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9 February 2024

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Abstract

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.

Keywords: Agglomeration; Monopolistic competition; Multipurpose shopping; Place-based policy.

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The authors gratefully acknowledge financial support from JSPS KAKENHI (21J15651) and Grants-in-Aid for Scientific Research(B) (20H01485).

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 (e.g., Givord et al., 2013; Neumark and Simpson, 2015; Iwata and Kondo, 2021). For example, Givord et al. (2013) 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.

Place-based policies relate to two types of market failures. One is the shopping externality generated by multipurpose shopping (O'Sullivan, 1993), which is purchasing goods from stores on a single trip, and price distortions caused by imperfect competition among stores. The other is the migration fiscal externality generated by income transfer inefficiency by a place-based policy (Boadway and Flatters, 1982; Kono et al., 2007).

Empirical and theoretical studies have focused on the shopping externality. For example, Arentze et al. (2005) empirically show that agglomeration of retail stores relates to multipurpose shopping. Moreover, general equilibrium models in which households engage in multipurpose shopping with imperfect competition in a marketplace (e.g., shopping streets and shopping malls) have been developed (Henkel et al., 2000; Arakawa, 2006; Tabuchi, 2009; Ushchev et al., 2015). These models express the shopping externality with households' love of variety and monopolistic competition among retail stores. Place-based policies for retail agglomeration affect social welfare with a change in price distortion and variety distortion generated by monopolistic competition.

We turn our attention to the fiscal externality. Some place-based policies are applied with asymmetric income transfer among households. For example, subsidizing households who migrate from outside to an area around the downtown area causes fiscal externality. Actually, Aizawa and Kono (2023) theoretically show that such subsidizing is inevitably harmful from the viewpoint of welfare. To efficiently implement a place-based policy for retail agglomeration in the downtown area, we need to elucidate how much benefit place-based policies generate.

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.

Our paper relates to quantitative research that focuses on what drives retail agglomeration (e.g., Davis, 2006; Koster et al., 2019). For example, Koster et al. (2019) show the existence of shopping externality with the data for the number of pedestrians that pass shops in shopping streets. They evaluate the welfare impact measured by the profits of retail stores of a retail policy that subsidizes retail stores. In contrast to Koster et al. (2019), we focus on households' location choices as well as the stores' location choices in order to evaluate the welfare impacts of place-based policies. Our welfare evaluation, moreover, is based on a general equilibrium framework.

Some quantitative studies evaluate the welfare impacts of place-based policies (e.g., Busso et al., 2013) with quantitative spatial equilibrium models. These studies focus on spatial households' commuting and residing patterns in order to evaluate the welfare impact of policies to promote the growth of a business area. In contrast to these studies, we focus on spatial households' residing patterns affected by retail agglomeration in order to evaluate retail place-based policies. In particular, we focus on the agglomeration economy driven by the agglomeration of retail stores in marketplaces.

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

2.1. Basic assumptions

The model city is a closed city with $\overline{N}$ homogeneous households. This model city consists of $I + 1$ discrete locations. In each location, there are a marketplace and a residential zone. Let $\mathcal{I} \equiv \{0, 1, \ldots, I\}$ denote the sets of these discrete locations. We regard the 0th and ith ($i = 1, \ldots, I$) location as the downtown area and the ith suburb, respectively. For simplicity, we assume the suburbs are homogeneous. Households are free to choose the location in which to reside. Each Household visits the marketplace in the location where it lives for shopping. In the marketplaces, retail stores supply differentiated goods.

2.2. Households

We explain the utility and the budget constraint of households who reside in location i ($\in \mathcal{I}$). Households in the city derive utility from differentiated goods, housing measured in floor area, and a composite good. The utility of household residing in location 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 area, and 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. We express the homogeneity of the suburbs as $\overline{A}_1 = \overline{A}_2 = \cdots = \overline{A}_I$. M_i is assumed to be the constant elasticity of substitution function over the varieties (i.e., the differentiated goods) supplied in the ith residential zone:

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

where $q_i(k)$ is the consumption of the kth variety and m_i is the mass of varieties supplied in location 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 ψ denote the floor-area ratio in the suburb for housing. Households need $1/\psi$ unit of land for one unit of floor space in the suburb. We assume that households residing in the suburbs periodically pay land rent. Land consumption is regarded as flow.

