行政院國家科學委員會專題研究計畫 成果報告

全球化與都市結構
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行政院國家科學委員會補助專題研究計畫 ■ 成果報告 □期中進度報告

全球化與都市結構

（計畫名稱）

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計畫中文摘要

關鍵詞：新經濟地理，核心－邊陲模型，分歧現象

Paul Krugman（1991）以 Dixit and Stiglitz（1977）獨占性競爭模型為基礎，考慮了產業的規模報酬遞增特性，提出一般均衡的分析架構，探討廠商聚集與區位選擇，稱之為新經濟地理（New economic geography），基本架構為核心－邊陲模型（core-periphery model）。該模型說明了廠商內生產的報酬遞增、交通成本，和生產要素遷移的互動關係如何影響經濟活動的空間分佈與結構。模型引用演化賽局理論 (evolutionary game theory) 中的動態項"replicator dynamics"解釋勞工的遷移，根據區域的相對實質工資決定遷移。

此模型的聚集經濟，包含廠商內生產上的規模經濟，與市場性互動的外部性。廠商間的非市場性互動的外部性，並不在此模型的範圍內。因此交通成本成為決定廠商與人口分佈的主要決定因素。演化過程呈現了核心─邊陲的分歧現象(bifurcation)與鎖定效果 (luck-in effect)，過程中的小小差異，可能導致很大的影響 (history matters)。這些特性是核心─邊陲模型的重要特質之一，也是非線性動態過程可能呈現的混沌行為。

本研究計畫以核心─邊陲模型為基礎，模擬經濟活動可能演化的均衡結構，分析空間分佈均衡狀態可能的分歧現象(bifurcation)，以及產業聚集與所得分佈的關係；以模型為基礎，推導勞工遷移的動態模型，代替核心─邊陲模型直接由演化賽局理論所引用的動態設定，模擬分析經濟活動聚集的演化現象，並與原模型比較。

研究結果顯示產業活動的聚集會增加核心與邊陲區域的所得差距，核心邊陲結構的平均所得比經濟活動分散結構的平均所得高。非市場性的聚集效果會增加區域經濟活動的向心力，更加速趨近核心邊陲的空間結構。空間結構均衡狀態的分歧現象與性質與模型中的動態模式相關。

Globalization and the evolution of the spatial economy

Abstract

Cities are often considered engines of growth for economies. However, it has long been argued that growth is localized. The core-periphery model by Krugman (1991) explains the nature of agglomeration in simple and yet powerful ways.

This study empirically examines the properties of bifurcation and regional disparities under the original and proposed core-periphery model. We develop a dynamic pattern to explain the migration of workers instead of the given *replicator dynamics* term in the core-periphery model, and a production behavior to include the non-market agglomeration effect. The empirical results show that the difference between income in core and periphery regions rises with agglomeration. The average income is higher in the core-periphery structure than in a dispersed pattern. The increase of regional disparities may cause impoverishment of the peripheral region. Agglomeration and growth reinforce each other; however, inter-regional integration may benefit only the core region. The periphery is better off in a more dispersed pattern. Inclusion of the non-market spatial agglomeration effect enhances the centripetal forces, which further leads the system to a core-periphery pattern. The states of equilibria are highly sensitive to the formulation of the dynamic process.

Keywords: core-periphery model, bifurcation, replicator dynamics

1. Introduction

Inter-regional integration increases economic efficiency in the spatial economy. Fujita and Thisse (2002) strongly supported the idea that agglomeration and growth reinforce each other. Cities are often considered engines of growth (Hohenberg and Lees, 1985; Feldman and Florida, 1994). However, it has long been argued that growth is localized (Hirschman, 1958; Myrdal, 1957). Krugman (1991) applied a Dixit-Stiglitz type monopolistic competition model (known as the core-periphery model) to explain how economic activity may be agglomerated. This model shows "how the interactions among increasing returns at the level of firm, transport costs, and factor mobility can cause spatial economic structure to emerge and change" (Fujita *et al*., 1999). It clarifies the nature of spatial inequalities in simple and yet powerful ways.

The dual role of individuals as workers and consumers adds both production and consumption capabilities to a region's economy. Initial expansion of a market pushes nominal wages up (the home market effect), and, consequently, leads to a rise in real wages (the price index effect). Migration of workers is explained by a given ad hoc dynamics: "*replicator dynamics*" which is routinely used in evolutionary game theory found in the classical Wright–Haldane–Fisher theory (Akin, 1979). It assumes that workers' migration decisions depend on the difference in real wages. This theory of dynamics, however, is not generated from the core-periphery model.

The externality assumed in the model relies only on market interactions involving economies of scale at the level of the individual firm. Non-market interactions that yield increasing returns, external to firms, are viewed as crucial in related studies (Baldwin and Martin, 2004; Fujita and Thisse, 2002). Due to supposition of the externality, transport costs are the key factor that determines distribution of industries.

The purpose of this paper is to investigate the features of regional discrepancies and bifurcation of the core-periphery model (Fujita *et al*., 1999), and to examine the characteristics of the model by the proposed dynamic terms and production behavior. In this paper, we first empirically simulate the core-periphery model to investigate features of the limiting distribution of manufactures. Then we theoretically modify the production behavior to incorporate the non-market agglomeration effect into the model and empirically examine features of the spatial development process. Finally, we apply the location decision model and the Polya process to derive a dynamic process that describes how workers migrate, instead of the given *replicator dynamics* term in the core-periphery model, and to explore whether the core-periphery bifurcation and other dynamic features are sensitive to modification of the dynamic term.

