Welfare Analysis of Place-Based Policies for Retail Agglomeration

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Developing a multipurpose shopping model in which retail stores are under monopolistic competition and consumers are free to choose where to reside, we evaluate the welfare impacts of place-based policies for retail agglomeration in a downtown. Results show that, with the constant elasticity of substitution of consumers, subsidizing consumers residing near a marketplace and land use regulation are harmful from the viewpoint of welfare. On the other hand, subsidizing retail stores operating in a marketplace is desirable from the viewpoint of welfare.

Key Words: *Agglomeration, Monopolistic competition, Multipurpose shopping, Place-based policy*

1. Introduction

Shopping is an indispensable daily activity in our lives. The decline of retail stores operating in downtown has been regarded as an urban problem over the past several decades. Local governments have taken policies in order to make retail stores agglomerate in the downtown. Recently, place-based policies have been taken by local governments. A feature of place-based policies is that stores and/or consumers in a targeted area are subsidized. For example, the city of Albuquerque in the U.S.A. subsidizes retail stores operating in the downtown. The city of Toyama in Japan subsidizes consumers that migrate from an area outside the downtown to an area around the downtown.

The policy impacts of place-based policies (e.g., the number and the productivity of retail stores) have been empirically investigated.[1),2),3)]. For example, Givord, et al. [1)] empirically showed that retail stores had more agglomerated in a targeted area in France by adopting a place-based policy. This result indicates that place-based policies would revitalize the downtown in a city. However, the place-based policy does not ensure that the social welfare increases because it may cause the decline of retail stores in other areas. We theoretically examine whether or not place-based policies increase social welfare.

Developing a multipurpose shopping model in which retail stores are under monopolistic competition and consumers are free to choose where to reside, we evaluate the welfare impacts of place-based policies for retail agglomeration in a marketplace. We focus on two place-based policies which have been taken by local governments. One is location subsidies to consumers, whereas the other is location subsidies to stores. We investigate how these place-based policies affect social surplus, evaluating the welfare impacts of these policies in terms of surplus. We show that subsidizing consumers residing near a marketplace is harmful from the viewpoint of welfare. On the other hand, subsidizing retail stores operating in a marketplace is desirable.

Our paper is organized as follows. Basic assumptions are introduced in Section 2. Welfare analysis is conducted in Section 3. Section 4 concludes our paper.

2. Model

(1) Basic assumptions

The basic structure of our model is as follows. The city is a closed city where $\overline{N}$ consumers reside. This city consists of residential zones where consumers reside and marketplaces where horizontally differentiated goods are sold. The number of the residential zones and the marketplaces are I and J, respectively.

Each marketplace is surrounded by residential zones. The number of the residential zones around the jth marketplace is I_j. Hence, $\sum_{j=1}^{J} I_j = I$ holds. All the consumers residing the residential zones around the jth marketplace visit the marketplace for shopping. In addition, all the consumers in the city are homogeneous and free to choose where to reside. Each residential zone contains buildings for housing. The buildings are produced by combining one unit of land and housing capital (or building materials).

(2) Consumers

Consumers derive utility from differentiated goods, housing measured in floor area, and a composite good. Let J and I_j denote the set of the marketplaces and the residential areas around the jth marketplace, respectively. We express J as $J \equiv \{1, 2, \ldots, J\}$. In addition, using I_j $(j \in J)$, we express I_j as

$$I_j \equiv \left\{ \sum_{a=0}^{j-1} I_a + 1, \sum_{a=0}^{j-1} I_a + 2, \ldots, \sum_{b=0}^{j-1} I_a + I_j \right\} \quad \forall j \in J,$$

where $I_0 = 0$. The set of the residential zones I is given by $\cup_{j=1}^{J} I_j$ (i.e., $I = \cup_{j=1}^{J} I_j$). The utility of consumers residing in residential zone i $(\in I)$ is given by $U_i(M_i, h_i, a_i)$, where M_i is the composite index of the consumption of differentiated goods, h_i is the consumption of housing square footage, and a_i is the consumption of the composite good. M_i is assumed to be an additively separable function over the varieties supplied in a marketplace:

$$M_i = \int_0^{m_{j(i)}} u(q_i(k)) \mathrm{d}k, \tag{1}$$

where

$$j(i) = \begin{cases} 1 & (i \in I_1), \\ 2 & (i \in I_2), \\ \vdots & \\ J & (i \in I_J), \end{cases}$$

$q_i(k)$ is the consumption of the kth variety, m_j is the mass of varieties supplied in the jth marketplace. We explain the net income of consumers residing in zone i. We assume public ownership. That is, land and firms in the city are equally owned by all the consumers. The consumers' net income is composed of common income y, travel cost to the marketplace t_i, equal share of profits and rents Π, and subsidy (or tax) $s_i(s)$. We call s policy instrument. We assume that no policy is implemented if $s = 0$: $s_i(0) = 0$ $(\forall i \in I)$.

