Commuting and Spatial Structure in Japanese Metropolises

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Abstract

In this paper we extend an approach by Merriman, et al. (1995) to time-series data of commuting flow in Tokyo, and 1990 commuting data in other Japanese metropolises. We find that spatial structure of Tokyo Metropolitan Area is going toward US cities like LA, but smaller Japanese metropolises still have concentrated spatial structures and less excess commuting than four major metropolises. Discrepancy seems to be explained by differences in urban structures and so far.

I. Introduction

The Tokyo Metropolitan area (TMA) is the largest metropolitan area in the industrialized world with about 30 million residents, 16 million jobs and over 200 independent units of local government. This vast region is highly integrated with significant numbers of workers commuting from residential rings 40 kilometers away to work in central Tokyo. For some workers, commuting times are extraordinarily lengthy and the congestion at peak commuting hours is legendary worldwide.

More than 20 years ago, Hamilton (1982) noted that the most widely used model of the urban economy, the monocentric city model, "yield(s) specific predictions of the volume of commuting which will occur from houses to jobs." Hamilton's work suggested that the monocentric city model greatly under-predicted actual commuting and therefore cast doubt on the usefulness of this model for analyzing urban economic phenomena. White (1988) empirically demonstrated that, given the distribution of jobs and residences, households (and workers) locate to minimize commuting. Small and Song (1992) show that Hamilton (1982) and White (1988) measure quite different things. Hamilton rejects only the monocentric city model while White tests the hypothesis of commute minimization given available residence and work locations.

Research on Los Angeles (LA) by Small and Song (1992) confirms Hamilton's (1982) rejection of the monocentric city model as a predictor of aggregate commuting. More importantly, Small and Song (1992) demonstrate that White's (1988) results are dependent on the degree of disaggregation of origin and destination zones. When zones are finely disaggregated, they show that about two-thirds of all commuting is 'excess' (measured by time).

Merriman, et al. (1995) examine whether these results extend to Tokyo. They examine Tokyo commuting patterns to determine to what extent the volume of commuting is an inevitable result of the functioning of such a vast interconnected economic system and to what extent it is the result of inefficient matching of workers and jobs. Their methodology is similar to Small and Song's (1992) but, using data from the TMA, they obtain quite different results: they find little evidence of excess commuting and only minor effects from aggregation of data. They discuss whether differences in results are the product of differences in methodology or differences in spatial commuting patterns.

Merriman, et al. (1995) show significant difference in excess commuting between US and Japanese cities, but measurement of excess commuting is conducted only for Tokyo and only for 1985. Perhaps even more important than point-of-time estimates of unnecessary commuting are estimates of the change in commuting that might result from decentralization of Tokyo area employment. Policy makers have discussed a number of options for reducing the size of Tokyo, these include zoning regulations to limit new development in congested areas of Tokyo and even movement of national government offices from the 23 wards of central Tokyo. Proponents claim that a major benefit of these initiatives would be a reduction in congestion and long distance commutes. Merriman, et al. (1995) have simulated employment decentralization ideally and have estimated the amount of commuting time saved. However, no empirical study on dynamics in excess commuting is executed.

Estimates in commuting in other metropolitan areas in Japan are also important. Mega-city like Tokyo has decentralized structure with sub-centers in surrounding regions and even within central wards, while smaller metropolises usually have a unique strong center. However, comparing with another mega-city Osaka (including Kyoto and Kobe), Tokyo has monocentric characteristics with its stronger center. Those differences in urban structures might produce differences in spatial commuting patterns. However, no empirical study on comparison between metropolises is examined.

In this paper we extend an approach by Merriman, et al. (1995) to time-series data of commuting flow in Tokyo, and 1990 commuting data in other Japanese metropolises. We find that spatial structure of Tokyo Metropolitan Area is going toward US cities like LA, but smaller Japanese metropolises still have concentrated spatial structures and less excess commuting than four major metropolises.

II. Model Specification

Our analyses use detailed data from the Japanese Census of the Population on the observed volume of commuting among origin and destination jurisdictions. For instance, commuting in Tokyo Metropolitan Area (TMA) generates from and concentrates on 211 jurisdictions within about 60 kilometers of the center of Tokyo (see Merriman, et al., 1995).

Only for TMA, we are able to use estimates of the time required for all trips in our flow matrix, which was developed by Merriman, et al (1995). Because public transit is the fastest and most popular mode choice in the Tokyo area our estimates made use of a government census of Tokyo area transit users (Transportation Census of Metropolises) to measure travel time.

