Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 12 (2016) 263 – 277

Transportation Research Procedia

www.elsevier.com/locate/procedia

The 9th International Conference on City Logistics, Tenerife, Canary Islands (Spain), 17-19 June 2015

Logistics facility distribution in Tokyo Metropolitan area: Experiences and policy lessons

Takanori Sakai [a]*, Kazuya Kawamura [a], Tetsuro Hyodo [b]

[a] *Department of Urban Planning and Policy, University of Illinois at Chicago, 412 S. Peoria St., Suite 215, Chicago, Illinois, 60607, U.S.A.*
[b] *Department of Logistics and Information Engineering, Tokyo University of Marine Science and Technology, 2-1-6, Etchujima Koto-ku, Tokyo, 135-8533, Japan*

Abstract

We use the large-scale freight survey data to examine the historical transition of the logistics facility distribution in the Tokyo Metropolitan Area (TMA) and investigate the possible causal factors for the changes. The analysis revealed the decentralization of logistics facilities during the period 1980-2003 and suggested that the asset price bubble during 1986-1991 was likely a significant factor. In addition, the examination of the relationship between logistic facility locations and land-use regulations indicates the challenges that even a relatively common land-use regulation framework faces. The study offers valuable insights into the spatial distribution of logistics facilities in the largest metropolitan area in the world.

Peer-review under responsibility of the organising committee of the 9th International Conference on City Logistics

Keywords: Logistics distribution; locational analysis; land-use policy

1. Introduction

The evolutions in logistics practices that occurred along with globalization, the innovations in information and communication technologies (ICTs) and infrastructure development, have resulted in the changes in logistics land-use in metropolitan regions around the world. What Dablanc and Rakotonarivo (2010) define as logistics sprawl, “the

* Corresponding author. Tel.: +1-312-996-5240; fax: +1-312-413-2314.
E-mail address: tsakai3@uic.edu

2352-1465
Peer-review under responsibility of the organising committee of the 9th International Conference on City Logistics
doi:10.1016/j.trpro.2016.02.064

historical trend towards spatial deconcentration of logistics terminals in metropolitan areas" (p. 6087), is widely observed in North American and European cities as a consequence of the changes in both the requirements for logistics operations and the supplies of spaces and transportation systems in metropolitan areas. It is suspected that logistics sprawl often leads to mismatches between logistics and other land uses, potentially exacerbating the negative impacts of urban freight traffic such as congestion, emissions, energy use and infrastructure damages. However, formulating effective policy responses to either prevent the sprawl in first place or address the impacts requires understanding the forces that drives logistics sprawl and the role of the public sector, especially regarding the land regulations. In most urban areas, location choice of logistics facility is a part of business strategies of private entities and the regulations and controls of the facility development are often (but not always) the purview of local municipalities. As such, the spatial distributions of logistics facilities in metropolitan areas often do not subscribe to any holistic vision or policy framework. As freight and freight facility demands are rapidly growing in metropolitan areas, understanding the shifts in logistics distribution is increasingly important for policy development to achieve the sustainable urban transportation system.

The goal of this study is to contribute to the body of works on the dynamics of logistics facility distribution and the relevant policies. In this study, we use the data from the 2003 Tokyo Metropolitan Freight Survey (TMFS), one of the most comprehensive and the largest urban freight surveys, to examine the historical trend in the logistics facility distribution in the Tokyo Metropolitan Area (TMA) and to investigate the possible explanatory factors of spatial distribution. We especially focus on the influence of the asset price bubble that occurred during the period 1986-1991 in the TMA. We also examine the relationship between land-use regulations and the logistics facility distribution.

The contents of the rest of the paper are as follows; in section 2, the literature review that covers the studies of the logistics facility distribution is provided; in section 3, the data and analytical approach are presented; in section 4, key features of the TMA that are potentially relevant to logistics facility distribution – population and densely inhabited area, transportation network, land price and land use regulations – are briefly reviewed; in section 5, the analysis of the logistics facility distribution in the TMA and its relations with land price and land-use regulations are provided; the final section summarizes the major findings and proposes the topics to be addressed in future research.

