POSSIBILITIES AND LIMITATIONS OF THE APPLICATION OF OPERATIONS RESEARCH TECHNIQUE TO REGIONAL PLANNING: WITH A CASE IN KOREA*

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1. INTRODUCTION

Many techniques have been applied to comprehensive regional planning through the processes of goal-building, research and analysis, plan-establishing, implementation-schedling, and evaluation. Operations research (OR) is one of those techniques. OR has been developed in such fields of military operations, industrial engineering and business management during the last three decades in several developed western countries.

It is a recent tendency for public administrators and researchers to be interested in OR for their scientific decision making. Therefore, we see that OR has not only a weak basis on, but a few practical applications to urban and regional planning. Such situation is worse in developing countries.

This paper aims at investigating the possible basis and limitations or obstacles of OR application to public decision making, especially regional planning. A practical example of OR application to regional planning in Korea and its evaluation will be introduced.

2. CHARACTERISTICS OF OPERATIONS RESEARCH AND REGIONAL PLANNING

Operations Research: Its Characteristics and Contents

OR is essentially the application of analytical procedures in the analysis of decision making problems. From this definition, we can see that OR has three key terms. First, OR is applications oriented and should not be thought of as pure research. Second, OR generally involves the use of analytical procedures which are used to construct a mathematical or logical model of the problem under analysis. Third, the use of OR models is generally oriented to decision making situations.

OR consists of many technical areas which have been developed by now. Main areas of them are linear programming, nonlinear and integer programming, dynamic programming, inventory and replacement analysis, simulation, PERT/CPM, queueing theory, deterministic decision theory, and probabilistic/stochastic decision theory.

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Regional Planning: Its Scope and Characteristics

Planning is, in its generic sense, a method of decision making that proposes or identifies goals or ends, determines the means or programs which achieve or are thought to achieve these ends, and does so by the application of analytical techniques to discover the fit between ends and means and the consequences of implementing alternative ends and means. Regional planning applies this method to determine public investment and other policies regarding future growth and change of regional areas.

Therefore, regional planning is a process to maximize utility of scarce resources for desirable growth and change of regions by analytical techniques. It is an endeavor for finding the best alternative among several means which could achieve goals or ends of regional development.

Common Features of Operations Research and Regional Planning

OR and regional planning have a common feature in a sense that they are oriented to decision making techniques. Operations researchers try to find the optimum solution in a given problem, while regional planners give efforts to seeking the best alternative for achieving a established goal.

OR and regional planning are also commonly characterized by analytical procedures. OR consists of analytical and programming techniques, and regional planning uses analytical methods as its scientific approach.

In addition, OR is common to regional planning in goal-oriented situations. By OR, we seek the optimum values of decision variables in order to provide maximum effectiveness. Regional planning is a process for establishing desirable goals and for finding the best path to achieve the goals.

3. POSSIBILITIES AND LIMITATIONS OF OPERATIONS RESEARCH APPLICATION TO REGIONAL PLANNING

Possibilites of Operations Research Application to Regional Planning

OR contributes to current efficiency and improvement of the planning process in three ways:

First, through the development of models and analogues, OR provides an understanding of the relevant factors and of the ways they interact.

Second, by calculation and simulation, it predicts the possible consequences of alternative actions and policies.

Third, by calculation, planned experimentation, and simulation, it assists in the selection of the best path to the desired goals.

In addressing the application of OR in regional planning, distinction should be made among the three levels of decisions that regional planners must make.

Lower level of decisions is operational decisions which involve singular objectives being generally acceptable to the various components of the regional system. Middle level decisions involve multiple objectives that are often conflicting. This kind of decision will be called a strategic decision, since it is the strategy for implementing the general policy of the program that is in question. Higher level decisions involve not only conflicts in objectives but also conflicts in the general policies of the

program. This is typical of programs that are just getting started or those that are politically controversial and subject to frequent policy changes. This type of decision can be referred to as a policy decision.