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

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

where $p_i^M(k)$ is the price of the kth variety supplied in location 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 ith suburb, respectively. $p_i h_i$ and $(R_i^H/\psi)h_i$ are the total housing cost and land rent in the ith suburb, respectively. The price per square foot of housing in the ith suburb can be expressed as $p_i^H = p_i + R_i^H/\psi$. The composite good is assumed to be the numéraire.

We assume public ownership of land and firms for simplicity. Net income y_i is composed of common income y, equal share of profits and rents Π, and subsidy (or tax) $s_i(s)$: $y_i = y + \Pi + s_i(s)$. Each place-based policy determines $s_i(s)$, where s (≥ 0) expresses the tax paid by each non-subsidized household for the policy. Tax s also indicates the level of the policy. We refer to s as the policy instrument.

The current paper quantitatively evaluates the welfare impacts of two place-based policies: location subsidies to households, and location subsidies to stores.[1] These place-based policies subsidize households (retail stores) in targeted areas with each policies. Households (retail stores) in the same zone can receive the same amount of subsidy. Let n_i and $s_i^M(s)$ denote the total number of households residing in location i and the total subsidy provided to retail stores operating in location i, respectively. The formal definitions for the two place-based policies are as follows.

[1]Similar policies to both policies are adopted by local governments in the real world (e.g., Albuquerque in the United States and Toyama in Japan).

Definition 1 (location subsidies to households)**.** *Location subsidies to households in the downtown area are the place-based policies such that the following equations hold.*

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

Definition 2 (location subsidies to stores)**.** *Location subsidies to stores in the downtown area are the place-based policies such that the following equations hold.*

$$s_i(s) = -s/\overline{N} \quad (i \in \mathcal{I}), \quad s_i^M(s) = \begin{cases} s & (i = 0), \\ 0 & (i = 1, \dots, I), \end{cases} \tag{5}$$

Location subsidies to households are intended to encourage households to reside in the downtown area. Location subsidies to stores imply that retail stores operating in the downtown area are subsidized. The total subsidy is equal to the sum of collected taxes from households in the target area. Eqs. (4) and (5) indicate that with these policies, households incur the cost of the total subsidies:

$$\sum_{i \in \mathcal{I}} n_i s_i(s) + s_i^M(s) = 0. \tag{6}$$

Income transfer among households with location subsidies to households is asymmetric in terms of locations. Such asymmetric income transfer among households is a source of market failure called fiscal externality(Boadway and Flatters, 1982). Location subsidies to households can cause a negative welfare impact due to the fiscal externality. Unlike location subsidies to households, location subsidies to stores does not generate the fiscal externality since all the households pay the same amount of tax.

We solve the following utility maximization problem:

$$\max_{\{q_i(k)\}_k, h_i, a_i} U_i(M_i, h_i, a_i) \quad \text{s.t.} \quad \text{Eqs. (2) and (3).} \tag{7}$$

We obtain the demand functions from the two stage maximization problem. The conditional demands are given by $q_i^*(k) = p_i^M(k)^{-\sigma} P_i^\sigma M_i$ $(\forall k \in [0, m_i])$, where superscript

" * " denotes the optimal solution and P_i is the price index for the varieties supplied in location i: $P_i = \left(\int_0^{m_i} p_i^M(k)^{1-\sigma}\mathrm{d}k\right)^{1/(1-\sigma)}$. Using the price index, we obtain the demand functions: $M_i^* = \mu_1 y_i/P_i$, $h_i^* = \mu_2 y_i/p_i^H$, $a_i^* = \mu_3 y_i$. Let V_i denote the indirect utility of households residing in location i. Substituting the demand functions into the utility yields

$$V_i = \ln y_i - \mu_1 \ln P_i - \mu_2 \ln p_i^H + \overline{A}_i + \xi, \tag{8}$$

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

2.3. Retail stores

Retail stores supply differentiated goods in marketplaces. Under monopolistic competition, each retail store rents one unit of land in a marketplace and supplies a variety in the marketplace. The total mass of retail stores in each marketplace is endogenously determined by free entry.