2. Literature Review

The recent trends in logistics facility distribution in metropolitan areas are reported by several studies, mainly in the context of decentralization. Dablanc and Ross (2012) analyze the data for the Atlanta Piedmont Megaregion and find that warehousing establishments moved outward by 2.8 miles (4.5 km) on average during the period 1998-2008, while the business establishments in general moved outward only by 1.3 miles (2 km) during the same period. In a subsequent study (Dablanc et al., 2014), the same approach is also applied to the Los Angeles and Seattle Metropolitan Areas for the period 1998-2009. The results indicate a significant logistics sprawl in Los Angeles, while in Seattle the spatial distribution of logistics facilities compacted. Cidell (2010) investigates the trends in logistics facility distributions in and across metropolitan areas in the U.S. and reveals "the move towards inland distribution centers and the suburbanization of freight activity" though she also found exceptions. Dablanc and Rakotobarivo (2010) provide a case of Paris, focusing on the locations of large parcel and express transport companies. Their analysis indicates that freight terminals of those companies have significantly decentralized in the past few decades; the average distance to their barycenter was 6 km in 1974 and increased to 16 km by 2008. Sakai et al. (2015) analyze the historical trend on the distribution of logistics facilities in the TMA based on the establishment year data using the 2003 TMFS data. They find that the average distance of the inland logistics facilities from the urban center increased by roughly 4 km between 1980 and 2003. They also indicate that logistics facilities tend to be located farther from their optimum locations in terms of shipment distance as the facilities are located farther away from the urban center.

In contrast to the abovementioned studies focusing on the historical transition of spatial distributions, other studies attempt to unveil the location choice mechanism for logistics facilities. Hagino and Endo (2007) analyze the potential of lands for future distribution facility development using the multinominal logit model framework for the TMA; they develop location choice models for regional freight facilities and distribution centers using demographic information, accessibility, land price and land use regulations as main explanatory variables based on the 2003 TMFS data. Similarly, Nguyen and Sano (2010) apply the mixed logit model to analyze the location choices of logistics firms. They estimate models for retailers, product wholesalers and other manufacturers and identify zonal population, number of workers, land price, number of employees and floor area of a firm as statistically significant predictors. Woudsma et al. (2008) develop spatial-autoregressive models for estimating logistics land use development over time using accessibility and other indicators using the data from Calgary, Canada. They find that the accessibility indicator based on the degree of congestion has a stronger influence on logistics land use than the one based on travel time. Van den Heuvel et al. (2013) analyze the dynamics of the spatial concentration of logistics establishments in North Brabant, Netherlands. The analysis for the period 1996-2009 indicates that the experiences of the facilities in the concentration areas or in the provinces which cover those areas influence the selection of such areas for relocation.

While the present study begins with the examination of the transition of logistics facility distribution in the TMA in the line of Dablanc and her colleagues' works for other metropolitan areas and also the study by Sakai et al. (2015) that uses the same data set from the 2003 TMFS[1], we also attempt to venture into a causal analysis by examining the relationship between the logistics facility distribution and the effects of local conditions and transportation access, taking advantage of the richness of data for the TMA. The details of the data and the approach are mentioned in the following section.

3. Methodology

3.1. Data

The 2003 TMFS targeted the 119,737 establishments in the TMA, and collected a total of 29,485 responses (the response rate is 24.6%). The sampling frame was designed based on industry and facility type categories using the business records. In the survey, all factories and logistics facilities (warehouses, distribution centers, truck terminals, intermodal facilities and oil terminals) of manufacturing, transportation, wholesale, retail, restaurant and service industries were included in the sampling frame.

The focus of our study is logistics facilities. While the TMFS covers the facilities of various sizes, we only use the records for the facilities that are more than 400 square meters (m^2) in floor area (2,803 samples) out of the entire logistics facility data (4,109 samples); the threshold of 400 m^2 was selected because it includes the facilities that jointly cover approximately 90% of both shipment weights and vehicle trips associated with the logistics facilities. Furthermore, we exclude the facilities that are located in the coastal area of the Tokyo Bay from the analyses. In the TMA, which is the primary international gateway in Japan and has major seaports such as Tokyo, Yokohama, Kawasaki and Chiba, the logistics facilities in the coastal area play a significant role in urban logistics; however, these facilities are located in heavily industrialized areas and are distinct from the inland facilities in terms of function and locational dynamics. Since including the coastal facilities would obscure the important historical trend of the distribution of inland facilities, we only focus on the facilities that are located more than 1.5 km from the coastal line of the Tokyo Bay. After filtering out the facilities under 400 m^2 and those in the coastal area, the final data set consists of 1,971 records (see Table 1 for the breakdown).

