Quantitative evaluation of benefits of place-based policies for retail agglomeration

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Local governments have recently adopted place-based policies in order to revitalize decayed shopping areas in downtown areas. Developing a multipurpose shopping model, we quantitatively evaluate the welfare impacts of place-based policies for downtown retail agglomeration. In the model, retail stores are under monopolistic competition, and households are free to choose where to reside. Results show that, whether or not place-based policies are efficient depends on the recipients of government subsidies, even if the policies promote retail agglomeration in downtown areas. We show that the total benefits of location subsidies to households and location subsidies to stores are 566 and −342 million JPY per year, respectively.

Key Words: *Agglomeration, Monopolistic competition*

1. Introduction

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

Impacts of place-based policies on retail stores have been empirically investigated.[1),2)] For example, Givord et al.[1)] empirically show that, in France, the government has promoted the agglomeration of retail stores by a place-based policy, which indicates that place-based policies can revitalize downtown areas. However, the place-based policy does not ensure that social welfare increases because it can produce deadweight losses in the policy-implemented market, and can cause a decline in the number of retail stores in other areas. We quantitatively clarify which place-based policies increase social welfare, and which decrease social welfare.

We cannot declare that place-based policies for retail agglomeration increase social welfare since the policies relate to the price distortion, the variety distortion, and the fiscal externality. Nevertheless, place-based policies have been beyond the scope of theoretical analysis with multipurpose shopping. To efficiently apply a place-based policy for retail agglomeration in the downtown area, we need to understand the magnitude of the benefit of the policy.

We quantitatively evaluate the welfare impacts of place-based policies for retail agglomeration by developing a multipurpose shopping model. In the model, retail stores are under monopolistic competition, and households are free to choose where to reside. We focus on two place-based policies which have been adopted by local governments. One is location subsidies to households, and the other is location subsidies to stores. In our paper, location subsidies to households implies that households residing in the downtown area receive subsidies, whereas households residing in the suburbs pay tax. Location subsidies to stores implies that retail stores operating in the downtown receive subsidies, whereas all the households pay the same amount of tax. Income transfer among households with location subsidies to households is asymmetric in terms of residential zones. Hence, location subsidies to households can cause a negative welfare impact in terms of the fiscal externality.

Our investigation finds that whether or not place-based policies are socially efficient depends on the recipients of the subsidies, even if the policies promote downtown retail agglomeration. We show that the total benefits of location subsidies to households and location subsidies to stores are 566 and −342 million JPY per year, respectively. These results indicate that policy makers should apply symmetric income transfer among households with place-based policies rather than asymmetric income transfer.

The rest of our paper is organized as follows. Basic assumptions are introduced in Section 2. The results of the quantitative analyses are shown in Section 3. Section 4. concludes our paper.

2. Model

(1) Basic assumptions

The basic structure of our model is as follows. We consider a closed city where homogeneous $\overline{N}$ households reside. This city consists of the downtown area and homogeneous suburbs. Let $I \equiv \{0, 1, 2, \ldots, I\}$ denote the set of residential zones. I is the number of the suburbs in the city. We regard residential zone 0 as the downtown area and zone i $(= 1, \ldots, I)$ as the suburb. There is one marketplace in each residential zone. In the marketplaces, retail stores supply goods; households choose where to reside.

(2) Households

Households in the city derive utility from differentiated goods, housing measured in floor area, and a composite good. The utility of households residing in residential zone i $(\in I)$ is given by

$$U_i(M_i, h_i, a_i) = \mu_1 \ln M_i + \mu_2 \ln h_i + \mu_3 \ln a_i + \overline{A}_i, \quad \mu_1 + \mu_2 + \mu_3 = 1, \tag{1}$$

where M_i is the composite index of the consumption of differentiated goods, h_i is the consumption of housing measured by floor space, a_i is the consumption of the composite good, and $\overline{A}_i$ is the level of amenities in zone i, which is a constant term. $\overline{A}_1 = \overline{A}_2 = \cdots = \overline{A}_I$ holds since the suburbs are homogeneous. M_i is assumed to be the constant elasticity of substitution function:

$$M_i = \left(\int_0^{m_i} q_i(k)^{(\sigma-1)/\sigma} \mathrm{d}k \right)^{\frac{\sigma}{\sigma-1}}, \tag{2}$$

where $q_i(k)$ is the consumption of the kth variety, m_i is the mass of varieties supplied in zone i.