We assume that there exists the heterogeneity of cost function among retail stores in order to represent differences in these stores. All the retail stores incur the same marginal production cost c to supply varieties. The retail store that supplies the kth variety incurs $k + r_i(k)$ for the fixed cost, where k also represents the fixed cost that depends on the variety, and $r_i(k)$ is the land rent of a constant unit of land for the 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 marketplace i, respectively. $\pi_i^M(k)$ is given by

$$\pi_i^M(k) = (p_i^M(k) - c)Q_i(k) - k + \frac{s_i^M(s)}{m_i} - r_i(k) \quad \forall k \in [0, m_i]. \tag{9}$$

We assume that each store pays the bid rent for renting a unit of land. Using profit (9) yields the maximum land rent that the kth retail store can pay:

$$r_i(k) = \max_{p_i^M(k)} \left((p_i^M(k) - c)Q_i(k) - k + \frac{s_i^M(s)}{m_i} \right). \tag{10}$$

Eq. (10) implies that the more the demand for a variety in a marketplace, the larger 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 $Q_i(k) = n_i q_i^*(k)$. Solving maximization problem (10) with this total supply yields the price of varieties supplied in location i: $p_i^M(k) = c\sigma/(\sigma - 1)$ $(\forall i, k)$. 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 total demand for varieties supplied in the same marketplace are the same:

$$Q_i(k) = \mu_1 n_i y_i/(p^M m_i) \quad \forall k \in [0, m_i]. \tag{11}$$

2.4. Firms that supply floor space

Floor space is supplied by developers and house builders. Developers and house builders supply floor space in the downtown area and the suburbs, respectively. They are assumed to be perfectly competitive.

2.4.1. Developers

Following Brueckner (2007) and Domon et al. (2022), we formulate developers' behavior. Developers produce buildings with 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 g is the production function and 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

$$\pi_0^H = p_0^H \overline{L}_0 H_0 - \overline{L}_0 g^{-1}(H_0) - \overline{L}_0 R_0^H, \tag{12}$$

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 profit (12) yields the maximum land rent that developers can pay:

$$R_0^H = \max_{H_0} (p_0^H H_0 - g^{-1}(H_0)). \tag{13}$$

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

$$H_0^* = \theta^{1/(1-\beta)}(\beta p_0^H)^{\beta/(1-\beta)}, \tag{14}$$

$$\pi_0^H = \overline{L}_0 \left[\theta^{1/(1-\beta)}(\beta^{\beta/(1-\beta)} - \beta^{1/(1-\beta)})(p_0^H)^{1/(1-\beta)} - R_0^H\right], \tag{15}$$

$$R_0^H = p_0^H H_0^* - g^{-1}(H_0^*) = \theta^{1/(1-\beta)}(\beta^{\beta/(1-\beta)} - \beta^{1/(1-\beta)})(p_0^H)^{1/(1-\beta)}. \tag{16}$$

2.4.2. House builders

House builders supply floor area in the suburbs with constant marginal cost c^H and zero fixed cost.

2.5. Market equilibrium condition

We introduce market equilibrium conditions. In the equilibrium, given the spatial distribution of households (i.e., $(n_i)_{i\in\mathcal{I}}$), the housing market clearing condition holds and the mass of retail stores is determined in free entry. We focus on the market equilibrium at which the numbers of households residing in the suburbs are the same (i.e., $n_1 = n_2 = \cdots$) since these suburbs are homogeneous. We show allocation with only the downtown area and the 1st suburb in the market equilibrium.

The prices regarding housing and land rent are determined with 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:

$$n_0 h_0^* = \overline{L}_0 H_0^*, \tag{17}$$

$$n_1 h_1^* = \psi \overline{L}_1. \tag{18}$$

Using Eqs. (17) and (18), we obtain the floor area price and the land rent in the location:

$$p_0^H = \left[\mu_2 \theta^{-1/(1-\beta)} \beta^{-\beta/(1-\beta)} n_0 y_0 / \overline{L}_0\right]^{1-\beta}, \tag{19}$$

$$R_1^H = \psi(\mu_2 n_1 y_1 / (\psi \overline{L}_1) - c^H), \tag{20}$$

where $\overline{L}_1$ is the area of land in the suburb. Substituting c^H and Eq. (20) into total housing price p_1^H yields $p_1^H = \mu_2 n_1 y_1 / (\psi \overline{L}_1)$.