The budget constraint of the consumers is given by

$$\int_0^{m_{j(i)}} p^M_{j(i)}(k) q_i(k) \mathrm{d}k + p^H_i h_i + a_i = y_i + s_i(s), \tag{2}$$

where $p^M_j(k)$ is the price of kth variety supplied in the jth marketplace, p^H_i is the price per square foot of housing in residential zone i, $y_i \equiv y - t_i + \Pi$ is the net income without subsidy (or tax). The composite good is assumed to be the numéraire.

We solve the following utility maximization problem:

$$\max_{\{q_i(k)\}_k, h_i, a_i} U_i(M_i, h_i, a_i) \quad \text{s.t.} \quad \text{Eqs. (1) and (2).} \tag{3}$$

Using the weak separable preference represented by the utility function, we decompose the utility maximization problem into two problems regarding two-stage budgeting. The conditional demands are functions of k, $\{p^M_{j(i)}(k)\}_k$, $m_{j(i)}$, and M_i:

$$q^*_i(k) = \widetilde{q}^*_i(\{p^M_{j(i)}(k)\}_k, m_{j(i)}, M_i) \quad \forall k \in [0, m_j],$$

where superscript " $*$ " denotes the optimal solution. We assume that all the consumers consume all the varieties (i.e., $q^*_i(k) > 0$ $(\forall k \in [0, m_j])$). On the other hand, the demand functions are functions of $\{p^M_{j(i)}(k)\}_k$, $m_{j(i)}$, p^H_i, y_i, and s:

$$\begin{aligned} M^*_i &= \widetilde{M^*_i}(\{p^M_{j(i)}(k)\}_k, m_{j(i)}, p^H_i, y_i, s), \\ h^*_i &= \widetilde{h^*_i}(\{p^M_{j(i)}(k)\}_k, m_{j(i)}, p^H_i, y_i, s), \\ a^*_i &= \widetilde{a^*_i}(\{p^M_{j(i)}(k)\}_k, m_{j(i)}, p^H_i, y_i, s). \end{aligned}$$

Substituting M^*_i into $q^*_i(k)$ yields

$$q^*_i(k) = \widetilde{q^*_i}\left(\{p^M_{j(i)}(k)\}_k, m_{j(i)}, \widetilde{M^*_i}(\{p^M_{j(i)}(k)\}_k, m_{j(i)}, p^H_i, y_i, s)\right).$$

(3) Retail stores

Retail stores supply differentiated goods in marketplaces. Each retail store supplies a variety in a marketplace. Retail stores that operate in each marketplace are under monopolistic competition. Hence, the total mass of retail stores in each marketplace is endogenously determined by free entry.

Let $Q_j(k)$ denote the supply of the kth variety in marketplace j. All the retail stores incur the same marginal production cost c to supply varieties. On the other hand, the retail store that supplies the kth variety incur $k + r_j(k)$ for the fixed cost, where k also represents the fixed cost that depends on varieties, and $r_j(k)$ is land rent. Retail stores in the same marketplace receive the same amount of subsidy. Let $\pi^M_j(k)$

be the profit of the retail store supplying the kth variety in marketplace j. Under the assumption, $\pi_j^M(k)$ is given by

$$\pi_j^M(k) = (p_j^M(k) - c)Q_j(k) - k + \frac{s_j^M(s)}{m_j} - r_j(k), \tag{4}$$

where $s_j^M(s)$ is the total subsidy provided to marketplace j. Since no consumer incurs tax to subsidize retail stores for $s = 0$ (i.e., $s_i(0) = 0$ ($\forall i \in I$)), we assume $s_j^M(0) = 0$ ($j \in J$). The total subsidy provided to all the marketplace are paid by consumers:

$$\sum_{i \in I} n_i s_i(s) + \sum_{j \in J} s_j^M(s) = 0 \quad \forall s \geq 0, \tag{5}$$

where n_i is the total number of consumers residing in residential zone i.