2. The model

In the core-periphery model (Fujita *et al*., 1999), every consumer shares the same Cobb-Douglas tastes for the two types of goods: manufactured goods and agricultural goods. The quantity index is a subutility function defined over a continuum of varieties of manufactured goods. There are two sectors in the economy; monopolistically competitive manufacturing and perfectly competitive agriculture. The agricultural good is assumed to be produced using a constant-returns technology. Manufacturing involves economies of scale. Production of quantity q of manufacturing goods requires labor input l, as follows.

$$l_i = F + c_i q_i , \qquad (1)$$

where F indicates fixed inputs and c_i is marginal input requirement.

The optimal solutions from both consumer and producer behaviors derive four endogenous variables of each location: income, price index of manufactures, the nominal wage rate of workers, and the real wage rate (in Appendix).

Worker's migration decision mainly depends on the difference in real wages. The dynamic process used in the model is the "replicator dynamics" in the evolutionary game theory.

$$\dot{X}_i = r\left(\omega_i - \varpi\right) X_i \qquad (2)$$

where X_i describes the population share at location *i*,; w_i is the real wage at location *i*, and $\overline{w}$ is the average real wage.

2.1 The proposed production behavior

The basic force that drives spatial agglomeration in the core-periphery model relies only on market interactions, which is different from most of the existing literature dealing with causes of agglomeration. In the model, marginal input requirement c_i is constant in all locations. This assumption leads to a constant equilibrium output q and a constant equilibrium labor input l for all firms in all locations. This result implies that all scale (or market-size) effects in the model do not work through a larger market or production at a larger scale, but only work through changes in variety. In this section, we modify the production behavior to relax the limitation of the market-size effect. In the proposed production behavior, the marginal input requirement at location *i*, c_i, is assumed to be negatively related to the manufacture share X_r of location *i*. The higher the manufacture share of the location, the larger will be the agglomeration economies at the location. Consequently, equilibrium output q_r^M and equilibrium labor input l_r^M vary from location to location.

2.2 The proposed dynamic process: *Polya process* and the probability of residence choice

The dynamic process in core-periphery model (replicator dynamics) is exogenous from the evolutionary game theory. In this section, we derive a dynamic pattern based on the model to explain migration of workers. The Polya processes introduced in Arthur (2000) are based on a class of path-dependent stochastic processes. Let s_{it} describe the size of the total population of all relevant locations at time *t,* and X_{it} describe the proportion of population of location *i* at time *t*. Assume the change of population at location *i* follows the dynamic process:

$$s_{it+1} = s_{it} + z_{it}, \qquad (3)$$

where z_{it} equals one with probability P_{it}, zero otherwise.

The expected change of the location's share in total population depends on the determinate part, which contains the probability of residence choice.

$$E[X_{it+1} | X_{it}] = X_{it} + \frac{1}{(a+t)}[P_{it} - X_{it}], \qquad (4)$$

where a is the initial total population.

The utility of resident at location i, U_{it}, consists of two components: the observed part V_{it} and the unobserved part e_{it}.

$$U_{it} = V_{it} + e_{it}. \qquad (5)$$

The probability of residents preferring location i over all other locations is:

$$P_{it} = \Pr ob\{U_{it} > U_{it}, \quad for\ all \quad j \neq i\}. \qquad (6)$$

The indirect utility of resident from core-periphery model is applied to explain the choice behavior of the residents.

3. Simulation

We first examine the features of core-periphery model in a two regions experiment. In the case of more than two regions, evolution of manufacturing shares of ten locations is simulated. We simulate the model with the proposed production behavior as in Section 2.1. We apply the Polya process in Section 2.2 as the dynamic term, instead of the replicator dynamics in the core-periphery model, to examine the bifurcation features.

4. Concluding remarks

In the original core-periphery model, all manufacturers tend to be concentrated in a single core region if transport costs are sufficiently low. On the other hand, manufacturers are more dispersed if transport costs are sufficiently high. This allows for the possibility of convergence or divergence between regions, and results in bifurcation and lock-in effects in the process of spatial evolution. The market outcome is likely to depend on the initial conditions.

When manufacturers get concentrated in a region, the income level is much higher in the core location than in the periphery. The difference between income in core and periphery regions increases with the degree of agglomeration. The average income is higher in the core-periphery structure than in a dispersed pattern. The increase of regional disparities may cause impoverishment of the peripheral region. The simulated result supports the idea that agglomeration and growth reinforce each other. However, inter-regional integration may benefit only the core region, i.e. increased income of the core region may come at the expense of the peripheral region. In general, the core region benefits from agglomeration. On the contrary, the periphery is better off in a more dispersed pattern. Both transport costs and economic structures may foster agglomeration and the limiting manufacture distributions show the power law. Inclusion of non-market spatial agglomeration enhances the centripetal forces, which further leads the system to a core-periphery pattern. The states of equilibria are highly sensitive to the formulation of the dynamic process.

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