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“General Equilibrium Analysis of Fiscal Transfers in an Aging Society”

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General Equilibrium Analysis of Fiscal Transfers in an Aging Society†

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Abstract

We analyze fiscal transfer policies using a quantitative spatial general equilibrium model given heterogeneous local productivities and amenities, migration of young and elderly population, and inter-regional trade. We confirm that fiscal transfers improve welfare by reducing congestion in urban areas and increasing public services and real wages in rural areas. Contrary to the literature, introducing mobility of elderly population indicates possibility of optimal transfers that enable the central government to accomplish welfare gains without sacrificing national output. We calibrate the model to the Japanese economy and conduct some counterfactual simulations. The results show that Japans' central government's current fiscal transfers improve welfare of young and old population by 17.5% and 20.4%, respectively, compared with a zero-transfer case. However, they reduce national output by 12.5%. If the central government makes the transfers at a uniform rate across regions, it improves welfare of working and old population by 20.3% and 27.2%, respectively, compared with the zero-transfer case, without reducing the national output.

Keywords: Agglomeration force; Economic geography; Place-based policies; Population aging
JEL codes: H20, H77, R12, R13

1 Introduction

Many industrialized countries are experiencing significant demographic changes in recent years. Rapid population aging simultaneously arises with the expansion of spatial economic disparities. Specif-

†The opinion in the article does not reflect the views of the Ministry of Finance Japan, or members of its staff.

ically, in Japan, peripheral regions had faced outflow of working population, while metropolitan areas had experienced inflow of workers in late 1900s. Now, the difference of demographic composition between central and peripheral regions and inequality of local outputs and productivities are larger (Figure 1). Prefectures with higher population-aging rates have smaller local GDP and income per capita. They also have lower population density (Figure 2). Studying the impacts of demographic composition (i.e., portion of elderly) on local and national economy yields useful implications for policymakers concerned with the disparities across regions.

Governments in developed countries have conducted fiscal allocation from central to peripheral regions for balanced regional development and to ensure equal living standard across regions. However, little is known about its endogenous impacts on residents' welfare, local outputs and demographic compositions in terms of regional population-aging, even though substantial amount of budget is disbursed to peripheral regions. Larger fiscal allocation to a specific region may cause the relocation of economic activity across regions through the following channels: (1) Relocation of workers and aged population and (2) Change of interregional trade flow. Given that empirical work that have estimated the short-term impact of fiscal allocation policy may not have captured the relocation of economic activity across regions, analyzing the general equilibrium model is fruitful for understanding the overall impact of these policies (Neumark and Simpson (2015)).

We aim to shed light on the implication of the governments fiscal transfers from the perspectives of regional difference of demographic composition and endogenous impact on geographical mobility. Accordingly, we develop a quantitative spatial general equilibrium model based on Allen and Arkolakis (2014) and Redding (2016). Our model contains heterogeneous local productivities and amenities, migration of young and elderly population, and inter-regional trade. We introduce arbitrary fiscal transfers from the central government to local governments and quantitatively evaluate the impact of fiscal transfers on regional productivity, output, wage, and welfare.

Our analysis shows that fiscal transfers improve welfare by reducing congestion in urban areas and increasing public services and real wages in rural areas. Contrary to the literature, introducing mobility of elderly population indicates possibility of optimal transfers, which enables the central government to accomplish welfare gains without reducing national output.

We calibrate the model to the Japanese economy and conduct some counterfactual simulations. The results show that Japans' central government's current fiscal transfers improve welfare of young and old population by 17.5% and 20.4%, respectively, compared with the zero-transfer case. However, they reduce national output by 12.5%. If the central government makes the transfers at a uniform rate across regions, it improves welfare of working and old population by 20.3% and 27.2%, respectively, compared with the zero-transfer case, without reducing national output.

Our study contributes to two recent strands of literature. First, we incorporate the setup of working and aged population into quantitative general equilibrium analysis of economic geography (e.g. Allen and Arkolakis (2014), Redding (2016), Caliendo, Parro, Rossi-Hansberg, and Sarte (2018)). We show how regional composition of population endogenously affects local amenities and productivities. Second, we complement the literature on place-based policies (e.g. Glaeser and Gottlieb (2008), Kline and Moretti (2014), Neumark and Simpson (2015), Fajgelbaum, Morales, Suárez Serrato, and Zidar (2019),

Figure 1: Population aging and local economy

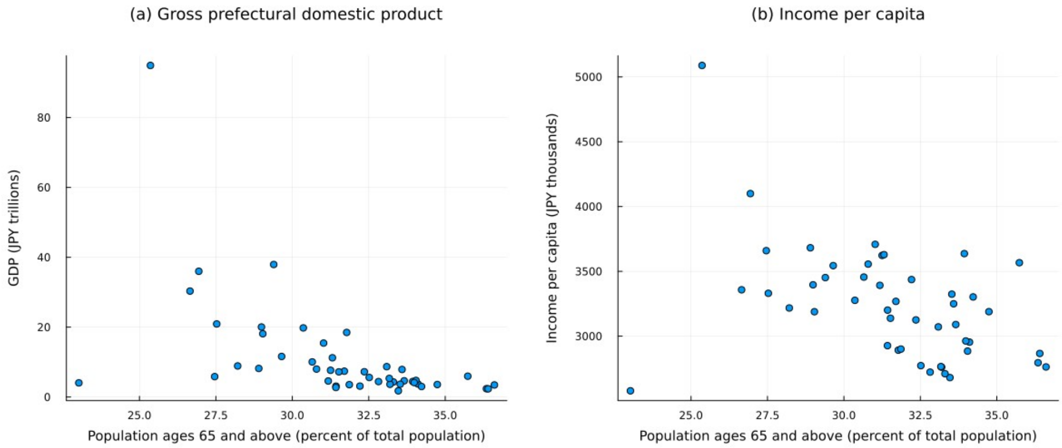
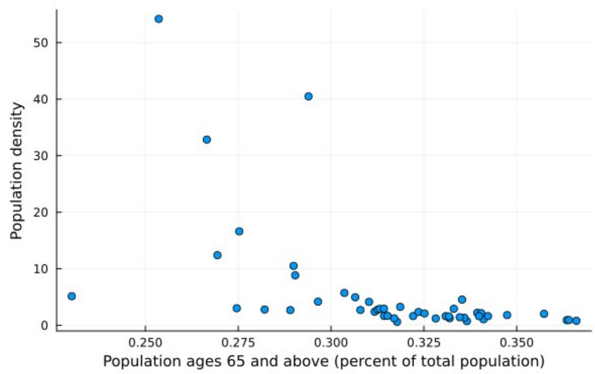


Figure 2: Population aging and population density



Fajgelbaum and Gaubert (2020), Blouri and Ehrlich (2020)). Specifically, our study is closely related to Henkel, Seidel, and Suedekum (2021), who have argued that fiscal transfers improve economic disparities across regions and welfare at the cost of national productivities and outputs. However, we complement their research by explaning the different impacts of fiscal transfers on working and aged population. Our model explains possibility of optimal transfers that enable the central government to improve welfare and national output.

The remained of the study is organized as follows. Section 2 describes theoretical model, Section 3 documents the implication of the model, Section 4 describes the data and presents calibration, Section 5 presents the counterfactual exercises, and Section 6 concludes the study.

2 Model

We consider an economy with I regions. The economy consists of young households, old households, I regional governments, and a central government. Young households inelastically supply labor and choose where to live based on real wages, population, amenities, and governments' policies in the regions. Old households are also mobile across regions and receive national pension benefits. The central government imposes labor income tax to finance the fiscal transfers to regions and pension benefits. Each regional government also levies local labor income tax to provide local public services.

2.1 Household

There are two types of households, namely, young households ($\lambda = y$) and old households ($\lambda = o$). The economy is endowed with $\bar{L} = \sum_i \sum_\lambda L_\lambda(i)$ population. $L_y(i)$ indicates the homogeneous workers in region i who earn wage $w(i)$. $L_o(i)$ corresponds to elderly population receiving pension benefits π.

We define a Cobb-Douglas utility of households with type λ in region $i \in \mathbf{I}$ as follows:

$$U_\lambda(i) = u_\lambda(i) G(i)^\gamma C_\lambda(i)^{1-\gamma}, \tag{1}$$

where $\gamma \in [0, 1]$. $u_\lambda(i)$ is a location-specific preference shifter of type λ, $G(i)$ is the consumption of public services, and $C_\lambda(i)$ denotes that of private goods of type λ. We do not distinguish between the consumption of public services by household types, while the consumption of a private good is separately defined. The location-specific preference $u_\lambda(i)$ contains an exogenous component $\bar{u}_\lambda(i)$, including scenic resources, and an endogenous component related to local population size:

$$u_\lambda(i) = \bar{u}_\lambda(i) \prod_{\lambda=y,o} L_\lambda(i)^{-\beta_\lambda}, \tag{2}$$

where β_λ denotes the strength of the negative effect of type λ population density on location-specific utility.

