

CHAPTER 16

ESTIMATING URBAN AGGLOMERATION ECONOMIES FOR JAPANESE METROPOLITAN AREAS: IS TOKYO TOO LARGE?

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16.1 INTRODUCTION

Tokyo is Japan's largest city with a population currently exceeding 30 million people. Congestion in commuter trains is almost unbearable with the average time for commuters to reach downtown Tokyo (consisting of the three central wards of Chiyoda, Minato and Chuo) being 71 minutes one-way in 1995. Based on these observations, many argue that Tokyo is too large and that drastic policy measures are called for to correct this imbalance. However, it is also true that the enormous concentration of business activities in

downtown Tokyo has its advantages. The Japanese business style that relies heavily on face-to-face communication and the mutual trust that it fosters may be difficult to maintain if business activities are geographically decentralized. In this sense, Tokyo is only too large when degglomeration economies such as longer commuting times and congestion externalities exceed these agglomeration benefits.

In this chapter, we estimate the size of agglomeration economies using the MEA (Metropolitan Employment Area) data and apply the so-called Henry George Theorem to test whether Tokyo is too large. Kanemoto et al. (1996) was the first attempt to test optimal city size using the Henry George Theorem by estimating the Pigouvian subsidies and total land values for different metropolitan areas and comparing them. We adopt a similar approach, but make a number of improvements to the estimation technique and the data set employed. First, we change the definition of a metropolitan area from the Integrated Metropolitan Area (IMA) to the Metropolitan Employment Area (MEA) proposed in Chapter 5. In brief, an IMA tends to include many rural areas while a MEA conforms better to our intuitive understanding of metropolitan areas. Second, instead of using single-year cross-section data for 1985, we use panel data for 1980 to 1995 and employ a variety of panel-data estimation techniques. Finally, the total land values for metropolitan areas are estimated for all prefectures in the Annual Report on National Accounts.

16.2 PRODUCTION FUNCTIONS WITH AGGLOMERATION ECONOMIES

Aggregate production functions for metropolitan areas are used to obtain the magnitudes

of urban agglomeration economies. The aggregate production function is written as $Y = F(N, K, G)$, where N , K , G , and Y are the numbers of persons employed, the amount of private capital, the amount of social overhead capital and the total production of a metropolitan area, respectively. We specify a simple Cobb-Douglas production function:

$$(1) \quad Y = AK^\alpha N^\beta G^\gamma,$$

and estimate its logarithmic form, such that:

$$(2) \quad \ln(Y/N) = A_0 + a_1 \ln(K/N) + a_2 \ln N + a_3 \ln(G/N),$$

where Y , K , N , and G are respectively the total production, private capital stock, employment, and social overhead capital in an MEA. The relationships between the estimated parameters in equation (2) and the coefficients in the Cobb-Douglas production function (1) are $\alpha = a_1$, $\beta = a_2 + 1 - a_1 - a_3$, $\gamma = a_3$.

The aggregate production function employed can be considered as a reduced form of either a Marshallian externality model or a new economic geography (NEG) model. The key difference between these two models is that the Marshallian externality model simply assumes that a firm receives external benefits from urban agglomeration in each city, while an NEG model posits that the product differentiation and scale economies of an individual firm yields agglomeration economies that work very much like externalities in a Marshallian model.

Let us illustrate the basic principle by presenting a simple example of a Marshallian model. Ignoring the social overhead capital for a moment, we assume that all firms have the same production function, $f(n, k, N)$, where n and k are respectively labor and capital inputs, and external benefits are measured by total employment N . The total production in a metropolitan area is then $Y = mf(N/m, K/m, N)$, where m is the number

of firms in a metropolitan area. Free entry of firms guarantees that the size of an individual firm is determined such that the production function of an individual firm $f(n, k, N)$ exhibits constant returns to scale with respect to n and k . The marginal benefit of Marshallian externality is then $mf_N(n, k, N)$. If a Pigouvian subsidy equaling this amount is given to each worker, this externality will be internalized and the total Pigouvian subsidy in this city is then $PS = mf_N N$. If the aggregate production function is of the Cobb-Douglas type, $Y = AK^\alpha N^\beta$, it is easy to prove that the total Pigouvian subsidy in a city is:

$$(3) \quad TPS = (\alpha + \beta - 1)Y.$$

The Henry George Theorem states that if city size is optimal, the total Pigouvian subsidy in equation (3) equals the total differential urban rent in that city [see, for example, Kanemoto (1980)]. Further, it is easy to show that the second order condition for the optimum implies that the Pigouvian subsidy is smaller than the total differential rent if the city size exceeds the optimum. On this basis, we may conclude that a given city is too large if the total differential rent exceeds the total Pigouvian subsidy. The Henry George Theorem also holds in the NEG model, assuming heterogeneous products if the Pigouvian subsidy is similarly implemented. However, Abdel-Rahman and Fujita (1990) concluded that the Henry George Theorem is applicable even without the Pigouvian subsidy, although this result does not appear to be general.

Now let us introduce social overhead capital, concerning which there are two key issues. The first of these concerns the degree of publicness. In the case of a pure local public good, all residents in a city can consume jointly without suffering from congestion. However, in practice most social overhead capital does involve considerable congestion

and thus cannot be regarded as a pure local public good. If the social overhead capital were a pure local public good, then applying an analysis similar to Kanemoto (1980) would show that the agglomeration benefit that must be equated with the total differential urban rent is the sum of the Pigouvian subsidy and the cost of the social overhead capital. However, for impure local public goods, the agglomeration benefit includes only part of the costs of the goods.

The second issue is whether firms pay for the services of social overhead capital. In many cases, including water supply, sewerage systems and transportation, firms pay at least part of the costs of these services. In the polar case where the prices of such services equal the values of their marginal products, the zero-profit condition of free entry implies that the production function of an individual firm, $f(n, k, G, N)$, exhibits constant returns to scale with respect to the three inputs, n , k and G , in equilibrium. In the other polar case where firms do not pay for social overhead capital, the production function is homogeneous of degree one with respect to just two inputs, n and k .

Combining both the publicness and pricing issues, we consider two extreme cases. One is the case where the social overhead capital is a private good and firms pay for it (the private good case). In this case, the total Pigouvian subsidy is $TPS = (\alpha + \beta + \gamma - 1)Y = a_2Y$ and the Henry George Theorem implies $TDR = TPS$, where TDR is the total differential rent of a city. The other case assumes that the social overhead capital is a pure public good and firms do not pay its costs (the public good case). The total Pigouvian subsidy is then $TPS = (\alpha + \beta - 1)Y = (a_2 - a_3)Y$ and the Henry George Theorem is $TDR = TPS + C(G)$, where $C(G)$ is the cost of the social overhead capital. Although the evidence is anecdotal, most social overhead capital

adheres more closely to the private, rather than the public, good case.

16.3 CROSS-SECTION ESTIMATES

Before applying panel-data estimation techniques to our data set, we first conduct cross-sectional estimation on a year-by-year basis. Table 16.1 shows the estimates of equation (2) for each year period from 1980 to 1995. The estimates of a_1 are significant and do not appear to change much over time. The estimates of a_2 are also significant, though they tend to become smaller over time. We are most interested in this coefficient, since $a_2 = \alpha + \beta + \gamma - 1$ measures the degree of increasing returns to scale in urban production. The coefficient for social overhead capital, a_3 , is negative or insignificant. As was observed and discussed in the earlier literature, including Iwamoto et al. (1996), this inconsistency implies the existence of a simultaneity problem between output and social overhead capital, since infrastructure investment is more heavily allocated to low-income areas where productivity is low. Because of this tendency, less-productive cities have relatively more social overhead capital and the coefficient of social overhead capital is biased downwardly in the OLS (Ordinary Least Squares) estimation. To control for this simultaneity bias, we use a Generalized Method of Moments (GMM) Three Stage Least Squares (3SLS) method in the next subsection.

