Relocation of manufacturing industry from the perspective of transport accessibility – An application of percolation theory

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ABSTRACT

Industrial relocation patterns has become one of the central issues for sustainable development of economics. In order to analyze the relocation patterns of manufacturing industries from the perspective of transport accessibility, this study took the electronic and information industry in the Yangtze River Economic Belt as an example to analyze the relocation patterns of manufacturing industries in China. Considering the transportation factors and economic factors, a topological network of Yangtze River Economic Belt was constructed. Based on this network, the relocation patterns of manufacturing industry both at present and in the planning period were analyzed by percolation theory. And results show that: first, percolation transitions exists during the process of industry relocation. Cities located in border regions are the bottlenecks for industry relocation. Second, both improvements in transport accessibilities and increase of production costs accelerate the process of industrial relocation in "fly-in" mode. Finally, preferential policies are needed for provinces in the upper reaches Yangtze River Economic Belt to attract industrial relocation.

1. Introduction

Since the Reform and Open Policy, China has been enjoying continuous economic growth. Particularly, the eastern coastal regions of China have reached economic standards that match those of moderately developed countries. In order to accelerate and coordinate the future development of its regional economies, in 2013, the Yangtze River Economic Belt, together with "One Belt and One Road", and the Collaborative Development of Beijing-Tianjin-Hebei, were proposed as three important national strategies.

The Yangtze River is the most important east-west axis of urban development in China. It holds a key strategic position in the development of the regional economies. Relying on the Yangtze River, the Economic Belt covers 9 provinces and 2 municipalities, stretching from the west to the east. Although this region is one of the strongest in China, the upper, middle and lower reaches of the Yangtze River differ considerably in their economic development. The upper and middle reaches are still largely undeveloped areas with incomplete infrastructures and fluent labor, while the lower reaches of the Yangtze River belong to the most developed regions of China. However, based on the advantages of inland waterway system, the Yangtze River Economic Belt is expected to become a new core area that carries much of the growth of China's economy.

Considering the anticipated role of the Yangtze River Economic Belt, China's central government released "Guidelines on the Development of the Yangtze River Economic Belt based on the Golden Waterway" (hereafter referred as "Guidelines") in 2014. And the "Outline of the Yangtze River Economic Belt Development Plan" (hereafter referred as "Plan") appeared later in 2016 to accelerate the development of the Yangtze River Economic Belt. According to both the Guidelines and Plan, an efficient and integrated transportation corridor is required to support economic development, relocate manufacturing industries westwards, upgrade the industry in the lower reaches of the river and stimulate economic agglomeration inland. Using the Yangtze River as the backbone, the policy document "Planning of an Integrated Transportation Corridor in the Yangtze River Economic Belt (2014–2020)" was released together with the Guidelines to improve accessibility and accelerate industrial upgrade and relocation in the Yangtze River Economic Belt. In other words, transport investment and policy is seen as the engine of regional economic growth and spatial diversification.

Several scholars (Liu and Hu, 2010; Zhang et al., 2011; Zhang, 2012) have casted doubt on the effectiveness of the stipulated policies, arguing that imperfect accessibility of inland regions strongly hinders the development of regional economies. What is more, most manufacturing industries that agglomerated in the coastal provinces are labor-intensive

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or process natural resources. Consequently, these industries may be reluctant to relocate to the west with currently less skilled labor and away from the natural resources, increasing transportation costs. In addition, while improved accessibility within the Yangtze River Economic Belt will reduce transportation costs and other production factors, without guiding policies inland cities may be trapped in blind competition and the construction of redundant new infrastructure for industrial relocation. Thus, to support either view, it is relevant to understand the diffusion process of manufacturing industries in the lower reaches to the upper and middle reaches of Yangtze River as a function of accessibility-related factors. What are the spatial characteristics of the relocation process? What bottlenecks affect their relocation?

To give an answer to these questions, this study applies percolation theory to analyze the relocation characteristics of the electronic and information industry. We assert that percolation theory may offer new perspectives on the problem compared to conventional economic analyses, which did not reach a consensus. Percolation theory focuses on phase transitions and bottlenecks, a perspective not offered by conventional location theories. The electronic and information industry is taken as an example because it is one of the five important manufacturing industries being motivated to relocate inland by China's central government.

The remainder of this paper is structured as follows. Section 2 reviews the relevant literature to position the current study into the context of earlier theoretical and empirical studies about the topic. In Section 3, we introduce percolation theory. Section 4 describes the data collection. The percolation process and its characteristics for the electronic and information industry in the intra-Yangtze River Economic Belt are analyzed in Section 5. The paper is completed with a summary and conclusions.

2. Literature review

Industrial location is a major topic in economic geography and regional economics. Over the years, an abundant amount of theoretical and empirical work has increased our knowledge and understanding of factors influencing the location and relocation of different types of firms. The huge amount of both theoretical and empirical studies on industrial location can provide an analytical framework and theoretical background for the study of industrial relocation.

