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AGGLOMERATION

Tomoya Mori

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Tomoya Mori*,†

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Abstract

This article provides a review of selected researches on the mechanism, spatial scale and spatial distribution of economic agglomeration. It starts with a classification of the existing models of agglomeration in terms of the sources of agglomeration force suggested by the Spatial Impossibility Theorem by Starrett (1978). It then discusses the tension between economies and diseconomies of agglomeration. Finally it briefly touches on the measures of agglomeration and dynamic aspect of agglomeration.

Keywords: Agglomeration, Economic geography, Impossibility Theorem

*Institute of Economic Research, Kyoto University, Yoshida-honmachi, Sakyo-ku, Kyoto 606-8501, Japan. E-mail: mori@kier.kyoto-u.ac.jp

†Research Institute of Economy, Trade and Industry, 11th floor, Annex, Ministry of Economy, Trade and Industry (METI) 1-3-1, Kasumigaseki Chiyoda-ku, Tokyo, 100-8901 Japan.

Agglomeration of economic activities is the phenomenon that has been observed since the human shifted from migratory life to sedentary life after the spread of farming throughout. Urban agglomeration still continues today. According to United Nations (2015), urban share of the world population has increased from less than 30% in 1950 to 54% in 2014. The shares are higher in more developed regions: e.g., 79%, 81% and 93% in Western Europe, the US and Japan, respectively. This article provides a review of selected researches on the mechanism and spatial scale of economic agglomeration.

Starret's Theorem Consider a closed economy with positive transport costs for products but with no relocation costs for agents. Then, there is no competitive equilibrium involving transportation of goods, if location space is homogeneous, and complete markets exist for all goods everywhere. The only equilibrium possible under these conditions is characterized by the autarky at each location. This result was established by Starrett (1978) and is known as the *Spatial Impossibility Theorem* (Fujita, 1986, p.127). It essentially means that the formation of agglomeration must be associated with at least one of the followings: (*i*) heterogeneous location space, (*ii*) increasing returns to scale or indivisibility, (*iii*) non-market spatial externalities, and (*iv*) imperfect competition.

Mechanism Agglomeration due to exogenous heterogeneity of location space (type, *i*) is theoretically trivial, though empirically relevant. It happens, for example, under the comparative advantage of locations, while otherwise retaining the competitive paradigm.

Models of type (*ii*) typically assume scale economies in market formation accounting for agglomeration of producers and consumers who are otherwise dispersed due to the heterogeneity among locations in terms of comparative advantage and/or preference (Berliant and Wang, 1993; Berliant and Konishi, 2000; Konishi, 2000).

Most models for the formation of business districts within a city belong to type (*iii*) (e.g., Solow and Vickrey, 1971; Beckmann, 1976; Fujita and Ogawa, 1982), where local spillovers among firms are assumed to generate positive production externalities (see Fujita and Smith, 1990, for a survey of this class of models). Spillovers induce knowledge creation and diffusion. Empirical evidence suggests that this effect is greater in a larger city (e.g., Glaeser and Maré, 2001; Bacolod et al., 2009; Gould, 2007). Microeconomic models for this type are still under development, where the series of papers by Berliant and Fujita (e.g., 2008, 2012) have been pioneering the formalization of knowledge creation mechanism building on Berliant et al. (2006).

Models of type (*iv*) are abundant, and include a wide variety of *market pooling* models. *Spatial oligopoly* models explain the agglomeration of retail stores (e.g., Wolinsky, 1983; Dudey, 1990; Konishi, 2005). In these models, consumers have imperfect information on the types and prices of goods sold by stores before they visit them. The greater the agglomeration of stores, the more likely it is that consumers will find their favorite commodities. The concentration of stores is explained by the market-size effect due to taste uncertainty and/or lower price expectation.

A variety of *matching externalities* are modeled in the context of labor market (e.g., Kim, 1990, 1991; Helsley and Strange, 1990; Combes and Duranton, 2006), capital market (Helsley and Strange, 1991), and the adoption of production technologies (Helsley and Strange, 2002; Duranton and Puga, 2001). Andini et al. (2013) show evidence on the positive effects of matching and learning, and negative effects of poaching due to labor market pooling.

Type (*iv*) also includes *the new economic geography* (NEG) initiated by Krugman (1991c,a); Fujita (1993). In these models, pecuniary externalities based on product differentiation and plant-level scale economies play the key role. On the one hand, consumers love for variety, so that their utility level is higher in a city offering a wider variety of products, *ceteris paribus*. On the other hand, each firm has an incentive to produce a differentiated good, since its production exhibits increasing returns. In the presence of transport costs, the concentration of consumers and that of producers induced each other (see, e.g., Fujita et al., 1999, for formulations of this mechanism).

Finally, much less explored, but an important cause of economic agglomeration is scale econoimes in transportation. Advantages at the vertices of transport network has been recognized by the work of Hakimi (1964). But, the structure of the network is largely endogenous subject to *density* and *distance economies in transportation*. Mori and Nishikimi (2002) explained the industrial agglomeration triggered by the formation of a transport hub in the presence of economies of density, while Mori (2012) explained the formation of hubs and trunk links on a continuous location space in the presence of both density and distance economies. Ample evidence indicates the positive association between the centrality in transport network and population agglomeration (e.g., Haines and Margo, 2006; Duranton and Turner, 2012; Green, 2007).

