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Industrial Agglomeration and Public Goods Provision from a Political Economy Perspective

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This study explores the migration of mobile workers between two regions to form new communities with the immobile workers in the spatial distribution and the local public goods being provided by the new communities via voting in the Forslid and Ottaviano (2003) version of new economic geography. The tax rate for the provision of local public goods in each region is determined by either a decentralized system or by a centralized system. The results show that in a decentralized system, there are two effects of an increase in the tax rate when the share of mobile workers increases. One is the increase in agglomeration force to form an "agglomeration rent" (Baldwin and Krugman, 2004). The other is the change of preference for public goods via voting since the number of mobile workers dominates that of immobile workers. In a centralized system, there are two tax rate alternatives for each region with equal probability.

Keywords: new economic geography, public goods, spillover, core periphery, political economy approach
JEL classification: H20, H41, R12

1 Introduction

This paper explores the industrial distribution between two regions with the provision of public goods with spillovers by a political economy approach.

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Specifically, the provision of public goods will increase the utility of residents in the region and attract people to move in to form a new spatial distribution of production. This issue has been explored by many studies in the field of New Economic Geography (NEG). However, the migrants will then form a part of the new community of the region. This means the migrants will then have the rights to vote for the provision of public goods. However, the migrants might have different preference for the public goods and influence the decision by voting especially for the case of the number of migrants being large. These two issues can continuously impact each other. This study is intended to incorporate these two issues to explore the spatial distribution of mobile workers and the provision of public goods with spillovers by the new community via voting.

There are many examples of the migrants influencing the voting results in Taiwan though they did not directly decide the provision of the public goods. In the past decades, New Taipei City attracted many migrants who formed a political force which the candidates cannot ignore for elections. Yunlin Association in New Taipei City is an example formed by the migrants. In fact, due to the poor conditions for living, a large number of people moved out from Yunlin. There are 18 branches of Yunlin Association in many cities of Taiwan, including Taipei City, New Taipei City, Taichung City, and so on. The number of the migrants in New Taipei City from Yunlin is more than seventy hundred thousand. The candidates usually intended to attract these migrants for elections. Recently, Taoyuan has been a growing city due to many migrants. The population of Taoyuan city is 1,762,963 in 2001, and 2,272,391 in 2021 (see Table 1). In these twenty years, the growth rate is 29.39%. In the same period, the population of Taiwan is 22,405,568 in 2001, and 23,375,314 in 2021 with only 4.32% growth rate, and −4.15% growth rate for Taipei and 11.02% for New Taipei City. Many migrants of Taoyuan city are young households. These young households have a preference for public goods differing from the old generation. Some sport facilities and stadiums were thus provided by the local government these years for these migrants' preference.

Two related issues are involved in this study. One is the spatial distribution of firms (mobile workers) between two regions. In the seminal paper of NEG, Krugman (1991) developed a general equilibrium model with monopolistic competition for market structure from Dixit and Stiglitz (1977) to explore industrial distribution of agglomeration or dispersion between two regions. The results show the manufacturing firms will symmetrically

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Table 1: Population of Taoyuan City

Year	Population	Year	Population
2001	1,762,963	2011	2,013,305
2002	1,792,603	2012	2,030,161
2003	1,822,075	2013	2,044,023
2004	1,853,029	2014	2,058,328
2005	1,880,316	2015	2,105,780
2006	1,911,161	2016	2,147,763
2007	1,934,968	2017	2,188,017
2008	1,958,686	2018	2,220,872
2009	1,978,782	2019	2,249,037
2010	2,002,060	2020	2,268,807
		2021	2,272,391

Source: Demographics, Department of Household Registration, Ministry of Interior, ROC (2022)

distribute in two regions when the transport costs are high, while they will agglomerate in one of the regions when transport costs are low. Forslid and Ottaviano (2003) proposed an analytically footloose entrepreneur model by introducing heterogeneity between highly skilled mobile and low-skilled immobile workers. The skilled workers can be thought of as self-employed entrepreneurs who incur a fixed cost, while unskilled workers incur variable cost in the production of manufactured goods.[1] Though the common assumption that all individuals share the same preference in NEG, Murata (2003) and Tabuchi and Thisse (2002) show that the heterogeneity in preference can weaken agglomeration force due to the mobile people are attached to their regions not only for financial reasons but also for non-market attributes (Candau, 2008).

Some studies explores the provision of public goods through tax competition in the structure of NEG. Andersson and Forslid (2003) use Forslid and Ottaviano (2003) version of the Krugman (1991) model to study the effects of taxes on the location of manufacturing production. They show

[1] Ottaviano, Tabuchi, and Thisse (2002), and Pflüger (2004) provide two other analytically solvable models.

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that an equilibrium with mobile workers dispersed across countries is destabilized by increased taxes on the mobile workers. Their taxation is the coexistence of immobile and mobile factors of production in contrast to the traditional studies of tax competition for mobile factors, such as Ludema and Wooton (2000) and Kind, Knarvik, and Schjelderup (2000). Gerritse (2014) studies government tax competition for firms under agglomeration effects. He shows that if regions set policy at the same time, harmonization can still improve welfare. This clarified the argument that agglomeration forces eliminate the need to harmonize policy if large regions set policy first though there is an agglomeration rent to avert races to the bottom (Baldwin and Krugman, 2004).

The other related issue is provision of public goods by a political economy approach, a classic issue in public finance. Consider an economy consisting of geographically distinct districts. In each district, there is a local public good, which benefits not only the citizens in the district but also the other districts via spillovers. Then how should authority allocate the provision of public goods and how should the costs of provision be shared? Should there be a centralized system in which the provision decisions are made by a central government and financed from general revenues, or a decentralized system in which the choices are made by local governments and financed by local taxation? Oats (1972) assumes that each government maximizes the aggregate surplus of its constituents. In a centralized system, the government chooses a uniform level of public spending for each district. In a decentralized system, the local government will neglect the benefits going to other districts, and thus the local public goods will be under-provided. However, the uniformity of centrality is argued to be neither empirically nor theoretically satisfactory (Besley and Coate, 2003; Lockwood, 2002; Persson and Tabellin, 2000). Some studies thus use different settings to analyze this issue. Besley and Coate (2003) use a political economy approach for public spending of decentralized and centralized systems and conclude that costs are shared in a centralized system, creating a conflict of interest between citizens in different jurisdictions. This conflict will play out in the legislature when decisions are made by a legislature of locally elected representatives. Lorz and Willmann (2005) provide a political economy approach to explain the degree of centralization in economic policy making. They show that the resulting degree of centralization is sub-optimally low. A political economy approach has also been used for the selection of a transportation system, road investment and pricing for the uses of transportation facilities

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(Brueckner and Selod, 2006; De Borger and Proost, 2012, 2016).

Some studies assume that skilled workers are allowed to migrate according to the tax policies for provision of public goods in regions, like Baldwin and Krugman (2004), Borck and Pflüger (2006), and Haufler and Wooton (2010). However, after the skilled workers migrate between regions, they become citizens and may influence the decision of provision of public goods in regions by voting due to heterogeneous preference for public goods and the number of migrants. The new level of public goods influence the relative utility between two regions and change the distribution of skilled workers in regions in the long run. This study thus explores the move of mobile workers to form the spatial distribution between two regions and how the local public good provision by voting simultaneously. The voting is executed by a political economy approach which includes two systems, a decentralized system and a centralized system. The decision making of each local government depends on the representative of the region in the decentralized system. In the centralized system, each region elects a representative to form a parliament which then elects a representative to make the decision for each region. The results show that in a decentralized system, there are two effects of the increase in tax rate when share of mobile workers increases. One is the increase in agglomeration force to form an "agglomeration rent" (Baldwin and Krugman, 2004). The other is the change of preference for public goods via voting due to the number of mobile workers dominating that of immobile workers. In a centralized system, there are two tax rate alternatives for each region with the same probability.

The remainder of this paper is organized as follows. The model based on this analysis is described in Section 2. The provision of local public goods and the distribution of firms is introduced in Section 3. The equilibrium distribution of firms and the provision of public goods are analyzed in Section 4. A discussion for the model is provided in Section 5. The final section provides some concluding remarks.

2 A two-region model

This paper uses the footloose entrepreneur model of Forslid and Ottaviano (2003) to investigate the effects of a public good on the location of firms from a political economy perspective. The political economy approach for the provision of public good employs a majority voting mechanism for a decentralized system, and a legislature of locally elected representatives by a

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minimum winning coalition for a centralized system. In this model, skilled labor is mobile, while unskilled labor is immobile.

There are two regions, i =1, 2, and two sectors, sector A (agriculture) and sector X (manufacturing). A homogeneous good is produced in sector A with a constant returns-to-scale technology using only unskilled labor, while differentiated manufactured goods are produced in sector X with increasing returns-to-scale technologies using both skilled and unskilled labor. Total skilled labor and unskilled labor are H and L ($H > L$).[2] That is, $H_1 + H_2 = H$ and $L_1 + L_2 = L$, where H_i and L_i for i =1,2 denote the labor endowment in region i. Skilled workers can migrate between regions while unskilled workers are geographically immobile. The public goods are considered to be provided in each region with spillovers. Unskilled workers and skilled workers have difference preferences for the public goods. The utility functions of unskilled labor and skilled labor are thus expressed as

$$U_i^L = X_i^{\mu} A_i^{1-\mu} G_i^{\theta}, \quad i = 1, 2, \tag{1}$$

$$U_i^H = X_i^{\mu} A_i^{1-\mu} G_i^{\delta}, \quad i = 1, 2, \tag{2}$$

where $\mu \in (0, 1)$ is expenditure share for manufacturing goods, $\theta, \delta \in (0, 1)$ are preference parameters of public goods for unskilled and skilled labor, respectively, X is the manufacturing index, A is the consumption of the homogeneous good, and G is the level of a public good that is available, which is the local public good and the spillover from the other region's public good. In this setting of utility functions, the different preference for public goods across the skilled and unskilled workers reflects the heterogeneous demand for public goods of migrants and the original residents. This heterogeneity also reflects the different income levels of these two groups of workers.[3]

$$G_i = g_i + r g_j, \quad i = 1, 2, \quad i \neq j, \tag{3}$$

[2]This means the number of skilled laborers is more than that of unskilled laborers. This assumption is to make the following analysis easier.

