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A new economic geography model of central places

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ABSTRACT

One of the most striking feature of the space-economy is that cities form a hierarchical system exhibiting some regularity in terms of their size and the array of goods they supply. In order to show how such a hierarchical system may emerge, we consider a model with monopolistically competitive markets for the industrial sectors. As transport costs steadily decrease from large values, the urban system formed by several small cities entails structural changes in that some cities expand at the expense of the others by attracting a growing number of industries. Beyond some threshold, some cities disappear from the space-economy. Such an evolution of the urban system describes fairly well what has been observed in various historical periods that have experienced major changes in transportation technologies and/or political unification.

1. Introduction

The main thrust of new economic geography is that steadily decreasing transport costs foster the agglomeration of economic activities in a small number of urban regions. Tackling the formation of the urban system from this angle is especially relevant because, ever since the beginning of the Industrial Revolution, the transport sector has undergone the most stunning changes. According to Bairoch (1997) "On the whole, between 1800 and 1910, it can be estimated that the lowering of the real average prices of transportation was on the order of 10 to 1." [our translation]. Transport costs have continued to decrease after World War I. For example, in the United States, Glaeser and Kohlhase (2004) observe that over the twentieth century, the costs of moving manufactured goods have declined by over 90% in real terms. The World Bank (1995) reports comparable drops from 10 to 3 and from 10 to 1.5 in maritime and air freights, respectively.

To a large degree, however, by focussing primarily on the two-location framework of international trade theory, the existing literature has failed to address its main objective. Using the dataset of World Urbanization Prospects 2009, we want to figure out whether the above prediction is supported by casual empirical evidence. Specifically, we have computed the ratio of the population in the top five urban agglomerations to the total population in each OECD country having at least five agglomerations with more than 750,000 inhabitants over the period 1950–2005.[1] This leaves us with 10 countries. By focussing on the share, instead of the level, of urban population we control for the urban population growth, while retaining OECD countries allows us to avoid comparing countries having very different transport infrastructure. In order to determine the evolution of the population share in each country's five largest metros, we have computed the correlation between the value of this share and the corresponding year. Note that testing the significance of the correlation between the share and the year is equivalent to testing the significance of coefficients when regressing the share on the year. The correlation is positive and significant in 8 out of 10 countries (Australia, Canada, France,

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[1] According to World Urbanization Prospects (United Nations, Department of Economic and Social Affairs, http://esa.un.org/wup2009/wup/source/country.aspx), the term "urban agglomeration" refers to the population contained within the contours of a contiguous territory inhabited at urban density levels without regard to administrative boundaries. It incorporates the population in a city plus that in the suburban areas lying outside of, but being adjacent to, the city boundaries. However, some countries do not produce data according to the concept of urban agglomeration but use instead that of metropolitan area or city proper. Whenever possible, these data are adjusted to match the concept urban agglomeration. When sufficient information is not available to permit such an adjustment, data based on the concept of city proper or metropolitan area are used.

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Italy, Japan, Mexico, Republic of Korea, and Turkey), whereas the correlation is almost zero in the US and negative and significant only for the UK.[2] Thus, we find it fair to say that those results do not reject the main prediction of new economic geography.

Building on this, we want to study whether and how a system of central places may emerge in a multi-location space when transport costs keep decreasing. To achieve our goal, we consider a spatial economy endowed with different industrial sectors operating under monopolistic competition and increasing returns, in which the number, size, and location of cities are determined endogenously. More precisely, we focus on the size and location of cities (the *urban* aspect) as well as on the spatial distribution of each industry across cities (the *industrial* aspect) when workers are free to choose where to live and for which industry to work. The novelty of our analysis is that the hierarchical principle of central place theory (i.e. the number of goods supplied in a city rises with its size and the spacing of cities having the same size is equal) stems from a symmetry-breaking process, which is itself triggered by falling transport costs.

That said, we may summarize our main findings as follows. First of all, when transport costs are high, we show that there exist a large number of small and equidistant cities. That each city has the same size and industrial structure makes all goods accessible to its workers and to the farmers living in its hinterland. This takes the concrete form of consuming a limited range of varieties of each good as importing varieties from other cities is very expensive. Such a pattern agrees with the fact that, in pre-industrial economies characterized by high transport costs, a city's rural hinterland was often its main external market. As transport costs steadily decrease, the volume of trade grows and the urban system entails some structural changes: some cities expand at the expense of the others by attracting industries and workers. The reason is that bigger cities allow firms to better exploit scale economies, even though the goods produced in small cities are also produced in big cities. To put it bluntly, the urban system now involves *the coexistence of cities having different sizes and different industrial structures*, i.e. small towns and big cities. Moreover, in equilibrium, only adjacent cities are equidistant, which means that our setting allows for an equilibrium pattern in which city locations are asymmetric.

