

A System Dynamics Approach To Analyze The Relationship Between Transportation And Regional Development In Taiwan

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Abstract

Disparities, both sectoral and regional, always exist during the process of national economic development. The disparities between the agricultural and non-agricultural sectors of Taiwan have steadily increased due to the rapid industrial and economic growth encouraged by the government. Awareness of the effect from the physical development on regional disparity has risen since the enforcement of the Six-Year Economic Development Plan in 1976. In the Taiwan Area, four regional plans have been drafted and successively enforced in order to decreased such regional disparities.

The purpose of this paper is : (1) to study the regional disparities in Taiwan based on average per capita income and employment opportunity as indicators on four regional planning regions; (2) to develop a system dynamics model to portray the relationship between transportation and regional development disparities in Taiwan; and (3) to provide a future direction for regional policy based on conclusions drawn from the result of (1) and (2).

INTRODUCTION: History and Situation

In the postwar period, while shifting from an agrarian to a predominantly manufacturing-industrial base. Taiwan's economy has enjoyed rapid and sustained growth. It maintained GNP growth at an average annual rate 8.2 % during the 1950s, 9.1% during the 1960s and 10.1% during the 1970s. These high growth rate were achieved under a series of nine consecutive medium-term plans, initiated in 1953 and extending through 1989. Taiwan has enjoyed substantial increases in GNP and per capita income, but it also has experienced heavy region's disparities.

Because earlier economic development plans are predominantly sectoral in nature and do not incorporate regional resources allocations and spatial considerations, the resultant inequitable development has caused increasing differences in the standards of social infrastructure and economic activities among four regions (Northern, Central, Southern, and Eastern Regions).

Increase in the spatial concentration of population and regional economic development disparities has prompted the government to focus its attention on spatial development issues in the middle of the 1970s. For instance, the island-wide comprehensive development planning was first introduced in the 1970s, and was officially

adopted in 1979. One of its key goals is the creation of a better balance among regions. To achieve a more rational distribution of population and industry, the government has adopted some public policies; the most important policy is to improve infrastructure so as to reduce welfare disparities between the less-developed and more-developed regions.

In order to enhance economic development and achieve a more balanced distribution of population and economic activities, several transportation projects have been undertaken since 1974. They are: (1) the construction of the North-South Freeway; (2) the electrification of the railway system; (3) the expansion of the provincial highway Route 1; (4) the extension of the North-Link and South-Link Railways; (5) the construction of three cross-island highways; and (6) the construction of the Chiang Kai-Shek International Airport.

Since transportation investment has been viewed as an important policy instrument to curtail the social economic disparity among regions, it is urgent to use a systematic study on the dynamic effect between transportation and regional social economic development to understand the structure behavior and to dispel the illusion of the blackbox in decision making. In this paper, we apply the system dynamic approach to study the adjustment and control mechanism of transportation construction and other regional development policy instruments, and discuss the long term development tendency of their interaction and coordination. By tests in changing structure and parameters of the system model, we can find out possible way to improve the behavior of the system.

THE MODEL: Concept and Construction

It is well-known that economic activities and developments are unequally distributed in space: the unequal spatial distribution is generally referred to as "spatial socio-economic inequality". One cause of spatial inequality is the physical infrastructure location factors, including the availability of harbors, airports, the quality of road and railway networks, the availability of industrial sites, etc.

The importance of infrastructure to economic development in developing countries has been well recognized. We can find statistical evidence supporting the view that infrastructure investment has been the most important ingredient of capital formation in the early stages of development in industrial countries. However, from a theoretical point of view, there is still much controversy on to what extent infrastructure investment is essential to the process of economic development. With respect to regional development, there also has been a hot debate over whether infrastructure must precede development.

Regional planning aims at achieving changes in spatial and economic structure so as to guarantee a harmonious adjustment to social and economic needs in society. Regional development theories indicated that the regional development and infrastructure policy has been closely related, since infrastructure is an integral component of a set of regional potentiality factors. Infrastructure determines the growth perspectives of a region. It also has impacts on the spatial disparities. Infrastructure can be regarded as (material and immaterial) public capital which constitutes the foundation of all other socio-economic activities in a region. In Taiwan, the public infrastructure investment has been viewed as the most powerful instrument to stimulate socio-economic and regional development.