Households residing in the downtown area do not need land for housing. In the downtown area, floor space is supplied with residential buildings. On the other hand, households residing in the suburb need land for housing. In the suburb, floor space is supplied with housing and land. Let ϕ denote the floor-area ratio in the suburb for housing. Households need $1/\phi$ unit of land for one unit of floor space in the suburb. We assume that households residing in the suburb periodically pay land rent. We regard land consumption as a flow.

The budget constraint of the households residing in zone i is given by

$$\begin{cases} \int_0^{m_0} p_0^M(k) q_0(k) \mathrm{d}k + p_0^H h_0 + a_0 = y_0 \\ \qquad (i = 0), \\ \int_0^{m_i} p_i^M(k) q_i(k) \mathrm{d}k + p_i h_i + (R_i^H/\psi) h_i + a_i = y_i \\ \qquad (i = 1, \ldots, I), \end{cases} \tag{3}$$

where $p_i^M(k)$ is the price of the kth variety supplied in zone i, p_0^H is the price per square foot of housing in the downtown area, and y_i is the net income of households. p_i and R_i^H $(i = 1, \ldots, I)$ are the price of housing and land rent per square foot in the suburb, respectively. $p_i h_i$ and $(R_i^H/\psi)h_i$ are the total housing cost and land rent in the suburb, respectively. We summarize the prices with $p_i^H \equiv p_i + R_i^H/\psi$ $(i = 1, \ldots, I)$, which is the housing price per square foot in the suburb. The composite good is assumed to be the numéraire.

We assume public ownership of land and firms for simplicity. Households' net income y_i is composed of common income y, equal share of the sum of profits and rents Π, and subsidy (or tax) $s_i(s)$: $y_i = \widetilde{y}_i(s) \equiv y + \Pi + s_i(s)$. Each place-based policy determines $s_i(s)$ and s $(\in \mathbb{R})$ expresses the level of policy implemented. We call s the policy instrument.

We considers two place-based policies: location subsidies to stores, and location subsidies to households. Households (retail stores) in the same zone can receive the same amount of subsidy for the policies. Let n_i and $s_i^M(s)$ denote the total number of households and the total subsidy provided to retail stores in residential zone i, respectively. The formal definitions for the place-based policies are as follows.

Definition 1. Location subsidies to households in the downtown area is the place-based policy such that the following equations hold.

$$s_i(s) = \begin{cases} (\overline{N} - n_0)s/n_0 & (i = 0), \\ -s & (i = 1, \dots, I), \end{cases} \tag{4}$$

$$s_i^M(s) = 0 \quad (i \in I). \tag{5}$$

Definition 2. Location subsidies to stores in the downtown area is the place-based policy such that the following equations hold.

$$s_i(s) = -s/\overline{N} \quad (i \in I), \tag{6}$$

$$s_i^M(s) = \begin{cases} s & (i = 0), \\ 0 & (i = 1, \dots, I). \end{cases} \tag{7}$$

"Location subsidies to households" implies that households residing in the downtown area receive subsidies, whereas households residing in the suburbs pay tax. "Location subsidies to stores" implies that retail stores operating in the downtown receive subsidies, whereas all the households pay the same amount of tax. Income transfer among households with location subsidies to households is asymmetric in terms of residential zones. Such asymmetric income transfer among households is a source of market failure called fiscal externality. The subsidies with the policies are paid by households:

$$\sum_{i \in I}(n_i s_i(s) + s_i^M(s)) = 0. \tag{8}$$

We solve the following utility maximization problem:

$$\max_{\{q_i(k)\}_k, h_i, a_i} U_i(M_i, h_i, a_i) \quad \text{s.t.} \quad \text{Eqs. (2) and (3).} \tag{9}$$

We decompose the utility maximization problem into two problems regarding two-stage budgeting. The conditional demands are given by

$$q_i^*(k) = p_i^M(k)^{-\sigma} P_i^\sigma M_i \quad \forall k \in [0, m_i],$$

where superscript " * " denotes the optimal solution and P_i is the price index for the varieties supplied in residential zone i:

$$P_i = \left(\int_0^{m_i} p_i^M(k)^{1-\sigma} \mathrm{d}k \right)^{1/(1-\sigma)}.$$

The demand functions are given by

$$M_i^* = \mu_1 y_i / P_i, \quad h_i^* = \mu_2 y_i / p_i^H, \quad a_i^* = \mu_3 y_i.$$

Substituting M_i^* into $q_i^*(k)$ yields

$$q_i^*(k) = \mu_1 p_i^M(k)^{-\sigma} y_i / P_i^{1-\sigma}.$$

Let V_i denote the indirect utility of households residing in residential zone i. Substituting the demand functions into the indirect utility yields

$$V_i = \ln y_i - \mu_1 \ln P_i - \mu_2 \ln p_i^H + \overline{A}_i + \xi, \tag{10}$$

where $\xi = \mu_1 \ln \mu_1 + \mu_2 \ln \mu_2 + \mu_3 \ln \mu_3$.