Young households supply one unit of labor and private consumption of young households in region i is given by

$$C_y(i) = \frac{w(i)(1 - \tau(i))}{P(i)}, \tag{3}$$

where $w(i)$ is the wage rate in region i, $\tau(i)$ is the tax rate in region i, and $P(i)$ is the price index in region i, which is defined below. Old households receive pension benefits and the amount is common across regions. Next, private consumption of old households in region i is given by

$$C_o(i) = \frac{\pi}{P(i)}. \tag{4}$$

2.2 Production

Intermediate goods. Every region i produces one unique differentiated variety of goods under perfect competition using labor as the only factor of production. A worker in region i produces $a(i)$ units of this good, where $a(i)$ corresponds to the local productivity level. Region i's productivity is supposed to be as follows

$$a(i) = \bar{a}(i)L_y(i)^{\alpha}, \tag{5}$$

where $\bar{a}(i)$ is the exogenous location-specific productivity and α determines the strength of external agglomeration economies resulting from the population density. Equation (5) differs from Allen and Arkolakis (2014) because we use the young population, not total population. Given that we attribute the positive impact of population density on local productivity to the spillovers of technology and knowledge among workers, our productivity equation (5) contains only the young population.

The intermediate goods are traded across regions. The price of an intermediate good produced in i and sold in n is denoted by $p(i,n)$. The perfect competition assumption implies that the price is equal to the marginal cost, consisting of production and transport costs;

$$p(i,n) = \frac{d(i,n)w(i)}{a(i)}, \tag{6}$$

where $d(i,n) \geq 1$ is the bilateral interregional trade cost and $d(i,n)$ units must be sent from i to arrive in n for one unit. We assume no intraregional trade cost, $d(i,i) = 1$.

Final goods. Following Henkel et al. (2021), a final good consists of a set of intermediates differentiated by the place of origin according to the CES aggregator. Suppose that final goods are not traded across regions, and the total amount of final goods consumed in region n, $Q(n)$, is given by

$$Q(n) = \left[\int_{\mathbf{I}} q(i,n)^{\frac{\sigma-1}{\sigma}} di\right]^{\frac{\sigma}{\sigma-1}} \tag{7}$$

where $\sigma > 1$ refers to the elasticity of substitution and $q(i,n)$ is the quantity of the variety of goods produced in region i and sent to region n for assembly. (7) implies that the demand for a variety $q(i,n)$ is

$$q(i,n) = \frac{p(i,n)^{-\sigma}}{P(n)^{1-\sigma}}E(n), \tag{8}$$

where $E(n)$ is the total expenditure of households and government in region n and $P(n)$ is the price of the final good in region n;

$$P(n) = \left[\int_{\mathbf{I}} p(i,n)^{1-\sigma} di\right]^{\frac{1}{1-\sigma}}.$$

Substituting (6) into this yields

$$P(n) = \left[\int_{\mathbf{I}} \left(\frac{d(i,n)w(i)}{a(i)}\right)^{1-\sigma} di\right]^{\frac{1}{1-\sigma}}. \tag{9}$$

Givrn that final goods are not traded across regions, they must be used for private consumption of working-age and elderly population or regional government's expenditure in region i.

$$Q(i) = G(i) + \sum_{\lambda=y,o} L_\lambda(i) C_\lambda(i). \tag{10}$$

2.3 Public sectors

The public sector consists of a central government and I regional governments. The central government levies labor income tax τ^c and τ^π to finance the fiscal transfers to regions and pension benefits, respectively. We denote $\theta(i)$ as a transfer rate from the central government to each regional government, which is the ratio of the amount of transfer from the central government to total output, $w(i)L_y(i)$. Each regional government set its local labor income tax, $\tau^\ell(i)$, to provide public services. Public goods in each region are financed by the local tax and income transfer from the central government.

$$G(i) = \left[\tau^\ell(i) + \theta(i)\right] \frac{w(i)L_y(i)}{P(i)}. \tag{11}$$

Furthermore, the tax rate that workers in region i face, $\tau(i)$, is the sum of the aforementioned three tax rates;

$$\tau(i) = \tau^\ell(i) + \tau^c + \tau^\pi. \tag{12}$$

Finally, the aggregate spending of region i is given by

$$\begin{aligned} E(i) &= (1 - \tau(i))\, w(i)L_y(i) + \pi L_o(i) + P(i)G(i) \\ &= [1 - \tau^c - \tau^\pi + \theta(i)]\, w(i)L_y(i) + \pi L_o(i). \end{aligned} \tag{13}$$

2.4 Utility

The indirect utility in region i for $\lambda = [y, o]$ is derived by substituting equations (2), (3), (4), and (11) into (1)

$$W_y(i) = \bar{u}_y(i) \frac{w(i)}{P(i)} L_y(i)^{-\beta_y+\gamma} L_o(i)^{-\beta_o} \left[\tau^\ell(i) + \theta(i)\right]^\gamma \left[1 - \tau(i)\right]^{1-\gamma}, \tag{14}$$

$$W_o(i) = \bar{u}_o(i) \frac{w(i)^\gamma \pi^{1-\gamma}}{P(i)} L_y(i)^{-\beta_y+\gamma} L_o(i)^{-\beta_o} \left[\tau^\ell(i) + \theta(i)\right]^\gamma. \tag{15}$$

The free mobile assumption implies that the populations of workers and elderly are adjusted so that their utility level, $W_\lambda(i)$, is the same across regions. To exclude a case in which the residences of the whole population are concentrated in one region, we need to assume that the congestion force dominates the sum of agglomeration force and pubic facilities, $\beta_y \geq \alpha + \gamma$.

2.5 Equilibrium

Given the exogenous amenity and productivity in regions, trade costs across regions, and governments' policies, the equilibrium is defined by the following conditions.

(i) Population clearing:

$$
\begin{aligned}
\int_{\mathbf{I}} L_y(i)di &= \bar{L}_y, \\
\int_{\mathbf{I}} L_o(i)di &= \bar{L}_o, \\
\bar{L}_y + \bar{L}_o &= \bar{L}.
\end{aligned}
\tag{16}
$$

(ii) Goods market clearing:

$$
w(n)L_y(n) = \int_{\mathbf{I}} p(n,i)q(n,i)\ di \qquad \forall n \in \mathbf{I}, \tag{17}
$$

where

$$
p(n,i)q(n,i) = \left(\frac{w(n)d(n,i)}{a(n)P(i)}\right)^{1-\sigma} \left(\left(1 - \tau^c + \tau^\pi + \theta(i)\right)w(i)L_y(i) + \pi L_o(i)\right) \tag{18}
$$

(iii) Balanced budget condition of the central government:

$$
\tau^c \int_{\mathbf{I}} w(i)L_y(i)di = \int_{\mathbf{I}} \theta(i)w(i)L_y(i)di, \tag{19}
$$

$$
\tau^\pi \int_{\mathbf{I}} w(i)L_y(i)di = \pi\bar{L}_o. \tag{20}
$$

(iv) Balanced budget condition of regional governments:

$$
G(i)P(i) = (\tau^l(i) + \theta(i))w(i)L_y(i) \qquad \forall i \in \mathbf{I} \tag{21}
$$

(v) Utility equalization condition:

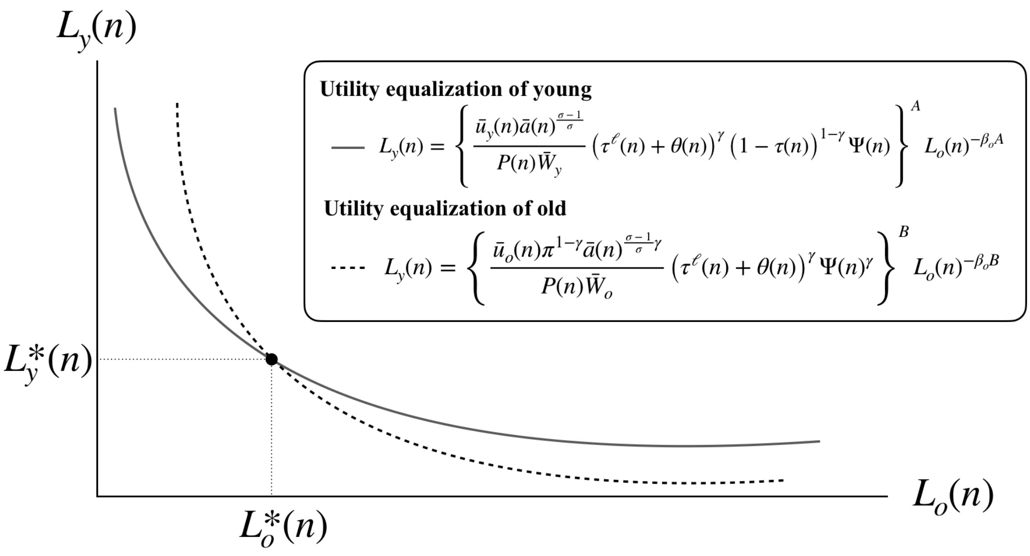
$$
W_y(i) = W_y(j) = \bar{W}_y, \tag{22}
$$

$$
W_o(i) = W_o(j) = \bar{W}_o, \quad \forall i, j \in \mathbf{I}. \tag{23}
$$

3 Equilibrium analysis

In this section, we show the impacts of fiscal transfers across regions with a simple example to provide a better understanding of the counterfactual simulations in Section 5. In preparation for the following

