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A cointegration analysis of dynamic externalities

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ABSTRACT

This paper presents a cointegration analysis on the effects of dynamic externalities upon economic growth using time-series data from 1975 to 2003 on the one-digit industries of the Tokyo metropolitan area in Japan. Some new time-series econometric methods that have been recently developed to conduct unit root and cointegration tests are used in the analysis, allowing for an endogenously determined structural change in the time period studied. It also proposes a new type of dynamic externalities, called Network dynamic externalities, to represent knowledge spillovers resulting from the whole agglomerated area via transportation networks, and shows that they have cointegrated relations with the total factor productivity (TFP) of the manufacturing, finance, wholesale and retail trade, as well as the overall industries. In addition, evidence is also found that Marshall–Arrow–Romer (MAR) dynamic externalities, which are associated with own industrial production concentration, affect the TFP of most industries selected for estimation. However, Jacobs dynamic externalities, which are represented by the diversity of industrial production, only contribute to the TFP of the services industry, and Porter dynamic externalities, which are expressed by the competitiveness within industries, do not influence the selected industrial TFP.

1. Introduction

Recent endogenous economic growth theories (Romer, 1986; Lucas, 1988) argue that economic growth can result endogenously from technological progress, which is brought about mainly through knowledge spillovers. Such knowledge spillovers are most likely to occur when firms of one or different industries agglomerate to a limited urban area. The resulting agglomeration economies are called dynamic externalities, which are considered as an engine of economic growth (see Glaeser et al., 1992; Henderson et al., 1995).

So far, there have been a large number of empirical works concerning the effects of dynamic externalities on economic growth using cross-sectional and/or panel data on cities. But, the analysis of time-series data on dynamic externalities has not been attempted. Given that dynamic externalities and economic growth are both a matter of time, it is important to investigate their temporal structures through a time-series analysis (see Audretsch and Feldman, 2004). Furthermore, the existing empirical literature on dynamic externalities usually classifies them into three types. That is, Marshall–Arrow–Romer (MAR) externalities, which concern knowledge spillovers among firms in one industry, Jacobs externalities, which are associated with knowledge spillovers resulting from the diversity of industries, and Porter externalities, which refer to knowledge spillovers caused by competition within industries (Glaeser et al., 1992). This classification is obviously based on the viewpoint of industrial scope. However, there could be other types of dynamic externalities from other scopes, for example, from a geographic scope (Rosenthal and Strange, 2004). Hence, it is meaningful to propose some new types of dynamic externalities and to test their impacts on economic growth.

To this end, the purposes of this paper are twofold. One is to conduct a time-series analysis of the effects of dynamic externalities on economic growth. In particular, since the time-series analysis involves specific methods and techniques, the paper will focus on a cointegration analysis of dynamic externalities as a first step of research in this direction, to investigate whether dynamic externalities have a cointegrated relation with the total factor productivity (TFP) in different industries. The second aim of this paper is to propose a new type of dynamic externalities, called Network dynamic externalities, and to test its effects on industrial TFP. Here, Network dynamic externalities are defined from a geographic scope, representing knowledge spillovers resulting from the whole agglomerated area via transportation networks. They involve not only the externalities relating the industrial activities but also those occurring outside of the field of industries, which differ from the existing three types of dynamic externalities classified by Glaeser et al. (1992).

Using several new time-series econometric methods that have been recently developed to conduct unit root and cointegration

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tests allowing for an endogenously determined structural break (change), we obtained some interesting results regarding dynamic externalities that differ from the existing literature. Especially, we find that the proposed Network dynamic externalities have cointegrated relations with the TFP of the manufacturing, finance, wholesale and retail trade, as well as the overall industries. For the existing three types of dynamic externalities, we discovered that MAR externalities affect the TFP of most industries selected for estimation. However, Jacobs externalities only have a cointegrated relation with the TFP of the services industry, and Porter externalities have no relationship with the selected industrial TFP.

This paper is organized as follows. The next section provides a more detailed review of recent empirical studies on dynamic externalities. Section 3 presents a basic model to estimate the effects of dynamic externalities on TFP and describes the data required. Section 4 explains the time-series econometric methods used in the estimation, and Section 5 presents the estimated results and the related discussions and interpretations. Finally, Section 6 summarizes the study.

2. Review of recent empirical studies on dynamic externalities

Since the 1990s, there have been a growing number of empirical studies on dynamic externalities. Among them, the paper of Glaeser et al. (1992) is a seminal one. It classifies dynamic externalities into three: Marshall–Arrow–Romer (MAR), Jacobs, and Porter dynamic externalities. It also uses data on the industrial employment growth in 170 SMAs in the US to estimate their effects, and finds some evidence of Jacobs and Porter dynamic externalities, although nothing about MAR dynamic externalities are observed.

