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Growth, agglomeration, and urban congestion

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ABSTRACT

We consider a microfounded urban growth model with two regions and a mass of mobile workers to study interactions among growth, agglomeration, and urban congestion. Unlike previous research in the urban growth literature, we formulate the model as a one-shot game and take an evolutionary game-theoretic approach for stability analysis. Our approach enables us to analyze stability of nonstationary equilibria in which populations of each region are not constant over time. We show that if both the expenditure share for housing and inter-regional transport cost are small, a stable stationary equilibrium does not exist. Moreover, in such a case, we show that there can exist a stable nonstationary equilibrium in which mobile workers agglomerate in one region at first but some of them migrate to the other region later. We argue that such a nonstationary location pattern is related to return migration.

1. Introduction

The purpose of this paper is twofold: to provide a microfounded urban growth model that can explain nonstationary location patterns such as return migration, and to propose an evolutionary game-theoretic method for the stability analysis of urban growth models.

As Fujita and Mori (2005) point out, analyzing urban growth models involves some technical difficulties because we must consider the additional dimension of space. In particular, a two-region model with mobile agents is usually considered and thus, the particular difficulty of this field is that we must incorporate the migration decisions of agents into a model. Indeed, the literature on urban growth models with migration is not yet well developed and although several interesting papers study this issue, they have the following two limitations:

1. analysis is focused on stationary states;
2. microfoundations for mobile agents' location choice are not clearly provided.

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Regarding the first point, most of the previous studies focus on stationary equilibria in which no mobile agent changes his location and, as a result, the populations of each region are constant over time.[1] However, spatial location patterns in a real economy are far from stationary. For example, there is a lot of evidence of *return migration* in which people return to their home countries after spending several years in foreign countries. Dustmann and Weiss (2007) illustrate that at least 32% of people migrating to Britain between 1992 and 2002 return to their home countries within 10 years of arrival. Aydemir and Robinson (2008) estimate that 37% of people migrating to Canada since 1980 left the country within 20 years of arrival. In this paper, we analytically show that there can exist a stable nonstationary equilibrium in which mobile workers agglomerate in one region at first but some of them migrate to the other region later, which is similar to these empirical observations. Moreover, we argue that focusing on stationary states might not always be innocuous, due to the strategic aspects of location choice, by showing that any stationary equilibrium is unstable in some cases.

Regarding the second point, if a growth model has mobile agents, equilibrium conditions induce a migration dynamic in addition to the usual dynamics such as Euler equations, because the agents choose location paths in addition to consumption and investment. For the model to be microfounded, the migration dynamic must come from individual decision problems. However, some of previous work in the literature abstract away from this point. For example, Baldwin and Forslid (2000) and Bond-Smith (2012), who consider dynamic extensions of new economic geography (NEG) models originated from Krugman (1991a), assume ad hoc dynamics for the equilibrium migration dynamic. Although they give useful insights into interactions between growth and economic geography, their models are not fully microfounded because they do not provide individual decision problems that give rise to their migration dynamics.

In this paper, we emphasize the strategic aspects of location choice and formulate the model as a one-shot game in which the mobile agents simultaneously choose their lifetime location schedules.[2] Payoffs for each location schedule are lifetime utilities derived from a dynamic NEG model and we characterize the mobile agents' Nash equilibrium strategies for their location paths. Thus, our equilibrium concept naturally extends that of static geography models, and equilibrium location paths come from the following individual decision rule: each mobile agent chooses a location path so that it is a best response to the aggregate path of population distributions induced by all other peoples' strategies. Although most of work in the urban growth literature does not explicitly address the strategic aspects of location choice, Fujita and Thisse (2003), who also consider a new economic geography and growth model, look at Nash location strategies focusing on stationary equilibria. However, because they exploit stationarity when characterizing equilibria, it is not clear whether their argument can extend to nonstationary cases.[3]

Another important purpose of this paper is to propose a simple evolutionary game-theoretic approach for stability analysis of urban growth models. Because we obtain a migration dynamic induced by equilibrium, it might be reasonable to use it for stability analysis. However, it is generally difficult to derive a smooth dynamic explicitly by aggregating individual equilibrium strategies. Indeed, we argue that stability analysis of the previous work in the literature is not completely sound from the technical point of view. Baldwin and Forslid (2000), for example, use a smooth "equilibrium" migration dynamic for stability analysis, but, as we point out, their dynamic is not founded on individual decision problems. Fujita and Thisse (2003) could derive a migration dynamic from individual decision problems *under the assumption that the economy monotonically converges to a target stationary state* and they use that dynamic for stability analysis.[4] Although their dynamic is not ad hoc, a technical problem arises in their stability analysis due to the strong assumption they need to derive the dynamic. In particular, because the assumption is exactly what they need to show stability of stationary equilibria, we argue that some of their argument for stability analysis is not really correct.[5]

In view of the difficulties above, we do not use an equilibrium migration dynamic. Instead, we introduce an evolutionary dynamic for the one-shot game in which mobile agents simultaneously choose their location paths, and conduct stability analysis of the game's Nash equilibria with that dynamic. That is, we employ the standard evolutionary game-theoretic method for equilibrium selection. Although an evolutionary dynamic is also used in static NEG models, its role is quite different there. In the case of static NEG models, it is possible to interpret the equilibria of the base model as *short-run* equilibria while interpreting (stable) rest points of evolutionary dynamic as *long-run* equilibria because the base

[1] See, for example, Fujita and Thisse (2003) and Peng et al. (2006).

[2] It might be more realistic to consider a dynamic game in which the mobile agents choose their locations period-by-period. However, because we consider a game with a continuum of players as in NEG models and hence, each player is negligible, it follows that the set of equilibrium outcomes will not change even if we consider such an extensive-form game.

[3] There are several other works that consider multi-regional growth models with mobile agents. Walz (1996) assumes that all final goods are freely traded and mobile workers can freely move, and, as a result, prices, including wage, are equalized between regions in every period. Therefore, space does not matter at all for mobile workers and a spatial configuration is completely determined by supply-side factors. In our model, prices are not necessarily equalized between regions due to the existence of trade and migration costs, and the location decisions of mobile workers play an important role for equilibrium outcome. Black and Henderson (1999) consider a system of cities under an endogenous growth framework. They consider "dynastic families" that allocate members of the family across cities. Hence, the decision makers in their model are like small-scale social planners. In our paper, we are interested in the situation where each individual decides his location path. See also Berliant and Wang (2004) for a survey of this field.

[4] See also Chapter 11 of Fujita and Thisse (2002).

[5] Under their definition, a stationary equilibrium is stable if in any neighborhood of the equilibrium, there exists an equilibrium path that monotonically converges to the equilibrium. They try to prove this by showing that the system of equilibrium dynamics has a solution (see p. 429 of Fujita and Thisse, 2002). However, the system includes the migration dynamic and it is obtained under the assumption that an equilibrium path monotonically converging to the stationary equilibrium exists. Thus, for their argument to go through, they must assume what they want to show.