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Development of a Sustainable Regional Economic Growth Model (SREG) Using Multiplier Theory

승수이론을 이용한 지속가능한 지역경제성장모델의 개발

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Abstract

This paper develops a Sustainable Regional Economic Growth Model (SREG) which estimates the relation of labor population change and employment increase in each occupation and maximum limits and minimum requirements of employment increase by labor population change in a specified region using multiplier theory. To develop the proposed model, sustainable regional economic growth is defined as a steady increase of labor population over a long term period and the limit of employment increase is defined as the estimated labor population change in the region with no need for commutation from the surrounded areas. Developed model was applied to 67 county in Pennsylvania State and the results revealed that the investment in infra-structure occupations, such as transportation, warehousing, utilities, information, communication, and other public utilities, maximizes the effects for increasing employment, whereas finance, insurance, and real estate occupations have minimum effects for increasing employment. Calculated minimum requirements of occupations show that infra-structure occupations is a critical factor for labor population change and maximum limits of occupations show that agriculture and finance occupations are difficult to increase independently.

Keywords : Sustainability, Regional economic growth, Optimization model

I. Introduction

Since the publication of 'Our Common Future', sustainable development has become a major concern for policymakers and planners in both developed and developing countries. One definition of sustainability is "development that meets the needs of the present without compromising the ability of the future generations to meet their own needs" (World, 1987).

There are many aspects in sustainability. First, it requires an elimination of poverty and deprivation, second, the conservation and enhance-

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ment of the resources that alone can ensure the permanent elimination of poverty, third, a broadening of the concept of development so that it covers not only economic growth but also social and cultural maintenance and development, and fourth, the unification of economics and ecology in decision making at all levels (Quaddus, 2001).

We are concerned about social and cultural development. In some economic development, especially in rural areas where economic size is small, a large amount of in-migration causes the out-migration of the native population by increasing the living costs, reducing the level of social services and destroying the existing social and cultural systems (Potepan, 1994).

Ross (1996) found that policies stimulating economic activity do not necessarily raise resident welfare, because of the competition for land between firms and households. Planning for sustainable development involves an exploratory search for resource use options, technology choices, system structural changes, and consumption patterns that can result in continuously rising, or at least non-declining, equitable quality of life levels and acceptable environmental status through declining ecological loading.

Operation of such a scheme at the regional level entails identification of links between resource endowment, developmental activities, assimilative capacity, environmental status, economic progress, amenities, and quality of life levels (George, 1997). One of the main aspects of sustainability can be defined as an increase of population density per net area (Churchill, 1999).

In this study, we defined sustainable regional economic growth as a steady increase of labor population over a long term period and set the limit of employment increase as the estimated surplus labor population in the region with no need for commutation from the surrounded areas. With this definition, the Sustainable Regional Economic Growth Model (SREG) was developed which estimates the maximum limits and minimum requirements of employment increase by surplus labor population in a specified region using multiplier theory.

Ⅱ. Regional economy growth

The theoretical base of the economic base model is the multiplier theory suggested by J.M. Keynes (Youn, 1998). This model was developed to understand the economic structure and urban growth based on the supposition that urban economics can be divided into basic activities and non-basic activities (Youn, 1998). There are some merits to using this model, such as the ease of estimating the regional effects of occupation growth, but it's difficult to classify each economic occupation into the two categories. However, there is a structural approach, called the shift-share model, to overcome this difficulty.

The shift-share model has been used in regional economics to examine changes in regional economic activity levels over time, relative to those in a larger base region comprised of the regions (Creamer, 1943). Since its development, it has been adapted to differences in regional crime growth, relative cigarette brand identification, regional growth of state and local tax sources, and insurance lines problem (Halperin, 1984). After the shift-share model, there have been more researches about regional economy, such as the input-output model. However, these traditional evaluation processes have been considered unsatisfactory, simply based on the expectation of a better alternative. Furthermore, there will always be limitations on the number of alternatives that can be tested (Lee, 1973).

Mathematical optimizing techniques have been developed and adapted to planning models to solve the general problem of the allocation of scarce resources because there seems to be a direct relationship between the essential objectives of planning and the problems for the solution of which mathematical programming techniques were developed. Therefore, the possibility of using such techniques within the planning process appears worthy of investigation at least (Lee, 1973).

In this study, we estimated the employment increase rate using the shift-share model, developed an optimization model for sustainable regional growth, newly analyzed the optimization coefficients by applying economic multiplier concepts, and suggested the maximum limit and minimum requirement of employment by surplus labor population.

