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Welfare properties of spatial competition with location-dependent costs

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Abstract

We analyze a two-firm spatial competition model in which firms must transport raw materials from a raw material site to their locations in order to produce. The model has two equilibrium configurations: (i) a symmetric one in which firms locates equidistantly from the raw material site, and (ii) an asymmetric one in which one firm locates at the raw material site and the other locates distantly from it. We show that these two configurations are possible as multiple equilibria, that the asymmetric equilibrium is more efficient than the symmetric one, and that the social welfare first falls then rises as transport costs decline.

JEL classification: L13; R39
Keywords: Spatial competition; Material transportation; Asymmetric equilibrium

1. Introduction

Over the past century, improvements in transportation technology and decreases in the significance of heavy manufactured goods in consumption bundles have been observed. Due to these historical changes, the costs of transporting raw materials are considered to play a less and less important role in the location decisions of many retail firms. In view of this, volumes of recent studies on retail firm location have focused on the effects of the distribution of consumers (and an those of shopping costs). However, it would also be interesting to investigate the effects of the historical change mentioned above on firm location, i.e., to explore the impact of the decline in the costs of transporting raw materials on firm location decisions and on social welfare. Moreover, it is still true that some retail firms must consider the costs of the transport of the raw materials for their products or services to their places of business. In such a case, they face location-dependent costs, which would influence their location and price decisions. As an example, consider stores (or restaurants) that sell (serve) seafood. In the neighborhood of a fishing port or a fish market, we often find stores and restaurants that provide seafood at reasonable prices, whereas we also find stores that offer similar seafood at high prices in a city center that is far from a fish market. Locating in a city center enables stores to access a large consumer market, whereas locating in the neighborhood of a fish market reduces transportation costs. Combined with the shopping costs for consumers, these differences in locational characteristics would lead to different prices for

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similar seafood. Other examples include stores that sell fresh vegetables and fruits, and local brand goods such as local brand beer, wine, and sake.

This paper studies the co-effects of access to a consumer market and the transport costs of raw materials on the location and price decisions of firms, and reveals what will happen with a change of raw material transport costs.

A large number of studies have previously investigated the location decision of firms competing within a demand space; the models described in these studies are called "spatial competition models." In his pioneering work, Hotelling (1929) analyzed a situation in which two firms compete for consumers with respect to location and price in a linear market in which consumers are uniformly distributed. Each consumer chooses one firm to buy one unit of a good inelastically. In doing so, she/he bears the shopping cost depending linearly on the distance between her/his location and the firm's location. A consumer chooses a firm that offers the lower sum of the price and shopping cost. Therefore, due to spatial differentiation, even if two firms charge different prices, a firm with the lower price cannot necessarily obtain all the demand. It is then possible that for given locations of firms, different prices appear as an equilibrium outcome. However, in the original Hotelling model, price equilibrium does not necessarily exist for given locations of firms. d'Aspremont et al. (1979) modified the Hotelling model and assumed that the shopping cost for a consumer is a quadratic function of the distance between the firm's location and the consumer. This modification enables us to obtain a price equilibrium for any firm's location. They then analyzed a case in which firms choose location then price endogenously, and showed that, in a sub-game perfect Nash equilibrium, two firms separately locate at either end of the linear market; i.e., each firm tries to locate as far from the other firm as possible. This result is called the "maximum differentiation principle." To this date, many studies have extended the basic spatial competition model and obtained various results.[1]

Alongside the literature on spatial competition, studies pioneered by Weber (1929) analyzed the effects of location-dependent costs on firms' locations. They explicitly considered the transportation of raw materials and investigated the optimal locations of firms that minimize the total costs of transporting raw materials from a raw material site to firms' locations and products from firms' locations to consumer places.

By combining these two approaches, we analyze a location-then-price spatial competition model which includes location-dependent costs. To the best of the authors' knowledge, Karlson (1985) would be the most relevant to our purpose.[2] Karlson (1985) considered a circular market in which consumers are uniformly distributed and two firms choose locations. A raw material site is assumed to locate in the circular market. A firm must transport raw materials from the raw material site to its location in order to produce, and the transportation cost depends linearly on the distance. Hence, the cost of transporting raw materials depends on the firm's location. Moreover, Karlson (1985) assumed that consumer's demand is elastic, that the shopping cost is linear in the distance, and that firms choose their locations and prices simultaneously. In this game, one firm can obtain all the demand by choosing the same location as the rival firm and cutting its price to slightly below the rival firm's price. This leads to the non-existence of a Nash equilibrium. Therefore, a local Nash equilibrium was examined in Karlson (1985).[3] It was shown that in a local Nash equilibrium, firms locate equidistantly from the raw material site (i.e., symmetric locations with respect to the raw material site) and choose the same price.

This paper modifies the model developed by Karlson (1985) by assuming that the shopping cost is quadratic in the distance, that the consumer's demand is inelastic, and that the game is two-stage (location-then-price) *a la* d'Aspremont et al. (1979).[4] Under these modifications, we can obtain a subgame-perfect Nash equilibrium (see d'Aspremont et al., 1979). We investigate equilibrium locations and prices in a linear market model, in which a raw

[1] For example, existing studies have examined the effects of changes in the shape of the market (circular, square, etc), in the demand function (elastic, inelastic), in the distribution of consumers (trigonometric, normal distribution), and in the number of firms.

[2] Spatial competition which includes the costs of transporting raw materials is examined also in Heal (1980) and in Matsushima (2004, 2006). Heal (1980) considered a circular market in which consumers are uniformly distributed and firms choose their locations. However, because it is assumed that a raw material site is located at the center of a circle, the cost of transporting raw materials is the same for all firms. Matsushima (2004, 2006) considered models with upstream and downstream firms, where downstream firms engage in the location-then-price competition. Upstream firms also locate in the same space, and decide the prices of raw materials to sell to downstream firms. However, in contrast with our model, it is assumed that upstream firms must bear the costs of transporting materials. Under these settings, the effects of a vertical merger were discussed.

[3] A local Nash equilibrium is a set of prices and locations such that no firm can benefit from *slightly* changing its location or price given the other firm's price and location.

[4] We can interpret the quadratic shopping cost as that in which consumers bear not only the monetary costs of going to a store but also its psychological costs, with the latter costs increasing more than proportionally to the distance.