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Inefficiencies in Firm Locations in the Service Industries with Product Differentiation

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Inefficiencies in Firm Locations in the Service Industries with Product Differentiation*

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Abstract

We examine the effects of product differentiation on welfare evaluation on firm location in the service industries. We consider the situation where symmetric firms locate in two regions with differences in region-specific costs. We demonstrate that firms excessively locate regions with lower costs regardless of product differentiation under differences in marginal costs and that firms insufficiently locate regions with lower costs under differences in fixed costs if the degree of product differentiation is small.

Keywords: Firm location; Difference in costs; Product differentiation

JEL classifications: L13; F12

1 Introduction

In recent times, service industries have played essential roles in the economy. According to the World Bank, the shares of the service sector (value added) of the GDP in 2021 are 63.9% in the world, 70.2% in the OECD countries, and 69.9% in the high income countries in 2021. In 2022, the corresponding shares are 53.0%, 52.2%, 49.1% and 33.8%

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in the upper middle income, middle income, lower middle income, and low income countries, respectively. As shown by Petty's law, the shares of service are gradually higher depending on the income (Table 1). As a result of economic development, the service industry will have become much more important.

Table 1: Services, value added (% of GDP)

Countries	Most Recent Year	Most Recent Value(%)
World	2021	63.9
OECD countries	2021	70.2
High income countries	2021	70.0
Upper middle income countries	2022	53.0
Middle income countries	2022	52.2
Lower middle income countries	2022	49.1
Low income countries	2022	33.8

Source: World bank (`https://data.worldbank.org/`)

As the prominence of the service industries, several studies focus on service industries. Firm location in service industries is one of the topics. Firm supplies service only in the place of consumption, and services are thus provided in several segmented markets,[1] Because of the scarcity of financial or managerial resources, firms choose their locations considering several factors, such as market size and region-specific costs. Behrens (2005) considers the difference in market size and examines home market effects to be satisfied in non-tradable goods industries, including service. Kurata, Ohkawa, and Okamura (2009, 2011, 2021) consider the economic efficiencies of firm location in oligopolistic service industries. In particular, Kurata, Ohkawa, and Okamura (2021) point out the possibility that firms in the region with lower costs can be insufficiently located from an economic welfare perspective under oligopolistic markets of homogeneous service in two regions with differences in region-specific costs.

Adding the factors for locations for service firms above, we consider product differ-

[1] We call the property "simultaneity of consumption and production" (Wong et al., 2006).

entiation effective. Since services are invisible, it is not easy to supply identical services and natural to consider a situation in which product differentiation exists. However, especially in the existing studies on the efficiencies of firm location, the authors considered homogeneous services to focus on the role of market size and difference in region-specific costs, and they were silent on the impact of product differentiation. [2] The impacts of product differentiation on firm location and economic welfare are not obvious, and it is worthwhile to incorporate product differentiation into the model to consider more realistic situations.

In this paper, we consider the impact of product differentiation on evaluating the economic welfare of firm locations in a service industry. We incorporate product differentiation into the Cournot-type quantity competition model in Kurata, Ohkawa, and Okamura (2021). We will examine whether, under a certain degree of product differentiation, firm location to regions with high or low region-specific costs is excessive (i.e., too many) or insufficient (i.e., too few) from an economic welfare perspective. The question is related to the literature on excess entry in the industrial organization. The excess entry theorem, established by Mankiw and Whinston (1986) and Suzumura and Kiyono (1987), states that in a single oligopolistic industry with free entry, firms excessively enter the market from the viewpoint of social welfare. We apply this "excess entry" framework to evaluating firm location from the welfare point of view.

We develop the following simple model. In the service industry, symmetric firms determine their location in either of two regions with differences in marginal and fixed entry costs. The total number of firms in the industry is exogenously determined and fixed, and each firm simultaneously determines which region to enter. After determining their locations, firms compete in each market in the Cournot fashion. We assume

[2] Behrens (2005) examines the effects of product differentiation on industrial location in the spatial model and shows that the reverse home market effect may arise when product differentiation is sufficiently low. Although we have different approaches, our interest is related to his research.

that there is a certain degree of differentiation in the services firms supply.