Ⅲ. Sustainable regional economic growth model

Optimization of Surplus Labor Population and Employment Growth

Employment causes the in-migration of labor population, which in turn increases the employment. To analyze this co-effect of employment and migration, we composed the optimization model in the form of equation (1).

$$\min \sum_i |LPC_i - \sum_j C_j E^i_j| \quad \cdots\cdots (1)$$

where, LPC_i: labor population change in i area

E^i_j: Employment change in j occupation in i area

C_j: Optimization coefficients

in equation (1) implies the co-effect of employment and migration, so we have to remove this co-effect to calculate the original value of employment of each occupation using economic multiplier theory shown below. If the increase ratio of employment by LPC is β and the increase ratio of LPC by employment in i occupation is γ_i, we can define LPC as equation (4) using the multiplier theory.

$$\beta = \frac{E}{LPC} \quad \cdots\cdots (2)$$

where, LPC: summation of labor population change

E: Summation of employment change

$$\gamma_i = \frac{LPC}{E_i} \quad \cdots\cdots (3)$$

$$LPC = \frac{\gamma_i E_i}{1-\beta\gamma_i} \quad \cdots\cdots (4)$$

Also, employment inducing effect E^i_0 by the employment in i occupation, can be expressed as equation (5).

$$E^i_0 = \frac{\beta\gamma_i E_p}{1-\beta\gamma_i} \quad \cdots\cdots (5)$$

If the value estimated in the model is exactly equal to the real value, we can derive that

$$LPC = \sum_i C_i E_i \quad \cdots\cdots (6)$$

Using equation (6), the original value of each occupation can be expressed as equation (7).

$$\gamma_i = \frac{C_i}{1 + \frac{C_i}{\sum_i C_i}} \quad \cdots\cdots (7)$$

where, $C_i = \frac{\partial LPC}{\partial E_i} = \frac{\gamma_i}{1-\beta\gamma_i}$

$$\beta = \frac{1}{\sum C_i}$$

Using each γ_i, we can estimate the potential of each occupation i, to create the other employment in equation (8).

$$Po_i = \sum_{i \neq j} \frac{\gamma_j}{\gamma_i} \quad \cdots\cdots (8)$$

Finally, the maximum limit of employment in each occupation can be defined as the ratio of total employment to the employment of other occupations in the boundary of LPC. The minimum employment is required in each occupation as a co-effect of employment by LPC.

$$\frac{(C_i - \gamma_i)\sum_j E_j}{\sum_j C_j} LPC \le E \le \frac{\sum_j E_j}{\sum_{k \neq i} \frac{\gamma_k}{\gamma_i}} \; or LPC \quad (9)$$

Ⅳ. Application

1. Classification of economic activities

In the view of standard occupation, there were

Table 1 Standard classifications of whole division

1990 Industry classification	2000 Industry classification	Standardized classifation
Agriculture, forestry, and fisheries	Agriculture, forestry, fishing and hunting, and mining	Agriculture, forestry, fishing and hunting, and mining
Mining		
Construction	Construction	Construction
Manufacturing, non-durable goods	Manufacturing	Manufacturing
Manufacturing, durable goods		
Transportation	Transportation and warehousing, and utilities	Infra-structure
Communications and other public utilities	Information	
Wholesale trade	Wholesale trade	Wholesale trade
Retail trade	Retail trade	Retail trade
Finance, insurance, and real estate	Finance, insurance, real estate, and rental and leasing	Finance, insurance, and real estate
Entertainment and recreation services	Arts, entertainment, recreation, accommodation and food services	Entertainment and recreation service
Personal services		
Educational services	Educational, health and social services	Education, health, and social services
Health services		
Public administration	Public administration	Public services
Business and repair services	Professional, scientific, management, administrative, and waste management services	
Other professional and related services	Other services (except public administration)	

*USCB: U.S. Census Bureau http://factfinder.census.gov/servlet/BasicFactsServlet

17 classifications in 1990 and 13 in 2000. In this study, we unified these classifications into 10 occupations which can represent all occupations, as shown in Table 1.

Construction, wholesale trade, retail trade, finance, insurance and real estate remained in the same items, but the other items were either separated or combined. Newly appeared items like information and management, which remain a small portion of the total occupation, were represented as more coarse concepts.

2. Labor population change and employment increase in each occupation

For applying developed model population data of 67 counties in Pennsylvania state were acquired from USCB websites in Table 2.

Optimization was executed using equation (1) for estimating the labor demand for employment increase in each occupation. Results in Table 3 show the relation of labor population change and employment increase in each occupation.

Infra-structure employment had a strong effect on employment of another occupation and first industries such as agriculture, forestry and mining were more efficient to regional economy growth than other industries such as manufacturing, retail trade and real estate. But construction had no relation with labor increase, presumably because construction is only tem

Table 3 Labor population and employment of each division

Industry	Labor increase / employment-growth
Agriculture, forestry, fishing and hunting, and mining	2.173
Construction	0.000
Manufacturing	0.953
Infra-structure	3.536
Wholesale trade	1.785
Retail trade	1.973
Finance, insurance, and real estate	0.403
Entertainment and recreation services	1.540
Education, health, and social services	0.951
Public services	1.563