Our approach is same as White's (1988) methodology - test of commute minimization. As Small and Song (1992) point out Hamilton's method is, strictly speaking, a test only of monocentricity rather than of commute minimization and, as White (1988) shows it may not be a valid measure of excess commuting in an actual metropolitan area. Using the travel flow and time data matrices described above we reallocated commuters to residence and employment jurisdictions to minimize total commuting time and distance. Our modeling and problem solving strategy basically follow the procedures used by White (1988), Small and Song (1992), and Merriman, et al. (1995). Like White (1988), we exclude workers who live outside our sample but work in it, or who live inside our sample but work outside it. Our data set excludes a larger share of residents and job in some smaller jurisdictions near the fringe. We believe the share of residents who originate outside or workers or terminate outside is sufficiently small that it will not greatly influence the results.

Excess commuting is defined by the following formula:

Excess = (observed commute – minimum commute)/(observed commute).

Additionally, we adopt the following two indices. Black and Katakos (1987) introduced Urban Consolidation Index (UCI) that is defined by:

UCI = (minimum commute)/(maximum commute).

If UCI is close to one, it means that workplace in the metropolis concentrates at one place and therefore we have no room to decrease commuting. Masuya, et al. (2001) developed another index, Travel Flow Ratio (TFR), defined by:

TFR = (observed commute – minimum commute)/(maximum commute – minimum commute).

TFR means relative position of observed commute in possible range of commute. If TFR is close to zero, observed commute is almost minimized. As TFR becomes larger, excess commute grows until maximum commute brings about TFR = 1.

III. Empirical Results

Table 1 shows average one-way commuting distance or time in the travel minimizing solution for the entire TMA in 1980, 1985, and 1990. Average one-way commuting distance falls by about three to four kilometers and time falls about eight minutes. Spatial structure seems to show little change because UCIs stay almost at the same value. The Excess and TFR are growing steadily. That indicates jobs in Tokyo are spreading out to suburbs producing increase of cross commuting. All data show significantly less excess commuting than Small and Song (1992) found in the LA metropolitan area. However, Tokyo seems to be going toward LA situation.

Other metropolises show differences in urban structures and that might produce differences in spatial commuting patterns. Thus comparative study might be help to understand how urban structure has an effect on commuting. In Table 2, 13 metropolises, their population and jobs-housing balance are shown in Figure 1 to Figure 3, including Tokyo (slightly different in covered jurisdictions) are summarized.

We examined minimum and maximum commute for those metropolises. Table 3 shows excess commutes in major metropolises (Tokyo, Osaka, Nagoya and Fukuoka) are larger than that in other metropolises. This empirical result comes from the fact that major metropolises have suburban subsenters – multi-nucleated spatial structures. Other Japanese metropolises still have concentrated spatial structures and less excess commuting than major metropolises. Because of their largeness in size, however, major metropolises have larger maximum commutes. Then UCIs show smaller values and accordingly no discrimination is seen in TFRs.

V. Conclusions

What have we learned from excess commuting studies? Hamilton's (1982) original contribution remains important because it alerted us to the fact that the monocentric city model makes strong and testable predictions about the volume and direction of commuting. His empirical results cast serious doubt on the reasonableness of the monocentric city model. Subsequent studies yielded mixed conclusions. White (1988) and following papers can all be seen as casting some doubt on Hamilton's (1982) dramatic findings. However, Small and Song's (1992) carefully done and finely disaggregated study of LA appears to both confirm Hamilton's 1982 study and explain White's (1988) conflicting results. Using disaggregated data on the TMA

Merriman, et al. (1995) find significantly less absolute, and a dramatically smaller percentage, of excess commuting than Small and Song (1992) find for the LA metropolitan area. This discrepancy is thought to be explained by differences in methodologies and data sources or by differences in urban structures and institutions. If difference in urban structures and institutions are the ultimate cause, universalistic claims about the quantity of excess commuting may be unwarranted.

In this context, this paper reveals that, although Tokyo is - probably Osaka, Nagoya, and Fukuoka are also - going toward US cities like LA that has more decentralized spatial structure and more excess commuting, other Japanese metropolises still have concentrated spatial structures and less excess commuting than four major metropolises. Thus discrepancy seems to be explained by differences in urban structures and so far.