The magnitudes of agglomeration economies may also be different between different size groups. Fig. 16.1 shows estimates of the agglomeration economies coefficient a_2 for three size groups: large MEAs with 300,000 or more employed workers, medium-sized MEAs with 100 - 300,000 workers, and small MEAs with less than 100,000 workers, in

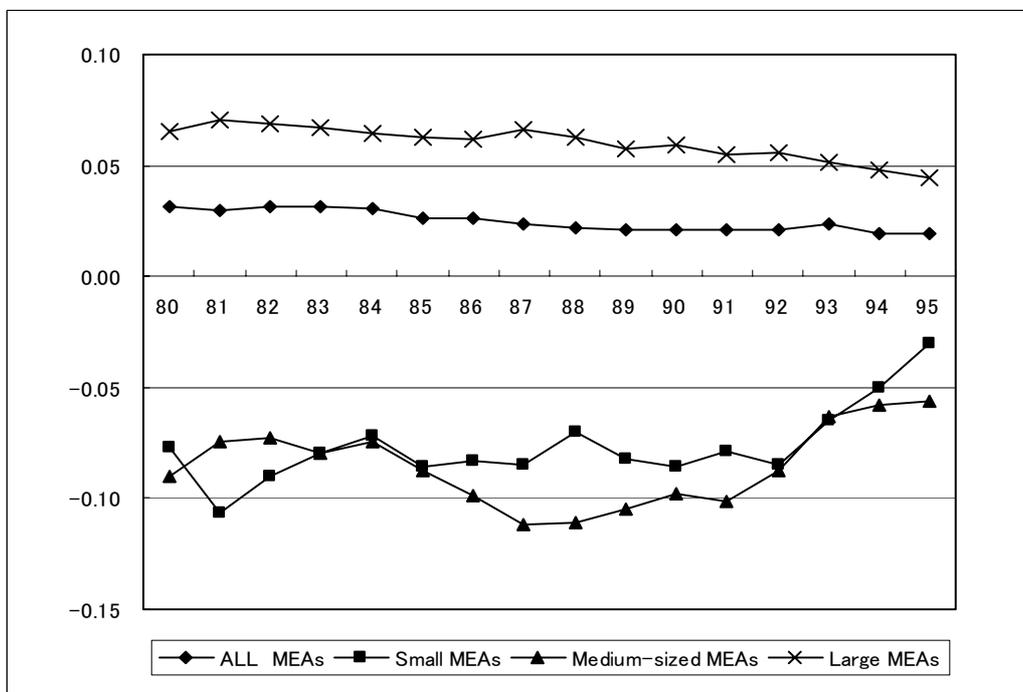
addition to the coefficient for all MEAs. The coefficient is indeed larger for large MEAs, while for small and medium-sized MEAs the coefficient is negative.

Table 16.1 Cross-Section Estimates of the MEA Production Function: All MEAs

Parameter	1980	1985	1990	1995
A_0	0.422** (0.153)	0.440** (0.18)	0.632*** (0.201)	0.718*** (0.182)
a_1	0.404*** (0.031)	0.469*** (0.039)	0.528*** (0.043)	0.449*** (0.037)
a_2	0.031*** (0.009)	0.026*** (0.009)	0.021** (0.009)	0.020** (0.007)
a_3	0.015 (0.045)	-0.031 (0.041)	-0.124*** (0.040)	-0.086** (0.032)
\bar{R}^2	0.608	0.568	0.644	0.653

Note: Numbers in parentheses are standard errors. *** significant at 1% level; ** significant at 5% level.

Fig. 16.1 Movement of agglomeration economies coefficient a_2 : 1980-95



In addition to the simultaneity problem, OLS cannot account for any unobserved effects that represent any unmeasured heterogeneity that is correlated with at least some of the explanatory variables. For example, the climatic conditions of a city that affect its aggregate productivity may be correlated with the number of workers because it influences their locational decisions. These unobserved effects also bias the OLS estimates. To improve these estimates, panel data estimation with instrumental variables is used to eliminate biases caused by the simultaneity problem and any unobserved city-specific effects.