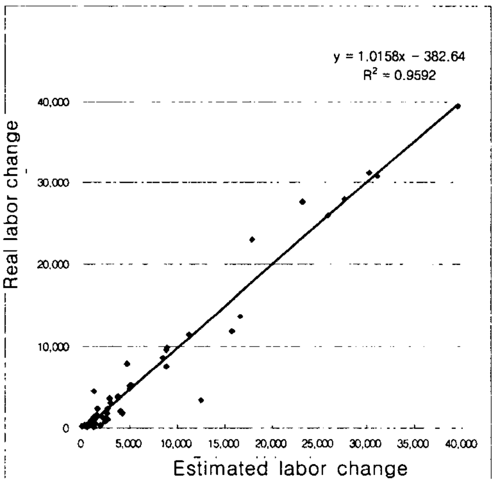

Fig. 1 Fitting results between real labor change and estimation

Table 2 Data acquisition

Source	Content	Unit	Min	Max	Mean	St. Dev.
USCB	1990 Pop.	N	4,802	1,585,577	177,338	268,992
	2000 Pop.	N	4,946	1,517,550	183,299	265,443

*USCB: U.S. Census Bureau http://factfinder.census.gov/servlet/BasicFactsServlet porary employment and employees in construction can move easily to other regions.

The fitting result between real labor change and that estimated by the optimization model is shown in Fig. 1, which verifies that the optimization model accurately explained the real phenomenon with R^2=0.96.

3. Original value estimation using the concept of economic multiplier

The results in Table 3 have co-effects between occupations. The original value in each occupation is derived using the equation (7). The results in Table 4 show the original value of each occupation and the multiplying-effects in each occupation. The original value in each occupation shows the same trend with the results of Table 3.

Using multiplying-effects in each occupation and equation (7), we demonstrated that investment in infra-structure occupations like transportation, warehousing, utilities, information, communication, and other public utilities maximize the potential for increasing employment whereas finance, insurance, and real estate occupations have a minimum effect on increasing employment.

4. Employment limits in each occupation

Maximum limits and minimum requirements can be estimated using the equation (9). Minimum requirements of agriculture and infra-structure occupations were bigger than those of other occupations, and that the maximum limits of finance, insurance, and real estate were bigger than those of other occupations in Table 5.

Calculated minimum requirements of occupations show that infra-structure occupations is a critical factor for labor population change and maximum limits of occupation show that agriculture and finance occupations are difficult to increase independently.

Table 4 Original value and multiplying-effect of each occupation

	Agr.	Man.	Who.	Ret.	Inf.	Fin.	Edu.	Rec.	Pub.	Total
Agr.	1.00	2.12	1.19	1.09	0.66	4.83	2.12	1.36	1.34	14.71
Man.	0.47	1.00	0.56	0.51	0.31	2.28	1.00	0.64	0.63	6.42
Inf.	1.51	3.19	1.79	1.64	1.00	7.28	3.20	2.05	2.02	22.68
Who.	0.84	1.78	1.00	0.91	0.56	4.06	1.78	1.14	1.13	12.21
Ret.	0.92	1.95	1.09	1.00	0.61	4.44	1.95	1.25	1.23	13.43
Fin.	0.21	0.44	0.25	0.23	0.14	1.00	0.44	0.28	0.28	2.25
Rec.	0.74	1.56	0.88	0.80	0.49	3.56	1.56	1.00	0.99	10.57
Edu.	0.47	1.00	0.56	0.51	0.31	2.28	1.00	0.64	0.63	6.40
Pub.	0.75	1.58	0.89	0.81	0.50	3.60	1.58	1.01	1.00	10.72
Total	5.90	13.61	7.21	6.51	3.58	32.33	13.64	8.37	8.25	
Original	1.90	0.90	1.59	1.74	2.86	0.39	0.89	1.40	1.41	

Table 5 Limits of occupation growth in each division

Industry	Min/1000 labor pop.	Max/1000 labor pop.
Agriculture, forestry, fishing and hunting, and mining	15	141
Manufacturing	3	226
Infra-structure	38	1,000
Wholesale trade	11	565
Retail trade	13	752
Finance, insurance, and real estate	1	150
Entertainment and recreation services	8	519
Education, health, and social services	3	344
Public services	8	497

V. Summary and conclusion

Previous research about sustainable development has mainly been concerned with ecological environments. In this study, we defined sustainable regional growth as a steady increase of labor population over a long term period and set limits of employment in each occupation as the estimated labor population change in the defined region, without any need for commutation from the surrounded areas. There is a co-effect of employment increase with change of labor population, so we introduced the economic multiplier concept to determine the original value of each occupation. Using this value, maximum limits and minimum requirements of each occupation according to labor population change can be suggested.

To apply the developed model, population and occupation data in 67 counties in Pennsylvania State were used. The model revealed that investment in infra-structure occupations such as transportation, warehousing, utilities, information, communication, and other public utilities maximizes the potential for increasing employment, whereas finance, insurance, and real estate occupations have a minimum effect on increasing employment. Calculated minimum requirements of occupations show that infra-structure occupations is a critical factor for labor population change and maximum limits of occupation show that agriculture and finance occupations are difficult to increase independently.

This research is the first approach to apply the regional economic model to a real planning problem with optimization and economic multiplier concepts. From theoretical perspectives, the multiplier theory was adapted to the optimization result for verifying the relation of labor population change and employment growth.

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