From the analysis, we obtain the following results. If product differentiation is significant, i.e., the natures of the services are different, firms will excessively locate in the lower-cost region and insufficiently in the higher-cost region. In contrast, if the products are similar, firms may insufficiently locate in the lower-cost region and excessively in the higher-cost region, depending on the fixed cost level. The results guarantee the robustness of the results in Kurata, Ohkawa, and Okamura (2021) and add some new insights on product differentiation in the study on firm location in service industries.

The remainder of the paper is as follows: In Section 2, we propose a model and derive the equilibrium. In Section 3, we explore the efficiency of the equilibrium location. Finally, in Section 4, we provide simple concluding remarks.

2 Setup

2.1 Model

We focus on the service industry in regions 1 and 2. In this industry, there are N symmetric firms. We assume the total number of firms, N, is exogenously given and fixed because some managerial resources, such as human capital, are scarce. Furthermore, we assume that $N > 2$.

When a firm locates in the region i, it must incur fixed entry cost f_i $(i = 1, 2)$. In providing the service, the firm faces a marginal cost of c_i. These costs are not firm-specific but region-specific. We assume that firms can locate only in one of the two regions because of some resource constraints.[3]

Each firm determines its location considering the region-specific costs (c_i, f_i) and its rivals' locations. Let n_i be the number of firms in the region i. The number of

[3] This assumption appears in Barros and Cabral (2000) and Fumagalli (2003).

locating firms, n_i, is endogenously determined as a result of location choice by each firm.

The markets in the two regions are segmented because of a property of the service. Firm j supplies differentiated service in the region i. We use subscript ij to express the service supply by firm j in the market i. The inverse demand for the service in the region i is given by

$$p_{ij} = a - x_{ij} - \gamma \sum_{k \neq j}^{n_i} x_{ik}, \tag{1}$$

where p_{ij} is a price of the service of firm j in the market i, x_{ij} is firm j's individual service, x_{ik} is its rival's individual service, $a(> 0)$ is a demand parameter of market i, and $\gamma \in (0, 1]$ is a common parameter, indicating product differentiation. When $\gamma = 1$, all firms supply homogeneous service in the market i.

We consider the following two-stage game: In the first stage, each firm simultaneously determines which market it enters by paying fixed entry cost f_i. In the second stage, give firms location choices, firms supply their service and compete in a Cournot fashion.

2.2 Equilibrium

We solve the game backward. In the second stage, given n_i, firm ij's gross profit, π_{ij}, is

$$\pi_{ij} = (p_{ij} - c_i)x_{ij}. \tag{2}$$

Note that the net profit of firm ij is given by $\pi_{ij} - f_i$.

The profit-maximizing condition for firm ij is given by

$$a - 2x_{ij} - \gamma \sum_{k \neq j}^{n_i} x_{ik} - c_i = 0. \tag{3}$$

We focus on the symmetric equilibrium hereafter, i.e., $x_{ij} = x_i$ and $\pi_{ij} = \pi_i$. From equations (2) and (3), each firm's equilibrium amounts of service, the equilibrium total service, and the resulting profit can be written as functions of the number of firms in each market; that is,

$$x_i = x_i(n_i) = \frac{a - c_i}{\gamma(n_i - 1) + 2}, \quad X_i = X_i(n_i) = \frac{n_i(a - c_i)}{\gamma(n_i - 1) + 2}, \quad \pi_i = \pi_i(n_i) = x_i^2. \quad (4)$$

We assume $a > c_i \geq 0$ to ensure the positive individual amounts of service. From (4), we derive the following properties:

Lemma 1

$x_i'(n_i) < 0$, $X_i'(n_i) > 0$, *and* $\pi_i'(n_i) < 0$.

These properties are known as business-strealing effect and quasi-competitiveness (Mankiw and Whinston, 1986).

We examine the first stage. For simplicity, we approximate the number of firms as a continuous variable.[4] If the resulting net profits are different across the markets, each firm located in the market with less net profit has the incentive to move to another market. The resulting net profit must be equalized at the equilibrium location in both markets. We define the equilibrium location as follows.

