The Regional Growth Model for the Control of Regional Income Disparities : A Survey in Japan

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I. Introduction

In every stage of development throughout history, regional income disparity has been of great interest to many scholars as well as to policy authorities. Regional income is considered the major input in the process of regional development. Consequently the interest in comprehensive or profound analysis of regional income disparity stemmed not only from academic motivation but also from the need for sound policy formation.

In Japan several theoretical and empirical studies have been done on the development of regional growth models which seek to redress the problem of regional income disparity. This paper surveys the major contributions made by the members of the Japan section of the RSAI in this field. In particular this paper highlights several regional growth models which focus attention on the controllability of regional income disparity viz-Optimal Programming Model, Neoclassical-Type Model, Rahman-Type Model and Model Reference Adaptive Model.

II. Optimal Programming Model

The Optimal Programming Model is divided into two programming models, namely, the Lefebvre (1968) -Moses (1960) Model and the Steiner (1959) -Marglin (1963) Model.

Kohno (1970) applied the Lefebvre -Moses Model to the optimal allocation of public investment and considered the construction of a detailed mechanism which endogenously derive the optimal allocation of public investment among different transport means through simultaneous solution with the production level.

As for the Steiner -Marglin Model, Kohno (1969) applied it to the optimal allocation of highway investment and formulated the Dynamic Optimum Allocation Model of highway investment to maximize net present values of economic effects subjects to such constraints as funds for each period, incompatibility, discreteness, and traffic demands.

Yasoshima, Kohno, Hirata and Nakamura (1975) extended the Kohno model to the Industrial Location Model including environmental factors. The results of the computa-

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tion show that no feasible solution exists so far as the actual pollutant emission coefficient and the actual environmental control level prevailing. A parametric programming procedure was performed assuming various reduced levels of pollutant emission possibly realized through future technical innovation. The final results of the computations give a set of trade-off relations between resident welfare and regional development plans.

Hidano (1977, 1979) considers an optimal regional development process under development speed constraints with special emphasis on regional government surplus revenue. This study shows that the optimal path is balanced growth of two facilities with a constant ratio independent of weight of the welfare function. An optimal timing of transportation investment in a two-region case is discussed with actual data.

III. Neoclassical-Type Model

The Neoclassical-Type Model is based on the growth theory by Samuelson and Solow.

Fukuchi and Nobukuni (1970) presented a national economy model divided into n regions with the following assumptions: (1) all regions have a Cobb-Douglas-type production function, (2) the regional growth rates of the production factors diverge from the overall average in proportion to the differences in productivity of the respective factors in the respective regions, and (3) the factors are fully employed.

The application of this model to the Japanese economy in the 1950's and early 1960's revealed that in spite of an increased income which was favorable for the reduction of income disparities, the stability condition was not satisfied because of too high a rate of growth.

Fukuchi (1983) attempted to extend this model to a basic model with corresponding weak and strong stability conditions of per-capita income in a multi-regional economy. The basic postulate is that the elasticities of interregional movements of labor and capital, discounted by average distance, are constant. Based upon this theoretical postulate, the stock and flow representations of basic models, and a general economy and a prototype economy are defined. Stability conditions of percapita income differences and trends in the regional shares of absolute income are discussed within these models. A conclusion is that the share of the absolute income shows an unbalanced growth while the stability condition is satisfied and per-capita income is equalized over time.

Mera (1975) assumed factors to be perfectly mobile interregionally, i.e., the physical location of every unit of labor and capital to be changeable instantaneously without cost. In such a system, physical distribution of productive factors is determined for any instant of time by the profit maximizing motive. Furthermore Mera tried to analyze the disparities of regional income arising from the regional production functions. In the case of Japan it can be concluded that when per worker incomes are equalized among prefectures or major sectors and regions through the redistribution of social capital, the national income would be less, by about 30 percent in the short run and by about 12 percent in the long run, than would be achieved through the traditional distribution of social capital. Thus, from the observed pattern, national income cannot be increased much by redistribu-

tion social capital. Therefore, although the interregional income equalization is a difficult task and costly in terms of foregone production, improvements in interregional income differential can be achieved without sacrificing much aggregate production, by a proper mix of available policy measures.

Kohno (1983) built the general market equilibrium model in which the theory of transfer and the theory of existence can be formulated. He applied it to the benefit valuation of the highway improvement in a two-region economy to verify the theory of transfer and theory of existence and analyzed several numerical results of this verification.

IV. Rahman-Type Model

The Rahman Model (1963, 1966) is treated as a model of a centralized economy.

The aim of this model is to analyze, in aggregative terms, the logic of regional allocation of investment in a two-region economy where the following conditions hold: (1) central control and planning of investment are aimed at maximizing the national income at the end of the planning period, (2) the regional sentiments demand that the process of economic growth should not bring about any wide disparity in the regional living standards, (3) the productivity of investment and the rate of saving both differ in the two regions and (4) the planning saving equals planned investment though central direction.

Rahman tried to analyze the following propositions: (a) if the multiplication with the rate of saving and the productivity of investment of the more productive region is greater than that of the less productive region, then the optimum program favors the more productive region throughout the entire plan-period. (b) given the case where the multiplication with the rate of saving and the productivity of investment of the less productive region is greater than that of the more productive region, and in a situation where the plan-period is sufficiently large, the optimum program must favor the less productive region in initial times.

The Rahman Model was modified by Sakashita (1976) for a mixed economy consisting of private and public sectors in the case of a two-region economy. This model considers a two-region economy in which the central government can impose current income taxes within a certain limit anytime it wishes. The results of Sakashita's analysis accord with the same results as that of Rahman.