Though the formation of a major city typically accrues from the first nature advantage (e.g., the location of a natural port), such a city often continues to prosper even after the original advantage of the location disappeared. That is, the agglomeration is *locked in* at its initial location due to the second nature advantage of agglomeration externalities. Bleakley and Lin (2012) showed evidence of such *path dependence* for the fall line cities in the US, Redding et al. (2011) for Frankfurt after the fall of Berlin Wall, and Michaels and Rauch (2013) for the Roman-era cities in France.

Spatial Scale Economies of agglomeration are eventually dominated in large cities by diseconomies, which may lead to the formation of new agglomerations or to the sprawl of individual agglomerations, depending on the tension between these two forces. Thus, both economies and diseconomies of agglomeration play roles in determining the spatial distribution as well as the spatial scale of agglomerations.

While there are a variety of theories offering mechanisms of agglomeration as overviewed above, many of them abstract from their spatial scale, by adopting a two-region setup or *the systems-of-cities* model by Henderson (1974), in which the economy consists of many “floating” cities among which products are either freely tradable or completely non-tradable.

The many-region setup of NEG is one of the few frameworks capable of addressing spatial scale of agglomeration. It suggests that both agglomeration and dispersion may occur at both *global* and *local scale*. On the one hand, the spread of consumers (due to, e.g., the presence of land-intensive production) results in the dispersion of establishments over the inhabited location space (*global dispersion*), whereas the agglomeration still takes place at the local scale (*local aggomeration*)(e.g., Akamatsu et al., 2012). On the other hand, dispersion due to urban costs (e.g., land rent for housing and congestion costs) takes the form of sprawl (*local dispersion*) of individual agglomerations (Akamatsu et al., 2015). Lower transport costs for urban products (relatively to land-intensive rural products) would result in the formation of *an industrial belt*, a continuum of agglomerations, where agglomeration takes place globally toward the belt (*global agglomeration*), while there is *local dispersion* along the belt. This is a typical form of urbanization observed along the trunk route of road and railway network connecting major cities, e.g., the Atlantic seaboard of the US stretching from Boston to Washington, D.C. (Mori, 1997). Mori and Smith (2015) showed evidence for these patterns for industrial agglomerations in Japan.

Other dispersion forces include *price competition* which works against the market pooling of firms in the same industry (e.g., Konishi, 2005; Ottaviano et al., 2002; Behrens and Murata, 2007). Combes and Duranton (2006) shows the negative externalities of labor market pooling under the *poaching* possibility.

Empirical evidence suggests that agglomeration effects attenuate within the 40-60km range, the typical size of a metropolitan area (e.g., Duranton and Overman, 2005; Mori and Smith, 2015). But, certain networking interactions in, e.g., advertisement industries and research and development, are found to be localized within a few kilometers range (e.g., Rosenthal and Strange, 2008; Kerr and Kominers, 2015; Arzaghi and Henderson, 2008; Buzard et al., 2015).

Measures Ellison and Glaeser (1997) initiated the quantitative analysis of industrial agglomeration by proposing a model-based scalar measure building on the Hirschman-Herfindahl index (Hirschman, 1945; Herfindahl, 1950). Among others, Duranton and Overman (2005) proposed a scalar measure based on the density of bilateral distances among establishments, while Mori et al. (2005) built on Kullback and Leibler (1951) divergence measure.

But, like the two-region setup in the theoretical models, these aggregate measures suffer from abstraction of spatial scale of agglomeration. In particular, the response of these measures to the changes in parameter values depends on the relevant spatial scale (Mori and Smith, 2015).

There are a few measures which are explicit about spatial scale of agglomeration. Mori and Smith (2014) proposed a statistical clustering approach to identify all the individual agglomerations of each industry on a map. Buzard et al. (2015), by building on the Ripley (1976)'s *K-function*, proposed a measure of the spatial scale of an individual agglomeration. Behrens et al. (2015) use a similar measure of local agglomeration.

Dynamics There are suggestive evidence for dynamic effects of agglomeration economies (e.g., Glaeser et al., 1992; Glaeser and Maré, 2001; Dumais et al., 2002; De la Roca and Puga, 2013). But, theories are yet to be developed. A few models of NEG explained the role of history and expectation in agglomeration (e.g., Krugman, 1991b; Ottaviano, 2001; Oyama, 2009). In particular, Oyama (2009) argues that the unique full-agglomeration equilibrium is a robust outcome under forward-looking behavior and asymmetry between the regions. But, again, his two-region setup obscures the implication of this result: it is not clear what the "full-agglomeration" in a two-region economy corresponds to in a many-region economy. Fujita and Thisse (2003) provided an initial assessment on the relation between agglomeration and innovation by combining the NEG model and the endogenous growth model by Grossman and Helpman (1991).

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