[3]This heterogeneous preference for public goods can be found in Taoyuan city of Taiwan explained in Section 1. Note that the heterogeneous preference in utility function was introduced in Murata (2003) and Tabuchi and Thisse (2002) though they did not include public goods. In addition, heterogeneous preferences for public goods with different levels of incomes can be found in Bergstrom and Goodman (1973) who proposed income being one of significant variables for the demand for public goods and estimated the elasticity of income variable for municipalities in US.

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where g_i denotes the public good provided by region i, and r$\in$ [0, 1) denotes the spillover from region j to region i.

Following Dixit and Stiglitz (1977), the index X for the manufactured goods is defined by

$$X_i = \left(\int_0^{n_i} d_{ii}(s)^{\frac{\sigma-1}{\sigma}} ds + \int_0^{n_j} d_{ji}(s)^{\frac{\sigma-1}{\sigma}} ds \right)^{\frac{\sigma}{\sigma-1}}, \quad i = 1, 2, \quad j = 1, 2, \quad j \neq i, \tag{4}$$

where $d_{ji}(s)$ denotes the amount of variety s being produced in region j and consumed in region i, $\sigma > 1$ denotes the elasticity of substitution, and n_i and n_j denote the number of varieties produced in region i and in region j.

The price index for the manufactured goods is then

$$\begin{aligned} P_i &= \left(\int_0^{n_i} p_i(s)^{1-\sigma} ds \right)^{\frac{1}{1-\sigma}} \\ &= \left(\int_0^{n_i} p_{ii}(s)^{1-\sigma} ds + \int_0^{n_j} p_{ji}(s)^{1-\sigma} ds \right)^{\frac{1}{1-\sigma}}, \\ &\qquad i = 1, 2, \quad j = 1, 2, \quad j \neq i, \end{aligned} \tag{5}$$

where $p_{ji}(s)$ is the price of variety s produced in region j and consumed in region i.

Each consumer spends a share μ of his income Y on manufactured goods, and a share $1 - \mu$ of his income Y on the homogeneous good. The demand for manufactured and homogeneous goods is then

$$X_i = \mu \frac{Y_i}{P_i}, \quad i = 1, 2, \tag{6}$$

$$A_i = (1 - \mu) \frac{Y_i}{P_i^A}, \quad i = 1, 2. \tag{7}$$

It is assumed that the unit requirement of the homogeneous good is one unit of unskilled labor. This good is freely traded, and the price is normalized to $P_i^A = w_i^L = 1, i = 1, 2$ (w_i^L being the wage of unskilled workers).[4]

[4]The condition, $\mu < \sigma/(2\sigma - 1)$, is needed to guarantee the wage equalization across sectors and regions for skilled workers (Forslid and Ottaviano, 2003, p.232).

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In the production of the differentiated goods, skilled labor only enters the fixed cost, while variable costs only consist of wages to unskilled workers. The cost of producing x_i units of manufactured commodity s in region i is

$$TC_i(s) = w_i\alpha + w_i^L\beta x_i(s), \quad i = 1, 2, \tag{8}$$

where w_i is the wage of skilled labor in region i, α is the requirement of skilled workers in producing each variety, and β is the requirement of unskilled labor per unit $x(s)$.

In the short run, the skilled workers in each region are fixed. Full employment implies that the number of manufacturing firms is

$$n_i = \frac{H_i}{\alpha}, \quad i = 1, 2. \tag{9}$$

In this model, unskilled labor is not allowed to migrate between regions. It is thus assumed that $L_i = L/2$ and total incomes in the two regions are

$$Y_1 = \frac{L}{2} + w_1\lambda H, \quad Y_2 = \frac{L}{2} + w_2(1-\lambda)H.^5 \tag{10}$$

where λ is the share of skilled labor in region 1.

When the distribution of the skilled labor between the two regions is given, the wages of skilled workers in the two regions and total income in the two regions can be obtained after some typical derivations:[6]

$$w_1^* = \frac{L\mu\left[(1-\lambda)(\sigma-\mu) + (1-\lambda)\phi^2(\sigma+\mu) + 2\lambda\phi\sigma\right]}{2H(\sigma-\mu)\left\{\lambda(1-\lambda)\left[\sigma(1-\phi)^2 - \mu(1-\phi^2)\right] + \sigma\phi\right\}}, \tag{11}$$

$$w_2^* = \frac{L\mu\left[\lambda(\sigma-\mu) + \lambda\phi^2(\sigma+\mu) + 2(1-\lambda)\phi\sigma\right]}{2H(\sigma-\mu)\left\{\lambda(1-\lambda)\left[\sigma(1-\phi)^2 - \mu(1-\phi^2)\right] + \sigma\phi\right\}}, \tag{12}$$

$$Y_1^* = \frac{L\sigma[\lambda + \phi(1-\lambda)][(1-\lambda)(\sigma-\mu) + \lambda\phi(\sigma+\mu)]}{2(\sigma-\mu)\left\{\lambda(1-\lambda)\left[\sigma(1-\phi)^2 - \mu(1-\phi^2)\right] + \sigma\phi\right\}}, \tag{13}$$

$$Y_2^* = \frac{L\sigma(1-\lambda+\phi\lambda)[\phi(1-\lambda)(\sigma+\mu) + \lambda(\sigma-\mu)]}{2(\sigma-\mu)\left\{\lambda(1-\lambda)\left[\sigma(1-\phi)^2 - \mu(1-\phi^2)\right] + \sigma\phi\right\}}. \tag{14}$$

[5]The total income in each region will remain unaltered after the taxation for local public good due to the assumption of average consumption basket in Section 3.

[6]The derivations are similar to Forslid and Ottaviano (2003) and Andersson and Forslid (2003).

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where $\phi \equiv \tau^{1-\sigma}$ is trade freeness, $\tau \in [1, \infty)$ is the parameter for transport costs.[7]

In addition, the price index for the manufactured good can be obtained as:

$$P_1^* = \left(\frac{\beta\sigma}{\sigma-1}\right)\left[\frac{\lambda H}{\alpha} + \frac{\phi(1-\lambda)H}{\alpha}\right]^{\frac{1}{1-\sigma}}, \tag{15}$$

$$P_2^* = \left(\frac{\beta\sigma}{\sigma-1}\right)\left[\frac{\phi\lambda H}{\alpha} + \frac{(1-\lambda)H}{\alpha}\right]^{\frac{1}{1-\sigma}}. \tag{16}$$

3 Provision of local public goods and distribution of firms

Based on the structure of Andersson and Forslid (2003), it is assumed that the two regions can impose proportional taxes, t_i, on both the skilled and unskilled workers. The tax revenue is then used to provide the public good. To avoid intractable interaction, we assume that the public good is produced by means of the average consumption basket; that is, a fraction μ of the tax revenue is spent on manufactured goods, and a fraction $1-\mu$ on homogeneous goods. This means that the income in each region for consuming both the manufactured and homogeneous goods remains unaltered after the taxation. It also implies the determination of short-run equilibrium is independent of taxes. Specifically, no matter what the level of taxation is, Eqs. (10) – (16) remain unaltered.[8] The amount of the public good provided in each region is equal to[9]

$$g_1 = \frac{t_1 Y_1}{P_1^{\mu}}, \quad g_2 = \frac{t_2 Y_2}{P_2^{\mu}}. \tag{17}$$

[7]Following Samuelson (1954), transport costs are assumed to take the "iceberg" form. That is, to ensure that one unit of product reaches the destination, τ units of the product have to be shipped.

[8]These implications by the average consumption basket are proposed in Andersson and Forslid (2003). That is, no matter what rate of t_1 and t_2, the price index for manufactured good, total incomes, and the wages of skilled workers in two regions keep unaltered.

[9]The taxation for financing public goods in Andersson and Forslid (2003) (A-F model) is different for skilled workers and unskilled workers, while (17) in our model is the same taxation for both types of workers. The taxation in A-F model is the sum of the taxes for each type of workers. Our model tax the total regional income (sum of the two regional incomes). The reason is that our focus is on the heterogeneous preference for public goods of residents' decision of providing public goods and keeps tax rates for both types of workers identical.