Table 1. Sample size of the logistics facilities

		No. of data points
All Logistics Facility with floor area data[1)]		4,109
400 m^2 or larger (2,803 data points)	more than 1.5 km from the coastal line	1,971
	less than 1.5 km from the coastal line	832
Smaller than 400 m^2 (1,306 data points)	more than 1.5 km from the coastal line	1,067
	less than 1.5 km from the coastal line	239

Note: 1) Floor area data is missing for 308 responses. Source: Sakai et al., 2015; TMFS data, calculations by authors.

[1] For a more comprehensive description of the data set and background, see Sakai et al. (2015).

Since only the data from a single year are available, we rely on the year of establishment to analyze the transition of logistics facility distributions. Therefore, the facilities that have been closed or converted to other uses prior to 2003 are not included in the analysis as those facilities were not captured in the 2003 TMFS. This approach could be problematic if there is a correlation between location and the probability of closure or conversion of a facility over time. For example, if the lifespans of logistics facilities tend to be shorter in the central locations than the outer areas, then the data would show a trend of centralization because the data would show newer facilities in the central area (even if the number of facilities in the central area remained constant over the years). Thus, the interpretation of the analysis results requires a great care. On the other hand, in the newly developed areas that had not been occupied, such bias should not exist. Therefore, we can expect the spread of the clusters observed in the analysis shows the actual shifts in the spatial distribution.

The average floor area and the shares of the facilities that satisfy the conditions to be included in the analysis (over 400m^2 of floor area and more than 1.5 km from the coastal line of Tokyo Bay) by year of establishment are shown in Table 2. The facilities existing in 2003 include many old facilities established decades ago. Excluding the facilities established before 1950 that are quite large on average, the average floor area gradually increases until 1990s and then drops in 2000s. The share of the facilities that have the floor area of over 400 m^2 is 68.2 %. After limiting to the inland facilities, the target facilities account for 48.0% or within 32.3% - 49.5% depending on year of establishment.

Table 2. Floor area characteristics of logistics facilities by year of establishment

Year of establishment	Total number of facilities	Avg. floor area (m^2)	Facilities over 400 m^2			
			All		More than 1.5 km from the coastal line of Tokyo Bay	
			(No.)	(%)	(No.)	(%)
-1950	140	4,154	92	61.3%	63	42.0%
1950s	217	2,920	104	44.8%	75	32.3%
1960s	460	3,496	265	53.4%	192	38.7%
1970s	749	3,948	511	64.0%	382	47.9%
1980s	909	4,167	648	67.7%	420	43.9%
1990s	1,131	4,269	819	68.5%	592	49.5%
2000-2003	421	3,286	311	69.3%	209	46.5%
N/A	82	2,557	53	37.9%	38	27.1%
All	4,109	3,891	2,803	68.2%	1,971	48.0%

Source: Sakai et al., 2015; TMFS data, calculations by authors.

We also use the data on demography, transportation infrastructure, land price and land use regulations in the TMA which were downloaded from public archives of the Government of Japan.

