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MONOCENTRIC VERSUS POLYCENTRIC MODELS IN URBAN ECONOMICS

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MONOCENTRIC VERSUS POLYCENTRIC MODELS IN URBAN ECONOMICS

This article overviews the development of the formal modelling framework for the urban spatial structure which started in 1960s and grew dramatically thereafter. Modelling in the 1970s focused on the endogenous formation of the central business district within a city. Then richer polycentric city models were developed in 1980s, where the number, location and spatial extent of the business districts are determined endogenously. The emergence of the new economic geography in 1990s provided a framework capable of explaining the spatial distribution of cities (rather than the business districts within a city) and their industrial structure in a general location-equilibrium model.

The formal modelling of urban spatial structure originated in the monocentric city model by Alonso (1964). The model was extended to include production, transportation and housing by Mills (1967; 1972) and Muth (1969), and was eventually integrated into a unified framework by Fujita (1989). In these traditional models, the city is a priori assumed to be monocentric, that is, all production activities within a city are supposed to take place in a point representing the *central business district* (CBD), and all workers living in the surrounding area are supposed to commute to the CBD. The success of this model is primarily due to its compatibility with the competitive paradigm, since the existence of the CBD is a priori assumed. In order to explain the urban morphology, however, it is essential to endogenize the CBD formation. For this purpose, Fujita (1986) provided a very useful insight based on the spatial impossibility theorem of Starrett (1978): in order to have endogenous formation of economic agglomeration, the model must have at least one of the following three elements: (*a*) heterogeneous space, (*b*) non-market externalities in production and/or consumption, and (*c*) imperfectly competitive markets.

The approach based on (*a*) explains the formation of the CBD by *comparative advantage* among locations, while otherwise retaining the competitive paradigm. One of the earliest such attempts was made by Schweizer, Varaiya and Hartwick (1976).

Most models of type (*b*) are based on *externalities from non-market interactions*. The earliest attempt was made by Solow and Vickrey (1971). In the one-dimensional location space, they considered the optimal allocation of urban land between business areas and roads when each unit of business area is assumed to generate a given number of trips to every other unit. But the first model of residential land use of this type is by Beckmann (1976), where the utility of each individual directly depends on the average distance to all other individuals and the amount of her land consumption. This preference leads to a *bell-shaped spatial population distribution as well as land rent curves*, where the CBD is represented by a densely inhabited area around the central location.

While Beckmann, Solow and Vickrey considered only a single type of agents (firms or consumers), Ogawa and Fujita (1980) and Imai (1982) developed two-sector monocentric models of a one-dimensional city. The dispersion force in this case is generated through land and labour markets. That is, the agglomeration of firms increases the commuting distance for their workers on average, which in turn pushes up the wage rate and land rent around the agglomeration, and this higher cost of labour and land discourages further agglomeration of firms. The most recent contribution along this line is by Lucas and Rossi-Hansberg (2002), who formally demonstrate the existence of an equilibrium and the endogenous formation of the CBD.

In the endogenous monocentric models discussed so far, the optimal distribution of firms requires greater concentration near the centre than does the equilibrium distribution. The reason is the locational externality generated by individuals: while the location of each individual directly affects the travelling cost for others to make contact with this individual, it is not taken into account when each individual makes a location decision.

Building on Ogawa and Fujita (1980), the first model of a *polycentric city* was developed by Fujita and Ogawa (1982). Their key assumption is that the benefit from interactions between two firms is a negative exponential function of the distance between them, unlike the linear dependence in previous models. When commuting costs are relatively high, this assumption leads to the formation of *multiple business districts* and the possibility of *multiple equilibria*.

The first urban economic model based on (*c*) is by Fujita (1988). His model demonstrated that pure market interactions alone can explain the agglomeration of economic activities with the use of the Chamberlinian monopolistic competition model. The agglomeration force is generated from the interaction among preference for product variety, transport costs, and increasing returns at the level of individual producers. In this model, the city may be monocentric or polycentric. Also it is possible that business and residential districts are mixed. These works were critical for the emergence of *the new economic geography* (NEG) in the 1990s (Krugman, 1991a; 19 91b; Fujita, 1993).

In the application of the NEG to urban economics initiated by Fujita and Krugman (1995), there are two key features. The first is the *general equilibrium modelling of an entire spatial economy* unlike all the models presented so far. The second is its focus on *the spatial distribution of cities,* while abstracting from the intra-city spatial structure. In particular, it is assumed that mobile firms and workers do not occupy land, so that an agglomeration of firms and population, that is, a city, forms at a point on the continuous location space. The second feature dramatically increases the tractability of the model. The agglomeration force in this model is essentially the same as in Fujita (1988), while the dispersion force is generated from the presence of immobile resources through transport costs between cities and non-city locations. The key to this approach is the recognition that the profitability of any given location for a firm can be represented by an *index of market potential*. The market potential at a given location reflects the trade-off among the proximity to consumers, the degree of competition, and the production cost at that location. In particular, the market potential of a given industry sharply decreases when it moves away from a city in which this industry is agglomerated, and then starts increasing again after a certain distance, exhibiting the presence of an *agglomeration shadow*. Differences in the degree of product differentiation and/or transport costs among industries lead to differences in the size of the agglomeration shadow, which in turn result in variations in the (roughly constant) spacing of agglomerations among industries (Fujita and Mori, 1997). In the presence of multiple industries, the *inter-industry demand externalities* lead to a formation of *hierarchical city systems* (Fujita, Krugman and Mori, 1999). This is reminiscent of Christaller (1933): the set of industries found in a smaller city is a subset of those found in a larger city.