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Substituting (20) into (27) yields the local public goods provided by local governments in the two regions in the short run:

$$g_1^* = \frac{t_1\left(L/2 + w_1^*\lambda H\right)}{P_1^{*\mu}}, \tag{18}$$

$$g_2^* = \frac{t_2\left[L/2 + w_2^*(1-\lambda)H\right]}{P_2^{*\mu}}. \tag{19}$$

The indirect utility function of unskilled labor and skilled labor in each region is thus

$$V_i^L = \mu^\mu(1-\mu)^{(1-\mu)}\frac{w_i^L\,(1-t_i)\left(g_i^* + rg_j^*\right)^\theta}{P_i^{*\mu}},$$
$$i = 1, 2,\ j = 1, 2,\ j \neq i, \tag{20}$$

$$V_i^H = \mu^\mu(1-\mu)^{(1-\mu)}\frac{w_i^*\,(1-t_i)\left(g_i^* + rg_j^*\right)^\delta}{P_i^{*\mu}},$$
$$i = 1, 2,\ j = 1, 2,\ j \neq i. \tag{21}$$

The political economy approach employed in this study uses the concept of minimum winning coalition mechanism at both the local level and central level. However, if within a region skilled (or unskilled) labor has a majority, they would form a minimum winning coalition. In a decentralized system, maximizing utility of the skilled (unskilled) labor will determine the tax rate for the provision of the local public goods for the region if skilled (unskilled) labor has a majority in a region. In a centralized system, each region generates a representative based on majority voting to send to the central level. Due to the presence of two regions in our study, each regional representative has a 50% probability to be selected as the central representative to decide the tax rate of each region by maximizing his own utility. However, it is assumed that the tax rate of the region with no central representative should not be higher than the region with the central representative to avoid the political opposition of the region with no central representative.[10]

[10]This assumption is to avoid tax rate of the region with no central representative being very high in a centralized system. For instances, if the regional representative of region 1 is the central representative, he will determine an extreme high rate for region 2 to increase

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For the distribution of firms, the skilled workers are allowed to migrate between the two regions depending on the indirect utility function that they can acquire in the region. The region with the higher indirect utility function attracts the skilled workers. Let the difference between the two indirect utilities be

$$\begin{aligned}\Delta V(\lambda, \phi, t_1, t_2, r_1, r_2) &\equiv V_1^H - V_2^H \\ &= \mu^{\mu}(1-\mu)^{(1-\mu)}\left[\frac{w_1^*\left(1-t_1^*\right)\left(g_1^* + rg_2^*\right)^{\delta}}{P_1^{*\mu}}\right. \\ &\quad \left. - \frac{w_2^*\left(1-t_2^*\right)\left(g_2^* + rg_1^*\right)^{\delta}}{P_2^{*\mu}}\right]. \end{aligned} \tag{22}$$

The movement of the skilled labor is expressed as

$$\dot{\lambda} \equiv d\lambda/dt = \begin{cases} V(\lambda, \phi, t_1, t_2, r) & 0 < \lambda < 1, \\ \min\{0, V(\lambda, \phi, t_1, t_2, r)\}, & \text{if } \lambda = 1, \\ \max\{0, V(\lambda, \phi, t_1, t_2, r)\} & \lambda = 0, \end{cases} \tag{23}$$

where t is the time. The ratio of the utilities of the mobile workers in the two regions is denoted by

$$\rho = \frac{w_1^* P_1^{*-\mu}\left(1-t_1^*\right)\left(g_1^* + rg_2^*\right)^{\delta}}{w_2^* P_2^{*-\mu}\left(1-t_2^*\right)\left(g_2^* + rg_1^*\right)^{\delta}}. \tag{24}$$

The movement of the skilled labor between the two regions depends on the difference in the indirect utilities of the regions. A change in λ will alter the wages of skilled workers in the two regions, total income in the two regions in (11) – (14), and the price index for the manufactured good in (15) and (16). These changes might alter the taxation for the provision of local public goods in (18) and (19). They will influence the difference between the two indirect utilities in (22).

The equilibrium for the distribution of firms has two types of configurations. The interior solution of λ needs the conditions of (22) to be zero and $d\Delta V/d\lambda < 0$. The boundary solutions ($\lambda = 0$ or $\lambda = 1$) need the

his utility (see Eq. (A11) in Appendix). If only a given percentage for the tax rate difference between two regions is allowed, the tax rates for the two regions can be determined. However, the tax combination needs to satisfy the stability condition of spatial distribution.

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condition of $\Delta V < 0$ or $\Delta V > 0$. Note that the provision of public goods by political economy approach needs to be assured for the two types of configurations in equilibrium.

4 Equilibrium distribution of firms and provision of public goods

This section explores the distribution of firms and provision of public goods simultaneously. Specifically, both the provision of public goods from the political economy approach and distribution of firms have to reach equilibrium. Because each firm has the same required number for skilled workers, the distribution of skilled workers will be the same as that of firms. The provision of public goods will be discussed in terms of two systems: a decentralized system and a centralized system. Numerically simulations are then provided.

4.1 Polar Cases of specific transportation costs

Proposition 1. In a decentralized system, when transport is costless, the agglomeration of the skilled labor at one region will be the stable equilibrium if $\{[t_i(\sigma+\mu)+rt_j(\sigma-\mu)]/[rt_i(\sigma+\mu)+t_j(\sigma-\mu)]\}^{\delta} > (1-t_j)/(1-t_i)$, where $t_i = [\delta(\theta+1)-\theta r(\sigma-\mu)]/[(\sigma+\mu)/(\delta+1)(\theta+1)-r^2]$ is the tax rate of the agglomeration region i, and $t_j = [\theta(\delta+1)-\delta r(\sigma+\mu)]/[(\sigma-\mu)/(\delta+1)(\theta+1)-r^2]$ is the tax rate of the peripheral region j.

proof. Two conditions need to be satisfied. First, the tax rates for provision of public goods in the two regions are the levels above if $\lambda = 0$ or 1. Second, the agglomeration distribution of the skilled labor is stable given the tax rates for provision of public goods being the levels above. That is, under the tax rates, it is required that $\rho > 1$, for $\lambda = 1$, or $\rho < 1$ for $\lambda = 0$. These two conditions are proved as follows.

(1) If $\lambda = 1$, t_1 is obtained by $(\partial V_1^H/\partial t_1) = 0$, and t_2 is obtained by $(\partial V_2^L/\partial t_2) = 0$. This yields that $t_1 = [\delta(\theta+1)-\theta r Y_2 P_2^{-\mu}/(Y_1 P_1^{-\mu})]/[(\delta+1)(\theta+1)-r^2]$, and $t_2 = [\theta(\delta+1)-\delta r Y_1 P_1^{-\mu}/(Y_2 P_2^{-\mu})]/[(\delta+1)(\theta+1)-r^2]$. For $\tau \to 1$ and $\lambda = 1$, we can obtain $t_1 = [\delta(\theta+1)-\theta r(\sigma-\mu)/(\sigma+\mu)]/[(\delta+1)(\theta+1)-r^2]$, $t_2 = [\theta(\delta+1)-\delta r(\sigma+\mu)/(\sigma-\mu)]/[(\delta+1)(\theta+1)-r^2]$. For the case of $\tau \to 1$ and $\lambda = 0$, we can obtain $t_1 = [\theta(\delta+1)-\delta r(\sigma+\mu)/(\sigma-\mu)]/[(\delta+1)(\theta+1)-$

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$r^2]$, and $t_2 = [\delta(\theta+1) - \theta r(\sigma-\mu)/(\sigma+\mu)]/[(\delta+1)(\theta+1) - r^2]$ (see Appendix A for details).

(2) Given the tax rates for the two regions, it is necessary to guarantee that $\rho > 1$, for $\lambda = 1$. Substituting P_1, P_2, w_1, w_2, Y_1, Y_2 into Eq. (24) yields that $\{[t_1(\sigma+\mu) + rt_2(\sigma-\mu)]/[rt_1(\sigma+\mu) + t_2(\sigma-\mu)]\}^{\delta} > (1-t_2)/(1-t_1)$. Similarly, for $\lambda = 0$, we obtain the condition $\{[t_2(\sigma+\mu) + rt_1(\sigma-\mu)]/[rt_2(\sigma+\mu) + t_1(\sigma-\mu)]\}^{\delta} > (1-t_1)/(1-t_2)$ (see Appendix B for details).

□

Proposition 1 illustrates the industrial distribution and tax rate for public goods provision in a decentralized system when transport is costless. The agglomeration at one region will emerge under the condition that the skilled workers' utility of agglomeration region is higher than the other (peripheral) region. In the meantime, the tax rate of provision of public goods of the agglomeration region is higher than that of the periphery due to $t_i - t_j = \{(\delta-\theta) + 4r\sigma\mu/[(\sigma-\mu)(\sigma+\mu)]\}/[(\delta+1)(\theta+1) - r^2] > 0$. The required condition can be rearranged as $(1-t_i)[t_i(\sigma+\mu) + rt_j(\sigma-\mu)]^{\delta} > (1-t_j)[rt_i(\sigma+\mu) + t_j(\sigma-\mu)]^{\delta}$. The ratio of disposable income and total available public goods (including spillovers from the other region) forms the utility function for skilled workers. A higher tax rate increases the level of public goods at the expense of lower disposable income. The spillover parameter, r, plays a centrifugal force and tends to affect the distribution towards dispersion because the above condition is unlikely to hold for a higher value of r. In the following section, the simulation analysis for a higher value of spillover parameter illustrates the symmetric distribution for the case which violates the above condition.

Proposition 2. In a centralized system, when transport is costless, the agglomeration of the skilled labor at one region will be the stable equilibrium when the tax rate is $t_1 = t_2 = \delta/[(1+\delta+r(\sigma-\mu)/(\sigma+\mu)]$ with 50% probability and $t_1 = t_2 = \theta/[1+\theta+r(\sigma+\mu)/(\sigma-\mu)]$ with 50% probability.

proof. Two conditions in Proposition 1 need to be satisfied. They are proved as follows.

(1) In a centralized system, if the central representative is the regional representative of region 1, we obtain $t_1 = t_2 = \delta/[1+\delta+r(\sigma-$

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$\mu)/(\sigma+\mu)]$. If the central representative is the regional representative of region 2, we obtain $t_1 = t_2 = \theta/[1+\theta+r(\sigma+\mu)/(\sigma-\mu)]$ (see Appendix A for details).