As mentioned earlier, in order to enhance economic development in Taiwan, several transportation projects have been planned and developed since 1970. However, the regional disparities have not been reduced by the development of these transportation facilities. Particularly, population migration to highly-developed regions has never declined.

The investments in transportation are expected to pave the way for development. In reality, transportation is not a separate entity of the socio-economic. It should be viewed, in terms of the regional development process, as the linkage among various socio-economic sectors of the regional economy. Causal, dynamic, feedback relationships exist between sectors of regional socio-economic development, i.e. population, industry, and transportation. It is useful to trace the pattern of the interregional development and the interacting relationships between transportation and regional development in Taiwan by using the System Dynamics approach.

There are three sectors in our study; the first two sectors are the key elements of regional socio-economic development:

- (1) Population sector, includes birth, death, and interregional migration submodels;
- (2) Industry sector, includes agriculture, manufacture, and commerce submodels;
- (3) Transportation sector, includes highway, railway, harbor, and airport submodels.

For the purpose of illustration, we use Northern region as the key descriptive variable and Eastern region as the auxiliary variable. In the conceptual descriptive model, the interacting relationships among regional transportation, population, and industry sectors are very complicated. First, transportation infrastructure investments in the Northern region affect regional per capita income and employment, and the disparities of these variables (per capita income, employment, etc.) in the Northern region to those of the other regions would result in shifting in population. Secondly, the completion ratio of transportation infrastructure in the Northern region is one of the primary industrial production attractive multipliers to stimulate the production activities. At the same time the material flow of region and interregions needs the accessibility provided by transportation. Thirdly, the labor force from the population sector is also one of the production factors, but the per capita income level will affect the birth control behavior and therefore affect the region's birth rate. From these main relationships, we can develop feedback loops to describe the interactions among the three sectors.

The Population Sector

In traditional transportation planning, the population forecast has been based mainly on extrapolation of trend, or on available forecast data which was also adapted in this study.

The hypothesis in our study is that the changes of spatial structures are due to shifting in interregional migration, which is determined by the differences in job opportunity and income per capita. The transportation accessibility also produces a migratory acceleration effect role. A change in population not only affects the labor force rate, but also the employment rate, income per capita, etc.

The regional population at any time is determined by births, deaths and migrations. The regional population determines the labor, employment, and income per capita of the

region. The migration is controlled by the relative job opportunity, income per capita, and transportation accessibility among the Northern and other regions. The simple concept for the population sector is shown in figure 1.

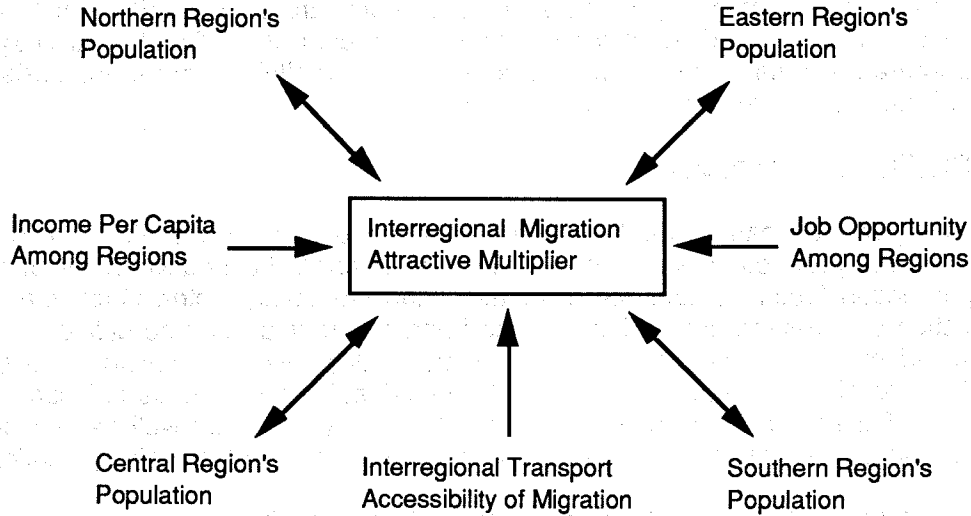


Figure 1. The Simple Concept for Population Sector

The Industry Sector

In figure 2, we show the simplified casual relationship within the industry sector.