(3) Retail stores

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

All the retail stores incur the same marginal production cost c to supply varieties. The retail store that supplies the kth variety incur $k + r_i(k)$ for the fixed cost, where k also represents the fixed cost that depends on varieties, and $r_i(k)$ is land rent of a constant unit of land for a store. Some retail stores can receive subsidies, as shown in Definition 2.

Let $Q_i(k)$ and $\pi_i^M(k)$ denote the supply of the kth variety and the profit of the retail store supplying the kth variety in residential zone i, respectively. $\pi_i^M(k)$ is given by

$$\pi_i^M(k) = (p_i^M(k) - c)Q_i(k) - k - r_i(k) + \frac{s_i^M(s)}{m_i}. \tag{11}$$

We assume that each store pays the bid rent. Using the profit yields the maximum land rent that each store can pay:

$$r_i(k) = \max_{p_i^M(k)} \left((p_i^M(k) - c)Q_i(k) - k + \frac{s_i^M(s)}{m_i} \right). \tag{12}$$

This equation implies that the more demand for a variety in a marketplace, the higher the bid rent. Hence, if the prices of a variety supplied in some marketplaces are the same, then a retail store operating in a larger marketplace can propose a higher bid rent.

The total supply (or demand) is given by

$$Q_i(k) = n_i q_i^*(k). \tag{13}$$

Using this equation and solving maximization problem (12) yields the prices of varieties supplied in zone i.

$$p_i^M(k) = c\sigma/(\sigma - 1), \quad \forall j \in J, \ \forall k \in [0, m_i].$$

Since the prices do not depend on i and k, we express $p_i^M(k)$ as p^M. Under the symmetric price equilibrium, the demand and the total demand for varieties are given by

$$q_i^*(k) = \mu_1 y_i/(p^M m_i) \quad \forall k \in [0, m_i], \tag{14}$$

$$Q_i(k) = \mu_1 n_i y_i/(p^M m_i) \quad \forall k \in [0, m_i]. \tag{15}$$

(4) Firms supplying floor space

Floor space is supplied by developers and house builders. Developers and house builders supply floor space in the downtown area and the suburb, respectively. They are under perfect competition.

a) Developers

Residential buildings are produced by combining land and housing capital (or building materials). The area of land in the downtown area is $\overline{L}_0$. The building output measured in height per unit of land is expressed as $g(b) = \theta b^\beta \quad (0 < \theta, 0 < \beta < 1)$, where b is the capital-to-land ratio. Let π_0^H and H_0 denote the developers' net profit in the downtown area and the height of buildings, respectively. π_0^H is given by

$$\pi_0^H = p_0^H \overline{L}_0 H_0 - \overline{L}_0 g^{-1}(H_0) - \overline{L}_0 R_0^H, \tag{16}$$

where g^{-1} is the inverse function of g and R_0^H is the land rent per unit of land in the downtown area.

We assume that developers pay the bid land rent. Using the profit yields the maximum land rent that developers can pay:

$$R_0^H = \max_{H_0} (p_0^H H_0 - g^{-1}(H_0)). \tag{17}$$

Solving this maximization problem yields the height of buildings, the aggregated profits, and the bid rent.

b) House builders

House builders supply floor area in the suburb with constant marginal cost c^H and no fixed cost.

(5) Market equilibrium condition

Considering the short-run equilibrium and the long-run equilibrium, we obtain the market equilibrium. In the short-run equilibrium, given the spatial distribution of households (i.e., $(n_i)_{i \in I}$), the market clearing condition of housing holds and the mass of retail stores is determined. In the long-run equilibrium, the spatial distribution is determined. We focus on the market equilibrium at which the numbers of households residing in the suburbs are the same (i.e., $n_1 = n_2 = \cdots = n_I$).