(2) Given tax rate $t_1 = t_2 = \delta/[1+\delta+r(\sigma-\mu)/(\sigma+\mu)]$, it is necessary to guarantee that $\rho > 1$, for $\lambda = 1$. Substituting the related variables into Eq. (24) yields $\{[(\sigma+\mu)/(\sigma-\mu)+r]/[r(\sigma+\mu)/(\sigma-\mu)+1]\}^{\delta} > 1$. Thus, the condition holds. Given the tax rate $t_1 = t_2 = \theta/[1+\theta+r(\sigma+\mu)/(\sigma-\mu)]$ for the case of $\lambda = 0$, it can also be proved that $\rho < 0$ for the stable condition (see Appendix B for details).

□

Proposition 2 illustrates the industrial distribution and tax rate for public goods provision in a centralized system when transport is costless. It yields an agglomeration distribution with no conditions, though there are two types of tax rate for provision of public goods. Comparing to a decentralized system in Proposition 1, a centralized system is more likely to reach agglomeration distribution when transport is costless.

Proposition 3. When the transport cost is extremely high, the symmetric distribution of the skilled labor between these two regions will be the stable equilibrium with the tax rate for provision of public goods of $t_1 = t_2 = \delta/(1+\delta+r)$ for each region in a decentralized system and a centralized system.

proof. Two conditions need to be satisfied. First, the tax rate for provision of public goods is $\delta/(1+\delta+r)$ for each region given $\lambda = 1/2$. Second, the symmetric distribution of the skilled labor is stable given the tax rate for provision of public goods being $\delta/(1+\delta+r)$. That is, under this tax rate, it is required that $\rho = 1$, and $d\rho/d\lambda < 0$ for $\lambda = 1/2$.

(1) If $\lambda = 1/2$, t_1 and t_2 are obtained by $(\partial V_1^H/\partial t_1) = 0$, and $(\partial V_2^H/\partial t_2) = 0$, respectively. This yields $t_i = \{\delta[(\delta+1) - rY_jP_j^{-\mu}/(Y_iP_i^{-\mu})]\}/[(\delta+1)^2 - r^2]$ $(i = 1, 2, j = 1, 2, j \neq i)$. Thus, $t_1 = t_2 = \delta/(1+\delta+r)$ for symmetric distribution $(\lambda = 1/2)$. In a centralized system, if the central representative is the regional representative of region 1, we obtain $t_1 = t_2 = \delta/(1+\delta+r)$. If the central representative is the regional representative of region 2, the same result for the tax rate is obtained (see Appendix A for details).

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(2) Given tax rate $t_1 = t_2 = \delta/(1+\delta+r)$, and $\lambda = 1/2$, we obtain $\rho = 1$. Thus, the symmetric distribution of the skilled labor between the two regions is an equilibrium. The stable condition needs to guarantee that $(d\rho/d\lambda) < 0$, which is held by the "no-black-hole" condition $\mu < [(1+r)(\sigma-1)(1+\delta-r)]/[(1+\delta)^2 - r(1+\delta)(\delta+r)]$ in a decentralized system and $\mu < [(1+r)(\sigma-1)]/[1+r+\delta(1-r)]$ in a centralized system (see Appendix B for details).

□

Proposition 3 illustrates the industrial distribution and tax rate for public goods provision when the transport cost is extremely high. Both a decentralized system and a centralized system for provision of public goods yield the same tax rate. Meanwhile, the industrial distribution is symmetric dispersion between the two regions when either system of public goods provision is employed with different no-black-hole conditions. Comparing these two conditions, we can yield that the stable condition is more likely to hold in a decentralized system than in a centralized system.[11]

4.2 Numerical simulations

The polar cases of specific transportation costs have been analyzed above. For further analysis, some numerical simulations are provided for the whole range of transportation costs. The values for the parameters are H= 120, L= 100, $\sigma = 4$, $\mu = 0.4$, $\delta = 0.5$, $\theta = 0.2$, $\alpha = 1$, $\beta = 0.5$, and $r = 0.3$. Figure 1 plots the ratio of utility, (24), as a function of λ for various transport costs under a decentralized system. Note that the majority of the labor will determine the tax rate for the provision of local public goods. Curve A illustrates that the symmetric distribution ($\lambda = 0.5$) is stable due to the negative slope when the transport costs are large ($\phi = 0.3$). The ratio of the utility of the two regions is equal to one when the regions have equal shares of skilled labor, with the same wage and local public goods.

[11] Let the upper bound of μ be $[(1+r)(\sigma-1)(1+\delta-r)]/[(1+\delta)^2 - r(1+\delta)(\delta+r)] = \mu_D$, and $[(1+r)(\sigma-1)]/[1+r+\delta(1-r)] = \mu_C$ it can be found that $\mu_D - \mu_C = [2r\delta^2(1+r)(\sigma-1)]/\{(1+\delta)(1-r)(1+r+\delta)[1+r+\delta(1-r)]\} > 0$. This implies that the range of μ in a decentralized system is larger than that in a centralized system. In addition, the conditions in both systems will be identical if there are no spillovers for public goods due to $\mu_D = \mu_C$ for $r = 0$.

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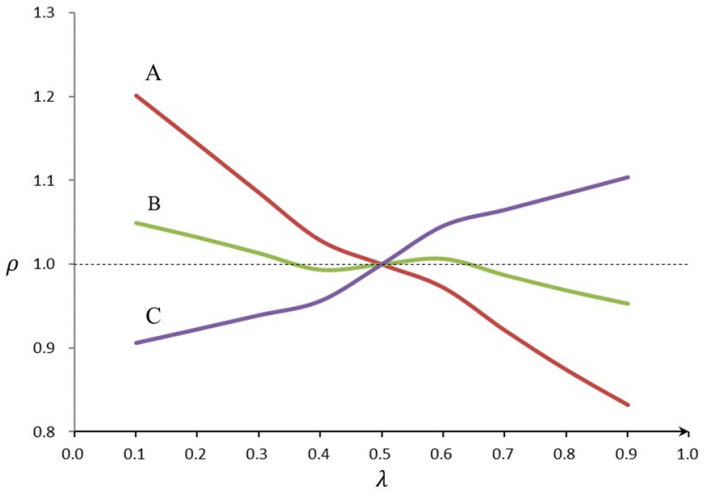


Figure 1: Ratio of utility for different transport costs in a decentralized system (A: $\phi = 0.3$, B: $\phi = 0.4$, C: $\phi = 0.8$)

Curve C shows that the agglomeration at region 1 and that at region 2 are two stable equilibria when the transport costs are small ($\phi = 0.8$). This is the so-called 'core-periphery pattern' in Krugman (1991). The symmetric distribution ($\lambda = 0.5$) on the curve is not stable due to the positive slope in this case. Curve B shows two asymmetric stable equilibria when transport costs are moderate ($\phi = 0.4$). When the industrial distribution is around $\lambda = 0.35$ and $\lambda = 0.65$, the utility in the two regions is equal. The political economy approach proposing the determination of public goods by majority labor results in this interesting outcome. This does not appear in the related studies of NEG with public good provision by the traditional approach.

The associated tax rates of the two regions with different transport costs in a decentralized system are shown in Table 2. When $\lambda < (>)0.42$, the skilled labor is less (more) than unskilled labor in region 1, and thus unskilled labor (skilled labor) determines the taxation for local public goods investment. Therefore, the tax rate for region 1 with $\lambda = 0.6 - 0.9$ is much larger than that with $\lambda = 0.1 - 0.4$ because the skilled labor's preference for public goods is higher than unskilled labor's. The reverse result for the tax rate of region 2 is thus shown with the value of λ. This phenomenon holds for different transport costs. However, the difference of tax rates of the two

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Table 2: Tax rates with different transport costs in a decentralized system

	$\phi = 0.3$		$\phi = 0.4$		$\phi = 0.8$	
λ	t_1	t_2	t_1	t_2	t_1	t_2
0.1	0.0610	0.3240	0.0632	0.3234	0.0700	0.3217
0.2	0.0695	0.3218	0.0706	0.3215	0.0748	0.3203
0.3	0.0764	0.3198	0.0769	0.3196	0.0793	0.3189
0.4	0.0824	0.3178	0.0852	0.3177	0.0836	0.3174
0.5	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778
0.6	0.3178	0.0824	0.3177	0.0852	0.3174	0.0836
0.7	0.3198	0.0764	0.3196	0.0769	0.3189	0.0793
0.8	0.3218	0.0695	0.3215	0.0706	0.3203	0.0748
0.9	0.3240	0.0610	0.3234	0.0632	0.3217	0.0700

regions gets smaller when the transport costs get smaller (a larger ϕ).

Figure 2 plots the ratio of utility, (24), as a function of λ for various transport costs under a centralized system. Note that each regional representative has a 50% probability to be selected as the central representative to decide the tax rate of each region. However, these two tax rate alternatives yield the same industrial distribution after the simulation analysis. Curve D illustrates that the symmetric distribution ($\lambda = 0.5$) is stable when the transport costs are large ($\phi = 0.3$). Curve F shows that the agglomeration at region 1 and that at region 2 are two stable equilibria when the transport costs are small ($\phi = 0.8$). These two outcomes are identical to those in Figure 1 of decentralized system. However, Curve E illustrates that the symmetric distribution ($\lambda = 0.5$) is stable when the transport costs are moderate ($\phi = 0.4$). This is different from Curve B in Figure 1. For these transport costs, asymmetric distribution is stable in the decentralized system.

The associated tax rates of the two regions with different transport costs in a centralized system are shown in Table 3. There are two tax alternatives due to each regional representative having a 50% probability to determine the tax rate for both regions. However, both regions have the same tax rates under the analysis. When the central representative is a skilled worker, the tax rates for both regions are higher. In contrast, the tax rates for both regions are lower when the central representative is an unskilled worker.