We assume that each store pays the bid rent to an absentee landowner. Under the free entry, the profits of stores are zero: $\pi_j^M(k) = 0$ ($\forall k \in [0, m_j]$). Using this condition, we can obtain the maximum land rent that each store can pay:

$$r_j(k) = (p_j^M(k) - c)Q_j(k) - k + \frac{s_j^M(s)}{m_j}, \tag{6}$$

Since the bid rent is equal to the maximum profit, the bid rent is given by

$$r_j(k) = \max_{p_j^M(k)} \left((p_j^M(k) - c)Q_j(k) - k + \frac{s_j^M(s)}{m_j} \right). \tag{7}$$

The total supply (or demand) is given by

$$Q_j(k) = \sum_{a \in I_j} n_a q_a^*(k), \tag{8}$$

The first order condition for maximization problem (7) is given by

$$\frac{Q_j(k)}{p_j^M(k)} (p_j^M(k) + (p_j^M(k) - c)\eta_j^M(k)) = 0, \tag{9}$$

where $\eta_j^M(k)$ is the price elasticity of the total demand: $\eta_j^M(k) = \partial \ln Q_j(k) / \partial \ln p_j^M(k)$. Using first order condition (9), we can obtain the prices of varieties supplied in marketplace j.

$$p_j^M(k) = \widetilde{p_j^M}(k, \{n_i\}_{i \in I_j}, m_j, \{p_i^H\}_{i \in I_j}, \{y_i\}_{i \in I_j}, s).$$

We assume that all the varieties supplied in a marketplace have equal prices:

$$p_j^M(k) = p_j^M(k') \quad \forall\, k, k' \in [0, m_j],\ \forall j \in J. \tag{10}$$

Since the prices do not depend on k, we express $p_j^M(k)$ as p_j^M. Furthermore, under the symmetric price equilibrium, the total demand for varieties supplied in the same marketplace are the same: $Q_j(k) = Q_j(k')$ ($\forall\, k, k' \in [0, m_j]$). Hence, we express $Q_j(k)$ as Q_j.

(4) Developers

Developers are assumed to be perfectly competitive and homogeneous. They supply residential buildings in residential zones.

Residential buildings (i.e., housing measured in floor area) are produced by combining housing capital (or building materials) and one unit of land. The area of land in each residential zone is assumed to be one. These buildings output per unit of land is expressed as $g(b)$, where g is the housing production function and b is the capital-to-land ratio. Let π_i^H and H_i denote the developer's net profit in residential zone i and the housing output, respectively. π_i^H is given by

$$\pi_i^H = p_i^H H_i - g^{-1}(H_i) - R_i^H, \tag{11}$$

where g^{-1} is the inverse function of g and R_i^H ($i \in I$) is the land rent in residential zone i.

We assume that developers also pay the bid rent to an absentee landowner. Under the free entry, the profits of developers are zero: $\pi_i^H = 0$. Using this condition, we can obtain the maximum land rent that developers can pay:

$$R_i^H = p_i^H H_i - g^{-1}(H_i). \tag{12}$$

Hence, the bid rent is given by

$$R_i^H = \max_{H_i} \left(p_i^H H_i - g^{-1}(H_i) \right). \tag{13}$$

The first order condition for maximization problem (13) is

$$p_i^H - \frac{\partial g^{-1}(H_i)}{\partial H_i} = 0 \quad \forall i \in I. \tag{14}$$

Using this condition, we can obtain $H_i^* = \widetilde{H_i^*}(p_i^H)$. Hence, the bid rent is expressed as

$$R_i^H = p_i^H H_i^* - g^{-1}(H_i^*) \quad \forall i \in I. \tag{15}$$

(5) Market equilibrium condition

We introduce short-run equilibrium and long-run equilibrium. In the short-run equilibrium, the market clearing condition of housing holds and the mass of retail stores is determined under fixed the spatial distribution of the consumers (i.e., n_i). In the long-run equilibrium, the spatial distribution is determined.

Let $\boldsymbol{n} \equiv (n_i)_{i \in I}$ denote the spatial distribution of the consumers in the city. Using the short run equilibrium condition, we can obtain these variables as functions of spatial distribution $\boldsymbol{n}$ and policy instrument

s:

$$m_j = \widetilde{m_j}(\boldsymbol{n}, s), \quad p_i^H = \widetilde{p_i^H}(\boldsymbol{n}, s), \quad y_i = \widetilde{y_i}(\boldsymbol{n}, s).$$

Substituting these functions into $\widetilde{p_j^M}$, we obtain $\widetilde{p_j^M}$ as a function of $\boldsymbol{n}$ and s. Since the prices, the masses, and the net income are functions of $\boldsymbol{n}$ and s, the demand functions are also functions of $\boldsymbol{n}$ and s in the short-run equilibrium. Hence, the indirect utility is also a function of $\boldsymbol{n}$ and s in the short-run equilibrium.