We focus on the market clearing conditions for housing. Since the marginal cost of house builders is constant, $p_1 = c^H$ holds. The other market clearing conditions regarding housing are the market clearing condition for floor space in the downtown area and land in the suburb:

$$n_0 h_0^* = \overline{L}_0 H_0, \tag{18}$$

$$n_1 h_1^* = \psi \overline{L}_1. \tag{19}$$

Using Eq. (18), we obtain the floor area price in the residential zone:

$$p_0^H = \left[\mu_2 \theta^{-1/(1-\beta)} \beta^{-\beta/(1-\beta)} n_0 y_0 / \overline{L}_0\right]^{1-\beta}. \tag{20}$$

Using Eq. (19), we obtain the land rent in the residential zone:

$$R_1^H = \psi(\mu_2 n_1 y_1/(\psi \overline{L}_1) - c^H), \tag{21}$$

where $\overline{L}_1$ is the area of land in the suburb. Substituting c^H and Eq. (21) into total housing price p_1^H yields $p_1^H = \mu_2 n_1 y_1/(\psi \overline{L}_1)$.

Next, mass of retail stores m_i is determined as follows. Since p^M and Q_i do not depend on k, $(p^M - c)Q_i + s_i^M(s)/m_i$ also does not depend on k. Land rent $r_i(k)$, shown by Eq. (12), monotonously decreases with an increase in k. Using this monotonicity, $r_i(k) \geq 0$ $(\forall k \in [0, m_i])$, and Eq. (12), we obtain the following condition for mass of stores m_i:

$$r_i(m_i) = (p_i^M - c)Q_i - m_i + \frac{s_i^M(s)}{m_i} = 0. \tag{22}$$

This equation implies that sales equals the cost for the store supplying variety m_j. Substituting Eq. (15) into Eq. (22) yields

$$m_i = \sqrt{\frac{\mu_1}{\sigma} n_i y_i + s_i^M(s)}. \tag{23}$$

We focus on the net income of households (i.e., y_i). With the assumption of the public ownership, the profits and rents, Π, are equally divided among households. Using the market clearing conditions yields net income $\widetilde{y}_0, \widetilde{y}_1$.

Let $\boldsymbol{n} \equiv (n_0, n_1)$ denote the spatial distribution of the households in the downtown and the suburb. Using $\widetilde{y}_i(\boldsymbol{n}, s)$, we obtain the prices, the masses, and the net income as functions of $\boldsymbol{n}$ and s. Hence, the indirect utilities are also functions of $\boldsymbol{n}$, s, and exogenous variables: $V_0(\boldsymbol{n}, s), V_1(\boldsymbol{n}, s)$

In the long-run equilibrium, the spatial distribution is determined. $\boldsymbol{n}$ is an equilibrium iff $\overline{V}$ exists such that the following conditions hold:

$$\begin{cases} V_i(\boldsymbol{n}, s) = \overline{V} & \text{if} \quad n_i > 0, \\ V_i(\boldsymbol{n}, s) < \overline{V} & \text{if} \quad n_i = 0, \end{cases} \quad (i = 0, 1), \tag{24}$$

and

$$n_0 + I n_1 = \overline{N}. \tag{25}$$

3. How much benefit the place-based policies generate

(1) Parameter calibration

In order to quantitatively evaluate the welfare impact, we calibrate exogenous parameters. We calibrate number of total households, $\overline{N}$; number of households in residential zone i, $\overline{n}_i$; number of the suburbs, I; expenditure share, μ_j $(j = 1, 2, 3)$; common income, y; marginal cost that house builders incur, c^h; elasticities of substitution, σ; land area in zone i, $\overline{L}_i$; marginal cost that retail stores incur, c; exogenous parameters regarding constructing buildings in the downtown area, β and θ; and amenities level in zone i, A_i.

Using the data of Sendai in Japan, we calibrate the parameters. The center of the CBD is at Sendai Station. We regard the downtown area as the area within a range of 2km from the CBD. We regard a suburb as the area within a range of 2km from the center of Izumi-Park town, which is a suburban town in Sendai. We consider that the center is at Sendai-Izumi Premium Outlet.

Table 1 shows the results of the calibration.

