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Viewpoint

Search costs generating industrial clusters ☆

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ABSTRACT

Multiple factors induce the formation of industrial clusters worldwide. This paper studies the formation of industrial clusters based on spatial competition and search costs in a game theoretic model. By establishing a spatial competition model, this paper compares firm profits under clustering to those without clustering. We find that search costs are an extremely important factor in the formation of industrial clusters that can give rise to industrial clusters in certain industries. This work contributes analytical and theoretical insights to the theory of industrial clusters.

Introduction

Industrial clusters, which are popular worldwide, have strong effects on national economies, and there is extensive research on their effects and formation. Based on data from multiple countries, Lee (2009) examined the effects of industrial clusters on innovation. Moral (2009) investigated the appearance of new firms in industrial clusters. Feser, Renski, and Goldstein (2008) addressed the relationship between industrial clusters and economic development. Recently, Iammarino and McCann (2006) studied the structures and evolution of industrial clusters. Bell, Tracey, and Heide (2009) modeled inter-organizational governance and path dependence in industrial clusters.

Various types of industrial clusters exist, and many factors can explain their formation. It is therefore important to further investigate industrial clusters. Porter (1998) developed the theory of industrial clusters and postulated that the theory underlying the benefits of industrial clusters was based on economies of scale, technology transfer and the availability of human capital. In his 1998 paper, Porter (1998) noted: "As firms physically congregate in one region, spillovers of knowledge, people and technology occur. These types of spillovers give rise to increased productivity and reduced costs for all firms in the region. Four major sources of productivity and cost benefits can be linked to industrial clusters: (1) access to inputs and infrastructure (2) labor and human resource pooling (3) access to information and performance measures and (4) complementary products." There is a substantial and important literature that extends Porter's interesting conceptualization using mathematical models. Ramcharan (2009) recently demonstrated that transportation costs determine an economic core. In practice, certain industrial clusters are located in cities with harbors because of the low transportation costs incurred, which appears to support the conclusions of Ramcharan (2009) and Porter (1998). In an interesting and significant recent work, Ridley (2008) discussed firm clustering to attract consumers and free riding giving rise to clusters within a game theoretic framework. Almazan, De Motta, and Titman (2007) examined firm location based on human capital and concluded that human capital gives rise to industrial clusters. Nie (2010) argued that technology spillovers can produce industrial clusters and presented the threshold necessary for the formation of industrial clusters.

Many factors other than the four sources cited by Porter (1998) also have major effects on industrial clusters, and industrial clusters have other distinguishing features that require elaboration. In practice, many firms with similar products but different brands are located at the same location to establish an industrial cluster, which contradicts conclusions regarding spatial competition. For example, Clinique and Lancôme often locate their own stores in the same shopping mall, and the relationship between them in a mall is not among the four sources in Porter (1998) or in other studies. The industrial clusters in this paper are defined as "firms physically congregating in one region".

These phenomena motivate this paper, the aim of which is to provide a rational explanation of these phenomena by introducing search costs. Search costs have important effects on firm strategies.

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Anderson and de Renault (1999) focused on the relationship between search costs and product diversity and argued that equilibrium diversity increases in search costs. Atakan (2006) employed matching theory with explicit search costs and explored whether Becker's assortative matching result generalizes to an economy in which agents engage in a costly search. Anderson and de Palma (2009) developed a search theory model under comparative advertisement and demonstrated that search costs have important effects on firm advertising. Interestingly, search costs affect a firm's price, and Galeotti (2010) argued that firms price less aggressively when search costs are low. In contrast, Samuelson and Zhang (1992) demonstrated that as search costs decrease, prices may increase and price dispersion may also increase. When search costs are low, Galeotti (2010) argued that the competition becomes fierce, while Samuelson and Zhang (1992) demonstrated that high prices result. Pereira (2005) argued that a decrease in search costs may lead to lower prices and lower price variance but may also lead to the opposite result. Considering the conclusions of Samuelson and Zhang (1992), a decrease in search costs first increases the ability of consumers who sample a firm to search for an alternative, which reduces prices. Second, it increases the number of consumers who sample a firm, which increases prices. In Samuelson and Zhang's (1992) setting, the second effect dominates the first.

Bakos (1997) argued that the electronic marketplace reduces the inefficiency caused by search costs. Pereira (2005) presented a search model for which a decrease in search costs may lead to lower prices and lower price variance but may also lead to the opposite outcome. There are also papers related to search costs and industrial clusters. Pascal and McCall (1980) explored the relationship between search costs and industrial clusters. While Pascal and McCall (1980) discussed firm search costs, this paper focuses on the search costs of consumers.

Regarding empirical and experimental aspects of search costs, Hong and Shum (2006) estimated search-cost distributions using price data. Hijzen, Inui, and Todo (2010) confirmed that the costs of searching foreign firms that are suitable for off-shoring are non-negligible, based on data from Japan. In two experiments, Diehl, Kornish, and Lynch (2003) argued that reducing quality search costs with smart agents can improve differentiation and price sensitivity.