3.2. Analysis of spatial distribution of logistics facilities

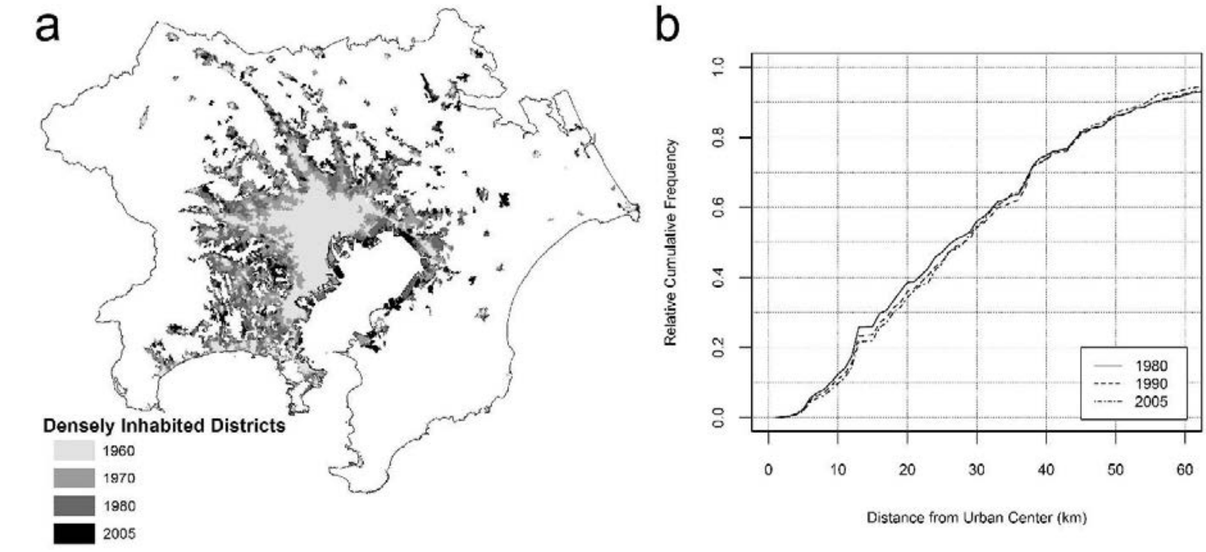
After a brief review of population and densely inhabited areas, transportation infrastructure, land price and land-use regulations in the TMA, we analyze the transition of logistics facility distribution applying a method called Kernel Density Estimation (KDE). The estimated spatial density based on KDE enables the visualization of the concentration of objects that are spatially spread, and thus, facilitates the intuitive understanding of the distribution. In this study, KDE is applied to the facilities established during every six years from 1980 to 2003. Kernel function and bandwidth, which defines the size of kernel, are free parameters while the selection of them changes the output (e.g. a bigger bandwidth results in larger clusters). Gaussian distribution is applied as a kernel function and the bandwidth, the standard deviation of isotropic Gaussian smoothing kernel, is set as 3 km, which we consider appropriate for this data set after several trials with different bandwidth values. In the analysis, we refer the location in front of the Tokyo Railway Station, which is the central point of the road network consisting of ring and radial roadways in the TMA and the most expensive land in Japan, as "urban center" and use the location as the key reference point for measuring spatial distribution over time.

While one of the study objectives is to analyze the pattern of spatial distribution of logistics facilities over time, we are also interested in how land price, especially the asset bubble during the period 1986-1991, affected the observed pattern. The distribution of logistics facilities is, therefore, analyzed across time in comparison with land price changes in some key locations in the TMA. Furthermore, we qualitatively assess how land-use regulations have affected the locations of logistics facilities and explore the policy implications.

4. Population, Transportation, Land Price and Land-use Regulations

4.1. Population and densely inhabited area

The population in the TMA, the survey area for the 2003 TMFS, was 36 million (28 % of the total for Japan) at the time of the survey (MIAC, 2005). Fig. 1.(a) depicts the spatial distribution of the population in the TMA based on the spread of "densely inhibited districts", which are defined as the areas exceeding 4,000 per square kilometer in population density. The figure indicates that a significant outward migration of the population occurred between 1960 and 1980; however, between 1980 and 2005, the pace of the migration slowed down considerably. The cumulative distribution curves for 1980, 1990 and 2005, shown in Fig. 1.(b), confirm that the TMA did not experience a sprawl during the period 1980-2005, in terms of population, unlike many other large urban areas in developed countries. The average distance from the urban center increased by only 0.4 km from 1980 to 2005. As such, it is reasonable to assume that the influence of the demographic change on the logistics facility distribution would have been limited in the TMA.