Suzuki (1994, 1998) extends the discussion to energy issues and mixed development. Suzuki and Tagashira (2000) deals with national-wide travel minimization. The discussion should cover those problems.

More importantly, recent every-5-years survey for commuting of workers who use mass-transit - 2000

Transportation Census of Metropolises (Daitoshi Kotsu Census) reveals that commuting time in three major metropolises decreased for the first time. Centralization of suburban residents is current trend in Japanese megalopolises, and might be promising cause to reducing commuting. Finding evidence whether changing urban structure contributes lower commuting time remains an issue for further academic study.

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Table 1
Optimal Commuting Assignment Solutions in the Tokyo Metropolitan Area

Year	Number of Workers	Total Distance Travelled Minimum km	Observed km	Maximum km	Average Distance Minimum km	Observed km	Maximum km	Distance Based Excess	UCI	TFR
1980	12713891	82089065	124174072	537004784	6.46	9.77	42.24	0.339	0.153	0.093
1985	14002641	92330935	141393051	603855198	6.59	10.10	43.12	0.347	0.153	0.096
1990	15599154	108064127	168461428	687766217	6.93	10.80	44.09	0.359	0.157	0.104

Year	Number of Workers	Total Time Travelled Minimum min	Observed min	Maximum min	Average Time Minimum min	Observed min	Maximum min	Time Based Excess	UCI	TFR
1980	12713891	535941524	623080001	1384293043	42.15	49.01	108.88	0.140	0.387	0.103
1985	14002641	594527428	697786670	1548284339	42.46	49.83	110.57	0.148	0.384	0.108
1990	15599154	673790007	802003594	1751777434	43.19	51.41	112.30	0.160	0.385	0.119

Data: Population Census.

Notes: UCI = Urban Consolidation Index
TFR = Travel Flow Ratio

Table 2
Japanese Metropolises Tested (as of 1990)

Metropolis	# of Zones	Area km2	Population	Daytime Population	Pop Density /km2	Daytime Pop Density /km2	Number of Workers				Density of Workers			Inner Rate
							Live	Work	Within Juris-diction	Live & Work	Live /km2	Work /km2	Live & Work /km2	%
Sapporo	24	4460	2234582	2236890	5.01	5.02	1047201	1047983	556571	1037652	2.35	2.35	2.33	53.6
Sendai	41	4005	1655344	1665589	4.13	4.16	804264	811577	456096	785321	2.01	2.03	1.96	58.1
Utsunomiya	33	5042	1225389	1236456	2.43	2.45	641180	649716	482974	620408	1.27	1.29	1.23	77.8
Maebashi	56	5152	1578174	1566021	3.06	3.04	814100	803145	567906	779761	1.58	1.56	1.51	72.8
Tokyo	336	16371	33374526	33403662	20.39	20.40	17188099	17221743	7683268	17080834	10.50	10.52	10.43	45.0
Shizuoka & Hamamatsu	41	4227	2359881	2356484	5.58	5.57	1265874	1262739	960011	1241877	2.99	2.99	2.94	77.3
Nagoya & Yokkaichi	196	11303	9162919	9187368	8.11	8.13	4762229	4780045	2729707	4730516	4.21	4.23	4.19	57.7
Osaka & Kyoto	253	14230	17976405	17987241	12.63	12.64	8635030	8642758	4042547	8572128	6.07	6.07	6.02	47.2
Okayama	36	3169	1477779	1485115	4.66	4.69	723716	726362	580697	709346	2.28	2.29	2.24	81.9
Hiroshima	58	5025	2027441	2033031	4.03	4.05	1001375	1007166	580497	989899	1.99	2.00	1.97	58.6
Fukuoka & Kitakyushu	76	3262	3868653	3900403	11.86	11.96	1745784	1770038	901002	1715037	5.35	5.43	5.26	52.5
Kurume	49	2410	1225462	1196432	5.08	4.96	575219	553966	395037	521941	2.39	2.30	2.17	75.7
Kumamoto	36	1855	1053344	1061032	5.68	5.72	496207	502669	387033	483649	2.67	2.71	2.61	80.0