16.4 PANEL ESTIMATES

We first estimate the panel model whose error terms are composed of the city-specific time-invariant term, c_i , and the error term, u_{it} , that varies over both city i and time t ,

$$(4) \quad y_{it} = A_0 + a_1 k_{it} + a_2 n_{it} + a_3 g_{it} + b_t d_t + c_i + u_{it} ,$$

where $y_{it} = \ln(Y_{it} / N_{it})$, $k_{it} = \ln(K_{it} / N_{it})$, $n_{it} = \ln(N_{it})$, $g_{it} = \ln(G_{it} / N_{it})$, and d_t is the time dummy. The use of the time dummy is equivalent to assuming fixed time-specific effects. Table 16.2 shows fixed and random effects estimates. A random effect model (RE) assumes the individual effects c_i are uncorrelated with all explanatory variables, while a fixed effect model (FE) does not require the assumption. Though Hausman test statistics indicate the violation of the random effect assumption for medium-sized MEAs and all MEAs, the estimation results of the random effect model are more reasonable than those of fixed effects. [See Wooldridge (2002, Chapter 10) for Hausman test statistics.]

The random effect estimates of the agglomeration coefficient a_2 are about five and nine percent for large and medium-sized groups, but negative for small MEAs. Those for social overhead capital are significantly negative for all groups.

Table 16.2 Panel estimates

	ALL MEAs		Small MEAs		Medium MEAs		Large MEAs	
	FE	RE	FE	RE	FE	RE	FE	RE
a_1	0.279*** (0.015)	0.310*** (0.014)	0.354*** (0.030)	0.376*** (0.027)	0.281*** (0.021)	0.325*** (0.020)	0.170*** (0.029)	0.194*** (0.026)
a_2	0.101*** (0.023)	0.031*** (0.007)	-0.016 (0.037)	-0.044 (0.030)	0.416*** (0.040)	0.096*** (0.026)	-0.044 (0.058)	0.059*** (0.010)
a_3	-0.084*** (0.020)	-0.108*** (0.017)	-0.147*** (0.034)	-0.132*** (0.029)	0.145*** (0.040)	-0.061* (0.031)	-0.151*** (0.030)	-0.113*** (0.026)
\bar{R}^2	0.623	0.770	0.741	0.761	0.311	0.721	0.502	0.862
Hausman	39.6		11.3		132.5		21.3	
chi (5%)	28.9		28.9		28.9		28.9	
Sample size	1888		528		896		464	

Note: Numbers in parentheses are standard errors. *** significant at 1% level; * significant at 10% level.

The estimation results in Table 16.2 fail to eliminate the simultaneity bias, because both fixed and random effects models can deal only with the endogeneity problem stemming from the unobserved city-specific effects, c_i . Correlation between the random term, u_{it} , and social overhead capital still provides a downward bias to the coefficients of social overhead capital and the results presented in Table 16.2 may reflect this problem. These considerations lead us to adopt a two-step Generalized Method of Moments (GMM) estimator which, in this case, yields the Three Stage Least Squares (3SLS) estimation in Wooldridge (2002, Ch. 8, pp. 194-8). [See Wooldridge (2002, Chap.8, 188-199) and Baltagi (2001, Chap. 8) for the explanation of GMM.]

We use time-variant instrumental variables (time dummies, k , n , and squares of n) and time-invariant ones (average snow-fall days per year for the 30-year period 1971 to 2000 and their squares, and the logarithms of the number of pre-school children and the number of employed workers who are university graduates in 1980). A major source of the bias could be the tendency of u_{it} to be negatively correlated with the social overhead capital. Appropriate instruments are then those that are correlated with the social overhead capital but do not shift the production function. The snowfall days per year satisfy the first property, because additional social overhead investment is often necessary in regions with heavy snowfalls. It is not clear if the variable satisfies the second condition, since the inconvenience caused by snow may also reduce productivity. The logarithms of the numbers of pre-school children and employed workers who are university graduates in 1980 are correlated with the regional income level that negatively influences the interregional allocation of social overhead capital. Since we use only the first year of our data set, they are exogenous for the subsequent production function and it is reasonable to assume orthogonality with future idiosyncratic errors.

The revised estimation results are presented in Table 16.3. The coefficients of social overhead capital are now positive but insignificant. The apparent simultaneity bias for social overhead capital is only partially eliminated. Sargan's J and F values from the first regression shown in Table 3 test the orthogonality condition for instrumental variables and the intensity of correlation between instruments and endogenous variables to be controlled. [See Hayashi (2000, Chap.3) for Sargan's J statistics.] While the F -statistics are significant for all groups, the J -statistics are significantly high for the two cases of all MEAs and medium-sized MEAs. The former results imply that the instruments we employed worked significantly well to predict the values of endogenous variables in the

first regression. The latter results imply, however, that our instruments have failed to eliminate the simultaneity bias at least in the two cases. The source of the bias is then likely to be the correlation between the instruments and city-specific unobserved effects. One possible solution is to apply GMM estimation to time-differenced equations, as argued by Arellano and Bond (1991) and Blundell and Bond (1998). Both of these methods were tried, but failed to yield satisfactory results. One cause of this failure is the fact that instruments that do not change over time cannot be used in the estimation of time-differenced equations.