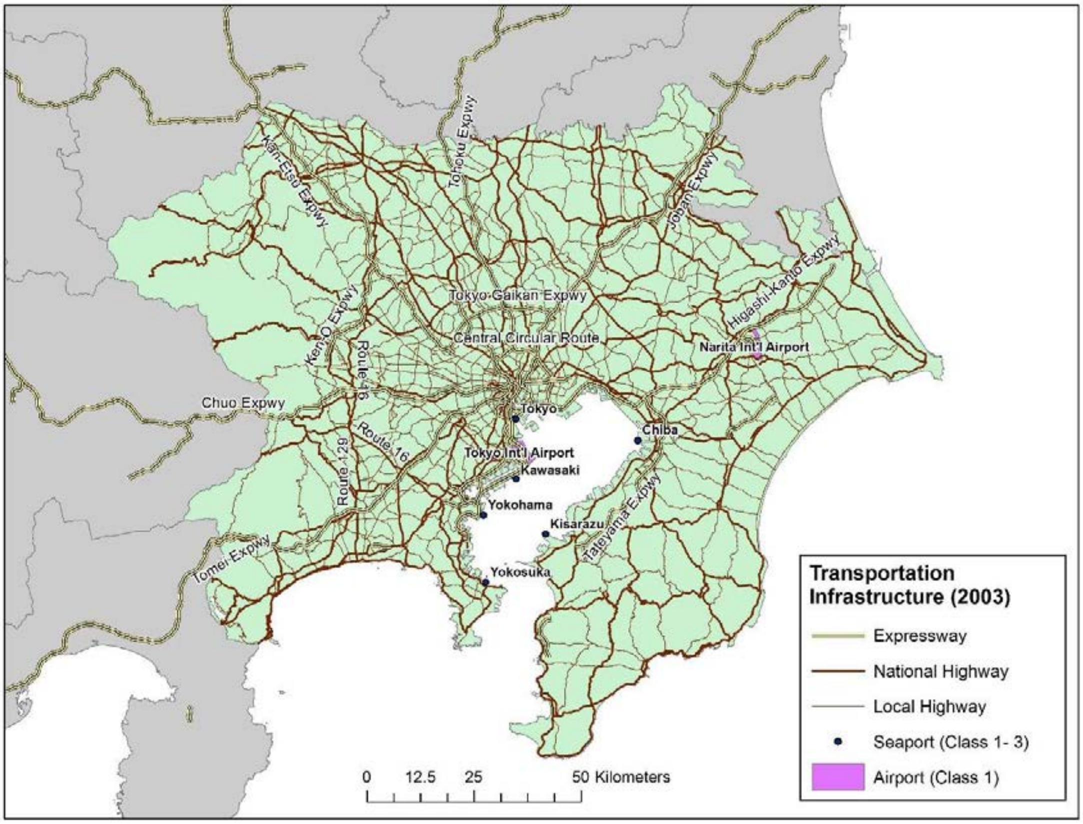


Source: Sakai et al, 2015; MIAC, 2014; MLITT, 1960, 1970, 1980, 2005, visualization by authors.

Fig. 1. (a) Spread of densely inhabited districts (1960, 1970, 1980 and 2005); (b) Distribution of population (1980, 1990 and 2005)

4.2. Transportation infrastructure

The TMA is characterized as the primary international gateway city in Japan, having two international airports and several large seaports along the Tokyo Bay (Fig. 2). Because of the significant traffic demand which often overwhelms the road network, the level of congestion in the TMA is extreme. The accessibility in the TMA, measured as the total land area that can be covered within one hour of travel by auto from the urban center, is less than half of those in Paris, New York, or Berlin while the sizes of the metropolitan areas are comparable (MLITT, 2011). The expressway network of three ring and nine radial roads was planned in 1963. However, the government has faced the difficulty on land acquisition for ring roads and the construction has not progressed substantially; only the northern and the eastern sections of Central Circular Route (ring road 1), the northern sections of Tokyo Gaikan Expressway (ring road 2) and the north-west sections of Ken-O Expressway (ring road 3) have been completed before 2003. Meanwhile, the government has been more successful in the construction of the radial roads; nearly all the radial road sections had been completed before the 1980s. The unfinished expressway network put stress on many surface roads that must carry the burden of the missing ring road sections. Between 2003 and today, a significant progress has been made in the development of ring roads in the TMA although it is still far from the completion of the entire network. The impact of such road system development on logistics facilities should be analyzed but it is out of the scope of this study using the 2003 TMFS data.