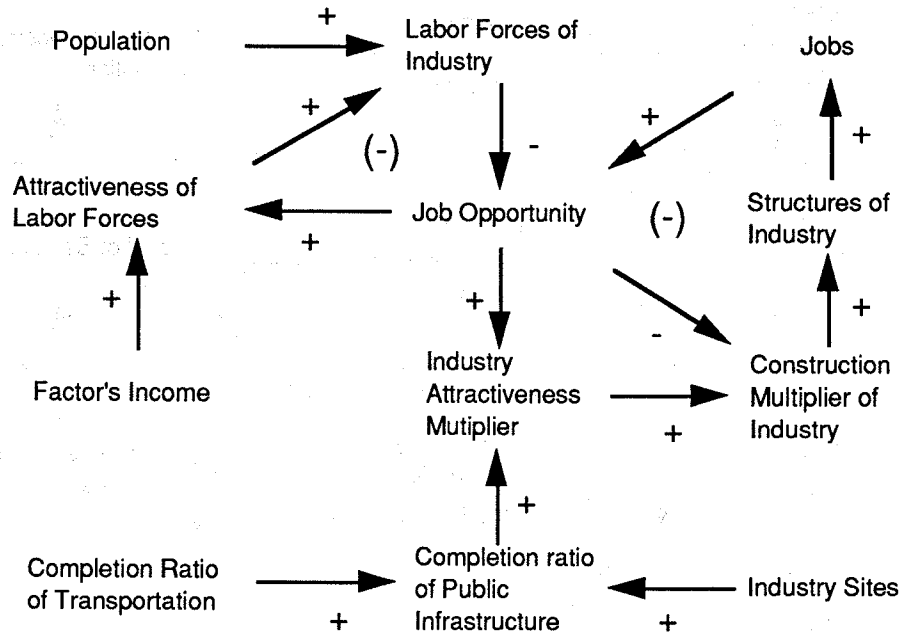


Figure 2. The Simplified Feedback Loop of Industry Sector

The socio-economic activities of the region create the job opportunities, trans-

The linkages among the above three sectors are described below:

- (1) Population sector provides the labor force to industry sector that stimulates the production activities. The performance of production (for example, income per capita) will affect the relative socio-economic status among regions that results in a population migration.
- (2) The accessibility of movements is perceived to be the primary constraint to the migration activities of population sector. The travel demand of passenger trips (work trip and non-work trip) are induced from the population sector.
- (3) The transportability demand by each industry relates to its production. The more products are produced, the more transportability of transportation is demanded. Transportation sector provides the completion ratio of transportation infrastructure that results in a change on production function.

We show the simplified causal diagram of the system in figure 4.