Figure 3 shows the industrial distribution with transport costs in a de-

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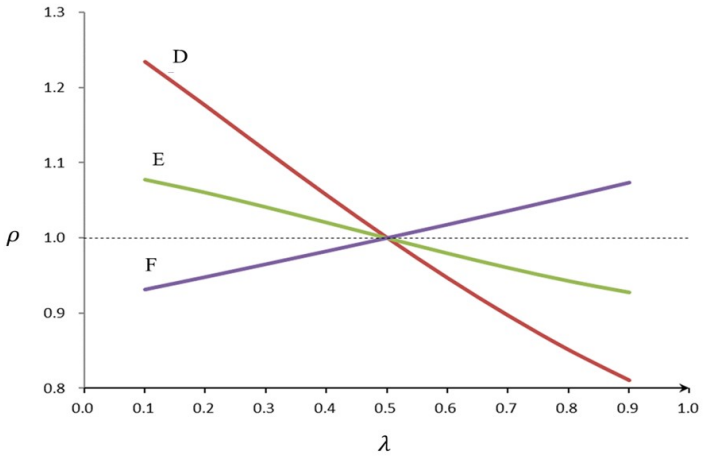


Figure 2: Ratio of utility for different transport costs in a centralized system (D: $\phi = 0.3$, E: $\phi = 0.4$, F: $\phi = 0.8$)

Table 3: Tax rates with different transport costs in a centralized system

	$\phi = 0.3$		$\phi = 0.4$		$\phi = 0.8$	
λ	$\bar{t}$	$\bar{\bar{t}}$	$\bar{t}$	$\bar{\bar{t}}$	$\bar{t}$	$\bar{\bar{t}}$
0.1	0.1257	0.2890	0.1263	0.2883	0.1282	0.2858
0.2	0.1280	0.2860	0.1283	0.2856	0.1295	0.2839
0.3	0.1300	0.2932	0.1301	0.2829	0.1308	0.2819
0.4	0.1317	0.2805	0.1318	0.2804	0.1321	0.2799
0.5	0.2778	0.2778	0.2778	0.2778	0.2778	0.2778
0.6	0.2805	0.1317	0.2804	0.1318	0.2799	0.1321
0.7	0.2832	0.1300	0.2829	0.1301	0.2819	0.1308
0.8	0.2860	0.1280	0.2856	0.1283	0.2839	0.1295
0.9	0.2890	0.1257	0.2883	0.1263	0.2858	0.1282

Note that there are two tax alternatives. One is $t_1 = t_2 = \bar{t}$ and the other is $t_1 = t_2 = \bar{\bar{t}}$.

centralized system. When transport costs are low ($0.45 < \phi < 1$), the skilled labor agglomerates at one region with only unskilled labor in the other region to form the core-periphery pattern. When the transport costs

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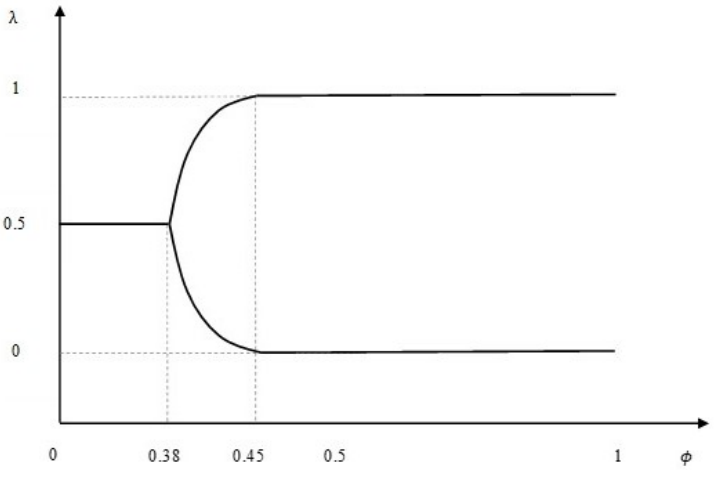


Figure 3: Industrial distribution in a decentralized system ($r = 0.3$)

are high ($0 < \phi < 0.38$), the industrial distribution is symmetric in the two regions. However, when the transport costs are moderate ($0.38 \leq \phi \leq 0.45$), the industrial distribution is asymmetric, with a higher ratio of skilled labor in one region and a lower ratio in the other region. This outcome is similar to the smooth supercritical pitchfork bifurcation in Borck and Pflüger (2006).

Figure 4 shows the industrial distribution with transport costs in a centralized system. There are only two types of distribution: agglomeration at one region with low transport costs ($0.5 < \phi < 1$), and symmetric distribution with high transport costs ($0 < \phi < 0.5$). Thus, a centralized system tends to provide separation force for industrial distribution in a large range of transport costs. Differing from Andersson and Forslid (2003), the industrial distribution in this study does not include multiple distributions.

The above results are for the cases with a lower spillover ($r = 0.3$) of local public goods. A higher value for parameter $r = 0.5$ is introduced for the cases with high spillovers. Figure 5 shows that only a symmetric distribution ($\lambda = 0.5$) exists for any value of transport costs in a decentralized system. The intuition of this outcome is that a large spillover of local public goods induces a free-rider phenomenon for local public goods. When the share of skilled labor is higher in one region, it generates a higher tax rate due to the higher total income. This then induces a lower disposable wage

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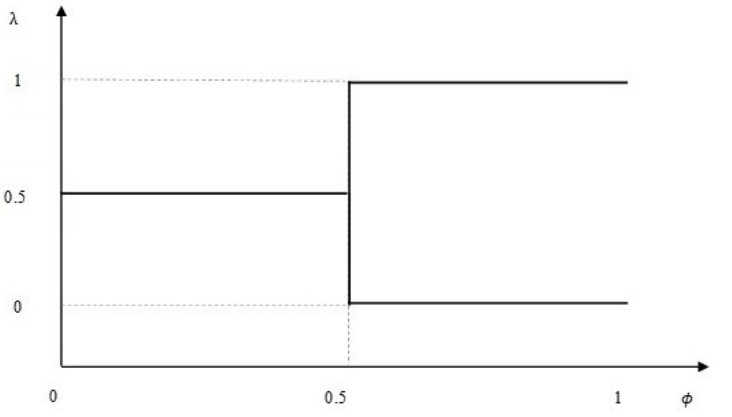


Figure 4: Industrial distribution in a centralized system ($r = 0.3$)

for the skilled labor and thus lowers the utility level. In the other region the skilled labor enjoys high spillover of local public goods while paying a lower tax rate. This will then cause the skilled labor in the region with $\lambda > 0.5$ to move to the other region, finally forming a symmetric distribution between the two regions. The higher spillover of $r = 0.5$, however, does not cause a large change in the industrial distribution for the same tax rate of local public goods in a centralized system. Figure 6 shows a smaller change to the value of the transport cost which is at the transition between agglomeration and symmetric dispersion of industrial distribution.

5 Discussion

Comparing with the existing studies, the analysis in this study yields some findings in a decentralized system. First, tax rate for provision of public goods increases in λ (share of mobile workers) in region 1. Specifically, there are two effects of the increase in tax rate when share of mobile workers increases. One is the increase in agglomeration force to form an "agglomeration rent" (Baldwin and Krugman, 2004). The other is the change of preference for public goods via voting due to the number of mobile workers dominating that of immobile workers. The latter reinforces (mitigates) the former if the preference for public goods of mobile workers is greater than (less than) that of immobile workers. Second, as the trade freeness increases, the agglomeration rent increase at first and then decreases to form

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Figure 5: Industrial distribution in a decentralized system ($r = 0.5$)

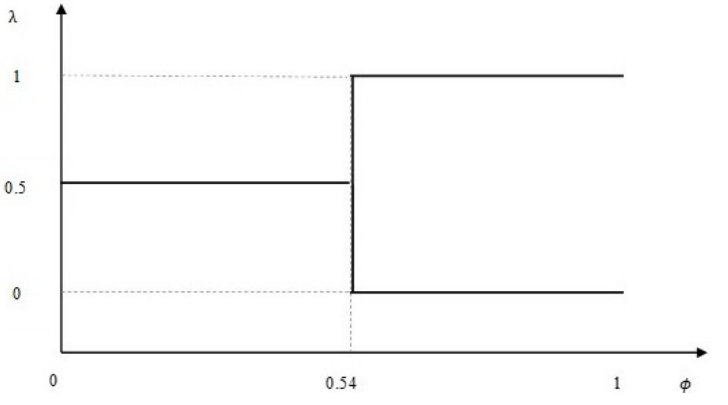


Figure 6: Industrial distribution in a centralized system ($r = 0.5$)

a bell shape.[12] That is, it implies a 'race to the top' in taxes before leading to a 'race to the bottom' as in Baldwin and Krugman (2004). Third, when transport costs increases, the tax rate in agglomeration area increases while that of periphery area decreases due to the benefits of the spillover effect from agglomeration area. For spatial symmetric cases, the tax rate is iden-

[12]Following Baldwin and Krugman (2004), the agglomeration rent can be defined as the ratio of indirect utility function of the two regions for a core-periphery pattern, $\lambda = 1$ in Eq.(24). It is then obtained that $d\rho/d\Phi$ is positive as $\Phi \to 0$, and negative as $\Phi \to 1$.

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tical for two regions and keeps unaltered when transport costs increase. In these cases, the spillover effects of both regions are the same.

In a centralized system, there are two tax rate alternatives for each region with the same probability. However, the tax rates are identical for both regions under the assumption of the central representative from a region will not harm the other region. If the assumption is relaxed, a higher tax rate for the region with no central representatives will be expected because the region with the central representative can set a lower tax rate and benefit from spillover effects. For instance, if a difference in taxes of two regions is allowed, then the equilibrium taxation in two regions will be $t_1 = \delta/[1 + \delta + er(\sigma - \mu)/(\sigma + \mu)]$, $t_2 = et_1(e > 1)$ for 50% probability and $t_2 = \theta/[1 + \theta + er(\sigma + \mu)/(\sigma - \mu)]$, $t_1 = et_2(e > 1)$ for 50% probability for Proposition 2.[13] This result is different from the equilibrium taxation in the existing studies.