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. Using this monotonicity, non-negative condition for land rent $r_j(k) \geq 0$ ($\forall k \in [0, m_j]$), and Eq. (10) we obtain the following condition for mass of stores m_j:

$$r_i(m_i) = (p_i^M - c)Q_i - m_i + \frac{s_i^M(s)}{m_i} = 0. \tag{21}$$

This equation implies that sales equals the cost for the store supplying variety m_i. The kth retail store ($k > m_i$) cannot operate in marketplace i because this store cannot pay land rent. Substituting Eq. (11) into Eq. (21) yields

$$m_i = \sqrt{\frac{\mu_1}{\sigma} n_i y_i + s_i^M(s)}. \tag{22}$$

We focus on the net income of households (i.e., y_i). With the assumption of the public ownership, the profits and rents are equally divided among households:

$$\Pi = \overline{N}^{-1} \left(\pi_0^H + \overline{L}_0 R_0^H + I \overline{L}_1 R_1^H + \widetilde{\Pi}_0 + I \widetilde{\Pi}_1 \right). \tag{23}$$

where $\widetilde{\Pi}_i = \int_0^{m_i} \pi_i^M(k) + r_i(k)\, \mathrm{d}k$. Using the market clearing conditions regarding housing yields

$$\overline{L}_0 R_0^H + \pi_0^H = \mu_2 n_0 y_0 (1 - \beta), \tag{24}$$

$$\overline{L}_1 R_1^H = \mu_2 n_1 y_1 - c^H \psi \overline{L}_1. \tag{25}$$

Using Eqs. (9) and (22) yields

$$\widetilde{\Pi}_0 + I\widetilde{\Pi}_1 = \frac{1}{2}\left(\frac{\mu_1}{\sigma}n_0y_0 + \frac{\mu_1}{\sigma}In_1y_1 + s_0^M(s) + Is_1^M(s)\right). \tag{26}$$

Substituting Eqs. (24)–(26) into Eq. (23) yields

$$\Pi = \frac{1}{\overline{N}}\left[n_0y_0\left(\frac{\mu_1}{2\sigma} + \mu_2(1-\beta)\right) + In_1y_1\left(\frac{\mu_1}{2\sigma} + \mu_2\right) + \frac{s_0^M + Is_1^M}{2} - c^H\psi I\overline{L}_1\right].$$

We can obtain $y_i = y + \Pi + s_i(s)$ for $i = 0, 1$:

$$y_0 = \widetilde{y}_0(n_0, n_1, s) = \phi\left(y + \frac{s_0^M + Is_1^M}{2\overline{N}} - \frac{c^H\psi I\overline{L}_1}{\overline{N}} + (1-b)s_0 + bs_1\right), \tag{27}$$

$$y_1 = \widetilde{y}_1(n_0, n_1, s) = \phi\left(y + \frac{s_0^M + Is_1^M}{2\overline{N}} - \frac{c^H\psi I\overline{L}_1}{\overline{N}} + as_0 + (1-a)s_1\right), \tag{28}$$

where $\phi = (1-a-b)^{-1}, a = \overline{N}^{-1}n_0\left(\mu_1/(2\sigma) + \mu_2(1-\beta)\right), b = \overline{N}^{-1}n_1\left(\mu_1/(2\sigma) + \mu_2\right)$.

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:

$$V_0(\boldsymbol{n}, s) = \ln\widetilde{y}_0 + \frac{\mu_1}{2(\sigma-1)}\ln\left(\frac{\mu_1n_0\widetilde{y}_0}{\sigma} + s_0^M\right) - \mu_2(1-\beta)\ln(n_0\widetilde{y}_0) + \Psi_0 + \kappa, \tag{29}$$

$$V_1(\boldsymbol{n}, s) = \ln\widetilde{y}_1 + \frac{\mu_1}{2(\sigma-1)}\ln\left(\frac{\mu_1n_1\widetilde{y}_1}{\sigma} + s_1^M\right) - \mu_2\ln(n_1\widetilde{y}_1) + \Psi_1 + \kappa, \tag{30}$$

where

$$\Psi_0 = \overline{A}_0 + \mu_2(1-\beta)\ln\overline{L}_0 + \mu_2\beta\ln\mu_2 + \mu_2\ln(\theta\beta^\beta), \quad \Psi_1 = \overline{A}_1 + \mu_2\ln(\psi\overline{L}_1),$$

$$\kappa = -\mu_1\ln p^M - \mu_2\ln\mu_2 + \xi.$$

The spatial distribution in the equilibrium is determined by the following conditions:

$$\begin{cases} V_i(\boldsymbol{n}, s) = \overline{V} & \text{if} \quad n_i > 0, \\ V_i(\boldsymbol{n}, s) < \overline{V} & \text{if} \quad n_i = 0, \end{cases} \qquad (i = 0, 1), \tag{31}$$

and $n_0 + In_1 = \overline{N}$.

