eta_{ik} \tag{7}$$

(b) Demand for every good in every region is satisfied

$$\sum_n X^t_{njsr} + \sum_{i>1} X^t_{ijsr} = Z^t_{jsr} \tag{8}$$

$$Z^t_{jsr} = \begin{cases} \le \zeta^t_{jsr} & s = 2,3 \\ = \zeta^t_{j1r} + \sum_{s \ne 1} \varepsilon_{js}(\zeta^t_{jsr} - Z^t_{jsr}) \end{cases} \tag{9}$$

(c) Only one variation can be realized for each region and for each firm

$$\eta_{nk} = \begin{cases} 1; \\ 0; \end{cases} \quad \sum_k \eta_{nk} = 1$$

$$\eta_{ik} = \begin{cases} 1; \\ 0; \end{cases} \quad \sum_k \eta_{ik} = 1 \tag{10}$$

(d) Pollution in a region cannot be more than the admissible level for each pollutant

$$\sum_{n,k} \sum_{j,s} \alpha^t_{1\vartheta jsk} \cdot X^t_{njs} \cdot \eta_{nk} \le D^t_{1\vartheta} \tag{11}$$

$$\sum_{j,s,k} \alpha^t_{i\vartheta jsk} \cdot X^t_{ijs} \cdot \eta_{ik} \le D^t_{i\vartheta} \quad (i \ne 1) \tag{12}$$

As a whole

$$\sum_{n,k} \sum_{j,s,\vartheta} \Psi_\vartheta \, \alpha^t_{1\vartheta jsk} \cdot X^t_{njs} \cdot \eta_{nk} \le D^t_1 \tag{13}$$

$$\sum_k \sum_{j,s,\vartheta} \Psi_\vartheta \alpha^t_{i\vartheta jsk} \cdot X^t_{ijs} \cdot \eta_{ik} \le D^t_i \quad (i \ne 1) \tag{14}$$

(e) Employment in the region should be restricted to lower and upper limits

For every professional group

$$^{\cdot}L^t_{1u} \le \sum_{n,k} (L^{0,t}_{nku} + \sum_{j,s} L^t_{njsku} \cdot X^t_{njs}) \times \eta_{nk} \le {}^{\cdot\cdot}L^t_{1u} \; ; \tag{15}$$

$$^{\cdot}L^t_{iu} \le \sum_k (L^{0,t}_{iku} + \sum_{j,s} L^t_{ijsku} \cdot X^t_{ijs}) \times \eta_{ik} \le {}^{\cdot\cdot}L^t_{iu} \tag{16}$$

As a whole

$$'L_1^t \le \sum_{u,n,k} (L_{nku}^{0,t} + \sum_{j,s} L_{njsku}^t \cdot X_{njs}^t) \times \eta_{nk} \le ''L_1^t \tag{17}$$

$$'L_i^t \le \sum_{u,k} (L_{iku}^{0,t} + \sum_{j,s} L_{ijsku}^t \cdot X_{ijs}^t) \times \eta_{ik} \le ''L_i^t \tag{18}$$

(f) The contribution of the firm to the market should have limits (lower bound according to profitability, upper according to anti-monopoly regulation)

$$'\nu_{njs\tau}^t \le \frac{X_{njs\tau}^t}{\sum_n X_{njs\tau}^t + \sum_{t>1} X_{ijs\tau}^t} \le ''\nu_{njs\tau}^t \tag{19}$$

(g) Production should be profitable for each firm

$$\sum_{t=1}^{t=T} \varphi(t) \sum_{\tau,j,s} P_{js\tau}^t \cdot X_{njs\tau}^t \ge \sum_{t=1}^{t=T} \varphi(t) \sum_k (C_{nk}^t + \bar{C}_{nk}^t + \tilde{C}_{nk}^t)\eta_{nk} \tag{20}$$