Definition 1 (Equilibrium Location)

The equilibrium location (n_1^e, n_2^e) *is a pair of* (n_1, n_2) *such that*

(i) $n_1 + n_2 = N$,

(ii) $\pi(n_1) - f_1 = \pi_2(n_2) - f_2$, *and*

(iii) For given (n_1, n_2), *condition (3) holds.*

In this paper, we confine our attention to the case with $n_i \geq 1$.[5] As proved in Kurata, Ohkawa, and Okamura (2021), we find the equilibrium location (n_1^e, n_2^e) for

[4] We ignore "integer problem" of the number of firms. This approach has often been adopted in the research on oligopolies (e.g., Suzumura and Kiyono, 1987; Elberfeld, 1986).

[5] In this paper, perfect agglomeration is out of our focus.

the interval $[1, N-1]$, given fixed entry costs levels f_1 and f_2.[6]

3 Inefficiencies in the Equilibrium Location

We now investigate whether the equilibrium location is efficient. Total surplus in the region i, denoted by W_i, is defined as the sum of consumer surplus and producer surplus in each market; that is,

$$W_i = U(x_{i1}, \ldots, x_{in_i}) - c_i \sum_{j=1}^{n_i} x_{ij} - n_i f_i, \tag{5}$$

where

$$\begin{aligned} U(x_{i1}, \ldots, x_{in_i}) &\equiv a \sum_{j=1}^{n_i} x_{ij} - \frac{1}{2}\left(\sum_{j=1}^{n_i} x_{ij}^2 + 2\gamma \sum_{j=1}^{n_i} \sum_{j \neq k} x_{ij} x_{ik} \right) \\ &= a \sum_{j=1}^{n_i} x_{ij} - \frac{\gamma}{2} \left(\sum_{j=1}^{n_i} x_{ij} \right)^2 - \frac{1-\gamma}{2} \left(\sum_{j=1}^{n_i} x_{ij}^2 \right). \end{aligned}$$

From (4) and (5), we have the equilibrium level of W_i:

$$W_i^e = \frac{n_i \left[\gamma(n_i^e - 1) + 3\right] (a - c_i)^2}{2\left[\gamma(n_i^e - 1) + 2\right]^2} - n_i^e f_i, \tag{6}$$

which is a function of n_i^e, $W_i^e = W_i(n_i^e)$. Social welfare is defined as a sum of the total surpluses in both regions, that is,

$$W^e(n_1, n_2) \equiv W_1(n_1^e) + W_2(n_2^e). \tag{7}$$

To investigate efficiencies of the equilibrium location, as Kurata, Ohkawa, and Okamura (2009, 2011, 2021), we consider a marginal movement of a firm from region 2 to region 1, which is parameterized by a change in n_1 such that $\frac{dn_2}{dn_1} = -1$ because $n_1 + n_2 = N$ holds from condition (i) for the equilibrium location. We consider the equilibrium location to be efficient if $\left.\frac{dW(n_1,n_2)^e}{dn_1}\right|_{n_i = n_i^e} \equiv \frac{dW^e}{dn_1} = 0$, and inefficient if $\frac{dW^e}{dn_1} \neq$

[6]On the existence of the equilibrium location, see Kurata, Ohkawa, and Okamura (2021).

0. In the latter case, firms excessive locate in region 1 if $\frac{dW^e}{dn_1} < 0$, and insufficiently locate if $\frac{dW^e}{dn_1} > 0$.[7] When firms excessively locate in region 1, firms insufficiently locate in region 2, and vice versa.