On the spatial distribution, higher spillover effects will encourage symmetric distribution in both voting systems. However, the impact of spillovers in a decentralized system is much larger than in a centralized system.

The above results are under the assumption of H>L. In this situation, the decision of public goods provision is determined by skilled (mobile) workers for the agglomeration region in a core-periphery pattern and both regions in a symmetric pattern due to the representative voting. What will be the results for the cases with the condition H<L? First, when the condition is L/2 <H<L, the decision will be determined by skilled (mobile) workers for the agglomeration region in a core-periphery pattern but by unskilled (immobile) workers for both regions in a symmetric pattern. Second, when the condition is L/2 >H, the decision will be determined by unskilled (immobile) workers for both regions in any distribution patterns.

There are two stylized facts consistent with the findings above. First, many cities with a large number of population are levied with higher taxes than small cities. These cities, such as New York, Los Angeles, London, Toyko, and so on, are agglomerated with many industries and various workers. A higher tax reflects the agglomeration rent for these agglomerated areas and the preference for public goods of the residents. Second, new migrants moved into a city and became citizens who might influence the decision of provision for public goods via voting. The cities formed by a large num-

[13]The similar approach in proof for (1) of Proposition 2 in Appendix A is employed. In addition, these tax rates need to satisfy the stability condition of spatial distribution.

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ber of migrants yield larger impacts to the decision than the cities formed by few migrants. Taoyuan is an example of the former and Tainan is an example of the latter. Many sports facilities are provided in Taoyuan reflecting the preference of the public goods of the large number of migrants. In contrast, most traditional public goods were provided in Tainan reflecting the preference of the original residents. In addition, New Taipei City is a mixed example with original residents in some areas and many migrants in the other areas. In districts such as Banqiao and Sanchong, migrants become the majority and thus the public goods reflects the need of the migrants. In the original developed area, Hsinchuang district, the public goods related to traditional cultural (for instance, historical temples) reflect the preference of original residents while the public goods of baseball stadium and basketball stadium provided in new developed areas reflect the preference of new migrants. In Sanshia district, another example similar to Hsinchuang, the old city area and the National Taipei University area present two different types of public goods reflecting the preferences of the original residents and migrants.

6 Conclusions

This study explores the move of mobile workers between two regions to form the new communities with immobile workers of spatial distribution and how the local public goods being provided by the new communities via voting simultaneously in the Forslid and Ottaviano (2003) version of new economic geography. The skilled (mobile) workers and unskilled workers have different preferences for the local public goods. The decision-making on the tax rate for the provision of local public goods of each region is determined by a decentralized system and by a centralized system, respectively. In a decentralized system, the decision-making on the tax rate of each local government depends on the representative of the region based on majority voting. In a centralized system, each region elects a representative to form a central parliament, which then elects a representative to make the decision. Each representative has a 50% probability of deciding the tax rate of each region.

The results of this study show the symmetric distribution of the skilled labor between these two regions is a stable equilibrium with the same tax rate for the provision of public goods in each region in both a decentralized system and a centralized system when transport costs are extremely high. In

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contrast, when transport is costless, the agglomeration of the skilled labor is the stable equilibrium in a decentralized system if the public goods effect is higher than the loss of disposable income.

In a decentralized system, there are two effects of the increase in tax rate when share of mobile workers increases. One is the increase in agglomeration force to form an "agglomeration rent" (Baldwin and Krugman, 2004). The other is the change of preference for public goods via voting due to the number of mobile workers dominating that of immobile workers. The latter reinforces (mitigates) the former if the preference for public goods of mobile workers is greater than (less than) that of immobile workers. In a centralized system, there are two tax rate alternatives for each region with the same probability. However, the tax rates are identical for both regions under the assumption of the central representative from a region will not harm the other region.

In addition, this paper shows that the spillover of local public goods plays a role in industrial dispersion by a political economy approach. A higher spillover of local public goods will encourage free riding and a tendency to not invest in local public goods. This will then contribute to symmetric industrial distribution because a higher share of skilled labor will induce a higher tax for local public goods and lower the disposable wage, while the skilled labor in the other region can enjoy the spillover effect without paying extra expenses.

There are at least two possible avenues for future research. First, we may extend this study to an economy with more than two regions. Specifically, the provision of local public goods among three or more regions by a political economy approach can be explored in the model of NEG. The industrial distribution among these regions might be different, especially in a centralized system, due to the coalition of the representatives in a central government being much more complicated. Second, it may also be interesting to consider unavoidable public goods with negative effects on the residents rather than public goods with positive effects. The political economy approach can capture the interactions of the representatives for the decision-making for the negative public goods. The industrial distribution might thus be influenced due to the negative public goods being attributed to the production of firms.

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Appendix A

In the case where the governments of the two regions maximize the utility attained by skilled labor, the indirect utility functions of skilled labor and unskilled labor in each region are

$$V_1^H = \mu^\mu (1-\mu)^{1-\mu} w_1^* P_1^{*-\mu} (1-t_1) \left(t_1 Y_1^* P_1^{*-\mu} + r t_2 Y_2^* P_2^{*-\mu}\right)^\delta, \tag{A1}$$

$$V_2^H = \mu^\mu (1-\mu)^{1-\mu} w_2^* P_2^{*-\mu} (1-t_2) \left(r t_1 Y_1^* P_1^{*-\mu} + t_2 Y_2^* P_2^{*-\mu}\right)^\delta. \tag{A2}$$

$$V_1^L = \mu^\mu (1-\mu)^{1-\mu} w_1^L P_1^{*-\mu} (1-t_1) \left(t_1 Y_1^* P_1^{*-\mu} + r t_2 Y_2^* P_2^{*-\mu}\right)^\theta, \tag{A3}$$

$$V_2^L = \mu^\mu (1-\mu)^{1-\mu} w_2^L P_2^{*-\mu} (1-t_2) \left(r t_1 Y_1^* P_1^{*-\mu} + t_2 Y_2^* P_2^{*-\mu}\right)^\theta. \tag{A4}$$

Note that Y_1^*, Y_2^*, P_1^*, and P_2^* are independent of t_1 and t_2 due to the assumption of the average consumption basket. Thus,

$$\frac{\partial V_1^H}{\partial t_1} = \mu^\mu (1-\mu)^{1-\mu} w_1^* P_1^{*-\mu} \left(t_1 Y_1^* P_1^{*-\mu} + r t_2 Y_2^* P_2^{*-\mu}\right)^{\delta-1} \times \left[-\left(t_1 Y_1^* P_1^{*-\mu} + r t_2 Y_2^* P_2^{*-\mu}\right) + \delta (1-t_1) Y_1^* P_1^{*-\mu}\right]. \tag{A5}$$

$$\frac{\partial V_2^H}{\partial t_2} = \mu^\mu (1-\mu)^{1-\mu} w_2^* P_2^{*-\mu} \left(r t_1 Y_1^* P_1^{*-\mu} + t_2 Y_2^* P_2^{*-\mu}\right)^{\delta-1} \times \left[-\left(r t_1 Y_1^* P_1^{*-\mu} + t_2 Y_2^* P_2^{*-\mu}\right) + \delta (1-t_2) Y_2^* P_2^{*-\mu}\right]. \tag{A6}$$

$$\frac{\partial V_1^L}{\partial t_1} = \mu^\mu (1-\mu)^{1-\mu} w_1^L P_1^{*-\mu} \left(t_1 Y_1^* P_1^{*-\mu} + r t_2 Y_2^* P_2^{*-\mu}\right)^{\theta-1} \times \left[-\left(t_1 Y_1^* P_1^{*-\mu} + r t_2 Y_2^* P_2^{*-\mu}\right) + \theta (1-t_1) Y_1^* P_1^{*-\mu}\right]. \tag{A7}$$

$$\frac{\partial V_2^L}{\partial t_2} = \mu^\mu (1-\mu)^{1-\mu} w_2^L P_2^{*-\mu} \left(r t_1 Y_1^* P_1^{*-\mu} + t_2 Y_2^* P_2^{*-\mu}\right)^{\theta-1} \times \left[-\left(r t_1 Y_1^* P_1^{*-\mu} + t_2 Y_2^* P_2^{*-\mu}\right) + \theta (1-t_2) Y_2^* P_2^{*-\mu}\right]. \tag{A8}$$

Proof for (1) of Proposition 1

When the distribution of skilled labor in two regions is agglomeration in region 1 ($\lambda = 1$) in a decentralized system, the tax rate for the public goods

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is determined by maximizing the utility of skilled labor (unskilled labor) in region 1 (region 2).

Letting (A5) and (A8) be nil and solving them for t_1 and t_2 simultaneously yields the equilibrium tax rate for the two regions of:

$$t_1 = \frac{\delta(\theta+1) - \theta r Y_2^* P_2^{*-\mu} / \left(Y_1^* P_1^{*-\mu}\right)}{(\delta+1)(\theta+1) - r^2}, \tag{A9}$$

$$t_2 = \frac{\theta(\delta+1) - \delta r Y_1^* P_1^{*-\mu} / \left(Y_2^* P_2^{*-\mu}\right)}{(\delta+1)(\theta+1) - r^2}. \tag{A10}$$

For $\tau \to 1$ and $\lambda = 1$, it can be obtained that $P_1^* = P_2^*$, and $Y_1^* = [L(\sigma+\mu)]/[2(\sigma-\mu)]$, $Y_2^* = L/2$ from Eqs.(13)–(16). Thus, $t_1 = [\delta(\theta+1) - \theta r(\sigma-\mu)/(\sigma+\mu)]/[(\delta+1)(\theta+1) - r^2]$, $t_2 = [\theta(\delta+1) - \delta r(\sigma+\mu)/(\sigma-\mu)]/[(\delta+1)(\theta+1) - r^2]$. For the case of $\tau \to 1$ and $\lambda = 0$, the tax rate for the public goods is determined by maximizing the utility of skilled labor (unskilled labor) in region 2 (region 1). Similarly, $\partial V_2^H/\partial t_2 = 0$ and $\partial V_1^L/\partial t_1 = 0$ will yield the tax rate of each region: $t_1 = [\theta(\delta+1) - \delta r(\sigma+\mu)/(\sigma-\mu)]/[(\delta+1)(\theta+1) - r^2]$, and $t_2 = [\delta(\theta+1) - \theta r(\sigma-\mu)/(\sigma+\mu)]/[(\delta+1)(\theta+1) - r^2]$.