The estimates of the agglomeration economy parameter, a_2 , are smallest for small MEAs and become larger for larger MEAs. An important difference from the OLS and RE estimates is that the sign of a_2 is positive even for small MEAs, which was negative in the earlier estimations. Accordingly, although our GMM 3SLS estimates display a number of shortcomings, they yield more reasonable estimates than those we have obtained elsewhere. We use the GMM 3SLS estimates as the relevant agglomeration economy parameter in the next section.

Table 16.3 GMM 3SLS estimates

	All MEAs	Small MEAs	Medium MEAs	Large MEAs
a_1	0.518*** (0.030)	0.601** (0.066)	0.479*** (0.047)	0.344*** (0.048)
a_2	0.044*** (0.005)	0.027 (0.018)	0.053*** (0.013)	0.068*** (0.007)
a_3	0.047 (0.033)	0.077 (0.081)	0.023 (0.069)	0.056 (0.045)
J -statistics (D.F.)	16.28 (4)	5.73 (4)	24.57 (4)	3.78 (4)
chi (5%)	9.49	9.49	9.49	9.49
1st stage F -statistics	216.85	81.10	105.19	91.73
Sample size	1888	528	896	464

Note: *** significant at 1% level.

16.5 A TEST FOR OPTIMAL CITY SIZES

Any policy discussion in economics must start with identification of the sources of market failure. In general, an optimally sized city balances urban agglomeration economies with diseconomy forces, and the first task is to check if these two forces involve significant market failure. On the side of agglomeration economies, a variety of micro-foundations are possible, including Marshallian externality models [see Duranton and Puga (2003)], new economic geography (NEG) models [see Ottaviano and Thisse (2003)], and a reinterpretation of the non-monocentric city models of Imai (1982) and Fujita and Ogawa (1982) as presented by Kanemoto (1990). Although the latter two do not include any technological externalities, the agglomeration economies that they produce involve similar forms of market failure. That is, urban agglomeration economies are external to each individual or firm and a subsidy to increase agglomeration may improve resource allocation. This suggests that agglomeration economies are almost always accompanied by significant market failure.

In addition to these problems, the determination of city size involves market failure due to lumpiness in city formation. A city must be large enough to enjoy benefits of agglomeration, but it is difficult to create instantaneously a new city of a sufficiently large size, due to the problems of land assembly, constraints on the operation of large-scale land developers, and the insufficient fiscal autonomy of local governments. If we have too few cities, individual cities tend to be too large. In order to make individual cities closer to the optimum, a new city must be added. It may of course also be difficult to

create a new city of a large enough size that can compete with the existing cities.

These types of market failure are concerned with two different ‘margins’. The first type represents divergence between the social and private benefits of adding one extra person to a city, whereas the second type involves the benefits of adding another city to the economy. In order to test the first aspect, we have to estimate the sizes of external benefits and costs. To the authors' knowledge, no empirical work of this type exists concerning Japan. The so-called Henry George Theorem can test the second aspect. According to this theorem, the optimal city size is achieved when the dual (shadow) values for agglomeration and deglomeration economies are equal. For example, the agglomeration forces are externalities among firms in a city and the deglomeration forces are the commuting costs of workers who work at the center of the city, then the former is the Pigouvian subsidy associated with the agglomeration externalities and the latter is the total differential urban rent.