Differentiating equation (7) with respect to n_1, we have

$$\frac{dW^e}{dn_1} = n_1^e(p_1(n_1^e) - c_1)\frac{dx_1^e}{dn_1} - n_2^e(p_2(n_2^e) - c_2)\frac{dx_2^e}{dn_1}. \tag{8}$$

Each term in equation (8) stands for marginal changes in welfare through changes in incumbent firms' outputs. In other words, it reflects the externality to the incumbent firms caused by the movement of a firm. The first term corresponds to a negative externality to the incumbent firms in region 1 due to an increase in the number of firms, while the seconx term corresponds to a positive externality to the incumbent firms in region 2 due to a decrease in the number of firms. Equation (8) implies that welfare evaluation crucially depends on the sizes of the positive and negative externalities. The externality in each region consists of the number of firms locating in the region, n_i, and the change in profit due to the business-stealing effect, $(p_i - c_i)\frac{dx_i^e}{dn_i}$. Note that the price-cost margin $(p_i - c_i)$ affects the size of the latter effect (Kurata, Ohkawa, and Okamura, 2021).

3.1 Differences in marginal costs

First, we focus on the case with the differences in marginal costs: $0 \leq c_1 < c_2$ and $0 < f_1 = f_2$. From (4) and the condition (ii) for the equilibrium location, we obtain

$$\pi(n_1^e) = \pi(n_2^e) \quad \Leftrightarrow \quad \frac{\gamma(n_2^e - 1)}{\gamma(n_1^e - 1)} = \frac{a - c_2}{a - c_1} < 1 \quad \Leftrightarrow \quad n_1^e > n_2^e. \tag{9}$$

Differentiating (5) with respect to n_i yields

$$W_i'(n_i) = \frac{\pi(n_i)}{2}g(n_i) - f_i, \tag{10}$$

[7]We assume that the second-order condition for the uniqueness of the welfare-maximizing number of firms holds. For the details, see Ohkawa and Okamura (2003).

where

$$g(n_i) \equiv 1 - \gamma + \frac{2(2-\gamma)}{\gamma(n_i - 1) + 2}. \tag{11}$$

Since $g(n_i)$ is a decreasing function of n_i, we have $g(n_1^e) < g(n_2^e)$ from (9). Thus, differentiating W with respect to n_i and evaluating it at the equilibrium yield

$$\begin{aligned} \frac{dW}{dn_1} &= W_1'(n_1^e) + W_2'(n_2^e)\frac{dn_2}{dn_1} \\ &= \frac{\pi(n_1^e)}{2} g(n_1^e) - f_1 - \left(\frac{\pi(n_2^e)}{2} g(n_2^e) - f_2\right). \quad \Leftrightarrow \quad g(n_1^e) - g(n_2^e) < 0. \end{aligned} \tag{12}$$

This relation holds for any $\gamma \in (0, 1]$. Therefore, we establish the following result:

Proposition 1

Irrespective of the degree of product differentiation, firms excessively locate in the market with a smaller marginal cost.

Proposition 1 states that firms excessively locate to the region with lower marginal costs, regardless of product differentiation. This result implies that the analysis results with homogeneous goods are robust; as shown in Kurata, Ohkawa, and Okamura (2021), the intuitive explanation is as follows: Under common fixed costs, equilibrium gross profits are the same across regions. Then, the change in profit due to the business-stealing effect will not differ much across regions because the difference in price-cost margins across regions is not significant. As a result, the evaluation of economic welfare depends critically on the size of the number of firms in equilibrium. Since there are more firms in market 1, the negative externality of market 1 due to firm inflows, shown in equation (8), exceeds the positive externality of market 2 due to firm outflows, and the sign of $\frac{dW^e}{dn_1}$ is negative. In other words, firms excessively locate in regions with lower marginal costs.

3.2 Differences in fixed costs

Next, we consider the case with differences in fixed costs: $0 \leq c_1 = c_2 = c$ and $0 < f_1 < f_2$. Since $\pi(n_1^e) - \pi(n_2^e) = f_1 - f_2 < 0$ holds in the equilibrium location, we have

$$\frac{(a-c)^2}{[\gamma(n_1^e - 1) + 2]^2} < \frac{(a-c)^2}{[\gamma(n_2^e - 1) + 2]^2} \quad \Leftrightarrow \quad \gamma(n_1^e - 1) + 2 > \gamma(n_2^e - 1) + 2$$
$$\Leftrightarrow \quad n_1^e > n_2^e. \tag{13}$$