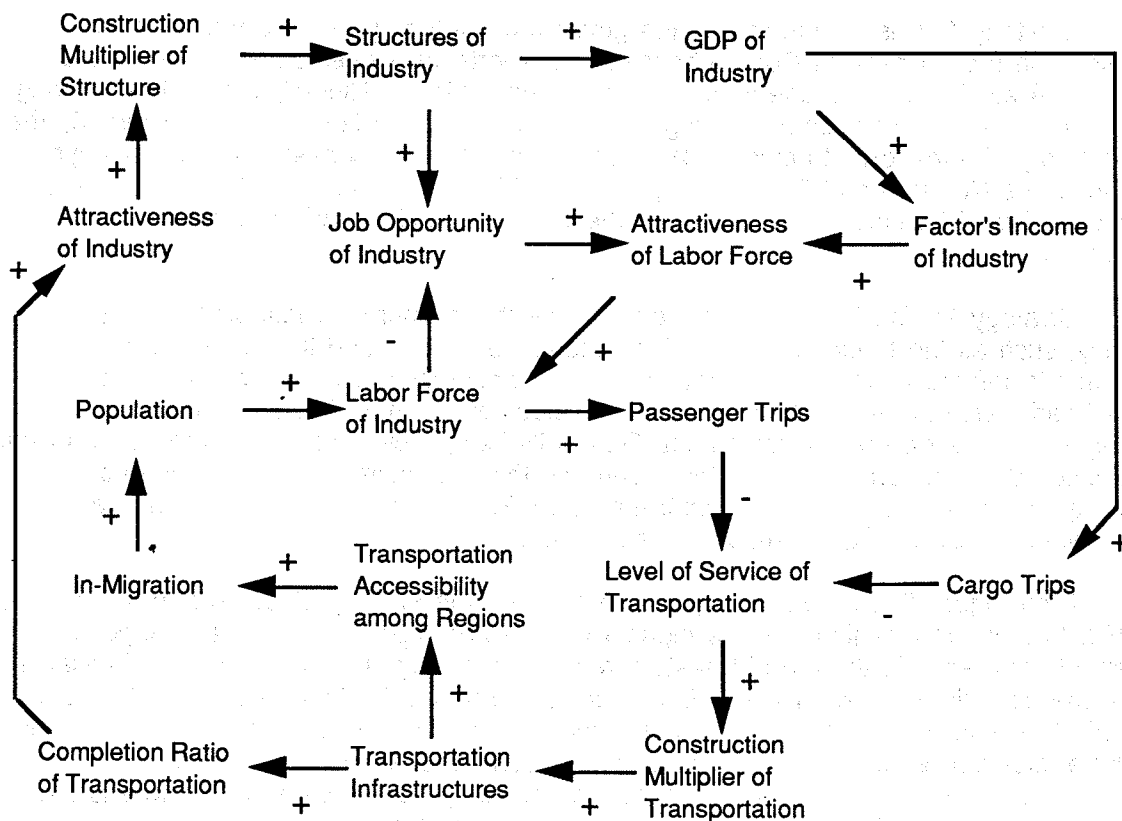


Figure 4. The simplified casual diagram of system

POLICY TEST

There are two types of strategies for decreasing regional disparities: (1) accelerating growth in the developed regions and encouraging the migration of unemployed population and low productive activities to these regions, i.e., taking people to jobs; and (2) creating job opportunities and highly productive activities in the less developed regions, i.e., taking jobs to people. The trend in regional development policy in Taiwan has been towards the strategy of "taking jobs to people" such as the Comprehensive Development Plan in Taiwan described previously and the Six-Year National Development Plan in Taiwan will be described below.

The results of policy simulation runs are divided into two groups: (1) the base run which is a pseudonym for the continuous status of the regions (i.e., whatever has been the history of the performance of the regions is assumed to continue into the future); and (2) the policy runs representing the impacts of some policies' corporation. In each run, we observed some key socio-economic variables of each region, such as population, interregional migration, structures and labor forces of each industry, gross domestic production, personal income, transportation capacity, and level of services. For the purpose of illustration, we use the relative ratio of personal income and job opportunity between Northern and Eastern Regions in our figures.

Figures 5, 6, and 7 show the different development of the four regional job opportunity and relative ratio of interregional personal income for the base run, as well as for strategy 1 and 2.

Strategy 1: It is assumed that the government will only use the transportation projects in the Long-Term Comprehensive Transportation Development Plans in the Taiwan Area. These investments are: (1) the construction of High-Speed Railway among Northern, Central, and Southern regions; (2) the electrification of the railway; (3) the secondary South-North freeway; (4) three cross-island freeways; (5) the freeways connect the Northern and Eastern Regions, etc.. These investments will improve the accessibility of transportation and then affect the production and productivity of industry.

Strategy 2: The investment policy will use the cooperative instruments of public policy, such as the transportation projects mentioned above and the other social economic infrastructure investments (such as industrial sites, public utility, social overheads, etc.) in the Six-Year National Development Plan in Taiwan. The plan is a blueprint for the national development. One of its key policy goals is the promotion of the balanced development of four regions. Through these investment, region's production activity will be affected. The job opportunity, GDP, and accessibility will then change the relative socio-economic status among regions.

From figure 5, we can clearly see that during the study period, from 1961 to 1989, the Northern region has the highest income per capita. The result of regional disparity between Northern and Eastern regions, based on income per capita, indicates that the disparity has reached its highest point at 2.3 in 1976 then decreased to 1.8 in 1985. This finding is similar to other developed countries, the disparity among regions will be improved as the economic development stabilized. Being a self-adjusted mechanism, in the base run, it shows that the disparity between northern and eastern regions will be 1.5 in 2011. The disparity in job opportunity has been steadily decreased since 1979, the relative ratio will decline to 1.025 in 2011.

From figures 6 and 7, it is obvious that the strategy 1 and strategy 2 lead to better results than the base run. The fluctuations in the development of the job opportunity and personal income are caused by the heavy transportation investment and the other cooperative public infrastructure projects. The indicator-- relative ratio of income per capita and job opportunity between Northern and Eastern regions, of strategy 1 will be 1.47 and 1.012 in 2011. And those of strategy 2 will be 1.4 and 1.006.