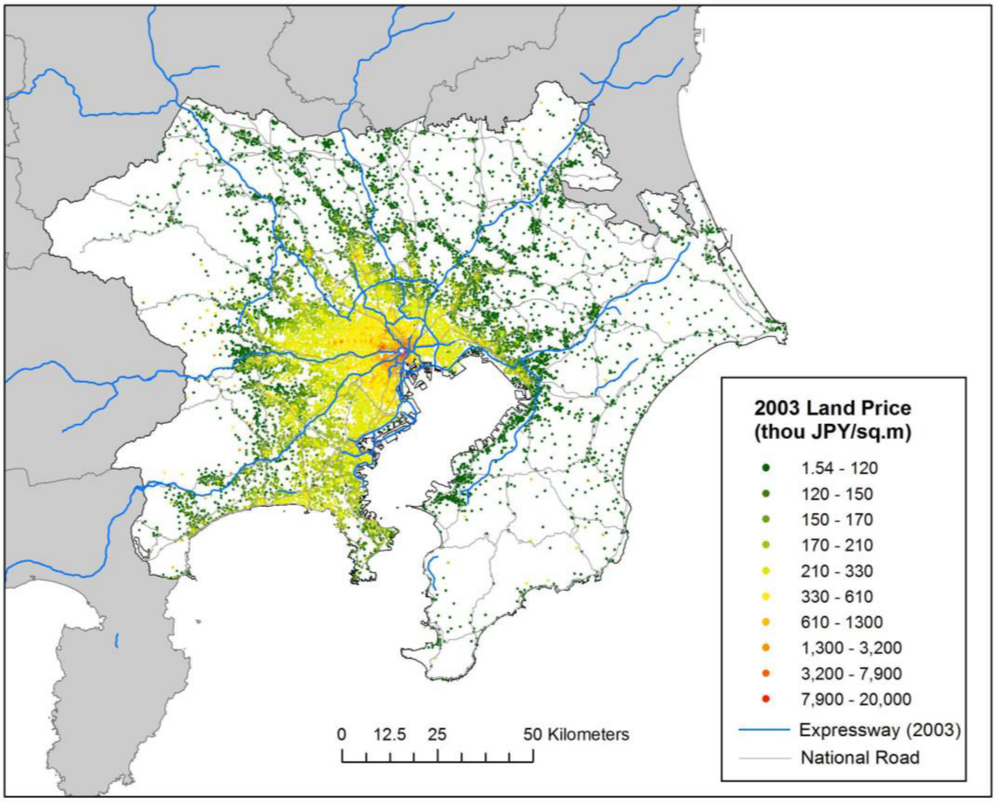


Note: National and local road network shows the system circa 1995. Source: Sakai et al., 2015; MLITT, 1996, 2003, 2008, 2012a, 2012b, visualization by authors.

Fig. 2. Transportation infrastructure in the Tokyo Metropolitan Area

4.3. Land price

Fig. 3 shows the official land prices in 2003 in the TMA based on the Publication of Land Prices and Prefectural Land Price Surveys (MLITT 1983-2003a,b). Such price was surveyed by the public sector, choosing the land that is considered typical at various aspects including land-use type in each of the corresponding areas. The pattern shown in Fig. 3 closely follows the densely inhabited districts that were shown in Fig. 1.(a). The land price is the highest in the urban center and, generally speaking, decreases for the areas that are farther away from the urban center. While the accessibility of the central locations should be attractive to many logistics operators, they need to consider the trade-off among the land price, accessibility and reliability (traffic congestion is more intense at the closer locations to the urban center). Land price is also related to the road network; lands along the major roads (both expressways and "national roads" that are major surface roads) show high prices relative to the locations in their surrounding areas, resulting in several prominent "fingers" of corridors in the figure. Lack of the strong ring road system and the monocentric land price distribution imply that the increase in land price would likely to force logistics facilities to choose locations that are farther away from the urban center.