In the long-run equilibrium, the spatial distribution is determined. We employ the complementary condition for the long-run equilibrium condition. Let V_i denote the indirect utility for consumers residing in residential zone i. $\boldsymbol{n}$ is an equilibrium iff $\overline{V}$ exists such that the following conditions hold:

$$\begin{cases} V_i(\boldsymbol{n}, s) = \overline{V} & \text{if} \quad n_i > 0, \\ V_i(\boldsymbol{n}, s) < \overline{V} & \text{if} \quad n_i = 0, \end{cases} \quad \forall i \in I, \tag{16}$$

and

$$\sum_{i \in I} n_i = \overline{N}. \tag{17}$$

3. Welfare analysis of place-based policies

We investigate welfare impact from the viewpoint of surplus. Among several measures of surplus, we employ the Allais surplus[5)]. The Allais surplus is defined as the amount of the numéraire good that can be extracted from the city when the utility level is kept constant.

In our model, the Allais surplus is the weighted sum of income minus expenditure of consumers with the weights being the number of consumers. Since the expenditure depends on the prices of the goods, we obtain the prices with the Hicksian demands and the market equilibrium condition. Hence, we can obtain the Allais surplus by the almost same procedure shown in Section 2.

Let AS and e_i denote the Allais surplus and the expenditure function of consumers residing in residential zone i, respectively. Using the expenditure functions and the equilibrium condition, we can obtain AS as a function of $\boldsymbol{n}$ and s under target utility level $\overline{U}$:

$$AS(\boldsymbol{n}, s, \overline{U}) = \sum_{i \in I} n_i(y - t_i + \Pi + s_i(s) - e_i), \tag{18}$$

We evaluate the welfare impact of adopting place-based policies. We focus on two place-based policies. One is location subsidies to consumers, whereas the other is location subsidies to stores. Similar policies to both the policies are taken by local governments in the real world (e.g., Albuquerque in U.S. and Toyama City in Japan).

(1) Model specification

Specifying utility function and housing production function, we demonstrate how place-based policies affect the Allais surplus. Canonical multipurpose shopping models in which retail stores are under monopolistic competition represent consumers' love of variety with Constant Elasticity of Substitution (CES) function [6),7),8)]. We evaluate the welfare impact under the following utility function:

$$U_i = \frac{\sigma\mu}{\sigma - 1} \ln M_i + (1 - \mu) \ln h_i + a_i, \quad 0 < \mu < 1, \tag{19}$$

where $M_i = \int_0^{m_{j(i)}} q_{j(i)}(k)^{(\sigma-1)/\sigma} \mathrm{d}k$. σ and μ are the elasticity of substitution between any two varieties and the shopping expenditure, respectively.[1] In addition to the above specification for consumers' preference, we specify housing production function employed urban economics models [9),10),11)]:

$$g(b) = \theta b^{\beta} \ (0 < \theta, \ 0 < \beta < 1). \tag{20}$$

Under these specifications, we can obtain the closed form of Allais surplus AS.

We focus on location subsidies to stores. This place-based policy is an example in which $ES \neq 0$ could hold. We assume that all retail stores operating in marketplace 1 are subsidized by this policy. The total subsidy to the stores is policy instrument s and this subsidy is equally paid by all the consumers. Under the assumption, the policy functions are given by

$$s_i(s) = -s/\overline{N}, \quad s_j^M(s) = \begin{cases} s & (j = 1), \\ 0 & (j \neq 1). \end{cases} \tag{21}$$

(2) Numerical examples

Conducting numerical analysis of equilibrium and the Allais surplus at the equilibrium for $s \geq 0$, we investigate how the surplus changes on the equilibrium. We consider a spatial economy that consists of the downtown and the suburb in a city. There are more residential zones in the downtown than the zones in the suburb. We represent the assumption as $J = 2$, $I_1 = 5$, and $I_2 = 3$. Hence, the number of the residential zones for the downtown is five, whereas that for the suburb is three. The travel costs to the marketplaces are the same: $t_i = 10$ ($\forall i \in I$). On the other hand, we set common income of consumers y at 1000.