Figure 3: Equilibrium population of worker and elderly



analysis, we first derive the conditions satisfied by the equilibrium worker and elderly population in each region. Using (17) and (18), we obtain labor demand curve in region n:

$$w(n) = \bar{a}(n)^{\frac{\sigma-1}{\sigma}} L_y(n)^{\frac{\alpha(\sigma-1)-1}{\sigma}} \Psi(n), \tag{24}$$

$$\text{where} \quad \Psi(n) \equiv \left[\int_{\mathbf{I}} \left(\frac{d(n,i)}{P(i)} \right)^{1-\sigma} E(i)di \right]^{\frac{1}{\sigma}}. \tag{25}$$

Higher $\Psi(n)$ implies higher demand of intermediate goods produced in region n. Substituting this into the indirect utility in region n, (14) and (15) yield the following equations:

$$L_y(n) = \left\{ \frac{\bar{u}_y(n)\bar{a}(n)^{\frac{\sigma-1}{\sigma}}}{P(n)\bar{W}_y} \left(\tau^{\ell}(n)+\theta(n)\right)^{\gamma} (1-\tau(n))^{1-\gamma} \Psi(n) \right\}^{A} L_o(n)^{-\beta_o A} \tag{26}$$

$$L_y(n) = \left\{ \frac{\bar{u}_o(n)\pi^{1-\gamma}\bar{a}(n)^{\frac{\sigma-1}{\sigma}\gamma}}{P(n)\bar{W}_o} \left(\tau^{\ell}(n)+\theta(n)\right)^{\gamma} \Psi(n)^{\gamma} \right\}^{B} L_o(n)^{-\beta_0 B}, \tag{27}$$

where

$$A \equiv \frac{\sigma}{\sigma(\beta_y - \gamma - \alpha) + 1 + \alpha}, \quad B \equiv \frac{\sigma}{\sigma(\beta_y - \gamma - \alpha\gamma) + \gamma(1+\alpha)}, \quad \text{and}$$

$0 < A < B$ holds*. Figure 3 plots (26) and (27), where $L_y^*(n)$ and $L_o^*(n)$ denote the equilibrium population of workers and the elderly, respectively;

*$A^{-1} - B^{-1} = \sigma^{-1}(1-\gamma)(-\alpha(\sigma-1)+1) > 0$ holds, thus $A < B$ holds.

$$L_y^*(n) = \left(\frac{\bar{u}_y(n)\bar{W}_o}{\bar{u}_o(n)\pi^{1-\gamma}\bar{W}_y} (1-\tau(n))^{1-\gamma} \Psi(n)^{1-\gamma} \bar{a}(n)^{\frac{(\sigma-1)(1-\gamma)}{\sigma}} \right)^{\frac{AB}{B-A}}, \tag{28}$$

$$L_o^*(n) = \left\{ \left(\frac{\bar{u}_o(n)\pi^{1-\gamma}}{\bar{W}_o} \right)^B \left(\frac{\bar{W}_y}{\bar{u}_y(n)} \right)^A [1-\tau(n)]^{-A(1-\gamma)} \left(\frac{[\tau^l(n)+\theta(n)]^\gamma}{P(n)} \right)^{B-A} \right.$$
$$\left. \times \Psi(n)^{B\gamma - A} \cdot \bar{a}(n)^{\frac{(\sigma-1)(B\gamma-A)}{\sigma}} \right\}^{\frac{1}{\beta_o(B-A)}}, \tag{29}$$

where $B\gamma - A < 0$.† The solid and dashed lines in Figure 3 correspond to the combinations of $L_y(n)$ and $L_o(n)$ that satisfy the utility equalization conditions of workers and the elderly, given the indirect utility levels, $\bar{W}_y$ and $\bar{W}_o$. The solid line is more gradual than the dashed line, indicating the disutility caused by an increase in worker population is larger for young households than old households. This is because an increase in the worker population has two negative effects, that is, decreases in the amenity and wage levels. Moreover, the decrease in wages worsens the workers' utility more, as shown in (14) and (15). Namely, an increase in worker population affects the amenity, but the subsequent decrease in wage caused has different impacts; low wage decreases elderly's consumption level of public goods and it depresses workers' consumption levels of both private and public goods. (28) and (29) lead to the following proposition;

Proposition 1. *When $\beta_y \geq \alpha + \gamma$ and $\alpha(\sigma-1) - 1 < 0$ are satisfied and indirect utility levels, $\bar{W}_y$ and $\bar{W}_o$, are given by,*

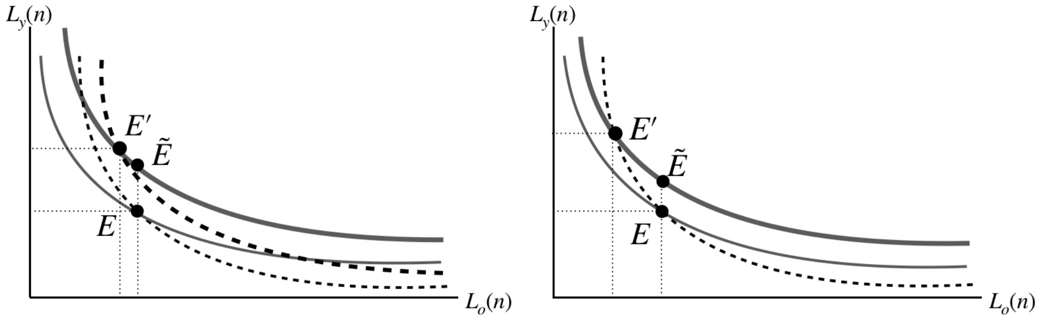
$$\frac{\partial L_y^*(n)}{\partial \bar{a}(n)} > 0, \ \frac{\partial L_y^*(n)}{\partial \bar{u}_y(n)} > 0, \ \frac{\partial L_y^*(n)}{\partial \bar{u}_o(n)} < 0, \ \frac{\partial L_y^*(n)}{\partial \Psi(n)} > 0, \quad \textit{and} \tag{30}$$
$$\frac{\partial L_o^*(n)}{\partial \bar{a}(n)} < 0, \ \frac{\partial L_o^*(n)}{\partial \bar{u}_y(n)} < 0, \ \frac{\partial L_o^*(n)}{\partial \bar{u}_o(n)} > 0, \ \frac{\partial L_o^*(n)}{\partial \Psi(n)} < 0. \tag{31}$$

The worker (elderly) population increases (decreases) with exogenous workers' amenity level, exogenous productivity level, and demand for intermediate goods, and decreases (increases) wth exogenous elderly's amenity level.

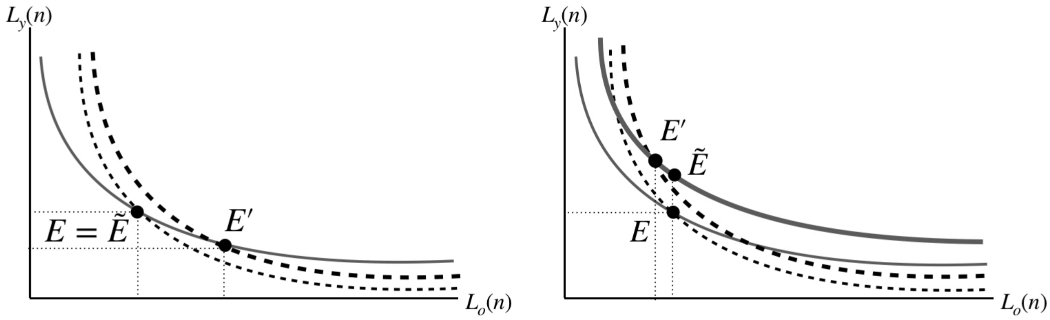
These results are shown in Figure 4, which displays how the equilibrium demographic composition varies in response to changes in exogenous productivity or amenity level given prices, variables for other regions, and indirect utility level. The figure has the following implications; (a) Higher productivity means higher wage-level, which makes both of workers and the elderly tolerant of congestion. Thus, both curves shift upward. Given that workers' utility put more weight on wages compared with the elderly, workers allow congestion more. Accordingly, worker population increases and elderly population decreases. (b) Higher amenity level of workers shifts only the solid line up, indicating that workers are more tolerant of congestion. Therefore, workers population increases, and to compensate for the disutility of elderly caused by the congestion, elderly population decreases. (c) Higher amenity level of the elderly has the

†The assumption that $\beta_y \geq \alpha + \gamma$ and $\alpha > 0$ implies that $(B\gamma)^{-1} - A^{-1} = (1-\gamma)(\beta_y/\gamma - 1) > 0$, that is, $B\gamma - A < 0$.