Table 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

3. How much benefit the place-based policies generate

3.1. Calibration

In order to quantitatively evaluate the welfare impact of the place-based policies, we calibrate exogenous parameters. Table 1 summarizes the calibrated parameters. The procedure of the calibration is as follows.

The exogenous parameters are calibrated with the data of Sendai in Japan. We regard Sendai Station and Sendai-Izumi Premium Outlet as the centers of the downtown area and a suburb, respectively. Sendai Station is the center of commercial area around the CBD in Sendai, whereas Sendai-Izumi Premium Outlet is the shopping mall in the suburban town called Izumi-Park town. The areas targeted by place-based policies, implemented in the real world, tend to be within a range of 2km from the centers in these areas. Hence, we regard the downtown area and the suburb as the area within a range of 2km from the Sendai Station and Izumi Premium Outlet, respectively. Because there are Izumi-Park town and a suburban town called Nagamachi around the Sendai Station, We set I at 2.

Numbers of households in the downtown area $\overline{n}_0$ and the suburb $\overline{n}_1$ and that of total households $\overline{N}$ are obtained with the data provided by *Population Census 2005 of Japan*.

We focus on how place-based policies affect the location choices of nuclear families rather than one-person households since some place-based policies with subsidies intend to agglomerate these families in downtown areas. Hence, we choose $\overline{n}_0$ and $\overline{n}_1$ as similar values to the number of nuclear families as much as possible. Although the census provides population and the number of the households residing in residential buildings in the downtown area, this number includes that of one-person households. We set $\overline{n}_0$ at $32,131$, calculated based on the population residing in residential buildings in the downtown area divided by three (i.e., two parents and a child). On the other hand, we set $\overline{n}_1$ at $7,253$, derived from the number of households residing in houses in the suburb. Number of total households $\overline{N}$ is given by $\overline{n}_0 + I\overline{n}_1 = 46,687$.

Land area $\overline{L}_i$ is obtained with the data provided by *the Population Census 2005 of Japan* and floor area ratio determined by Sendai City Government. We set the total floor space in the downtown area and the suburb at the total floor space in the residential buildings and the houses in the downtown area and the suburb, respectively. Using the data from urban planning provided by Sendai City Government, we set floor area ratio in the downtown area and the suburb at 4.0 and 0.6, respectively[2]. Dividing the total floor space by the floor area ratio, we set $\overline{L}_1$ and $\overline{L}_2$ at $675,977$ m^2 and $1,646,686$ m^2, respectively.

Common income y and expenditure share μ_j ($j = 1, 2, 3$) are obtained with the data provided by *the National Family Expenditure Structure Survey 2019 of Japan*. We set common income y at $3,923,988$ JPY/year. Assuming that the shopping expenditure of households μ_1 consists of the expenditure for food, manufactured goods, and clothes, we set μ_1 at 0.280. Moreover, we set μ_2 and μ_3 at 0.224 and 0.496, respectively.

Marginal cost c^h is obtained with the data provided by *the Statistical Survey of*

[2]See http://www.city.sendai.jp/toshi-kekakuchose/kurashi/machi/kaihatsu/toshikekaku/service.html (last accessed on 1 December 2022).

Construction Starts 2021 of Japan. We use the average production cost of houses per square foot of floor space in the data. Since housing consumption is assumed to be flow in our model, we use the average production cost transformed into the present value. Assuming that households pay the total housing price over 30 years with discount rate per year set at 2% , we set c^h at $6,566$ JPY/year.

Exogenous parameters of the production function for residential buildings β and θ are set at 0.70 and 0.0028 so that the consumption levels of floor space in the downtown area and the suburb are roughly 85 m^2 and 135 m^2, respectively. Domon et al. (2022) estimate β and θ as 0.75 and 0.0028, which are close to the calibrated parameters.

In our model, elasticity of substitution σ is equal to price elasticity under equilibrium since we employ the CES function. DellaVigna and Gentzkow (2019) show the histogram of price elasticities for goods that retail stores supply. Based on the histogram, we set σ (i.e., the price elasticity) at 2.5, which is similar to the elasticity taking the maximum value of the histogram.

We set A_2 at zero which is a normalization. We calibrate amenities level A_1 with long-run equilibrium condition (31). Using the calibrated parameters, we set A_1 at -0.034351.

Since marginal cost that retail stores incur c affects neither the market equilibrium nor the welfare analyses, the level of c does not matter. We set c at 1.0.