(h) Marginal period of investment return should not be more than feasible

$$\frac{\sum_{t=1}^{t=T} \varphi(t)(C_{nk}^t + \bar{C}_{nk}^t + \tilde{C}_{nk}^t)_e \cdot \sum_{t=1}^{t=T} \varphi(t)}{\sum_{t=1}^{t=T} \varphi(t) \left[\sum_\tau P_{js\tau}^t \cdot X_{njs\tau}^t - (C_{nk}^t + \bar{C}_{nk}^t + \tilde{C}_{nk}^t)_z\right]} \le T_{ok} \tag{21}$$

Subscripts e and z mean that only lump-sum investments or present-value costs are given in the costs within the brackets.

2.6. Analysis and modification of the model for selection of development strategies for firms in a region

The model described is one of many possible types. Different modifications of this model can be developed according to the objective function and boundary system, by changing the number of parameters considered in the model, by the method used to consider the dynamics, by data limitation, etc.

For instance, in the case where the demand $Z_{js\tau}^t$ for each good in the region is considered unknown and cannot be forecast and where the flexible (according to demand) prices of the goods in the market are given with the help of some function $f_{js\tau}^t(Z_{js\tau}^t)$, criterion (1) should be changed to give the maximum profit

$$\max\left\{\sum_{j,s,r,t}\varphi(t)\left[f^t_{jsr}(Z^t_{jsr})\cdot Z^t_{jsr} - C\right]\right\} \qquad (1')$$

Some modifications of the model may be required because a number of factors (parameters) included might not be essential under all conditions. More often than not transport costs are considerably smaller for some strategies. And if this aspect is excluded criterion (1) would be

$$C = \sum_{t=1}^{t=T}\varphi(t)\left[\sum_{n=1}^{n=N}\sum_{k\in G^n}(C^t_{nk} + \tilde{C}^t_{nk})\eta_{nk}\right.$$
$$\left. \pm \sum_{i=2}^{i=I}\sum_{k\in G^i}(C^t_{ik} + \tilde{C}^t_{ik})\eta_{ik}\right] \to \min \qquad (1'')$$

In such cases the algorithm of cost calculation, equations (2)–(4), should be changed, as well as the constraints system.

2.7. Algorithm of the problem solution

The model described is a rather complex problem for mathematical programming, being of large dimensions and with nonlinear objective functions and mixed (both integer and continuous) variables. A common approach to solving this kind of problem is to use approximate methods of local optimization, based on methods like "branch and bound", direct random choice of variants combined with heuvristic techniques. In the USSR we have used a *two-stage optimization* to solve problems like this.

The two-stage optimization is based on the principle of dividing into two groups of variables (Benders, 1962). Approximate stepwise methods are used for the group of continuous variables, and corresponding algorithms of choice or methods of integer programming are used for the group of integer variables.

Expert methods are very important for solving this class of problem. Moreover, using experts becomes rather useful and necessary at each new step of the model, especially when analyzing and interpreting the results. The