Proof for (1) of Proposition 2

In a centralized system, each region generates a representative based on majority voting. Each regional representative has 50% probability to be selected as the central representative. For $\tau \to 1$ and $\lambda = 1$, if the regional representative of region 1 is the central representative, he (she) will determine the tax rates for both regions to maximize V_1^H.

$$\frac{\partial V_1^H}{\partial t_2} = \mu^\mu (1-\mu)^{1-\mu} w_1^* P_1^{*-\mu} \delta \left(t_1 Y_1^* P_1^{*-\mu} + r t_2 Y_2^* P_2^{*-\mu}\right)^{\delta-1} \times \left(r t_2 Y_2^* P_2^{*-\mu}\right) > 0. \tag{A11}$$

This implies that the higher t_2 is, the higher V_1^H is. However, from the assumption of avoiding political opposition from region 2, we have $t_2 = t_1$. Thus, letting Eq.(A5) be nil yields $t_1 = t_2 = \delta/[1+\delta+rY_2^* P_2^{*-\mu}/(Y_1^* P_1^{*-\mu})]$. Substituting $P_1^* = P_2^*$, $Y_1^* = [L(\sigma+\mu)]/[2(\sigma-\mu)]$, and $Y_2^* = L/2$ into the tax rate yields $t_1 = t_2 = \delta/[1+\delta+r(\sigma-\mu)/(\sigma+\mu)]$. If the regional representative of region 2 is the central representative, he (she) will

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determine the tax rates for both regions to maximize V_2^L.

$$\frac{\partial V_2^L}{\partial t_1} = \mu^{\mu}(1-\mu)^{1-\mu} w_2^L P_2^{*-\mu} \theta \left(r t_1 Y_1^* P_1^{*-\mu} + t_2 Y_2^* P_2^{*-\mu}\right)^{\theta-1} \times \left(r Y_1^* P_1^{*-\mu}\right) > 0. \tag{A12}$$

This implies that the higher t_1 is, the higher V_2^L is. However, from assumption $t_1 = t_2$. Thus, letting Eq.(A8) be nil yields $t_1 = t_2 = \theta/[1 + \theta + rY_1^* P_1^{*-\mu}/(Y_2^* P_2^{*-\mu})]$. Substituting $P_1^* = P_2^*$, $Y_1^* = [L(\sigma + \mu)]/[2(\sigma - \mu)]$, and $Y_2^* = L/2$ into the tax rate yields $t_1 = t_2 = \theta/[1 + \theta + r(\sigma + \mu)/(\sigma - \mu)]$. For the case of $\tau \to 1$ and $\lambda = 0$, the same two tax rate levels are obtained.

Proof for (1) of Proposition 3

If $\lambda = 1/2$, the skilled workers are more than the unskilled workers in each region due to H/2 >L/2. In a decentralized system, the tax rate for the public goods is determined by maximizing the utility of skilled labor in each region. Thus, letting (A5) and (A6) be nil and solving them for t_1 and t_2 simultaneously yields the equilibrium tax rate for the two regions of:

$$t_i = \frac{\delta\left[(\delta+1) - \frac{rY_j P_j^{-\mu}}{Y_i P_i^{-\mu}}\right]}{(\delta+1)^2 - r^2}, \quad i = 1, 2, j = 1, 2, j \neq i. \tag{A13}$$

For the case of symmetric distribution ($\lambda = 1/2$), $Y_1^* = Y_2^*$, $P_1^* = P_2^*$. The tax rate of each region can be obtained: $t_1 = t_2 = \delta/(1 + \delta + r)$.

In a centralized system, each region generates a representative based on majority voting. Each regional representative has 50% probability to be selected as the central representative. Due to H/2 >L/2 in each region, each regional representative is a skilled worker. If the central representative is the regional representative of region 1, he (she) will determine the tax rates for both regions is to maximize V_1^H. From (A11), we have $\partial V_1^H/\partial t_2 > 0$. This implies that the higher t_2 is, the higher V_1^H is. From the assumption of avoiding political opposition from region 2, we have $t_2 = t_1$. Thus, letting (A5) be nil, we obtain

$$t_1 = t_2 = \frac{\delta}{1 + \delta + \frac{rY_2 P_2^{-\mu}}{Y_1 P_1^{-\mu}}}. \tag{A14}$$

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For the case of symmetric distribution ($\lambda = 1/2$), $Y_1^* = Y_2^*$, $P_1^* = P_2^*$. The tax rate of each region can be obtained: $t_1 = t_2 = \delta/(1+\delta+r)$. If the central representative is the regional representative of region 2, he (she) will determine the tax rates for both regions to maximize V_2^H. By employing the same approach above, the tax rate of each region is

$$t_1 = t_2 = \frac{\delta}{1+\delta+\frac{rY_1P_1^{-\mu}}{Y_2P_2^{-\mu}}}. \tag{A15}$$

For the case of symmetric distribution ($\lambda = 1/2$), the tax rate of each region can be obtained: $t_1 = t_2 = \delta/(1+\delta+r)$.

Appendix B

From Eq. (43), we have

$$\rho = \Gamma\Phi\Lambda \tag{A16}$$

where

$$\Gamma = \frac{w_1^*P_1^{*-\mu}}{w_2^*P_2^{*-\mu}},\ \Phi = \frac{1-t_1}{1-t_2},\ \Lambda = \left(\frac{t_1Y_1^*P_1^{*-\mu}+rt_2Y_2^*P_2^{*-\mu}}{rt_1Y_1^*P_1^{*-\mu}+t_2Y_2^*P_2^{*-\mu}}\right)^{\delta}.$$

Proof for (2) of Proposition 1

For the case of zero transport costs, from Eqs. (11), (12), (15) and (16), we have $w_1^* = w_2^*$, and $P_1^* = P_2^*$, thus $\Gamma = 1$. For $\lambda = 1$, substituting Eqs. (13) and (14) into (A14) yields $\rho = (1-t_1)/(1-t_2)\{[t_1(\sigma+\mu)+rt_2(\sigma-\mu)]/[rt_1(\sigma+\mu)+t_2(\sigma-\mu)]\}^{\delta}$. Thus, the condition $\{[t_1(\sigma+\mu)+rt_2(\sigma-\mu)]/[rt_1(\sigma+\mu)+t_2(\sigma-\mu)]\}^{\delta} > (1-t_2)/(1-t_1)$ will ensure the agglomeration at region 1 ($\rho > 1$). For $\lambda = 0$, the condition will be $\{[t_2(\sigma+\mu)+rt_1(\sigma-\mu)]/[rt_2(\sigma+\mu)+t_1(\sigma-\mu)]\}^{\delta} > (1-t_1)/(1-t_2)$ to ensure the agglomeration at region 2.

Proof for (2) of Proposition 2

Given tax rate $t_1 = t_2 = \delta/[1+\delta+r(\sigma-\mu)/(\sigma+\mu)]$, it is necessary to guarantee that $\rho > 1$, for $\lambda = 1$. For the case of zero transport costs, we have $\Gamma = 1$ as above. For $t_1 = t_2$, we have $\Phi = 1$. Substituting Eqs. (13) –

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(16) into Λ yields $\{[(\sigma+\mu)/(\sigma-\mu)+r]/[r(\sigma+\mu)/(\sigma-\mu)+1]\}^{\delta} > 1$. This implies $2\mu(1-r) > 0$ and thus this condition holds. Given tax rate $t_1 = t_2 = \theta/[1+\theta+r(\sigma+\mu)/(\sigma-\mu)]$ for the case of $\lambda = 0$, it can also be proved that $\rho < 0$ for the stable condition by an approach similar to the above.