Following a ladder of thresholds, we show that the urban system displays a series of pitchfork bifurcations in which small cities disappear gradually from the space-economy, while *a shrinking number of cities accommodate a growing range of activities*. Another important distinguishing feature of our results is that our economic geography is of the putty-clay type: workers and firms are free to launch a city anywhere but, once it exists, a city has a well-defined location that does not change, even in the absence of durable infrastructure such as roads and public facilities. Last, *cities gaining primacy in the urban hierarchy retain their high rank during the whole process*, the main victims being the towns at the bottom. All of this is in accordance with the fact that "cities show remarkable resilience" (Hohenberg, 2004).

Related literature. The bulk of the research on central place theory has been directed towards identifying geometric conditions under which a superposition of regular structures is possible. These considerations are only interesting if they are based on microeconomic foundations. If there are no economic forces which lead firms of different types to cluster, it is hard to see why a central place system would be more likely to emerge than any other configuration. One of the first economic contributions to central place theory we are aware of is due to Eaton and Lipsey (1982), who develop a spatial competition model of central places, and to Quinzii and Thisse (1990), who retain the same approach to show that the central place configuration is socially optimal. More recently, Hsu and Holmes (2009) have followed a similar approach and have extended it to the case of several sectors. Farmers are fixed and uniformly distributed along the real line, whereas workers are mobile. Consumers have perfectly inelastic demands up to some reservation prices; firms operate under increasing returns and price discriminate across consumers through goods delivery. Hsu (2009) then shows that the urban hierarchy principle holds once firms producing different goods face different fixed production costs.

All these papers build on spatial competition theory and focus on partial equilibrium. In contrast, Fujita et al. (1999) use the framework of new economic geography and deal with general equilibrium. As the population increases, they show that a more or less regular hierarchical central place system emerges within the economy. The urban hierarchy that emerges from their simulations is more involved than in Christaller: horizontal relations are superimposed onto the pyramidal structure of central place theory because cities supply differentiated products. Our setting belongs to the same strand of literature and supplements their analysis by investigating the role of another fundamental determinant of the spatial pattern of activities, i.e. transport costs. Before proceeding, we want to stress the fact that the urban hierarchical principle is different, though not independent, from the Zipf Law. As a result, our paper should *not* be viewed as a new attempt to provide microeconomic foundations to this law. Therefore, there is no need to discuss here the literature devoted to this lively research topic.

The rest of the paper is organized as follows. The model with several industries is described in the next section. In Section 3, we characterize the spatial–sectoral equilibria. Section 4 is devoted to the derivation of the hierarchical urban principle in the cases of one and several industries. Section 5 concludes.

2. The model

The spatial economy is described by a circumference $(0,1]$ of length 1. There are two production factors, one being immobile and the other mobile across space. It is convenient to think of them as being farmers and workers. In the agricultural sector, a homogenous good (e.g., rice) is produced under constant returns, perfect competition and zero transport cost; this good is taken as the numéraire. The economy involves a given number $I \geqslant 1$ of manufacturing sectors, which differ according to consumer expenditure share and the elasticity of substitution across product varieties. Each sector produces a differentiated good under increasing returns, monopolistic competition and positive transport costs; the array of varieties supplied by an industry varies with the mass of workers in this particular industry. Note, however, that the above interpretation of production factors and sectors is not necessary for our results to hold; it is made for expositional convenience only.

One may wonder why shipping the agricultural good is assumed to be costless, while shipping manufactured goods is costly. Recall that our primary purpose is to investigate how decreases in the transport costs of manufactured goods produced in cities affects the structure of the urban system. In order to isolate this effect, we have chosen to work with a setting in which farmers' wages are equalized across space; this is guaranteed by the assumption of zero transport cost for the agricultural good. We acknowledge the fact that this assumption is restrictive since decreasing transport costs for manufactured goods below some threshold, while preserving those of agricultural goods, stops the concentration process and leads to the redispersion of manufacturing firms and population (Fujita and Mori, 2005). One should keep in mind, however, that both types of transport costs have actually

[2] Using the data gathered by Eaton and Eckstein (1997), the correlation is positive for France and Japan for much longer time spans, that is, 1876–1990 in France and 1925–1985 in Japan.