Figure 4: Change in demographic composition



(a) High productivity (b) High amenity of worker



(c) High amenity of elderly (d) High demand of intermediate goods

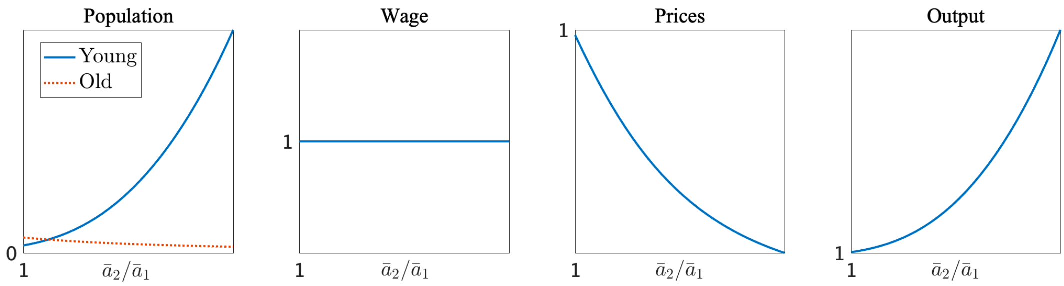
Note: E and E' denote the original equilibrium and equilibrium after a change, respectively. $\tilde{E}$ is the equilibrium when assuming that the elderly are not mobile across regions.

opposite impact to the previous case; it decreases worker population and increases elderly population. (d) Finally, higher demand of intermediate goods, namely higher Ψ, shifts both curves up through an increase in the output level. As mentioned before, workers have higher weight on wages, allowing for more congestion. Furthermore, worker population increases and elderly population decreases.

The effects of introducing mobility of the elderly are captured as the difference between E' and $\tilde{E}$ in Figure 4. As the figure shows, mobility of the elderly amplifies workers' migration through productivity, workers' amenity, and goods demand. Workers put more weight on those factors compared with the elderly. Thus, the elderly population decreases when introducing mobility of the elderly. Accordingly, the decrease in elderly population makes workers more tolerant of congestion, which is why worker population increases more.

Example 1: First, we show the impact of income transfer across regions using a simple example. Consider an economy consisting of two regional groups with different exogenous productivity and amenity levels. Regions $i = 1, \ldots I/2$, which we call group 1, have a productivity level, $\bar{a}_1$, and amenity level, $\bar{u}_{1y}$ and $\bar{u}_{1o}$. The other regions, group 2, have a productivity level, $\bar{a}_2(\geq \bar{a}_1)$, and amenity level, $\bar{u}_{2y}(> \bar{u}_{1y})$ and $\bar{u}_{2o}(> \bar{u}_{1o})$. Suppose that tax rates are the same. The trade cost between the same region group is 1 and that between different groups is $d > 1$. When there are no fiscal transfers across regions, that is, $\theta(i) = \tau^c\ \forall i$, the inequality across regions is as shown in Figure 5. As mentioned before, higher

Figure 5: Inequality across regions (group 2/group 1)



productivity increases worker population and decreases elderly population. As the productivity gap widens, worker population becomes larger and elderly population becomes smaller in more productive regions, group 2, which is displayed in Figure 5. The disparity in population is derived using (28) and (29);

$$\frac{L_{1y}}{L_{2y}} = \left(\frac{\bar{a}_1}{\bar{a}_2}\right)^{\frac{\sigma-1}{1-\alpha(\sigma-1)}} \cdot \left(\frac{\bar{u}_{1y}\bar{u}_{2o}}{\bar{u}_{1o}\bar{u}_{2y}}\right)^{\frac{\sigma}{(1-\gamma)(1-\alpha(\sigma-1))}} \cdot \left(\frac{\Psi_1}{\Psi_2}\right)^{\frac{\sigma}{1-\alpha(\sigma-1)}} \tag{32}$$

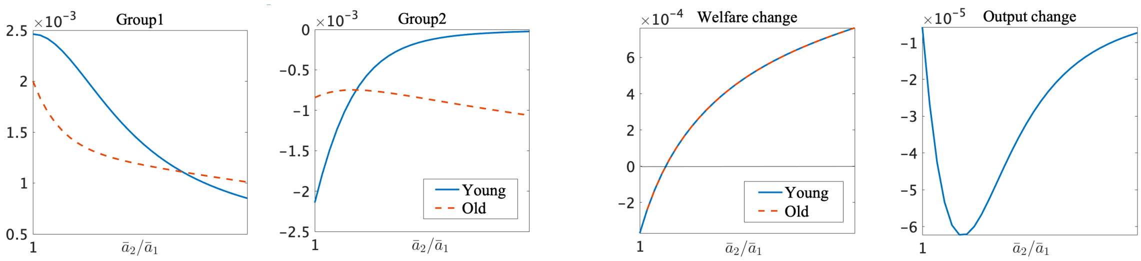
$$\frac{L_{1o}}{L_{2o}} = \left(\frac{\bar{a}_1}{\bar{a}_2}\right)^{\frac{\gamma-\beta_y}{\beta_o}\frac{\sigma-1}{1-\alpha(\sigma-1)}} \cdot \left(\frac{\bar{u}_{1o}}{\bar{u}_{2o}}\right)^{\frac{\sigma(\beta_y-\gamma-\alpha)+1+\alpha}{\beta_o(1-\gamma)(1-\alpha(\sigma-1))}} \cdot \left(\frac{\bar{u}_{2y}}{\bar{u}_{1y}}\right)^{\frac{\sigma(\beta_y-\gamma-\alpha\gamma)+\gamma(1+\alpha)}{\beta_o(1-\gamma)(1-\alpha(\sigma-1))}} \tag{33}$$
$$\times \left(\frac{\Psi_1}{\Psi_2}\right)^{\frac{\gamma-\beta_y}{\beta_o}\frac{\sigma}{1-\alpha(\sigma-1)}} \cdot \left(\frac{\tau_1^l+\theta_1}{\tau_2^l+\theta_2}\right)^{\frac{\gamma}{\beta_o}} \cdot \left(\frac{P_2}{P_1}\right)^{\frac{1}{\beta_o}},$$

where the subscripts denote the region groups. $\frac{\sigma-1}{1-\alpha(\sigma-1)} > 0$ and $\frac{\gamma-\beta_y}{\beta_o}\frac{(\sigma-1)}{(1-\alpha(\sigma-1))} < 0$ imply that workers live in more productive regions and the elderly live in less productive regions. As (24) shows, higher productivity raises wage-level, while the concentration of workers in more productive regions decreases the wage-level. These two effects cancel each other out, and as a result, wages are equal across regions. Additionally, prices in more productive regions are lower than those in less productive regions because productive regions can buy the intermediate goods produced in productive regions at lower price. This is based on the assumption the trade costs between the same group are cheaper.

Furthermore, consider small fiscal transfers from more productive regions to less productive regions, namely $\theta(i) > \tau^c$ for group 1 and $\theta(i) < \tau^c$ for group 2. The transfers increase the public services in recipient regions, group 1, and decrease those in the donor regions, group 2, that is, $\frac{\tau_1^l+\theta_1}{\tau_2^l+\theta_2}$ increases. Figures 6a and 6b show the result. As the figures imply, both workers and the elderly migrate from the donor regions to the recipient regions.

The intuition for this is as follows. The transfer raises the consumption level of public services and intermediate goods demand in the recipient regions through an increase in local governments' revenues and total expenditures, $E_1 = w_1 L_{1y}(1 - \tau_1 + \tau_1^l + \theta_1) + \pi L_{1o}$, respectively. Given the assumptions about trade costs, higher goods demand in recipient regions leads to higher sales and Ψ in recipient regions, subsequently increasing Ψ_1/Ψ_2. Therefore, the welfare level of workers and the elderly in the recipient regions increases, which subsequently makes agents migrate from the donor to the recipient regions and these benefits are counteracted.

Figure 6: Impacts of fiscal transfer



(a) Immigration rate

(b) Transfer effect

Rearranging (26), workers' welfare level is given by

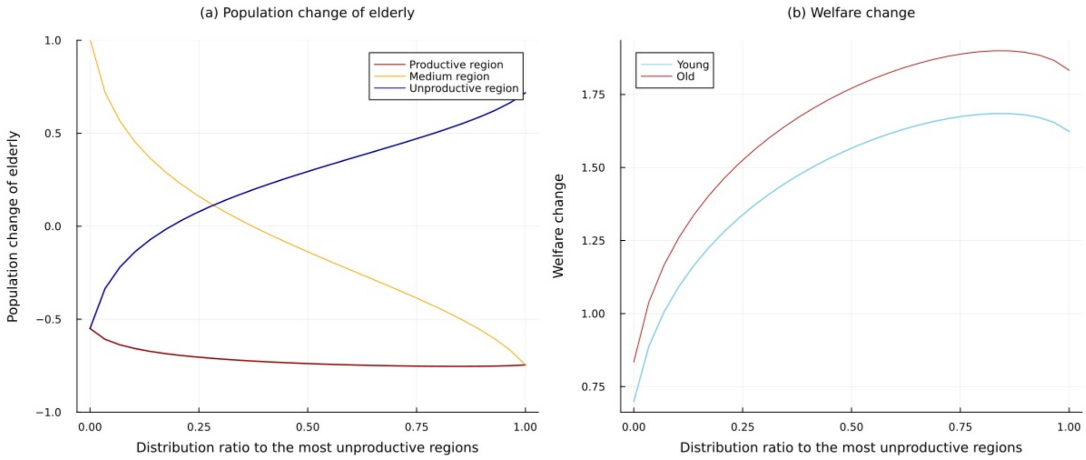
$$\bar{W}_y = \frac{\bar{u}_y(n)\bar{a}(n)^{\frac{\sigma-1}{\sigma}}}{P(n)} \left(\tau^{\ell}(n) + \theta(n)\right)^{\gamma} (1 - \tau(n))^{1-\gamma} \Psi(n) L_o(n)^{-\beta_o} L_y(n)^{-\frac{1}{A}} \tag{34}$$

This implies that the negative effects of worker congestion are decreasing in worker population, $L_y(n)$, because $A > 0$. Therefore, as the productivity gap widens, the migration rates of workers decreases. The productivity gap widens the inequality in worker population. Therefore, in recipient regions, the negative effects of an increase in workers are larger, and in donor regions, the benefits of a decrease in workers are lower. Thus, smaller workers move to recipient regions so that the welfare level is the same across regions.