Using the estimates of agglomeration economies obtained in the preceding section, we examine whether or not the cities in Japan (especially Tokyo) are too large. Our approach of applying the Henry George Theorem to test this hypothesis is basically the same as that in Kanemoto et al. (1996) and Kanemoto and Saito (1998). As noted in the preceding section, we consider two polar cases concerning the social overhead capital. One is the case where the social overhead capital is a private good and firms pay for it. In this case, the total Pigouvian subsidy is $TPS = a_2Y$ and the Henry George Theorem implies $TDR = TPS$, where TDR is the total differential rent of a city. The other case assumes that the social overhead capital is a pure public good and firms do not pay its cost. The total Pigouvian subsidy is then $TPS = (a_2 - a_3)Y$ and the Henry George Theorem is

$TDR - C(G) = TPS$, where $C(G)$ is the cost of the social overhead capital.

Unfortunately, a direct test of the Henry George Theorem is empirically difficult because good land rent data is not readily available and land prices have to be relied upon instead. Importantly, the conversion of land prices into land rents is bound to be inaccurate in Japan where the price/rent ratio is extremely high and has fluctuated enormously in recent years. Roughly speaking, the relationship between land price and land rent is: Land Price = Land Rent / (Interest Rate - Rate of Increase of Land Rent).

In a rapidly growing economy, the denominator tends to be very small and a small change in land rents generally results in a large change in land prices as well as highly variable prices. For instance, the total real land value of Japan tripled from 600 trillion yen in 1980 to about 1,800 trillion yen in 1990, and then fell to some 1,000 trillion yen in 2000. Given these possibly inflated and fluctuating land price estimates and the inability to get good land rent data, instead of testing the Henry George Theorem directly, we compute the ratio between the total land value and the total Pigouvian subsidy for each metropolitan area, to see if there is a significant difference in the ratio between cities at different levels of the urban hierarchy.

Our hypothesis is that cities form a hierarchical structure where Tokyo is the only city at the top [see, for instance, Kanemoto (1980) and Kanemoto et al. (1996)]. While equilibrium city sizes tend to be too large at each level of the hierarchy, divergence from the optimal size may differ across levels of hierarchy. At a low level of hierarchy, the divergence tends to be small because it is relatively easy to add a new city. For example, moving the headquarters or a factory of a large corporation can easily result in a city of

20,000 people. In fact, the Tsukuba science city created by moving national research laboratories and a university to a greenfields location resulted in a population of more than 500,000. However, at a higher level it becomes more difficult to create a new city because larger agglomerations are generally more difficult to form. For example, the population size difference between Osaka and Tokyo is close to 20,000,000 and making Osaka into another center of Japan would be arguably very difficult. We therefore test whether the divergence from the optimum is larger for larger cities, in particular if the ratio between the total land value (minus the value of the social overhead capital when it is a pure public good) and the total Pigouvian subsidy is significantly larger for Tokyo than for other cities.

The construction of the total land value data for an MEA is as follows. The Annual Report on National Accounts contains the data on the value of land by prefecture. We allocate this prefecture data to MEAs, using the number of employed workers by place of residence. The first round estimate is obtained by simple proportional allotment. The problem with this estimate is that land value per worker is the same within a prefecture, regardless of city size. In order to incorporate the tendency that it is larger in a large city, we regress the total land value on city size and use the estimated equation to modify the land value estimates. The equation we estimate is:

$$\ln(V_i) = a \ln(N_i) + b$$

where V_i is the first round estimate of the total land value, N_i is the number of employed workers in a MEA, and a and b are estimated parameters. In the estimation, care has to be taken with sample choice because in Japan there are many small cities and very few large cities. If we include all MEAs, then the estimated parameters are influenced mostly by small cities. Since we are interested in largest cities, we include the nineteen largest

MEAs in our sample. We drop the twentieth largest MEA (Himeji), because it belongs to the same prefecture as the much larger Kobe and the first round estimate could then be seriously biased. The estimate of a is 1.20 with t-value 21.45. Assuming $V_i = AN_i^a$, we compute the total land value of an MEA by

$$V_i = \frac{\bar{V}}{\sum N_j^a} N_i^a.$$

Table 16.4 presents the total land value, the total Pigouvian subsidy and social overhead capital in the largest twenty MEAs in those cases where the production function parameters are given by the GMM estimate for large MEAs in Table 16.3. The columns of “Pigouvian subsidy 1” and “Pigouvian subsidy 2” show the subsidies in the first case, $TPS = a_2Y$ and the second case, $TPS = (a_2 - a_3)Y$, respectively. In both cases the two largest MEAs, Tokyo and Osaka, have a significantly higher land value/Pigouvian subsidy ratio than the average city. This result supports the hypothesis that Tokyo is too large, but then it is likely that Osaka is also too large. These ratios are computed for the remaining years and the same tendency exists. These results contrast with Kanemoto et al. (1996) who found that the land value/Pigouvian subsidy ratio for Tokyo was slightly below the average for Japan's largest seventeen metropolitan areas. One possible source of this difference is the land value estimates used in this study, since the land values of Tokyo and Osaka are generally much higher than those in other Japanese cities.