Differentiating W with respect to n_i and evaluating it at the equilibrium yield

$$\left.\frac{dW}{dn_1}\right|_{n_1 = n_1^e} = \frac{\pi(n_1^e)}{2} g(n_1^e) - f_1 - \left(\frac{\pi(n_2^e)}{2} g(n_2^e) - f_2\right) \gtreqless 0$$
$$\Leftrightarrow \quad \frac{(a-c)^2}{2} \left(h(n_1^e) - h(n_2^e)\right) \gtreqless 0, \tag{14}$$

where

$$h(n_i) \equiv \frac{1}{[\gamma(n_i^e - 1) + 2]^2} \left[-(1+\gamma) + \frac{2(2-\gamma)}{\gamma(n_i - 1) + 2}\right]. \tag{15}$$

(14) informs that the welfare evaluation depends on the difference between $h(n_1^e)$ and $h(n_2^e)$. From (15), we derive

$$h'(n_i) \equiv \frac{1}{2\left[\gamma(n_i^e - 1) + 2\right]^4} \left[\gamma(1+\gamma) n_i - (2-\gamma)^2\right]. \tag{16}$$

(16) implies the following relations:

Lemma 2

(i) If $h'(1) > 0$, then $h'(n_i) > 0$ for all $n_i \in [1, N-1]$.

(ii) If $h'(N-1) < 0$, then $h'(n_i) < 0$ for all $n_i \in [1, N-1]$.

Now consider the case with $h'(1) > 0$ holds. From (16), we have

$$h'(1) = \frac{1}{32} \left[\gamma(1+\gamma) - (2-\gamma)^2\right] \propto 5\gamma - 4. \tag{17}$$

Thus, Lemma 1 (i) and (17) imply $h'(n_i) > 0$ if $\frac{4}{5} < \gamma \leq 1$. Furthermore, from (15),

$$h(1) = \frac{1}{4}(1 - 2\gamma). \tag{18}$$

Considering (13), for $\frac{4}{5} < \gamma \leq 1$, we have the following three possibilities in the relation between $h(n_1^e)$ and $h(n_2^e)$: (i) $h(n_2^e) < h(n_1^e) \leq 0$, (ii) $h(n_2^e) < 0 \leq h(n_1^e)$, and (iii) $0 \leq h(n_2^e) < h(n_1^e)$. In any cases, $h(n_1^e) - h(n_2^e) > 0$. Therefore, we have $\frac{dW^e}{dn_1} > 0$, which means that firm location is insufficient.

Proposition 2

Suppose that $\frac{4}{5} < \gamma \leq 1$. Then, each firm insufficiently enters in the market with a smaller fixed cost.

The result of insufficient location under a difference in fixed costs is included in Proposition 2. Proposition 2 implies that a small degree of product differentiation produces the same result as for homogeneous goods.

Next we focus on the case with $h'(N-1) < 0$. From (16), we have

$$h'(N-1) = \frac{1}{2\left[\gamma(N-2)+2\right]^4}\left[\gamma(1+\gamma)(N-1) - (2-\gamma)^2\right]. \tag{19}$$

The sign of (19) depends on the sign of the second square bracket. Define $f(\gamma) \equiv \gamma(1+\gamma)(N-1) - (2-\gamma)^2 = (N-2)\gamma^2 + (N+3)\gamma - 4$. Since $f(0) < 0$ and $f(1) > 0$ if $N > \frac{3}{2}$, there exists a unique threshold of γ in the interval $(0, 1]$. We find that $f(\gamma) < 0$ holds if $0 < \gamma < \hat{\gamma}$, where

$$\hat{\gamma} = \frac{-(N+3) + \sqrt{(N-1)(N+23)}}{2(N-2)}. \tag{20}$$

In other words, for $0 < \gamma < \hat{\gamma}$, we have $h'(N-1) < 0$.

Note that $f(\frac{1}{2}) = \frac{3}{4}(N-4)$. Thus, $\hat{\gamma} < \frac{1}{2}$ if $N > 4$. From (18), $h(1) > 0$ for all $\gamma \in (0, \hat{\gamma})$. If $N > 4$, then we have three possibilities in the relation between $h(n_1^e)$ and $h(n_2^e)$: (i) $h(n_2^e) > h(n_1^e) \geq 0$, (ii) $h(n_2^e) > 0 \geq h(n_1^e)$, and (iii) $0 \geq h(n_2^e) > h(n_1^e)$.