[1] In addition, $1 - \mu$ implies the housing expenditure.

Hence, 1% of the common income is the travel cost to the marketplace.

We also check the stability of equilibrium. We assume that $\boldsymbol{n}$ gradually evolves under the replicator dynamics [12]:

$$\frac{\mathrm{d}\boldsymbol{n}}{\mathrm{d}t} = \boldsymbol{F}(\boldsymbol{n}), \tag{22}$$

where $\boldsymbol{F}(\boldsymbol{n}) = (F_i(\boldsymbol{n}))_{i\in I}$ and $F_i(\boldsymbol{n}) = n_i(V_i - \boldsymbol{n}^\top \boldsymbol{V})$ $(\forall i \in I)$. $\boldsymbol{n}^\top \boldsymbol{V}$ represents the weighted average utility. A stationary point (i.e., $\boldsymbol{n}$ such that $\boldsymbol{F}(\boldsymbol{n}) = \boldsymbol{0}$) is linearly-stable if every eigenvalue of Jacobian matrix $\partial \boldsymbol{F}/\partial \boldsymbol{n}$ has a negative real part.[2] We call linearly-stable stationary points stable equilibria.

We conduct numerical analysis under utility function (19) and production function (20). There are five exogenous parameters: σ, μ, θ, β, c. Referring to the empirical results shown by Domon, et al.[11], we set θ and β at 0.0028 and 0.75, respectively. On the other hand, referring to the empirical result shown by Bergstrand, et al.[14], we set σ at 6.0. In addition, we set μ and c at 0.4 and 1, respectively. The value of μ means that the ratio of the shopping expenditure to the housing expenditure is about 66%.

We evaluate two place-based policies. One is location subsidies to stores operating in the downtown:

$$s_i(s) = -s, \quad s_j^M(s) = \begin{cases} s & (j=1), \\ 0 & (j=2). \end{cases} \tag{23}$$

The other is location subsidies to consumers residing in the downtown:

$$s_i(s) = \begin{cases} ((\sum_{a\in I_1} n_a)^{-1} - 1)s & (i \in I_1), \\ -s & (i \in I_2), \end{cases} \tag{24}$$

$$s_j^M(s) = 0 \quad \forall j \in J. \tag{25}$$

We investigated the equilibrium and the Allais surplus for $0 \le s \le 10$. Figure 1 shows the population in residential zone 1 and the Allais surplus on the stable market equilibria. The Allais surplus increases for the place-based policy expressed by Eq. (23) and decreases for the place-based policy expressed by Eq. (24) from $s = 0$. We also checked that the Allais surplus monotonously had decreased for $0.04 \le s \le 10$. We omit to represent the result for the range in order to clearly show that the Allais surplus increases for location subsidies to the retail stores.

[2] Note that the market equilibria are stationary points of the replicator dynamics.

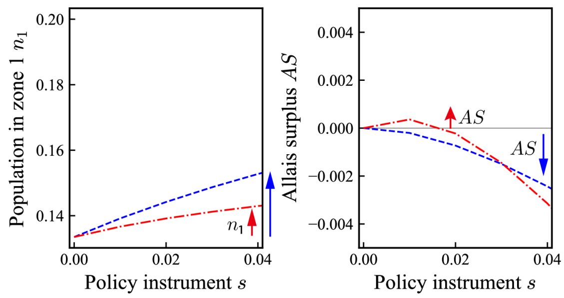

Fig.1 Stable market equilibria and the Allais surplus under utility function (19) and production function (20). Left figure: the equilibria; right: the Allais surplus on the equilibria. Red dashed-dotted line: the result obtained for policy function (23); blue dashed line: the result obtained for policy function (24).

4. Conclusion

We have evaluated how place-based policies affect social welfare. Conducting theoretical analysis under constant and variable elasticity of substitution between varieties supplied in marketplaces, we obtain two main findings: (1) subsidizing retail stores operating in a downtown is desirable from the viewpoint of welfare, and (2) subsidizing consumers residing near the downtown is harmful. A main reason for the difference is the level of the variety distortion generated by a place-based policy. Since directly subsidizing retail stores generates the direct benefit of the variety distortion, we obtain these results. Furthermore, we have shown that adopting policies that change the spatial distribution of consumers (e.g., land-use regulation) is harmful under the constant elasticity of substitution even though there are market distortions generated by monopolistic competition.

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