3.2. Simulation setting

We conduct equilibrium and welfare analyses with 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 implemented, 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 location 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

Table 2: The welfare impacts of the place-based policies with equivalent variation

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

equivalent variation for the households residing in zone i. EV_i is given by

$$EV_i \equiv E_i(P_i(\boldsymbol{n}_{\text{before}}), p_i^H(\boldsymbol{n}_{\text{before}}), U_{\text{after}}) - E_i(P_i(\boldsymbol{n}_{\text{before}}), p_i^H(\boldsymbol{n}_{\text{before}}), U_{\text{before}}), \tag{32}$$

where variables with subscripts "before" and "after" denote variables before and after place-based policies are implemented, respectively. Since $\boldsymbol{n}_{\text{before}}$ is the calibrated spatial households distribution, $\boldsymbol{n}_{\text{before}} = (\overline{n}_0, \overline{n}_1) = (32,181, 7,253)$ holds. Let $n_{i,\text{after}}$ denote the total number of households residing in location i with a implemented place-based policy. 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 evaluate the welfare impacts with SEV.

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.

3.3. Results

Table 2 shows the result of the welfare analyses[3]. Column (1) shows the result of implementing 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 implemented to generate income transfer with $100,000$ JPY. As SEV shows, a negative benefit being equal to 566×10^6 JPY occurs for each year.

Column (2) shows that of implementing 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 $98,700$ JPY. 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 the downtown area generates positive benefits with 566 million JPY per year, and (2) subsidizing households residing near the downtown causes negative benefits with -342 million JPY per year. The results indicate that policymakers should apply symmetric income transfer among households with place-based policies rather than asymmetric income transfer.

Our model can be extended in the following manner. In this chapter, quantitative

[3] Since we have $EV_1 = EV_2$ with our model specification, Table 2 omits EV_2. See Appendix A for details.

analysis with the CES preference is conducted. It will be a future topic to quantitatively evaluate welfare impacts with variable elasticity of substitution (VES) preferences. In Spatial Economics, quantitative models with VES preferences have recently been developed (e.g., Bertoletti et al., 2018; Arkolakis et al., 2019). Quantitative methods employed by such studies will enable us to evaluate more elaborate quantitative analyses.

Appendix

A. Theoretical detail regarding equivalent variation

We show the equivalent variations for locations are the same.

We will obtain the expenditure function. We solve the following expenditure minimization problem:

$$\min_{\{q_i(k)\}_k} \int_0^{m_i} p_i^M(k) q_i(k) \mathrm{d}k, \quad \text{s.t. } M_i = \left(\int_0^{m_i} q_i(k)^{(\sigma-1)/\sigma} \mathrm{d}k \right)^{\frac{\sigma}{\sigma-1}}. \tag{A1}$$

Let e_i^M be the expenditure function regarding the above problem. Solving this problem with the first order condition, we obtain expenditure function: $e_i^M = P_i M_i$, where $P_i = \left(\int_0^{m_i} p_i^M(k)^{1-\sigma} \mathrm{d}k \right)^{1/(1-\sigma)}$ is price index. We next solve the following expenditure minimization problem with expenditure function e_i^M:

$$\min_{M_i, h_i, a_i} e_i^M + p_i^H h_i + a_i, \quad \text{s.t. } \mu_1 \ln M_i + \mu_2 \ln h_i + \mu_3 \ln a_i + \overline{A}_i = \overline{U}, \tag{A2}$$

where $\overline{U}$ is a utility level. Solving this problem with the first order condition, we obtain expenditure function:

$$E_i \left(P_i, p_i^H, \overline{U} \right) = \zeta P_i^{\mu_1} p_h^{\mu_2} \exp \left(\overline{U} - \overline{A_i} \right), \tag{A3}$$

where $\zeta = \mu_1^{-\mu_1} \mu_2^{-\mu_2} \mu_3^{-\mu_3}$.

The equivalent variation with Eq. (A3) is given by

$$EV_i = \zeta P_i^{\mu_1} p_h^{\mu_2} \exp \left(U_{\text{before}} - \overline{A_i} \right) \left(\exp(U_{\text{after}} - U_{\text{before}}) \right), \tag{A4}$$

where P_i and p_h are the values determined by the market equilibrium condition before implementing a place-based policy. Since the expenditure of a household with U_{before} is equal to their income, $\zeta P_i^{\mu_1} p_h^{\mu_2} \exp \left(U_{\text{before}} - \overline{A_i} \right)$ is equal to the income. Hence EV_i does not depend on location i.

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