The measures of effectiveness of the regional development vary considerably from one level of decision making to another. At the operational level of decision, measures of effectiveness are easily defined and can generally be quantified. At the strategic level of decision, measures of effectiveness can generally be specified, but they frequently conflict and cannot be measured in the same units. At the policy level of decision, there is a significant controversy over what the measures of effectiveness are and how they are measured.

There is a difference in the contributions of OR at the three levels of decision making. At the operational level, OR has a relatively large basis of application. At the strategic level, fewer models of OR exist. The role of OR at the policy level is to merely provide insight into the decision analysis for regional planning.

Limitations and Obstacles of Operations Research Application to Regional Planning

First, there are many political problems involved in regional planning. They do not lend themselves to solution by the use of OR.

Second, OR has a weakness in its application to regional planning in the aspects of theoretical development and practical uses.

Third, OR is too costly, and the data needed for its application are not fully available.

Fourth, most of governmental officials have a little understanding on OR. Governmental programs are generally administered by persons who do not have strong analytical backgrounds.

Fifth, as problems are less well structured, OR professionals are less effective at incorporating qualitative factors into their decision making models.

4. A CASE OF OPERATIONS RESEARCH APPLICATION TO REGIONAL PLANNING IN KOREA

A Practical Example of Operations Research Model for Regional Planning in Korea

The Second Five-Year Economic Development Plan (1967–71) of Korea employed several quantitative models. The major models in the Plan were an input-output consistency model, a medium-term macroeconomic model, a short-term stabilization model, a mixed-integer linear programming model for the ateel and petro-chemical sectors, and a linear programming model for regional develoment. We will see the last one, a linear programming model for regional development, as a practical example of OR application to regional planning.

The objective function to be maximized in the model was a linear function of value added in each region. A series of solutions was conducted under different sets of constraint values in order to explore the trade-off between rapid growth of GNP and more equitable regional distribution of income and to find the most suitable industries for development in each region. Choices of activity location were determined in the model by market locations, resource locations, interregional trans-

portation costs, infra-structure capital costs, water-system capacities, and economies of scale. There were four potentially scarce resources in the model: domestic savings, foreign exchange, labor and water for municipal and industrial use.

Definitions of the variables used in the model were as follows:

X_i^r : output in region r of sector i

X_i^{rs} : amount of sector i output transported from region r to region s

$M_i^{c,r}$: competitive import of sector i commodities in region r

$M_i^{n,r}$: noncompetitive import of sector i commodities in region r

C_i^r : private consumption demand

G_i^r : government consumption demand

$\bar{V}_r$: minimum income constraint of region r

E_i^r : exports of sector i in region r

K^* : domestic savings requirements for the planned capital formation in the transport and export and import sectors

L : total estimated labor force in the terminal year

W^r : water capacity of region r

a_{ij}^r : ij-th input-output coefficient in region r

β_i^r : coefficient of consumption relative to income of sector i in region r

q_i : ratio of stock accumulation to output of sector i

b_{ij} : capital goods input-output coefficient of sectors i and j

z_j : factor for converting terminal year output in sector j to total plan-period output in sector j, based on prior estimates of growth rate in that sector; $z_j=\sum_{i=0}^{t}(1+r)^{i-t}$, where r is the prior growth rate estimate and t is the number of years in the planning period

n_j^r : man-years of labor used per unit of sector j output in region r

n_j^{rs} : man-years of labor used per unit of transport of sector j output between region r and region s

a_{wj}^r : water input-output coefficient with sector j in region r

v_j : income generated per unit of activity j

v_j^{r*s} : income in region r per unit of transport between regions r and s

s^r : average savings rate in region r, based on the urban-rural population distribution in that region;