Exapmle 2: Next, we show another example, where the exogenous amenities of the young and old population are identical and equal across regions $\bar{u}_\lambda(i) = \bar{u}$. There is no trade cost and the price index is the same across regions. This example considers an economy consisting of three regional groups with different exogenous productivity levels. Regions $i = \{1, \dots, I/3\}$, which we call group 1, have a high productivity level, $\bar{a}_1$, group 2 which is $i = \{I/3 + 1, \dots, 2I/3\}$, have a mediocre productivity level, $\bar{a}_2 (\leq \bar{a}_1)$, and the other regions, group 3, have a low productivity level, $\bar{a}_3 (\leq \bar{a}_2)$. In an initial equilibrium without fiscal transfers ($\tau^c = \theta(i) = 0, \forall i$), regions with higher productivity have larger young population ($L_{y1} \geq L_{y2} \geq L_{y3}$) and smaller old population ($L_{o3} \geq L_{o2} \geq L_{o1}$). Thus, regional amenities are lower in regions with higher productivity.

Now, we introduce small asymmetric fiscal transfers that the central government imposes as national tax τ^c and distributes the revenues only among groups 2 and 3. This transfer triggers the elderly's migration to groups 2 and 3. In Panel (a) of Figure7, we show population change of the elderly. Given that the distribution ratio to group 3 is bigger, migration to group 3 is larger. Additionally, population of group 1 is decreasing regardless of the value of the distribution rate to group 3. However, the absolute change in the elderly population reaches a maximum when the distribution ratio to group 3 is 82.8%. This is because the inflow of old population in group 3 reaches a limit, even when they receive large fiscal transfers. We omit a figure of changes in young population because we do not observe a substantial change. This is because the change in the old population is much larger, which improves the utility of

Figure 7: Effect of fiscal transfer



young residents in productive regions, and the old population in recipient regions consumes most of the increase in the public services.

Panel (b) of Figure 7 shows the utility changes. Fiscal transfers improve the common level of equalized utility across regions, regardless of the distribution ratio in the most unproductive regions. This is because fiscal transfers reduce overcongestion in group 1 and increase public services in the recipient regions. However, as illustrated in the concave-down curve in Panel (b) of Figure 7, the central government needs to adjust the optimal distribution ratio to obtain maximum welfare gain. As mentioned before, excessive transfers make unproductive regions reach a limit of accepting the migrating elderly, which reduces welfare gains. Based on the analysis of this example, in section 5, we analyze how Japanese government can improve the current fiscal transfer system by adjusting transfer rates to unproductive regions.

4 Data and calibration

In this section, we explain the quantitative implications of our model using the fiscal transfer system of Japanese government. Our calibration is for fiscal year 2014, which is the most recent year for which we could obtain inter-regional trade data. The financial data of prefectures is obtained from Annual Statistical Report on Local Government Finance in FY2014, compiled by Ministry of Internal Affairs and Communications.

For calibration, we assume that the data has been generated from the spatial general equilibrium. The fact that the observed actual net migration across prefectures is only around $2,405$ thousands people in 2014, which is only 1.9% of the total population, justifies our assumption.

First, We describe the government policy, explain the data used, and calibrate the model.

4.1 Fiscal transfers

The Japanese central government has five main fiscal transfer schemes to local governments, which support local governments' administration to supply public services of equal quality and reduce horizontal fiscal disparities across regions.

1. Local allocation tax grant: This is the unconditional transfer from the central government to prefectures and municipalities. Ministry of Internal Affairs and Communications supplies this transfer to fill the local governments' budget gap between the standard financial needs (e.g. care of elderly, maintain infrastructure, education services.) and standard financial revenue.

2. National treasury disbursement: This is the conditional transfers that support specific public works (e.g. social security, public construction projects.)

3. Local transfer tax: This involves allocation of national tax revenue at the fixed ratio (e.g. 33.1% of income tax) to adjust fiscal imbalance among local governments.

4. Special local government grant: This provides compensation for prefectures' and municipalities' decrease in individual inhabitant tax revenues due to the special deduction for housing loan.

5. Special grant for traffic safety measures: This grant supports prefectures' and municipalities' arrangement of traffic safety facilities.

Local allocation tax grant, local transfer tax, and special local government grant are a part of general account budgetting while national treasury disbursement and special grant for traffic safety measures are conditional transfers that must be spent on specific purposes. However, since we focus on discussing the impact of amount of transfers on welfare and productivity, we aggregate the values of these five transfers. Additionally, these five fiscal transfers are granted to prefectures and municipalities. As our analysis is conducted at the the level of prefectures, we sum up the transfers to prefectures and municipalities at the prefecture-level. Next, we calculate the transfer rate of each prefecture $\theta(i)$ by relating them to these prefectures' GDP.

4.2 Local taxes and pension premium

We also compute local tax rate $\tau^{\ell}(i)$ by aggregating local tax revenues of prefectures and municipalities and dividing them by these prefectures' GDPs. Figure 8 shows the relationship between regional population-aging and prefectures' revenues from local tax and fiscal transfers. As seen in Panel (a), the local tax rate is lower in prefectures with high rate of aging. As shown in Figure 1, the income per capita is lower in regions with higher aging. Given that Japans has a progressive tax regime, regions with low-income residents cannot obtain high tax revenues. Panel (b) of Figure 8 shows that prefectures with a larger aging population also have larger transfer rates. Larger transfers compensate for the shortfall of necessary expenses toward public services. We also set pension premium τ^{p} as 0.054, which is the proportion of revenues of Japanese National Pension and Employees' Pension Insurance to national GDP in 2014.

Figure 8: Population aging and the revenue of local governments

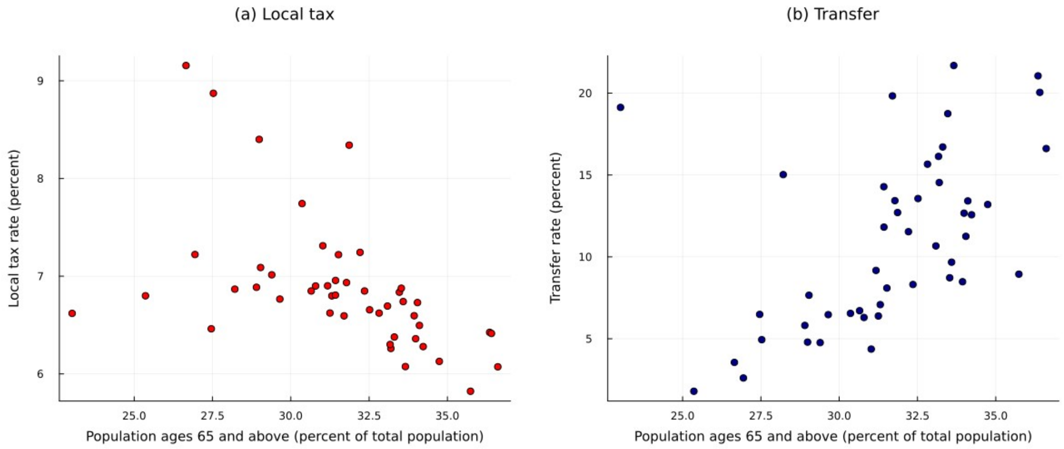
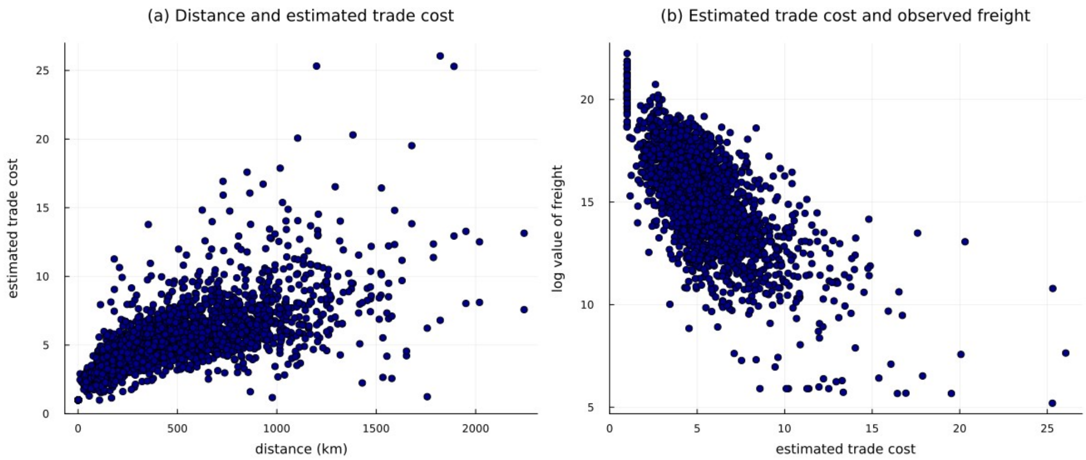