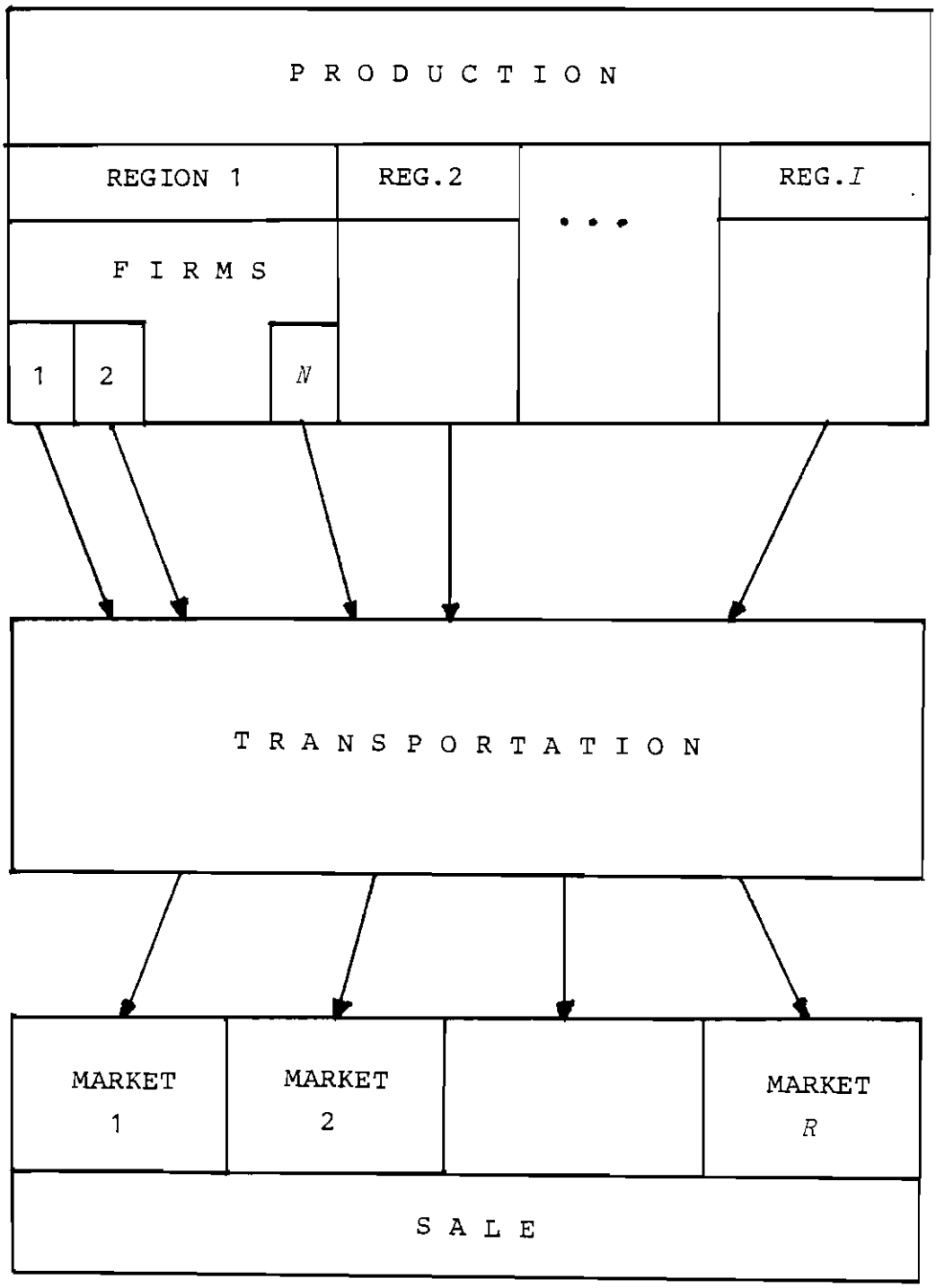
intensification of the role of experts has led to changes in the procedure for searching for a local optimal solution and the new procedures have been formed with the help of an interactive process.

There are two extreme positions in the set of interactive procedures used for selecting the development strategy for firms in a region.

(1) Selection of the strategy is realized by experts. As has been remarked, in this procedure a feasible set of strategies and all the data are obtained from experts. Values of the objective function are calculated with the help of computers. Experts choose the strategy with the best value of the objective function according to results of the analysis, taking into consideration factors that could not be reflected in the formalized model.

(2) Selection of the strategies is realized automatically. In this procedure the role of the experts is also very important, since they provide all the initial data and several parameters in the calculating scheme. The best strategy is determined as a result of computer model solution, with the help of special procedures of two-stage optimization. The solution is then subjected to expert analysis and correction if necessary. Thus, both using special computer procedures and correcting solutions during the interactive process are suitable for these two cases.

G E N E R A L S C H E M E O F T H E M O D E L



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