Table 3
Optimal Commuting Assignment Solutions in Japanese Metropolises, 1990

Metropolis	Total Distance			Average Distance			Excess	UCI	TFR
	Minimum	Observed	Maximum	Minimum	Observed	Maximum			
	km	km	km	km	km	km			
Sapporo	6378674	7977971	21338927	6.15	7.69	20.56	0.200	0.299	0.107
Sendai	5167196	6340034	21483833	6.58	8.07	27.36	0.185	0.241	0.072
Utsunomiya	4793889	5753812	21588253	7.73	9.27	34.80	0.167	0.222	0.057
Maebashi	4234668	5452318	22180340	5.43	6.99	28.45	0.223	0.191	0.068
Tokyo	117587325	184512363	882076114	6.88	10.80	51.64	0.363	0.133	0.088
Shizuoka & Hamamatsu	10694404	12510725	71290558	8.61	10.07	57.41	0.145	0.150	0.030
Nagoya & Yokkaichi	24595558	39007727	234810947	5.20	8.25	49.64	0.369	0.105	0.069
Osaka & Kyoto	46679690	76345068	419412515	5.45	8.91	48.93	0.389	0.111	0.080
Okayama	6656411	7407113	17329249	9.38	10.44	24.43	0.101	0.384	0.070
Hiroshima	5432260	7050708	26299446	5.49	7.12	26.57	0.230	0.207	0.078
Fukuoka & Kitakyushu	7924335	11445907	79750712	4.62	6.67	46.50	0.308	0.099	0.049
Kurume	2394261	3052127	17962975	4.59	5.85	34.42	0.216	0.133	0.042
Kumamoto	2892039	3418551	9219282	5.98	7.07	19.06	0.154	0.314	0.083