Source: MLITT, 1983-2003a,b, 1996, 2003, 2012b, visualization by authors.

Fig. 3. Official land price in 2003

4.4. Land-use regulations[1]

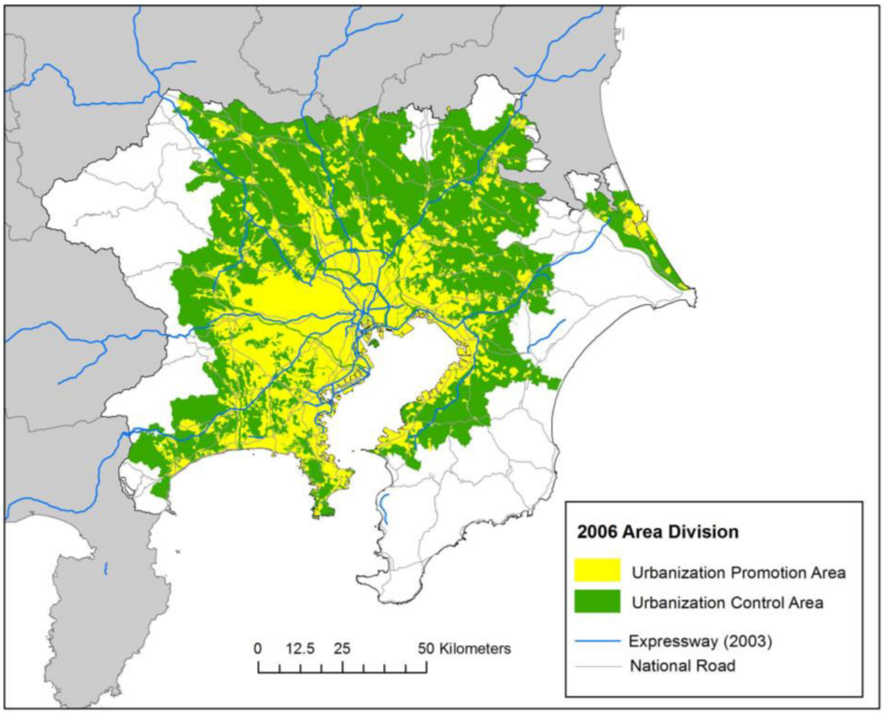
In Japan, the authority for land-use regulations resides with the prefectural governments. In the study area, there are the five prefectures and they set two types of regulations: Area Divisions and Zoning Districts.

Area Divisions are applied to some parts of the study area and consist of two categories: Urbanization Promotion Area (UPA) and Urbanization Control Area (UCA) (See Fig. 4). UPA is applied to the areas that are urbanized or planned for urbanization within roughly 10 years while UCA designation is given to the areas where development is strictly controlled to avoid urbanization (the development is limited to only 14 special cases that are defined in the City Planning Act). Zoning Districts are used to regulate the use type of the land. Most of the lands in UPA are specified as Land-use Zoning district, one of the 16 categories of the Zoning Districts, where one of nine land-use

[1] The framework of land-use regulations in Japan is stipulated in the City Planning Act (2014).

zone categories must be specified for the land. In general, the development of logistics facilities is possible in the areas designated as one of the five land-use zone categories (a residential use, two commercial use and three industrial use categories). Any development requires a permission of the prefectural governor, or in case of a city designated by an ordinance, the mayor (such city - there are five in the TMA - should have population of more than half million). As long as the regulations are satisfied and no laws are violated, the permission must be granted. However, the development permission for the areas in UCA is given only as an exception and must go through a rigorous process.

Thus, in the TMA (and other cities in Japan) land use is regulated by prefectures that can be considered as equivalent of states in the US in terms of government hierarchy, than small local municipalities. In terms of size, prefectures are roughly similar to urban counties in the US, typically ranging from 2,000 to 10,000 km^2 with some exceptions.



Note: Blank area is uncontrolled, for which Area Division is not specified. Source: MLITT, 2006, visualization by authors.