Furthermore, the relative decrease in transport costs for urban sectors may eventually lead to the formation of a *megalopolis* consisting of large core cities that are connected by an *industrial belt*, that is, *a continuum of small cities* (Mori, 1997). NEG remains the only general location-equilibrium framework which can investigate the spatial distribution of cities and their industrial structure in a unified manner.

There is also a large literature of spatial oligopoly (hence, type *c*) aiming to explain the spatial concentration of stores through *statistical economies of scale*. These models assume that consumers have imperfect information regarding the types (and the prices) of commodities sold by stores before they visit them. The greater the agglomeration of stores, the more likely it is that consumers will find their favourite commodities. The concentration of stores is explained by the market-size effect due to taste uncertainty and/or lower price expectation (see, for example, Konishi, 2005).

Finally, in all the models introduced thus far, all agents are assumed to be atomistic. Hence, land and labour markets are perfectly competitive. In contrast, Henderson and Mitra (1996) offer a model of *suburbanization* in which new *edge cities* are formed by *large land-developers* in the suburbs of the old CBD, formalizing Garreau's observation (1991) on the recent development of edge cities within large US metro areas. Given an existing CBD, the developer of a new edge city chooses the location and capacity of its business district strategically to maximize profits. The developer exercises monopsony power in the labour market in the edge city though her control over aggregate employment there. The proximity to the old CBD increases production efficiency through easier communication of firms between the CBD and the edge city, while it also increases residential land rents and wages of workers in the edge city. This model thus incorporates elements (*b*) and (*c*).

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See also location theory; spatial economics; urban agglomeration; urban economics; urban growth; urbanization; urban production externalities

Bibliography

Alonso, W. 1964. *Location and Land Use*. Cambridge, MA: Harvard University Press.

Beckmann, M. 1976. Spatial equilibrium in the dispersed city. In *Mathematical Land Use Theory*, ed. Y. Papageorgiou. Lexington, MA: Lexington Books.

Christaller, W. 1933. *Central Places in Southern Germany*. Trans. by C. Baskin. London: Prentice Hall, 1966.

Fujita, M. 1986. Urban land use theory. In *Location Theory*, ed. R. Arnott. London: Harwood Academic Publishers.

Fujita, M. 1988. A monopolistic competition model of spatial agglomeration: a differentiated product approach. *Regional Science and Urban Economics* 18, 87–124.

Fujita, M. 1989. *Urban Economic Theory: Land Use and City Size*. Cambridge: Cambridge University Press.

Fujita, M. 1993. Monopolistic competition and urban systems. *European Economic Review* 37, 308–15.

Fujita, M. and Krugman, P. 1995. When is the economy monocentric?: von Thünen and Chamberlin unified. *Regional Science and Urban Economics* 25, 505–28.

Fujita, M., Krugman, P. and Mori, T. 1999. On the evolution of hierarchical urban systems. *European Economic Review* 43, 209–51.

Fujita, M. and Mori, T. 1997. Structural stability and evolution of urban systems. *Regional Science and Urban Economics* 27, 399–442.

Fujita, M. and Ogawa, H. 1982. Multiple equilibria and structural transition of non-monocentric urban configurations. *Regional Science and Urban Economics* 12, 161–96.

Fujita, M. and Thisse, J.-F. 2002. *Economics of Agglomeration: Cities, Industrial Location, and Regional Growth*. Cambridge: Cambridge University Press.

Garreau, J. 1991. *Edge City: Life on the New Frontie*r. New York: Doubleday.

Henderson, J. and Mitra, A. 1996. The new urban landscape: developers and edge cities. *Regional Science and Urban Economics* 26, 613–43.

Imai, H. 1982. CBD hypothesis and economies of agglomeration. *Journal of Economic Theory* 28, 275–99.

Krugman, P. 1991a. Increasing returns and economic geography. *Journal of Political Economy* 99, 483-499.

Krugman, P. 1991b. *Geography and Trade*. Cambridge, MA: MIT Press.

Konishi, H. 2005. Concentration of competing retail stores. *Journal of Urban Economics* 58, 488–512.

Lucas, R. and Rossi-Hansberg, E. 2002. On the internal structure of cities. *Econometrica* 70, 1445–76.

Mills, E. 1967. An aggregative model of resource allocation in a metropolitan area. *American Economic Review* 57, 197–210.

Mills, E. 1972. *Studies in the Structure of the Urban Economy*. Baltimore, MD: Johns Hopkins University Press.

Mori, T. 1997. A modeling of megalopolis formation: the maturing of city systems. *Journal of Urban Economics* 42, 133–57.

Muth, R. 1969. *Cities and Housing*. Chicago: University of Chicago Press.

Ogawa, H. and Fujita, M. 1980. Equilibrium land use patterns in a non-monocentric city. *Journal of Regional Science* 20, 455–75.

Schweizer, U., Varaiya, P. and Hartwick, J. 1976. General equilibrium and location theory. *Journal of Urban Economics* 3, 285–303.

Solow, R. and Vickrey, W. 1971. Land use in a long narrow city. *Journal of Economic Theory* 3, 1468–88.

Starrett, D. 1978. Market allocations of location choice in a model with free mobility. *Journal of Economic Theory* 9, 418–48.