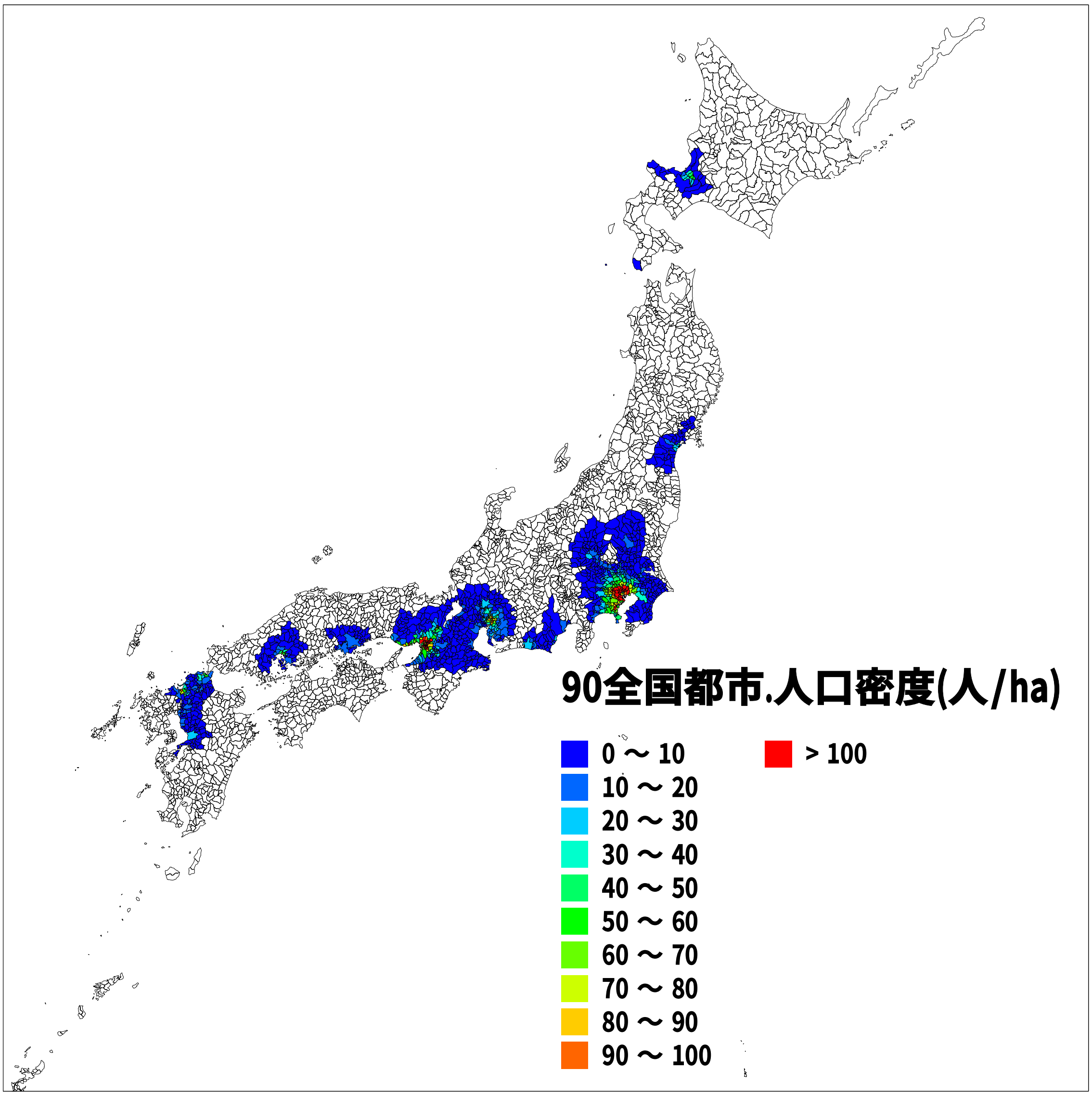

Figure 1
Population density in Japanese metropolises

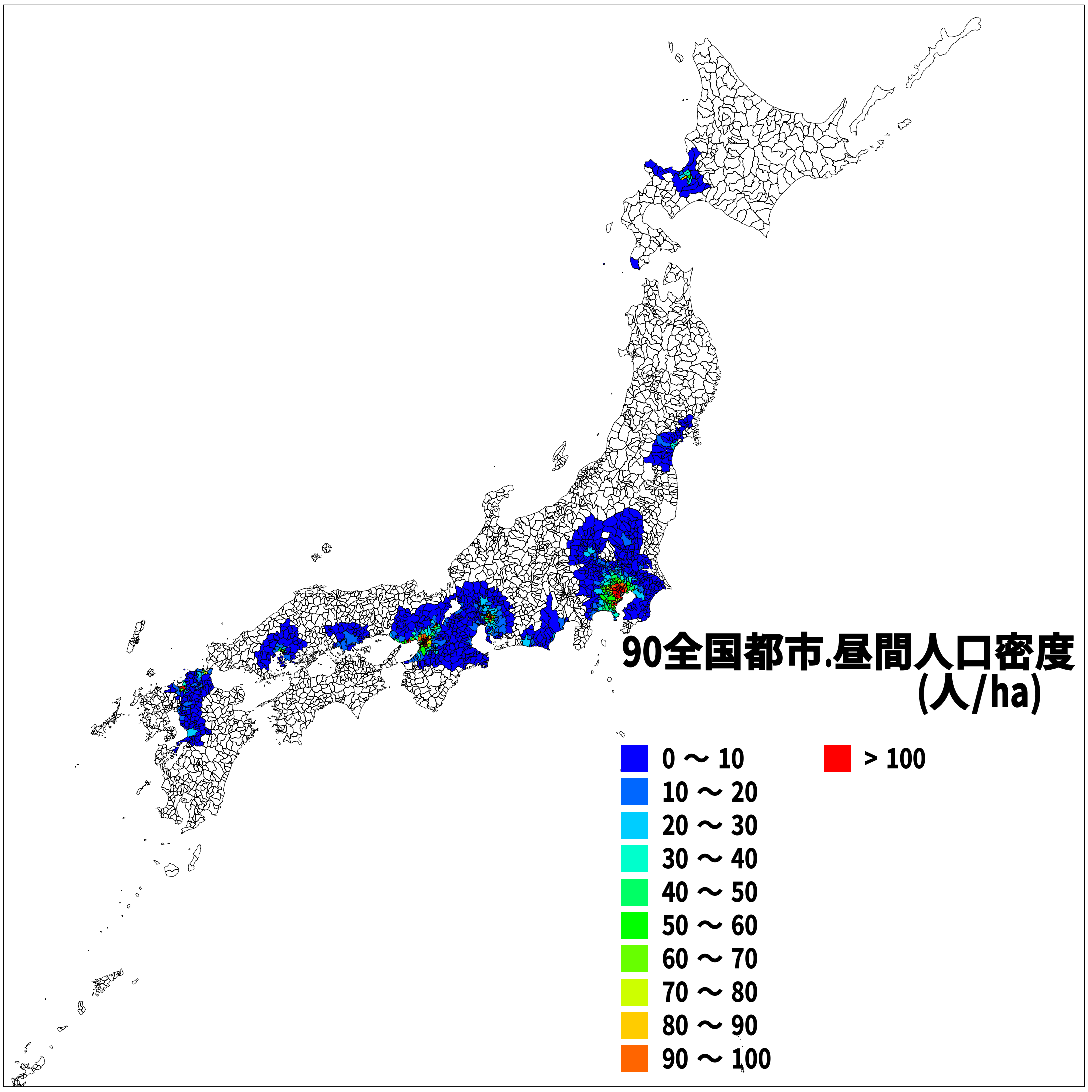

Figure 2