Outside of Tokyo and Osaka, Shizuoka, Hamamatsu and Kyoto also have high land value/Pigouvian subsidy ratios. This pattern is the same in the pure public good case. In the pure public good case, Sapporo has a negative ratio because the value of social overhead capital exceeds the total land value. This is caused by the fact that Sapporo is

located on Hokkaido Island, and therefore receives a disproportionately high share of social overhead capital investment.

Table 4 Total Land Values and Pigouvian Subsidies

MEA	Population	Land Value (a)	Pigouvian Subsidy 1 (b)	(a)/(b)	Social overhead capital (c)	Pigouvian Subsidy 2 (d)	(a)-(c)/(d)
Tokyo	30,938,445	518,810	9,493	55	133,310	1,613	239
Osaka	12,007,663	176,168	3,216	55	53,654	546	224
Nagoya	5,213,519	62,517	1,594	39	20,774	271	154
Kyoto	2,539,639	27,851	637	44	10,075	108	164
Kobe	2,218,986	21,913	575	38	12,345	98	98
Fukuoka	2,208,245	19,810	532	37	8,890	90	121
Sapporo	2,162,000	12,645	508	25	14,670	86	-23
Hiroshima	1,562,695	14,708	421	35	8,481	72	87
Sendai	1,492,610	12,529	377	33	7,604	64	77
Kitakyushu	1,428,266	11,059	311	36	6,719	53	82
Shizuoka	1,002,032	12,740	258	49	3,715	44	206
Kumamoto	982,326	6,505	206	32	4,892	35	46
Okayama	940,208	7,637	230	33	5,370	39	58
Niigata	936,750	7,519	231	33	5,698	39	46
Hamamatsu	912,642	11,489	242	47	3,707	41	189
Utsunomiya	859,178	8,021	223	36	3,551	38	118
Gifu	818,302	6,709	187	36	3,800	32	92
Himeji	741,089	6,143	205	30	4,640	35	43
Fukuyama	729,472	5,367	174	31	4,433	29	32
Kanazawa	723,866	7,412	182	41	3,957	31	112
Average		47,878	990	38	16,014	168	108

Note: Land value, Pigouvian subsidy, and social overhead capital are in billion yen.

16.6 CONCLUDING REMARKS

Using the estimates of the magnitudes of agglomeration economies derived from aggregate production functions for metropolitan areas in Japan, we have examined the hypothesis that Tokyo is too large. In a simple cross-section estimation of a metropolitan production function, the coefficient for social overhead capital is either negative or

statistically insignificant. The main reason for this is a simultaneity bias arising from social overhead capital being more heavily allocated to low-income regions in Japan. In order to correct for this bias, we adopt panel data methods. Simple fixed effects and random effects estimators still yield negative estimates. We also introduce instrumental variables and apply the GMM 3SLS to our panel data. The estimates become positive, but insignificant. The instrumental variables appear to reduce such bias but they may not be strong enough to yield an unbiased estimate.

Using the GMM estimates for agglomeration economies, we also examine whether the Henry George Theorem for optimal city size is satisfied. Tokyo and Osaka have a higher land value/Pigouvian subsidy ratio than other cities. This indicates that Tokyo and Osaka are too large on the basis of this criterion. However, these results are tentative and elaboration and extension in many different directions may be necessary.

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Caption list

Table 1 Cross-Section Estimates of the MEA Production Function: All MEAs

Fig. 1 Movement of agglomeration economies coefficient a_2 : 1980-95

Table 2 Panel estimates

Table 3 GMM 3SLS estimates

Table 4 Total Land Values and Pigouvian Subsidies