Sakashita's Model was extended to an n-region model by Ohtsuki (1971).

The Rahman Model was modified by Yamamura (1972) into a regional balanced growth model under the condition that no wide regional income disparity resulted at the end of the planned period. Yamamura tried to analyze the proposition that the controllability decreased rapidly given an initial high difference in regional income.

The discrete form of this model was reformed to a continuous case by Miyata and Yamamura (1983) and to a more generalized model for the redistribution policy of population by Yamamura and Ohta (1985b). The latter model revealed that the local autonomy policy and the savings ratio of a developing region play an important role in the redistribution of population.

Fujita (1978) developed a generalized Rahman Model by introducing scale economies and diseconomies in the production process. Fujita tried to analyze the case of n regions and variable returns to scale, and arrived at the following conclusion. If the investment allocation is free in the competitive economy, the allocation of investment will be switched from the more developed region to the less developed region only after the more developed region becomes so congested that the agglomeration economies accumulated in the initial stages are completely outweighed by agglomeration diseconomies accumulated in the later stages. To achieve the optimal growth path in the competitive economy the government should impose a sufficiently high congestion tax on investment in the more developed region so as to discourage the over-accumulation of capital.

V. Model Reference Adaptive Model

Among the various alternative methods for adaptive control, the use of the technique known as the Model Reference Adaptive Model is oriented and considered to be one of the most feasible approaches for regional growth analysis (Yamamura 1983, 1984, 1985a). The basic scheme of a Model Reference Adaptive Model is called a Parallel Model Reference Adaptive Model in order to differentiate it from other Model Reference Adaptive Model configurations.

The adaptive process of this type is due to the fact that a measure of the difference between the given index of performance specified by the reference model, and the index of performance of the adjustable system, is obtained directly by the comparison of states of the reference model with those of the adjustable model.

Model Reference Adaptive Model :

Reference model

$$y_M = f_M(u, p_M, x_M, t)$$

Where p_M represents parameters of the reference model.

$$y_S = f_S(u, p_S, x_S, t)$$

Where p_S represents parameters of the adjustable model.

The index of performance which expresses the difference between the given index of performance specified by the reference model and that of the adjustable model is given by :

$$J_{IP} = F(\epsilon, p_M - p_S, e, t)$$

where

$$\epsilon = y_M - y_S$$

$$e = x_M - x_S$$

The Model Reference Adaptive Model minimizes the J_{IP} defined above by parameter adaptation or by signal-synthesis adaptation via the adaptation mechanism that has generalized error as one of its inputs.

In a typical regional growth model, the reference model can be used to represent the

economy of the developed region and the adjustable model to represent the economy of the developing region.

The aim of such a model is to develop the economy of the developing region to the level of that of the developed region. Namely, the Model Reference Adaptive Model minimizes the J_{IP} defined above by parameter adaptation, or by signal-synthesis adaptation via the adaptation mechanism.

Parameter adaptation represents changes in industrial structure making the industrial structure of the developing region equal to that of the developed region.

Signal-synthesis adaptation represents changes of investment allocation among industrial sectors to develop the output of the developing region's economy to the level of the developed region's economy.

Another typical economic policy system can be defined where the real economic system is represented by the reference model and that of the economic planning model. Namely, the Model Reference Adaptive Model minimizes the J_{IP} defined above by parameter adaptation or by signal-synthesis adaptation via the adaptation mechanism.

The parameter adaptation represents the minimization of any norm of the difference between the state sector of the real economic system and that of the economic planning model.

The signal-synthesis adaptation represents an input control that minimizes the difference between the output of the real economic-system and that of the economic planning model.

Miyata and Yamamura (1987a, 1987b, 1987c) introduced the application of the Model Reference Adaptive Model to the Dynamic I-O analysis to yield a path of economic development which converges to the Turnpike by consideration of adaptation processes of technological system and their stability.

Yamamura (1986) has investigated the stability domain of the propensity to consume and the acceleration coefficient of the regional growth model, the regional income forecasting model, and the model reference adaptive model with the Volterra-Lotka type of discrete polynomial non-linear system.

As for the application of the Model Reference Adaptive Model to the real regional economy, Yamamura and Miyata (1989b) have clarified the adaptation processes associated with regional development within Japan's nine economic regions from 1970 to 1980.

Adi, Yamamura and Miyata (1988) have applied the Model Reference Adaptive Model to the regional population planning of Indonesia.

Alex and Yamamura (1990) have also applied the Model Reference Adaptive Model to the housing forecasting model of Ghana.

Yamamura (1989a, 1990, 1991) has also applied the Model Reference Adaptive Model to the international technology transfer of coal mining technology of Hokkaido, adaptive process of Japanese management in Meiji era and pollution control analysis in the global environment.

There are also many economic control studies for various applications of Model

Reference Adaptive Model.

VI. Conclusion

We have considered the main contribution papers by the members of the Japan section of the RSAI to the Optimal Programming Model, Neoclassical-Type Model, Rahman-Type Model and the Model Reference Adaptive Model.

Optimal Programming Model and the Rahman-Type Model will be expected to extend the Fuzzy and Stochastic Programming Model. The Neoclassical-Type Model will be expected to extend the General Market Equilibrium Model.

Among the four models, the Model Reference Adaptive Model is conceived to be a useful method for the quantitative analysis of the adaptive process of regional growth. This model could be expected to extend to various research fields particularly in development economics and ecological economics.

In this paper, only brief introductions have been given to the main papers of the members of the Japan section of the RSAI. For a more detailed work, readers are referred to Kohno and Higano, (1975, 1981).

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