Daytime population density in Japanese metropolises

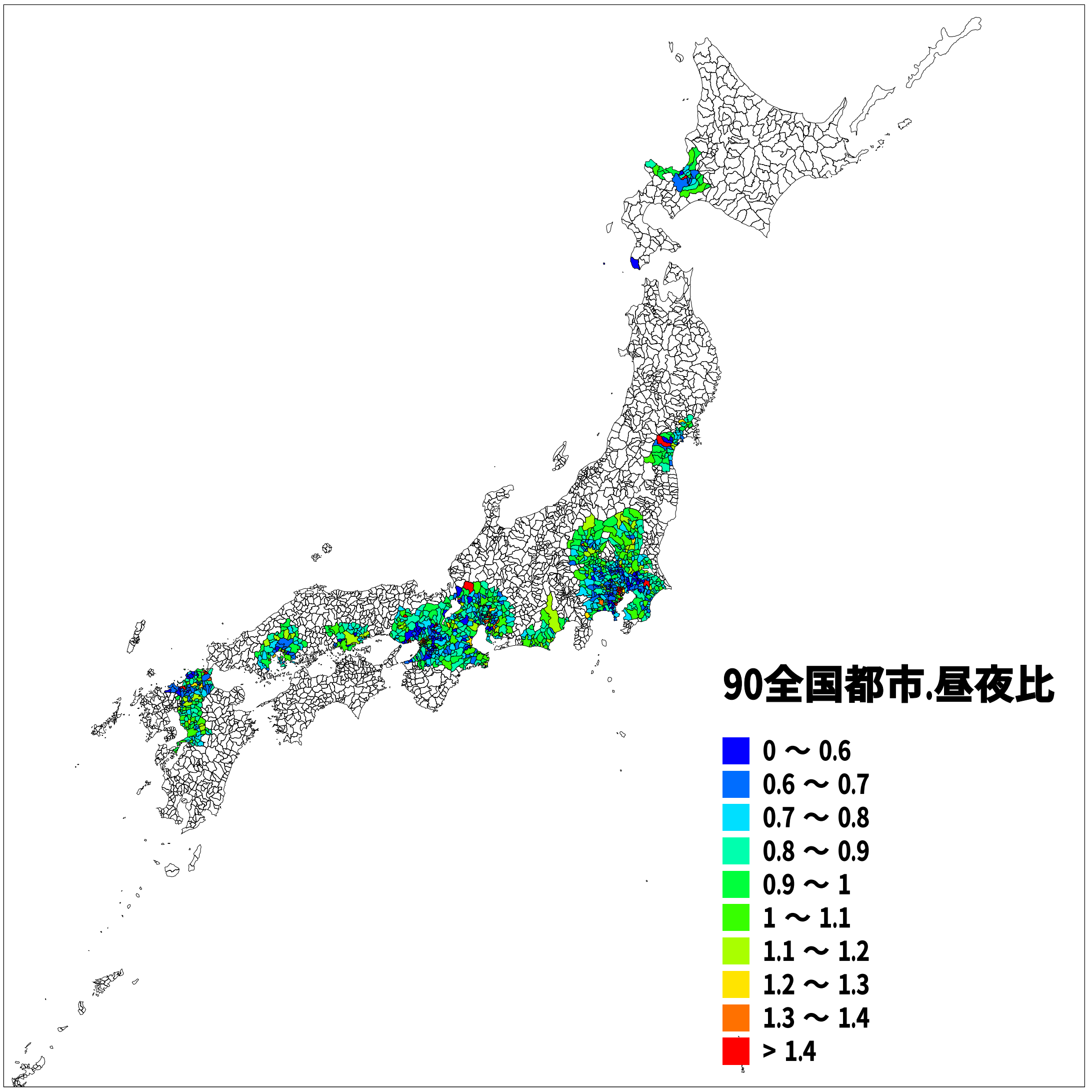

Figure 3

Day-night population ratio in Japanese metropolises