Henderson et al. (1995) use a dataset on the employment growth of manufacturing industries in 224 metropolitan areas of the US to study the effects of MAR and Jacobs dynamic externalities, but do not mention Porter dynamic externalities. They find empirical evidence of both MAR and Jacobs dynamic externalities. Especially, they indicate that MAR externalities exist in mature capital goods industries, while both MAR and Jacobs externalities are present in new high-tech industries. Later, Henderson (1997) uses panel data to investigate capital goods industries of the US further and confirmed that there is a strong effect of MAR externalities and a weak effect of Jacobs externalities in those industries. Moreover, he also points out that there was a time-lag structure within MAR externalities, which means that their effects on the employment growth are persistent over time. Recently, Henderson (2003) utilizes panel data on the US's high-tech industries to examine the effects of dynamic externalities on the total factor productivity. He finds some evidence of MAR externalities with a time-lag structure, but could find nothing indicating Jacobs externalities in any form.

In the 1990s, most of the empirical studies on dynamic externalities used employment growth as an indication of economic growth. Dekle (2002) points out that this approach neglects the growth of capital stocks, and such omission of key variables will cause a serious bias in estimation. He suggests that this difficult issue can be avoided when the growth of total factor productivity (TFP) is used to represent economic growth. In his paper, the effects of dynamic externalities on TFP are estimated, using Japanese prefectural data on four one-digit industries, i.e., finance, services, wholesale and retail trade, and manufacturing. He shows that there are no dynamic externalities of any types in manufacturing, while there are strong MAR externalities but no Jacobs or Porter externalities in finance, and that there are some MAR and Porter externalities but no Jacobs externalities in the services, and wholesale and retail trade industries in Japan.

Most recently, Bun and Makhloufi (2007) use panel data on Morocco's cities and industries to estimate the effects of dynamic externalities on the growth of both employment and productivity. They apply an autoregressive distributed lag model (ADL) in order to incorporate a time-lag structure into the estimation. They find that while MAR and Jacobs externalities have positive effects on both employment and productivity growth, Porter externalities have negative impacts. In a survey paper on the recent empirical literature of productivity and wage growth, Henderson (2007) emphasizes the importance of understanding the mechanisms of knowledge spillovers, which could involve networking, R&D, and advertising.

It seems that the empirical evidence found so far depends to a large extent upon what kinds of dynamic externalities were considered and what kinds of estimation methods were used. For example, MAR externalities are shown to have impacts on economic growth that differ from Jacobs and Porter externalities. Even for a single type of dynamic externalities, the effects on the manufacturing and services industries or on the capital goods and high-tech industries within manufacturing vary greatly. More importantly, empirical works using cross-sectional data gave different results from those that also assume a time-lag structure. These features of the existing literature suggest that there are at least two issues that need to be investigated further.

The first issue is that the existing classification of dynamic externalities does not adequately encompass their implications. As a matter of fact, the existing three types (MAR, Jacobs, and Porter) mainly concern only the industrial scope of dynamic externalities. That is, they are classified only in accordance with how knowledge spillovers occur within one industry and/or among different industries. In reality, however, knowledge spillovers are not limited to industries only. In fact, when people live or stay within a geographically limited area, knowledge spillovers will occur among them, and dynamic externalities will result. Knowledge spillovers and dynamic externalities should have a geographic scope (Rosenthal and Strange, 2004; Audretsch and Feldman, 2004). There could be other types of dynamic externalities to be added to the existing classification scheme.

As Rosenthal and Strange (2004) mention, Ciccone and Hall (1996) and Ciccone (2002) indicates that regional labor productivity is dependent upon employment density. Dekle and Eaton (1999) find that an increase in activity across all of Japan increases productivity in any prefecture. Rosenthal and Strange (2001) provide evidence that agglomeration economies attenuate across geographic space. These works suggest the importance of the geographic scope that dynamic externalities possess. Unfortunately, they do not show why and how the geographic scope matters. In our opinion, knowledge spillovers among people occur mainly through networks of transportation, which are an importance source of dynamic externalities. To represent this type of dynamic externalities, in this paper, we propose a new concept called Network dynamic externalities, which can be used to clarify the geographic scope of dynamic externalities, mentioned by Rosenthal and Strange (2004).

Secondly, nearly all of the existing empirical studies on dynamic externalities are based on cross-sectional and/or panel data analyzed with traditional econometric methods. Henderson (1997, 2003), and Bun and Makhloufi (2007) notice that there is a temporal aspect of dynamic externalities, and introduce a time-lag structure into their analysis in order to deal with it. But, since they do not use time-series data and advanced time-series analysis techniques, their treatment of the dynamism of dynamic externalities is not sufficient. In fact, given that dynamic externalities affect economic growth, it seems intuitive that there is a relationship between the externalities and growth, which is persistent or stationary over time. Obviously, their papers do not consider this issue. To examine such a stationary relationship, time-series data must be used and analyzed through the application of advanced time-series econometric methodologies.