Different theoretical frameworks, ranging from neoclassical theory (new economic geography) (e.g., Harris, 1954; Krugman, 1991; Venables, 1996; Fujita et al., 1999; Frenkel, 2001; Guimaraes et al., 2004; Lanaspa et al., 2008; Dewit et al., 2013; Zeng, 2016), behavioral theory (e.g., Calton, 1979; Guimaraes et al., 2000; Figueiredo et al., 2002; Arauzo and Manjon, 2004; Head and Mayer, 2004; Holguin-Veras et al., 2005; Kronenberg, 2012; Artal-Tur et al., 2013; Hou, 2016) and institutional theory (e.g., Papke, 1991; Gabe and Bell, 2003; Grosse and Trevino, 2005; Brown, 2011; Buckley et al., 2012) have been developed to explain industrial location patterns, elaborating or providing alternatives to classical industrial location theory (Weber, 1929) and market location theory (Losch, 1954), which were based on the minimization of transportation cost under isotropic conditions.

Based on these three types of location theories, many empirical studies have investigated the factors influencing industrial location. Moreover, several reviews have been completed. Arauzo et al. (2010) summarized 45 empirical studies in terms of methods used and substantive findings. Results showed that both discrete choice models and count data models have been mainly used. As for influential factors, both neoclassical factors (agglomeration economies, transport infrastructures, human capital characteristics (mainly wage and education)) and institutional factors (taxes, environmental regulations and incentive programs for new business) showed significant effects, while the effects of behavioral factors were more diversified due to data availability and the small number of studies. Jiang (2012), reviewing 115 studies, concluded that although the significance of location factors differed between studies, eight important determinants can be identified: transport accessibility, labor costs, land rent, raw materials, market scale,

supplemental facilities, preferential policies and technology innovation. Six of these determinants were related to production costs.

Only a few empirical studies investigated industrial relocation. Molle (1977) analyzed the reasons underlying firm relocation in Amsterdam, and found that limited development space and transport congestion were two of the most important determinants. Dijk and Pellenbarg (2000), Brouwer et al. (2004), Holl (2004), Manjon and Arauzo (2011) collected province-level or municipality-level data, and compared the differences in the determinants of start-ups and relocations. Their results showed that although there were no differences in the determinants of both start-ups and relocations, their partial or marginal effects differed. Later, Wang (2013) reviewed the literature on industrial relocation in China. He concluded that the Chinese studies lacked innovation in quantitative measurements of industrial relocation. Due to the lack of appropriate data, most studies were qualitative in nature. Only a handful of quantitative studies analyzed relocation trends of manufacturing firms using province-level statistical data or survey data (e.g., Chen, 2002; Zhou et al., 2015; Xue, 2016; Teng et al., 2016). According to their results, although factors of industrial relocation differed, the relocation trends of manufacturing industries in coastal regions are westward (or inland-oriented). Both location factors and supporting policies of inland cities will impact on relocation patterns of manufacturing industries.

Reflecting on these theories and the results of empirical studies, it seems that particularly the traditional focus on location factors should allow assessing the new policies. General support of policies and regulations are expected to be positive. As long as the demand for the manufacturing industry continues, increasing lack of space and rising production costs will be strong push factors for industries to consider relocation. Simultaneously, lower production costs in the west are the key pull factors. Thus, the most critically factors turning the policies into a success are the balance between supply and demand, together with accessibility by different transport modes.

Another issue concerns the impact of infrastructure on the regional economy. Again, mixed opinions can be found in the literature. A series of studies has endeavored to investigate the effects of infrastructure on regional economic development. Infrastructure capital usually includes transport-related facilities, water and waste water treatment facilities, telecommunications, and energy generation, transmission and distribution. According to Rietveld (1989), infrastructure was mainly considered as a production factor, a location factor and a factor (transportation infrastructure) of interregional trade flows. Later, Straub (2011), reviewing studies on infrastructure and development from the macro-level, concluded that due to data availability, the impact of infrastructure on regional development has become the study hotpot. Melo et al. (2013) argued that the effect of infrastructure on economic development varies across industry groups and transport modes. Combined with the results of other empirical studies (Cohen, 2010; Hong et al., 2011; Riccardo and Rodríguez-Pose, 2012; Pradhan and Bagchi, 2013; Baker et al., 2015; Crescenzi et al., 2016), mainly panel data models were employed to investigate the economic impacts of transport infrastructure.

Transport infrastructure, acts as a location factor and its development will decrease production costs for the manufacturing industries. Different infrastructure investment plans of the provinces and municipalities in the Yangtze River Economic Belt will not only impact the diffusion process of industrial relocation (relocation scales of manufacturing industries in each region), but also the diffusion patterns of industrial relocation (patterns of agglomerative relocation, bottleneck cities, etc.). However, mainstream approaches cannot be employed to investigate these two types of diffusion characteristics, in part because they lack the essential mechanism to explain diffusion and in part due to the unavailability of empirical data.

As an alternative, we apply percolation theory in this paper to analyze the relocation patterns and characteristics of the electronic and information industry in the Yangtze River Economic Belt. Production factors that relate to accessibility are considered to compare the dynamic process and pattern of industrial relocation. We attempt to shed lights on the problem and suggest policies for local governments on infrastructure