Figure 9: Estimated trade cost



4.3 Interregional trade cost

Similar to Henkel et al. (2021), we estimate interregional trade costs $d(i, n)$ following the standard gravity literature (e.g. Head and Mayer (2014)). We use data from 2015 Net Freight Flow Census (NFFC), which records freight transport between prefectures in 2014. The estimated elasticities of distance reported in Table 1 are similar to those in Henkel et al. (2021). We calculate the trade costs between each prefecture given that distance elasticity is equal to -1.1. Figure 9 clearly illustrates that the estimated trade costs are increasing in distance between exporting and importing prefectures and negatively affecting the freight value.

4.4 Estimation and calibration of parameters

We estimate the agglomeration effect on productivity α by estimating equation 5. Specifically, we use average elevation obtained from Geospatial Information Authority of Japan (1993) as an instrumental variable for population density to prevent biased estimation caused by the effect of productivity on the

Table 1: Estimated distance elasticities

	log(volume)		log(value)	
	(1)	(2)	(3)	(4)
log(distance)	-1.131***	-1.063***	-1.131***	-1.063***
	(0.021)	(0.020)	(0.021)	(0.020)
contiguity		1.028***		1.028***
		(0.099)		(0.099)
Exporter FE	Yes	Yes	Yes	Yes
Importer FE	Yes	Yes	Yes	Yes
Product FE	Yes	Yes	Yes	Yes
N	11,764	11,764	11,764	11,764
R^2	0.484	0.494	0.476	0.487

agglomeration of population. Average elevation is an important factor to determine residence because places with higher elevation, which usually includes mountainous regions in Japan, are unsuitable for habitation. Given that elevation of a region does not directly affect productivity level and vice versa, it is a valid instrument to obtain an unbiased estimator of α. The estimation result is shown in Table 2. The agglomeration effect is $\alpha = 0.07$, which falls within the range of $3 - 8$ percent as estimated in the literature (Ciccone and Hall (1996) and Rosenthal and Strange (2004); summarized in Combes and Gobillon (2015)).

For β_y and β_o, our calculation follows Bryan and Morten (2019) and Henkel et al. (2021). We assume that β_λ consists of the congestion externality β_0 and the strength of individual location tastes $1/3$. The congestion externality is calculated by $\beta_0 = \frac{\delta}{1-\delta}$ where δ is a constant income share of housing. We calculate β_0 for the young and old populations using expenditures of commodities by age group of household heads, obtained from the National Survey of Family Income and Expenditure (NSFIE), 2014. Then, we obtain $\beta_y = \frac{0.24}{1-0.24} + \frac{1}{3} = 0.65$ and $\beta_o = \frac{0.3}{1-0.3} + \frac{1}{3} = 0.76$.

The expenditure share of public services is calculated by average tax rate, similar to Henkel et al. (2021). We set $\gamma = 0.35$ based on tax and income data from e-Stat in 2014. We parameterize the elasticity of substitution $\sigma = 5$ following Simonovska and Waugh (2014). Table 3 provides summary of the parameters in our model.

Finally, we back out exogenous productivities $\bar{a}(i)$ and amenities $\bar{u}_\lambda(i)$ for each prefecture by simultaneously solving the nonlinear system of 3×47 equations (goods market clearing and utiliy equalization of young and old populations) for a given parameterization of trade costs, the parameters explained above, and all endogenous variables. Figure 10 reports the maps summarizing the degree of exogenous variables of each prefecture. Darker shades indicate higher values. As expected, higher values of exogenous and composite productivities are concentrated in regions around Tokyo, Osaka, and Nagoya, which are the

Table 2: Estimated agglomeration effect

Log productibity	(1)
Log population density (ages 15-64)	0.065**
	(0.027)
Instruments:	
Log average elevation	Yes
Observations	329
F-Stat (fisrt-stage)	27.9331
R^2 Adj.	0.448

Table 3: Parameters

Parameter	Value	Reference
Agglomeration effect of productivity α	0.07	Estimation in IV
Dispersion effect of young population on amenity β_y	0.65	NSFIE(2014)
Dispersion effect of old population on amenity β_o	0.76	NSFIE(2014)
Fraction of expenditure on public goods γ	0.35	e-Stat(2014)
Elasticity of substitution σ	5	Simonovska and Waugh (2014)

three major metropolitan area in Japan.

Panels (c) and (e) in Figure 10 show that the high values of exogenous amenities are more widely distributed than those of exogenous amenities. To justify the values of exogenous amenities, we plot the relation of overnight stays and exogenous amenities because prefectures with large overnight stays are considered to have a lot of amenities like scenic resources. Figure 11 clearly demonstrates that prefectures with high exogenous amenities have large tourism resources. However, Panels (d) and (f) in Figure 10 indicate that prefectures with high values of exogenous amenities tend to have low composite amenities because of congestion.

5 Counterfactual simulaiton

Armed with the calibrated model, we finally simulate two counterfactual scenarios to examine the welfare and output changes in fiscal transfers.

First, we simulate a case in which the central government abolishes the entire fiscal transfer system. Comparing the result of this simulation with current transfers, which we call "benchmark, enables us to analyze the effect of the benchmark on welfare and output. Specifically, we set zero central tax and fiscal transfer rate ($\tau^c = \theta(i) = 0, \forall i$) and obtain new values of endogenous variables that are consistent with the equilibrium conditions in Section 2.

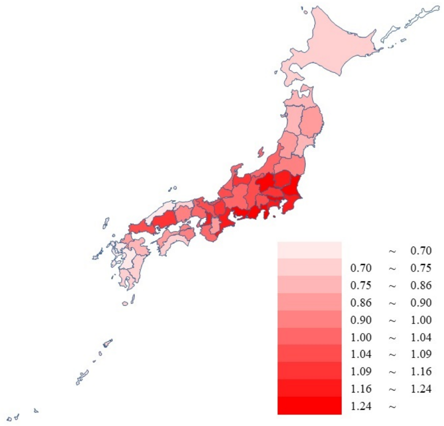
The second counterfactual exercise is to simulate a case in which the central government sets a uniform transfer rate across all regions, which is virtually a system to return funds of fiscal transfers to tax payment regions governments. We define fixed uniform transfer rate ($\theta(i) = \tau^c, \forall i$) and solve equilibrium conditions, similar to the first counterfactual exercise.

5.1 Migration

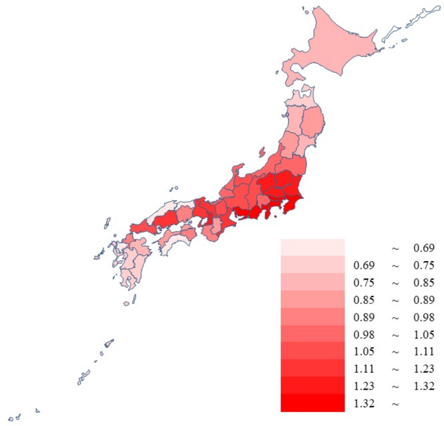
In the literature (e.g., Henkel et al. (2021)), it is expected that a large number of people move to rural areas after introducing fiscal transfers. In our theoretical model, this can be driven by two effects. The first is a direct effect of increase in local public services. Fiscal transfers increase revenues of local governments, which improves their public services and increases welfare of residents. Figure 12 shows that transfers of benchmark and uniform-rate scenarios increase public services of local governments, especially in rural areas with larger aging population, even though the magnitudes of the change are quite different. The second effect is an indirect effect where fiscal transfers promotes increases local real wages. Increases in public services promote migration to specific prefectures, which indirectly improves local productivities and real wages. Increases in real wages in rural areas attract population from urban areas. The indirect effect influences migration of young and old populations through change in local public services. As shown in Figure 13, fiscal transfers clearly improve local real wages in regions with higher rates of elderly population.