This paper investigates the role of search costs in industrial clusters using the game-theory techniques of the interesting papers of Fudenberg and Tirole (1991) and Chen and Zhang (2009), and it demonstrates that firms benefit from industrial clusters if search costs are present. This paper is in some senses an extension of the thoughts of Porter (1998), but the notion presented here is different from those of Porter. When establishing our model, we will refer to the interesting model of Bernhardt, Liu, and Serfes (2007). We will also refer to the classical spatial competition model employed by Hotelling (1929), Xefteris (2013) and Fernandes and Chamusca (2014).

By establishing a Hotelling spatial competition model comparing the case of industrial clusters with that of firms located in separate locations, this paper finds that search costs are an extremely important factor in the formation of industrial clusters, and search costs can also give rise to industrial clusters in certain industries, most notably in retailing industries.

The remainder of the paper is organized as follows: In section 'The model', the model of spatial competition with search costs is established. This model differs from existing ones because search costs are fully addressed. The model without clustering is discussed in section 'Profits without clustering', in which the equilibrium is also investigated. The model with two firms at the same location is established and discussed in section 'Profit with clustering'. In section 'Comparison of the respective profits', the model in section 'Profit with clustering' is compared to that in section 'Profits without clustering', and we find that search costs have a substantial impact on industrial clusters. Concluding remarks are offered in the final section.

The model

The model of two firms is formally established next. Two firms produce two differentiated products that are substitutes. For example, Adidas and Nike produce different brands of shoes, but their products can be substituted for one another. On a unit Hotelling line (the two endpoints are 0 and 1), the locations of the two firms are z_1 and z_2 ($z_1, z_2 \in [0,1]$). Consumer locations are arranged via a preference ordering on this Hotelling line. The expression ς_i ($i = 1, 2$) is firm i's product attribute. A consumer at location (preference) $\theta \in [0,1]$ who purchases firm i's product at price p_i ($i = 1, 2$) receives utility[1]

$$u_i = A - t|\theta - \varsigma_i| - p_i - \frac{1}{2}q_i - \bar{t}|z_1 - z_2|, \quad i = 1, 2, \tag{1}$$

and the corresponding total utility function U_i is

$$U_i = (A - t|\theta - \varsigma_i| - p_i - \frac{1}{2}q_i - \bar{t}|z_1 - z_2|) \cdot q_i, \quad i = 1, 2, \tag{2}$$

where A is the utility of consuming an ideal product or the utility of consuming a perfect product (without having to pay the price); q_i is the quantity of firm i[2]; $t|\theta - \varsigma_i|$ measures a consumer's disutility from consuming a product other than θ, and $|\theta - \varsigma_i|$ denotes the difference between the consumer's preference and product attribute. $t > 0$ is the marginal disutility. Consumer preferences depend on brand or product differentiation; consumers need to collect the necessary information on both firms (price, brand, product attribute, etc.) before purchasing. $\bar{t}|z_1 - z_2|$ is the search cost for the consumer ($\bar{t} > 0$ is a measure of search intensity or search efficiency).[3] The shorter the distance between the two firms, the lower the search costs that consumers should pay; $\theta \in [0,1]$ is a stochastic variable, with the density function $\rho(\theta)$ ($\theta \in [0,1]$) satisfying $\rho(\theta) \geqslant 0$ and $\int_0^1 \rho(\theta)d\theta = 1$.[4] We note that the above utility function is borrowed from Bernhardt et al. (2007), while the search and transportation costs are new introductions. The search cost $\bar{t}|z_1 - z_2|$ is a rational hypothesis.[5] When there are more firms, the search cost is higher. According to conclusions in operations research, search costs, similar to the traveling salesman problem (TSP) (in which, given a length L, the task is to decide whether any route is shorter than L), are calculated according to an exponential function of the number of firms (see the interesting paper on the NP-hard complexity (non-deterministic polynomial-time hard) of the traveling salesman problem (TSP) (Arora, 1998)). Therefore, additional firms yield substantially higher search costs. To simplify the model, only two firms are considered. Moreover, Hossain and Morgan (2006) rationally confirmed that shipping costs are often ignored in eBay auctions. It is tractable to employ a linear path in the above model. To simplify the model, we further assume that the search cost is proportional to the distance involved. Our conclusions hold for general cases.

[1] This type of utility value is derived from the interesting paper by Bernhardt et al. (2007). In contrast to Bernhardt et al. (2007), this paper assigns importance to customer location.

[2] Including quantity in the unit utility function implies that marginal utility is diminished when consumers consume more products.

[3] Zenou (2009) employed this type of search cost function for the labor market.

[4] The expected value of θ is closely related to the two brands. When $E\theta > 0.5$, as the expected value of the first brand is larger than that of the second brand, the second firm's product appears more preferable than that of the first firm. If $E\theta < 0.5$, the first firm's product is greater or more desirable.

[5] There are other types of brand competition, such as those referenced in Johnson and Myatt (2003) and Guo and Villas-Boas (2007). The model in this paper is based on that of Bernhardt et al. (2007).