In any cases, $h(n_1^e) - h(n_2^e) < 0$. Therefore, we have $\frac{dW^e}{dn_1} < 0$, which means that firm location is excessive.

Proposition 3

Suppose that $N > 4$ and $0 < \gamma < \hat{\gamma}$. Then, each firm excessively enters in the market with a smaller fixed cost.

Proposition 3 would result in firms excessively locating in the region with low fixed costs, the opposite of Proposition 2. The following intuitive explanation holds for these results. As with the marginal cost differential, more firms are located in region with low costs, region 1. Since the marginal costs are equal, the price-cost margin is small in region 1 and large in region 2. In other words, the disparity in the change in profit due to the business-stealing effect is significant. Although many firms are located in region 1, the size of the change in profits due to the business-stealing effect is larger in Region 2. As a result, there are cases where the positive externality of region 2 exceeds the negative externality of region 1. In this case, the sign of $\frac{dW^e}{dn_1}$ will be positive, i.e., firms insufficiently locate in region 1. However, as shown in (1), more significant product differentiation will result in smaller price movements and a smaller price-cost margin, i.e., smaller inter-regional differences in the change in profit due to the business-stealing effect. In this case, as in the case of marginal cost disparity, the negative externality in region 1 with more firms exceeds the positive externality in region 2 with fewer firms.

In the general case, where marginal and fixed costs differ, results in the above two cases are combined; as shown in Kurata, Ohkawa, and Okamura (2021), firms may insufficiently locate in the lower costs if the gap in fixed costs is significant. Otherwise, firms excessively locate in the region with lower costs.

4 Concluding Remarks

We have considered the effects of product differentiation on firm location in the service industries. When firms locate to two regions with disparities in region-specific costs, we have examined whether firms locate efficiently or, if not efficiently, whether excessively or insufficiently, in terms of economic welfare. We demonstrate that under the difference in marginal costs, firms excessively locate to the region with a lower cost regardless of the degree of product differentiation, but under the difference in fixed entry costs, firms may insufficiently locate to the region with a lower cost if the degree of product differentiation is small.

In this paper, we analyze competition in the market for services as the Cournot quantity competition because we incorporate product differentiation into the model following previous studies. However, it is more realistic to consider the market for services as the Bertrand price competition. Considering the different types of competition is our next task.

References

[1] Barros, P. and Cabral, L. (2000), "Competing for foreign direct investment," *Review of International Economics* 8, pp. 360–371.

[2] Behrens, K. (2005), "Market size and industry location: Traded vs non-traded goods," *Journal of Urban Economics* 58, pp. 24–44.

[3] Fumagalli, C. (2003), "On the welfare effects of competition for foreign direct investments," *European Economic Review* 47, pp. 963–983.

[4] Kurata, H., Ohkawa, T. and Okamura, M. (2009), "Location Choice, Competition, and Welfare in Non-tradable Service Industry," *International Review of Economics and Finance* 18, pp. 20–25.

[5] Kurata, H., Ohkawa, T. and Okamura, M. (2011), "Market Size and Firm Location in a Service Industry," *Review of International Economics* 19, pp. 1–14.

[6] Kurata, H., Ohkawa, T. and Okamura, M. (2021), "A higher-cost region excessively attracts firms," *The Journal of International Trade & Economic Development* 30, pp. 125–137.

[7] Mankiw, N. G. and Whinston, M. D. (1986), "Free Entry and Social Inefficiency," *Rand Journal of Economics* 17, pp. 48–58.

[8] Suzumura, K. and Kiyono, K. (1987), "Entry Barriers and Economic Welfare," *Review of Economic Studies* 54, pp. 157–167.

[9] Wong, Y.P, Wu, J., and Zhang, A. (2006), "A Model of Trade Liberalization in Services," *Review of International Economics* 14, pp. 148-168.