Proof for (2) of Proposition 3

To prove that a symmetric distribution is the stable equilibrium under extremely large transport costs, two conditions need to be satisfied. One is $\rho = 1$ as $\lambda = 1/2$. The other is $d\rho/d\lambda < 0$ as $\lambda = 1/2$. Differentiating (A16) with respect to λ yields

$$\frac{d\rho}{d\lambda} = \Phi\Lambda\frac{d\Gamma}{d\lambda} + \Gamma\Lambda\frac{d\Phi}{d\lambda} + \Gamma\Phi\frac{d\Lambda}{d\lambda}. \tag{A17}$$

A decentralized system

For the first condition, when transport cost approaches infinity, $\tau \to \infty$, and thus $\phi \to 0$, and substituting Eqs. (31) – (35) into (A16) yields $\rho = 1$ as $\lambda = 1/2$. For the second condition, after substituting Eqs. (31), (34), and (35) into (A13), the tax rate for each region can be rewritten as

$$t_1^* = \frac{\delta(1+\delta) - \delta r\left(\frac{1-\lambda}{\lambda}\right)^{\frac{\mu}{\sigma-1}}}{(1-\delta)^2 - r^2}, \tag{A18}$$

$$t_2^* = \frac{\delta(1+\delta) - \delta r\left(\frac{\lambda}{1-\lambda}\right)^{\frac{\mu}{\sigma-1}}}{(1-\delta)^2 - r^2}. \tag{A19}$$

The impacts of the short-run equilibrium wage, and price index in Eqs. (11), (12), (15) and (16) and the tax rates in (A18) and (A19) from a change in λ are as follows:

$$\frac{\partial P_1^{*-\mu}}{\partial\lambda} = \frac{\mu\beta\sigma}{(\sigma-1)^2}P_1^{*-\mu-1}\frac{H}{\alpha}\left(\frac{\lambda H}{\alpha}\right)^{\frac{\sigma}{1-\sigma}} > 0,$$

$$\frac{\partial P_2^{*-\mu}}{\partial\lambda} = -\frac{\mu\beta\sigma}{(\sigma-1)^2}P_2^{*-\mu-1}\frac{H}{\alpha}\left(\frac{1-\lambda}{\alpha}\right)^{\frac{\sigma}{1-\sigma}} < 0,$$

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$$\frac{d\left(w_1^*/w_2^*\right)}{d\lambda} = -\frac{1}{\lambda^2} < 0,$$

$$\frac{d\left(P_1^*/P_2^*\right)^{-\mu}}{d\lambda} = \frac{\mu}{\sigma-1}\frac{1}{(1-\lambda^2)}\left(\frac{\lambda}{1-\lambda}\right)^{\frac{\mu-\sigma+1}{\sigma-1}} > 0,$$

$$\frac{dt_1^*}{\partial\lambda} = \frac{r}{(1-\delta)^2-r^2}\left(\frac{\mu}{\sigma-1}\right)\left(\frac{1-\lambda}{\lambda}\right)^{\frac{\mu-\sigma+1}{\sigma-1}}\frac{1}{\lambda^2} > 0,$$

$$\frac{dt_2^*}{\partial\lambda} = \frac{-r}{(1-\delta)^2-r^2}\left(\frac{\mu}{\sigma-1}\right)\left(\frac{\lambda}{1-\lambda}\right)^{\frac{\mu-\sigma+1}{\sigma-1}}\frac{1}{(1-\lambda)^2} < 0.$$

Substituting the above items into (A17) and evaluating it at $\lambda = 1/2$ yields:

$$\frac{d\rho}{d\lambda} = -\left\{4\left[\delta r(\sigma+\mu r+\mu+\delta\mu)+\delta(\sigma-1-r-2\mu-\delta\mu)\right.\right.$$
$$\left.\left.+\left(1-r^2\right)(\sigma-1-\mu)\right]\right\}/[(1+r)(\sigma-1)(1+\delta-r)]. \quad \text{(A20)}$$

To ensue (A20) be negative, we can obtain:

$$\mu < \frac{(1+r)(\sigma-1)(1+\delta-r)}{(1+\delta)^2-r(1+\delta)(\delta+r)}. \quad \text{(A21)}$$

A centralized system

In a centralized system, there are two types of tax rates. For the first condition, when transport cost approaches infinity, it is obtained that $\rho = 1$ as $\lambda = 1/2$ for the two types of tax rates. The second condition is discussed as follows.

When the regional representative of region 1 is the central representative, the tax rate of each region is shown in (A14). After substituting Eqs. (13) – (16) into (A14), the tax rate for each region can be rewritten as

$$t_1 = t_2 = \frac{\delta}{1+\delta+r\left(\frac{1-\lambda}{\lambda}\right)^{\frac{\mu}{\sigma-1}}}. \quad \text{(A22)}$$

Substituting the impacts of the short-run equilibrium wage, price index, and tax rate from a change in λ into (A17) and evaluating it at $\lambda = 1/2$ yield:

$$\frac{d\rho}{d\lambda} = -\frac{\mu(\delta r-\delta-r-1)+(1+r)(\sigma-1)}{(1+r)(\sigma-1)}. \quad \text{(A23)}$$

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To ensure (A23) is negative, we can obtain:

$$\mu < \frac{(1+r)(\sigma-1)}{1+r+\delta(1-r)}. \tag{A24}$$

When the regional representative of region 2 is the central representative, the tax rate of each region is as shown in (A15). After substituting Eqs. (13) – (16) into (A14), the tax rate for each region can be rewritten as

$$t_1 = t_2 = \frac{\delta}{1+\delta+r\left(\frac{\lambda}{1-\lambda}\right)^{\frac{\mu}{\sigma-1}}}. \tag{A25}$$

However, the analysis for $d\rho/d\lambda$ and the tax rate for each region are the same as those in (A23) and (A24).

References

Andersson, Fredrik and Rikard Forslid (2003), "Tax Competition and Economic Geography," *Journal of Public Economic Theory*, 5(2), 279–303.

Baldwin, Richard E. and Paul Krugman (2004), "Agglomeration, Integration and Tax Harmonization," *European Economic Review*, 48(1), 1–23.

Bergstrom, Theodore C. and Robert P. Goodman (1973), "Private Demands for Public Goods," *American Economic Review*, 63(3), 280–296.

Besley, Timoyhy and Stephen Coate (2003), "Centralized versus Decentralized Provision of Local Public Goods: A Political Economy Approach," *Journal of Public Economics*, 87(12), 2611–2637.

Borck, Rainald and Michael Pflüger (2006), "Agglomeration and Tax Competition," *European Economic Review*, 50(3), 647–668.

Brueckner, Jan K. and Harris Selod (2006), "The Political Economy of Urban Transport-system Choice," *Journal of Public Economics*, 90(6–7), 983–1005.

Candau, Fabien (2008), "Entrepreneurs' Location Choice and Public Policies: A Survey of the New Economic Geography," *Journal of Economic Survey*, 22(5), 909–952.

De Borger, Bruno and Stef Proost (2012), "A Political Economy Model of Road Pricing," *Journal of Urban Economics*, 71(1), 79–92.

——— (2016), "The Political Economy of Pricing and Capacity Decisions for Congestible Local Public Goods in a Federal State," *International Tax and Public Finance*, 23(5), 934–959.

臺灣大學學術期刊資料庫

Demographics, Department of Household Registration, Ministry of Interior, ROC (2022), **URL**: http://ris.gov.tw/app/portal/346 (visited on 10/22/2022).

Dixit, Avinash K. and Joseph E. Stiglitz (1977), "Monopolistic Competition and Optimum Product Diversity," *American Economic Review*, 67(3), 297–308.

Forslid, Rikard and Gianmarco I. P. Ottaviano (2003), "An Analytically Solvable Core-periphery Model," *Journal of Economic Geography*, 3(3), 229–240.

Gerritse, Michiel (2014), "Competing for Firms under Agglomeration: Policy Timing and Welfare," *Regional Science and Urban Economics*, 49(1), 48–57.

Haufler, Andreas and Ian Wooton (2010), "Competition for Firms in an Oligopolistic Industry: The Impact of Economic Integration," *Journal of International Economics*, 80(2), 239–248.

Kind, Hans Jarle, Karen Helene Midlefart Knarvik, and Guttorm Schjelderup (2000), "Competing for Capital in a 'Lumpy' World," *Journal of Public Economics*, 78(3), 253–274.

Krugman, Paul R. (1991), "Increasing Returns and Economic Geography," *Journal of Political Economy*, 99(3), 483–499.

Lockwood, Ben (2002), "Distributive Politics and the Costs of Centralization," *Review of Economic Studies*, 69(2), 313–337.

Lorz, Oliver and Gerald Willmann (2005), "On the Endogenous Allocation of Decision Powers in Federal Structure," *Journal of Urban Economics*, 57(2), 242–257.

Ludema, Rodney and Ian Wooton (2000), "Economic Geography and the Fiscal Effects of Regional Integration," *Journal of International Economics*, 52(2), 331–357.

Murata, Yasusada (2003), "Product Diversity, Taste Heterogeneity, and Geographic Distribution of Economic Activities: Market vs. Non-market Interaction," *Journal of Urban Economics*, 53(1), 126–144.

Oats, Wallace E. (1972), *Fiscal Federalism*, New York: Harcourt, Brace Jovanovich.

Ottaviano, Gianmarco I. P., Takatoshi Tabuchi, and Jacques-François Thisse (2002), "Agglomeration and Trade Revisited," *International Economic Review*, 43(2), 409–435.

Persson, Torsten and Guido Tabellin (2000), *Political Economics: Explaining Economic Policy*, Cambridge: MIT Press.

臺灣大學學術期刊資料庫

Pflüger, Michael (2004), "A Simple, Analytical Solvable, Chamberlinian Agglomeration Model," *Regional Science and Urban Economics*, 34(5), 565–573.

Samuelson, Paul A. (1954), "The Transfer Problem and Transport Costs, II: Analysis of Effects of Trade Impediments," *Economic Journal*, 64(254), 264–289.

Tabuchi, Takatoshi and Jacques-François Thisse (2002), "Taste Heterogeneity, Labor Mobility and Economic Geography," *Journal of Development Economics*, 69(1), 155–177.

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產業聚集與政治經濟學觀點的公共財提供

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本研究在新經濟地理 (NEG) 的 Forslid and Ottaviano (2003) 模型中, 探討可移動勞工在兩區的遷徙而與不可移動勞工形成的新群體如何經由投票來提供公共財。而提供公共財的稅率決策分別探討由分散體系與集中體系來決定。研究結果顯示在分散體系中, 當可移動勞工比例上升時, 有兩種增加稅率的效果。一爲聚集力量的增加而形成聚集租 (Baldwin and Krugman, 2004), 另一因可移動勞工多於不可移動勞工而經由投票改變公共財的偏好。在集中體系中, 則有兩種相同機率的稅率方案。

關鍵詞: 新經濟地理, 公共財, 外溢, 核心邊陲, 政治經濟學
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