Overall, the direct and indirect effects cause migration of old and young populations. Figure 14 presents changes in young and old population from zero transfer scenario to benchmark for each prefecture. In red-shaded prefectures, local young populations increase from non-transfer scenario to the benchmark

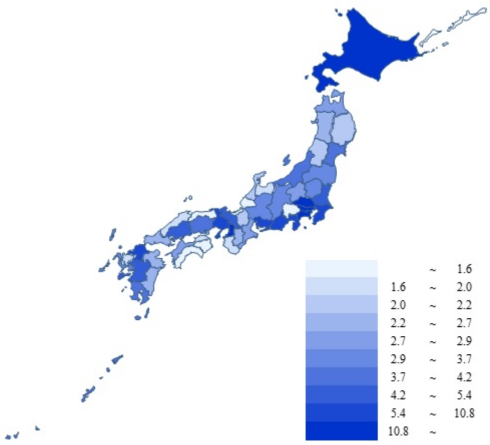
Figure 10: Estimated productivities and amenities



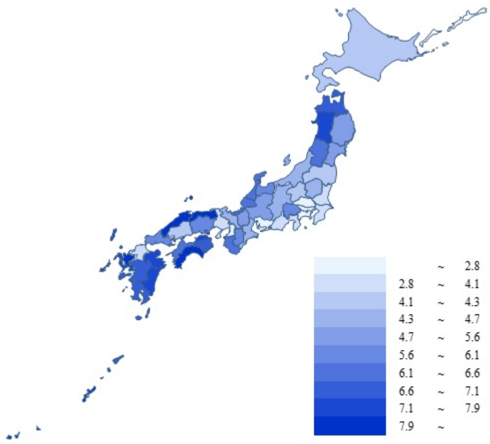
(a) Exogenous productivities



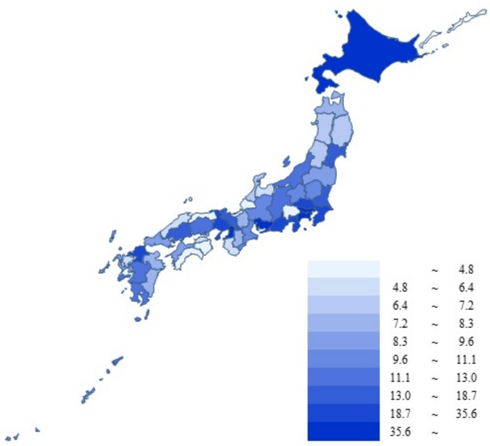
(b) Composite productivities



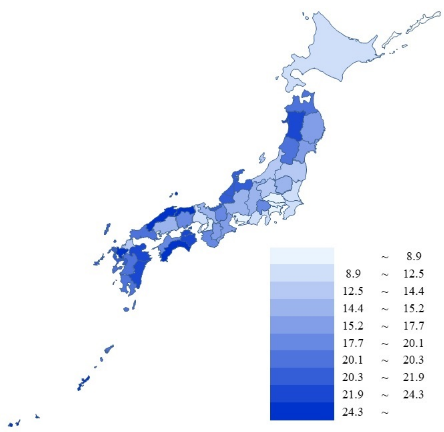
(c) Exogenous amenities of young population



(d) Composite amenites of young population

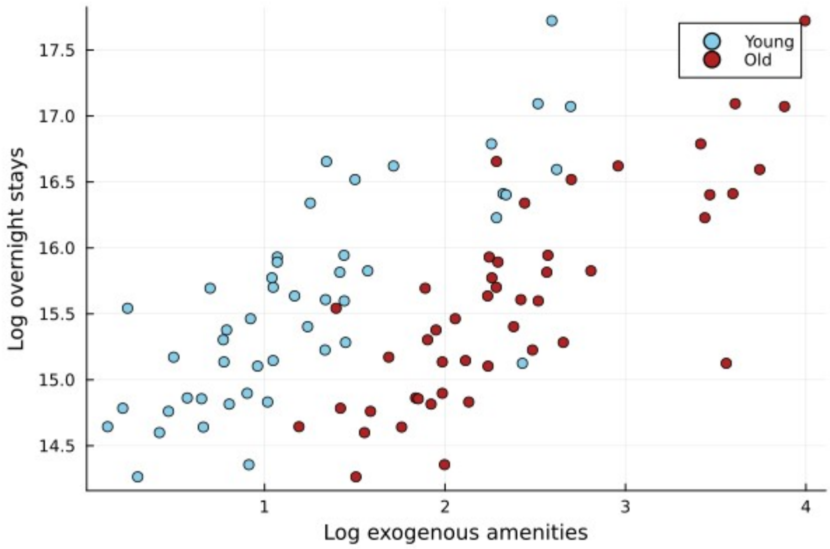


(e) Exogenous amenities of old population



(f) Composite amenities of old population

Figure 11: Exogenous amenities and observed attractiveness



and those shaded blue indicate the opposite. Darker shades indicate higher absolute values of change in population. As expected, both young and old populations move to rural areas. It is worth noting that old population decreases in many prefectures while the decline in young population is concentrated in a small number of metropolitan areas. This is because welfare of old population depends less on productivities and wages in prefectures and more on amenities and public services, when compared with young population. The elderly tend to move to areas that are less densely populated but have more public services. The working population more closely considers productivities and wage than elderly. The change of population from the benchmark to uniform-rate transfer scenario is presented in Figure 15. Interestingly, young population are more concentrated around the Tokyo metropolitan area (Tokyo, Kanagawa, Chiba, Saitama) than the elderly. Increase of productivity due to the uniform-rate transfer in the Tokyo metropolitan area induces young population's migration to the area. However, this migration decreases the utility of elderly and prevents further migration of old population into the area. Old population increases across several prefectures that have a comparatively larger economy than the surrounding prefectures.

5.2 Welfare and output

The migration induced by fiscal transfers affects equalized welfare across regions and national and local outputs. Henkel et al. (2021) report that transfers improve welfare but reduce national output. In our benchmark specification, welfare of young and old population increases by 17.5% and 20.4% respectively from non-transfer scenario. However, national output declines by 12.5%. This is because young population leaves productive regions as shown in Panel (a) of Figure 16. These regions experience considerably reduced local outputs while recipient regions increase outputs; however, they are not enough to cover the reduction of productive regions' outputs. If the central government sets a uniform transfer rate across regions, it is possible to improve welfare by 20.3% for young population and 27.2% for the