CONCLUSIONS

In this study, an interdependent, unbalanced growth path and linkage relationship has been hypothesized between transport development and regional socio-economic

1 N_EPI : Relative Ratio of Per Capita Income between Northern and Eastern Regions
 2 N_EJOR : Relative Ratio of Job Opportunity between Northern and Eastern Regions

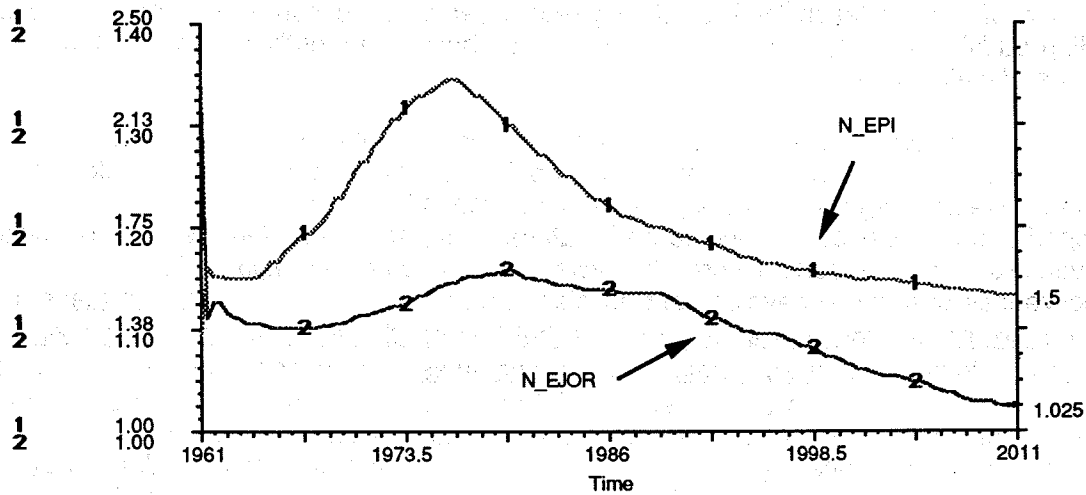


Figure 5. The Results of Base Run

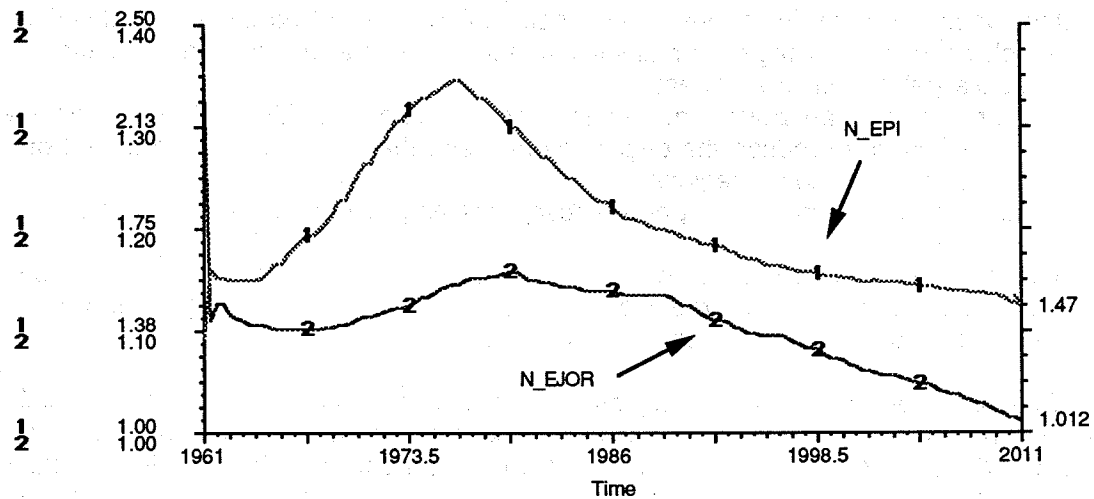


Figure 6. The Results of Strategy 1

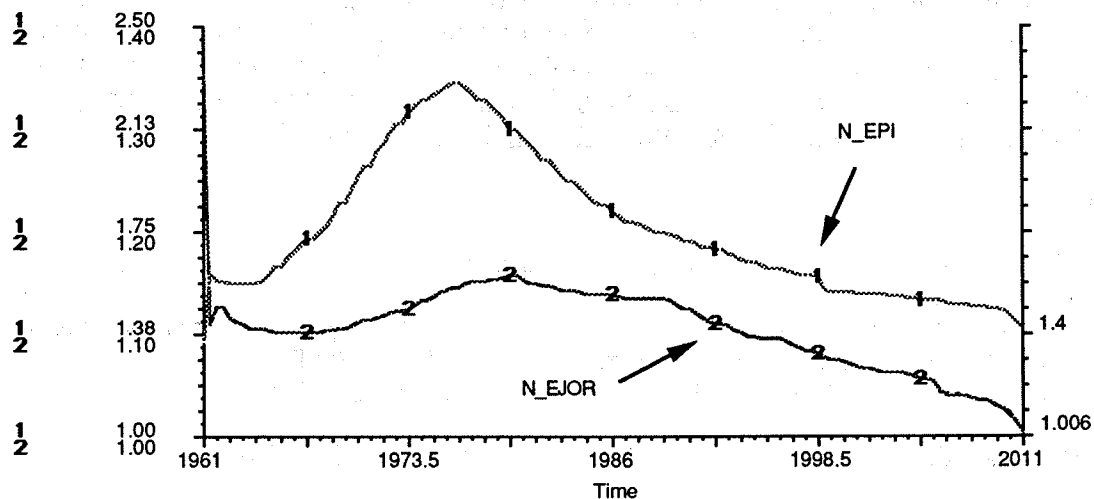


Figure 7. The Results of Strategy 2

growth. During the period under study, transportation had simultaneously played the role of "stimulator" and "respondent" in the process of the four regions' development. The contribution of transportation and the other infrastructure to GDP also showed an increasing trend. However, even with the rapid increase in public investment, the shortage of transportation facilities during recent years has become even more critical. Adding additional transportation infrastructure has become urgently needed for the regional development.

Economic growth over the years has had a fundamental impact on the socio-economic structure and physical development of Taiwan, and the impact on people are both positive and negative. On the positive side, economic growth has brought prosperity, raised per capita income and material living standards. On the negative side, uneven growth has caused an increasing development gap among regions. As for the effectiveness of regional development policies, it was found that transportation plays a key role to the development among regions, but it is not the sole stimulator of growth. Only direct investment in economic activities originates real economic growth. Although continuous improvements in the transportation system are essential and important at the time of regional socio-economic development, the incremental transport service capabilities will stimulate regional socio-economic expansion in a more indirect way, since it will create a favorable environment in which the direct socio-economic activities can be generated more easily. Our suggestions are:

- (1). Development priority in the less developed regions, should be given to industries which have a high regional multiplier effect, in order to realize the quickest possible gains from investment.
- (2). Infrastructures (transportation, industrial sites, public utilities, etc.) should be improved so as to reduce the disparities between the investment environment of less and more developed regions.
- (3). In less developed regions, indigenous resources and related industries should be developed.
- (4). Industries producing goods for which less-developed regions are highly dependent upon than more-developed regions should be actively prompted. To provided a better investment environment is favorable.

Economic development is not only an economic phenomenon, but a dynamic social process involving many non-economic aspects. Economic growth should go hand in hand with social development. We cannot afford to neglect economic development for the sake of social welfare. Similarly, we cannot sacrifice social well-being to intensify economic development. Hypothesis and findings such as those mentioned above have helped in capturing the dynamism behind the transportation infrastructure constructions and interregional development, and also lead to the determination of the development speed and future direction of the socio economy of the regions. We conclude, therefore, that what we need is not heavy investments but the ability to bring those three sectors of Population, Industry, and Transportation to function appropriately.

Reference

- (1) Adams, F. G. eds, 1980. *Modeling the Multiregional Economic System*. Toronto: Lexington Books.
- (2) Anderson, A. E. eds, 1984. *Regional And Industrial Development: Theories, Models And Empirical Evidence*. Amsterdam: Elsevier Science Publishers.
- (3) Folmer, H. , 1986. *Regional Economic Policy*. Dordrecht: Martinus Nijhoff Publishers.
- (4) Forrester, J. W. ,1969. *Urban Dynamics*, Cambridge: M.I.T. Press.