(2) Quantitative result

Simulation setting

We conduct equilibrium and welfare analyses for the place-based policies shown in Definitions 1 and 2. In order to evaluate the welfare of the market equilibrium after the place-based policies are applied, we evaluate the welfare impact of the place-based policies with the equivalent variation. Let $E_i(P_i, p_i^H, U)$ denote the expenditure function for goods supplied in residential zone i. In our analysis, the prices are the functions of spatial distribution of households $\boldsymbol{n}$: $P_i = P_i(\boldsymbol{n})$, $p_i^H = p_i^H(\boldsymbol{n})$. Let EV_i denote the equivalent variation for the households residing in zone i. EV_i is given by

$$EV_i \equiv E_i(P_i(\boldsymbol{n}_{\text{before}}), p_i^H(\boldsymbol{n}_{\text{before}}), U_{\text{after}}) - E_i(P_i(\boldsymbol{n}_{\text{before}}), p_i^H(\boldsymbol{n}_{\text{before}}), U_{\text{before}}), \qquad (26)$$

where variables with subscripts “before” and “after” denote variables before and after place-based policies are applied, respectively. Since we regard $\boldsymbol{n}_{\text{before}}$ as the calibrated spatial households distribution, $\boldsymbol{n}_{\text{before}} = (\overline{n}_1, \overline{n}_2) = (32,181, 7,253)$ holds. Let $n_{i,\text{after}}$ denote the population in zone i. The aggregated equivalent variation is given by $SEV \equiv n_{1,\text{after}} \times EV_1 + I \times n_{2,\text{after}} \times EV_2$. We employ SEV to evaluate the welfare impacts.

We conduct welfare analyses for each place-based policy by changing policy instrument s. In order to restrict income transfer among households with place-based policies to be applicable in the real world, we restrict s to satisfy the condition that the income transfer is within $100,000$ (JPY / year). Conducting the analyses, we elucidate the efficient level of the policy instrument. If applying a place-based policy decreases welfare, we calculate the size of the decrease in welfare by applying the policy that generates income transfer with $100,000$ (JPY / year).

Results

Table 2 shows the result of the welfare analyses. Column (1) shows the result of applying location subsidies to households. Since $n_{1\text{after}} > \overline{n}_1$ holds, this policy promotes the agglomeration in the downtown area. We check whether this policy monotonously decreases the welfare. The result shown in Column (1) is the result where the policy is applied to generate income transfer with $100,000$ Japanese yen. As SEV shows, a negative benefit being equal to 566×10^6 Japanese yen occurs for each year.

Column (2) shows that of applying location subsidies to stores. The sign of the result regarding welfare is the opposite of the location subsidies to households. The efficient level of income transfer is $98,700$ Japanese yen. Since this policy agglomerates households in the downtown area and increases the welfare, this policy is a desirable place-based policy.

The results shown in Table 2 indicate that policy makers should apply symmetric income transfer among households with place-based policies rather than asymmetric income transfer.

4. Conclusion

We have quantitatively evaluated how place-based policies affect social welfare. We obtain two main findings: (1) subsidizing retail stores operating in downtown is desirable from the viewpoint of welfare, and (2) subsidizing households residing near the downtown is harmful. The results indicate that policy makers should apply symmetric income transfer among households with place-based policies rather than asymmetric income transfer.

表–1 Calibrated parameters

Total households $\overline{N}$	46,687	Elasticities of substitution σ	2.5
Households in the downtown area $\overline{n}_0$	32,181	Land area in the downtown area $\overline{L}_1$	675,977
Households in the suburb $\overline{n}_1$	7,253	Land area in the suburb $\overline{L}_2$	1,646,686
Expenditure share for shopping μ_1	0.280	Marginal cost c	1.0
Expenditure share for housing μ_2	0.224	Parameter regarding buildings β	0.70
Expenditure share for other goods μ_3	0.496	Parameter regarding buildings θ	0.0028
Common income y	3,923,988	Amenities level in the downtown A_1	-0.034351
Marginal cost c^h	6,566	Amenities level in the suburb A_2	0
Floor area ratio in the suburb ψ	0.6	Number of the suburbs I	2

表–2 Equivalent variation for applying the place-based policies

		(1)	(2)
		Place-based policy	
		Location subsidies to households	Location subsidies to stores
Income transfer (JPY / year)		$100,000$	$98,700$
Spatial distribution of households	$n_{1,\text{after}}$	$35,007$	$34,345$
	$n_{2,\text{after}}$	$5,840$	$6,171$
EV per household (JPY / year)	EV_1	$-12,118$	$7,328$
	EV_2	$-12,118$	$7,328$
Total EV (10^6 JPY / year)	SEV	-566	342

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