Figure 12: Change in public services

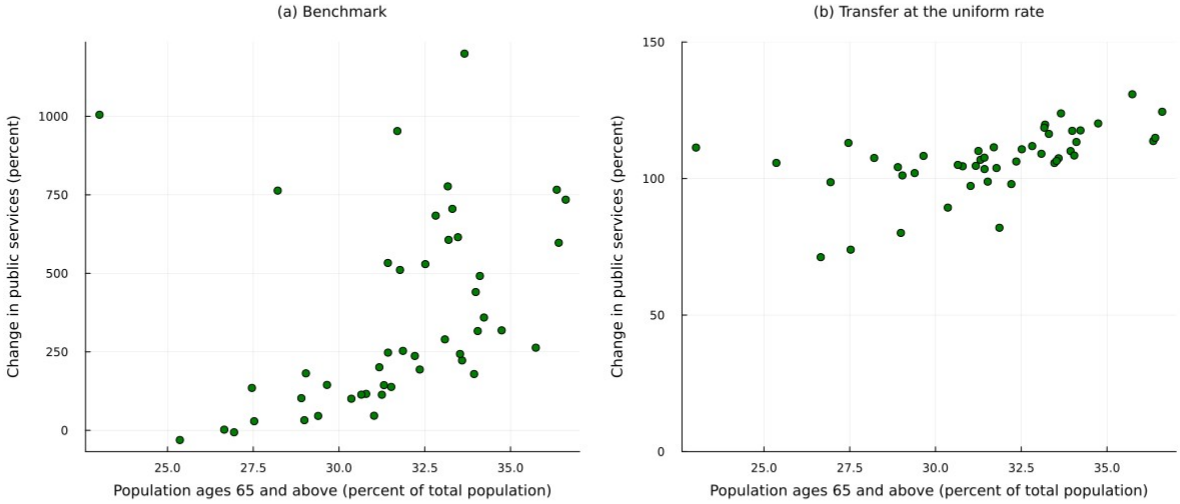


Figure 13: Change in real wage

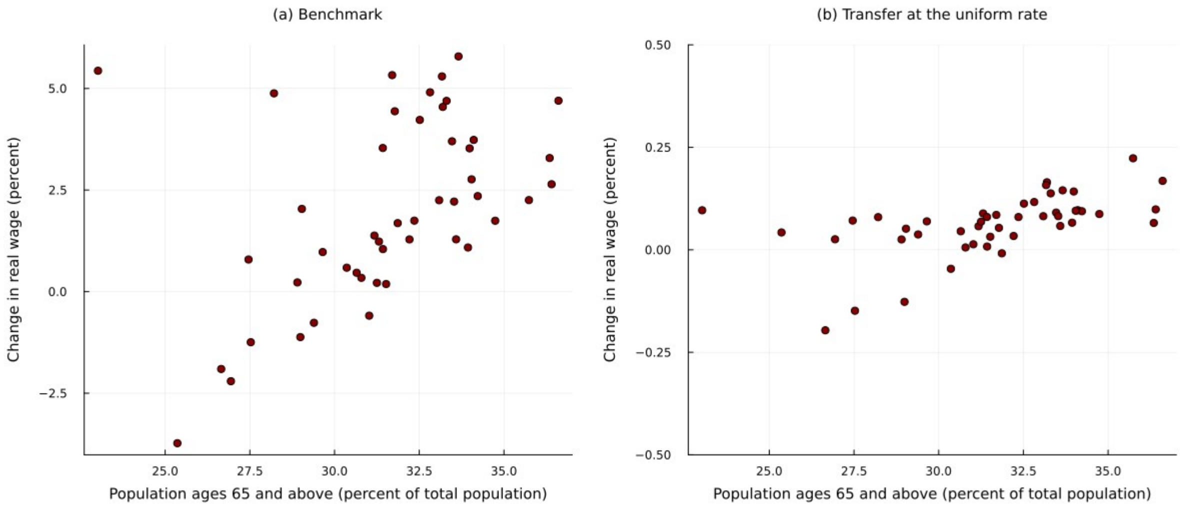
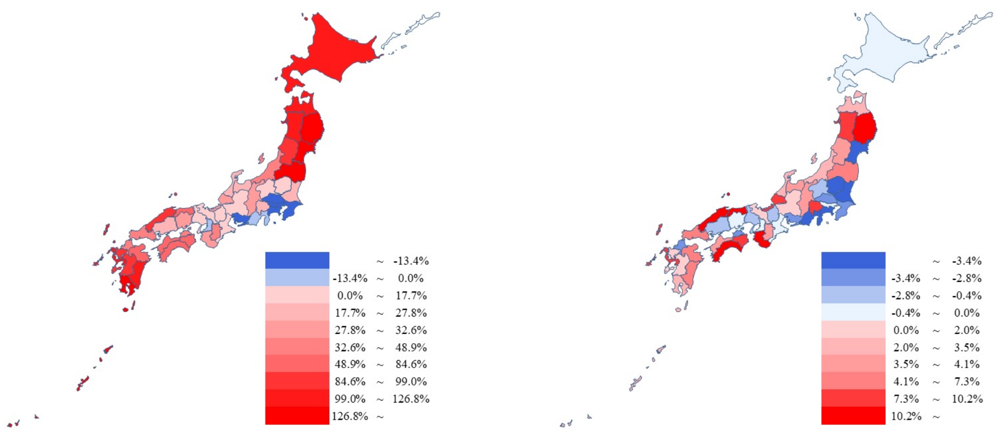
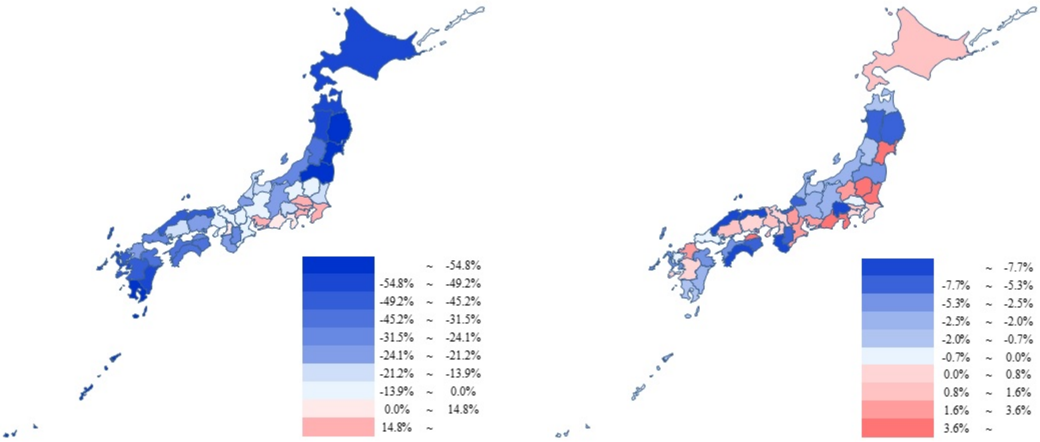


Figure 14: Change of population from zero-transfer scenario to benchmark



(a) Young population (b) Old population

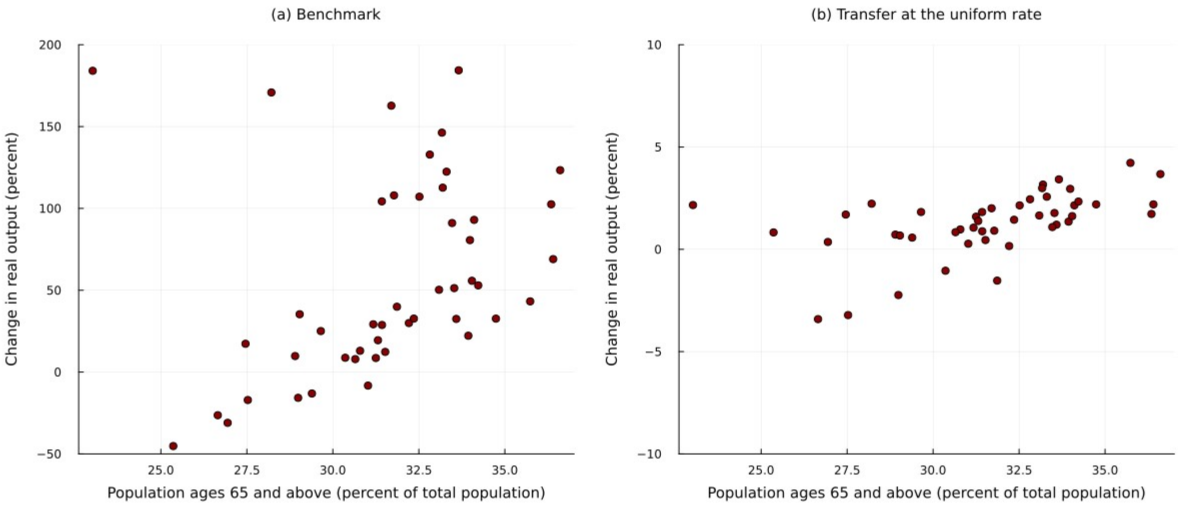
Figure 15: Change of population from benchmark to uniform-rate transfer scenario



(a) Young population (b) Old population

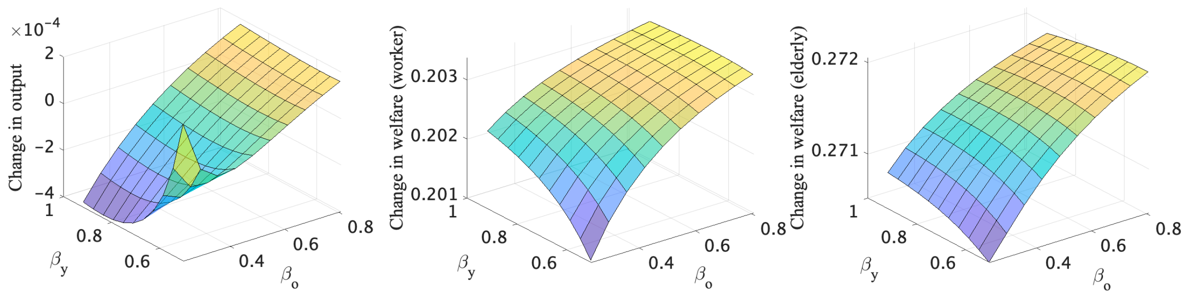
elderly without reducing national output. The uniform transfer rate can improve overcongestion in urban areas but does not affect local output as much as the benchmark, as reported in Panel (B) of Figure 16. Especially, it does not reduce the outputs of Tokyo and Osaka. It enables the central government to accomplish welfare improvement without sacrificing national output.

Figure 16: Change in real output



Robustness check: Finally, we check the robustness of our results. Figure 17 plots the changes in welfare and output for various values of β_y and β_o when introducing the uniform transfer. For each combination of (β_y, β_o), the exogenous amenity and productivity levels are re-calibrated to match the benchmark population and income distributions. The figure implies that when β_o is larger than about 0.55, the result that uniform transfer across regions improve the welfare level without reducing output is robust to the values of β_y and β_o.

Figure 17: Change in real output and welfare (from zero-transfer scenario)



6 Conclusion

We develop a quantitative spatial general equilibrium model to analyze fiscal transfers of the central government to local governments. Our model contains heterogeneous local productivities and amenities, migration of young and elderly population, and interregional trade. In analyzing location-based policies, such as fiscal transfers across regions, considering general equilibrium effects is essential for policymakers. In our analysis, influences of fiscal transfers are different for young and old populations and interact with each other. Especially, overlooking migration of elderly people makes policymakers miss the possibility of realizing improvement of both welfare and national output. Our counterfactual simulations show that current fiscal transfers by the Japanese central government improve welfare of young and old populations by 17.5% and 20.4%, respectively, compared with a zero-transfer case. However, they reduce national output by 12.5%. If the central government makes the transfers at a uniform rate across regions, it improves welfare of the working and old population by 20.3% and 27.2%, respectively, compared with the zero-transfer case, without reducing national output. Further analysis is essential to analyze the level of transfers to obtain maximum improvement of welfare and national output.

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