$$s_t^r=s_o^r+\sigma(p_t^{*r}/p_t^r)$$

$$p_t^{*r}=p_o^{*r}(1+n^*)+\lambda(N_t^r-N_o^r)$$

$$p_t^r=p_o^r(1+n^*)+\mu(N_t^r-N_o^r)/(N_t-N_o)$$

where p_t^r : total population at time t in region r

p_t^{*r}: population at time t in region r, urban areas

n^* : natural increase rate of population, annual, nationwide

N_t^r : employment in region r at time t

μ : coefficient of interregional migration relative to employment change

λ : coefficient of intraregional migration

σ : coefficient of the savings rate relative to the population distribution

The objective function had the following form imply maximization of a sum of regional incomes:

$$\max \sum_{j,r,s,} (v_j X_j^r + v_j^{r*s} X_j^{rs} + v_j^{r*s} X_j^{sr}) \tag{1}$$

The model had the five constraints as follows:

· Regional constraint on final demands:

$$X_j^r(1-q_j) - \sum_i a_{ij}^r X_j^r - \sum_i b_{ij} X_j^r - \sum_s X_j^{rs} - \sum_s X_j^{sr} + M_j^{s,r} + M_j^{n,r} - E_j^r - G_j^r \geq \beta_j^r \bar{V}^r \text{ ; for all j and all r, i=1, 2, ···, n} \tag{2}$$

· National constraint on domestic savings:

$$\sum_r s^r \left(\sum_j z_j v_j^r X_j^r + \sum_{j,s} v_j^{rs} z_j X_j^{rs}\right) - \sum_{i,j} z_j b_{ij} X_j^r - z_j q_j X_j^r \geq K^*$$

· National constraint on labor availability:

$$\sum_{j,i} n_j^r X_j^r + \sum_{j,r,s} n_j^{rs} X_j^{rs} \leq L \tag{4}$$

· Regional constraint on water resource:

$$\sum_j a_{wj}^r X_j^r \leq W^r \text{; for all r} \tag{5}$$

· Regional constraint on minimum income:

$$\sum_j v_j^r X_j^r + \sum_j v_j^{r*s} (X_j^{rs} + X_j^{sr}) = V^r \geq \bar{V}^r \text{; for all r} \tag{6}$$

Evaluation of the Model

The model seems to be reasonable in a sense of regional balancing and income maximizing subject to such main constraints as final demands, domestic savings, water resources and interregional equality.

However, it presents some deficiencies. First, the decision variables of the model, X_j^r, X_j^{rs} and X_j^{sr}, are not the variables for initial action in plan implementation. There should additionally exist functions which can transform regional output to regional investment.

Second, we cannot say that all equations and inequalities in the model are always linear. Especially, most of the coefficients of decision variables are not always proportional to the values of decision variables. That is, sensitivity analysis might have been required.

Third, it might be very hard to collect the actual data of the parameters in the model. Data collection is the most important and difficult thing for OR application to public decision making including regional planning.

Fourth, for resource allocation during the five years by year, time dimension is required. Generally, mid-term economic and spatial development plans should be programmed in year-base investment for practical implementation. In this sense, the model had to be developed in connection with dynamic programming.

Fifth and last, the model was net fully reflected in the Second Five-Year Plan of Korea. The reasonos are, I think, those that the Second Plan did not significantly consider regional planning in Korea at that time, and that the model could not only provide all necessary data, but was not also developed enough to be applied to actual regional planning.

5. FUTURE DIMENSION OF OPERATIONS RESEARCH FOR REGIONAL PLANNING IN KOREA

OR as well as systems analysis has a broad room to be applied in regional planning process at national, regional and local levels in Korea. We have come to use such analytic and objective methods as OR and systems analysis in planning spatial development.

In order for OR to be successfully applied to regional planning as a technique, we must endeavor in some aspects. One of them is to develop practical OR models which are relevant to the Korean situations. It is also necessary to establish urban and regional information systems with accurate data and powerful computer. In addition, we should improve the mechanics of applying OR to regional planning so as to reduce the resource costs for developing, analyzing and implementing OR models. It might be also required that we assess the appropriate mix between professional and technical training to best prepare students for having a practical influence on decision making of regional planning.

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