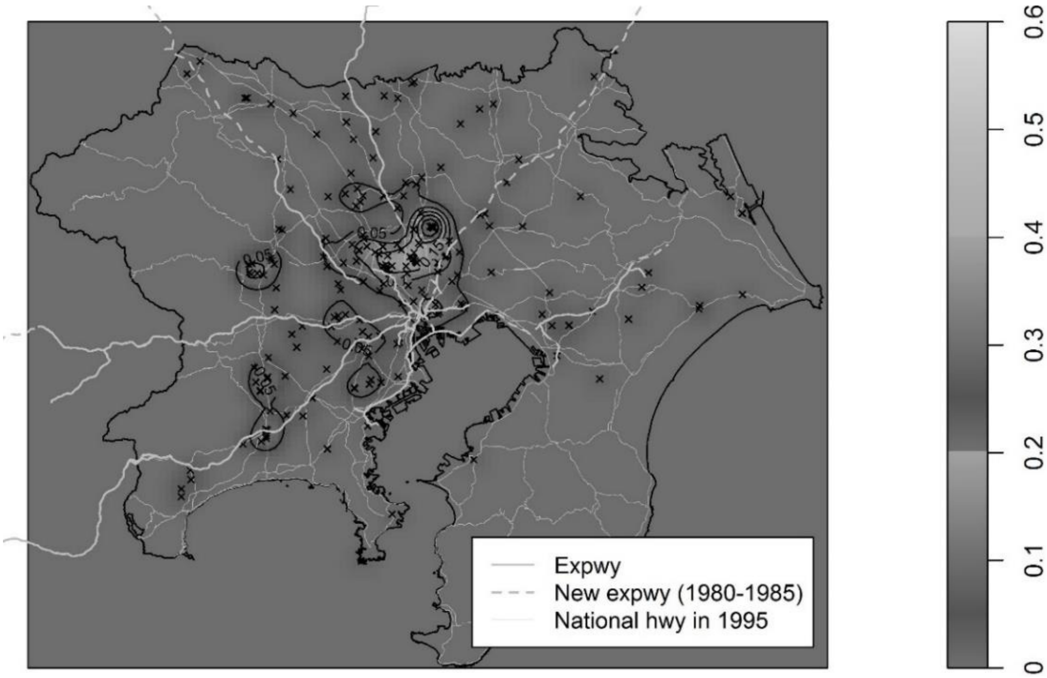
Fig. 4. Area Division in 2006

5. The Geography of Logistics Facilities in the Tokyo Metropolitan Area

5.1. Historical trend in inland logistics facility distribution

The distribution of new logistics facilities in the inland area (more than 1.5 km from the coastal line) during the period 1980-2003 was visualized for every six years using the KDE method. Fig. 5 to 8 indicate that the locational pattern of logistics facilities has changed over the years. A brief summary of the trend observed for each time period is provided below. From 1980 to 1985, the newly established facilities formed a single, high-density cluster, roughly 15-20 km to the north from the urban center around Route 298 (the northern section of Tokyo Gaikan Expressway (ring road 2) is parallel to this road but the operation had not started until 1992). Although some facilities are located outside of the cluster, they are dispersed over the study area. Compared with the previous six years, the main cluster of the facilities established between 1986 and 1991 stretches in the east-west direction, especially, to the west. Also, modest concentrations can be observed along Route 16 (roughly 40 km to the west from the urban center), at the intersection of Route 129 and Tomei Expressway (50 km to the south-west), and along the Higashi-Kanto Expressway (50 km to the east). During the period 1992-1997, the new logistics facilities spread more widely, mainly toward the west and the north-west directions. The concentration in the area that lies south-west from the urban center, along Tomei-Expressway, is also intense. The average distance from the urban center is the highest in this period. Finally, during the period 1998-2003, the main clusters of new facilities were formed along the Tokyo Gaikan Expressway (15-20 km to the north from the urban center) and Route 16- Route 129 - Tomei Expressway (40-50 km to the west and the south-west from the urban center). Also, a relatively intense density of logistics facilities can be seen along Tohoku-Expressway, roughly 35 km to the north from the urban center. The development during this time period shows a higher level of clustering compared with the previous time period.

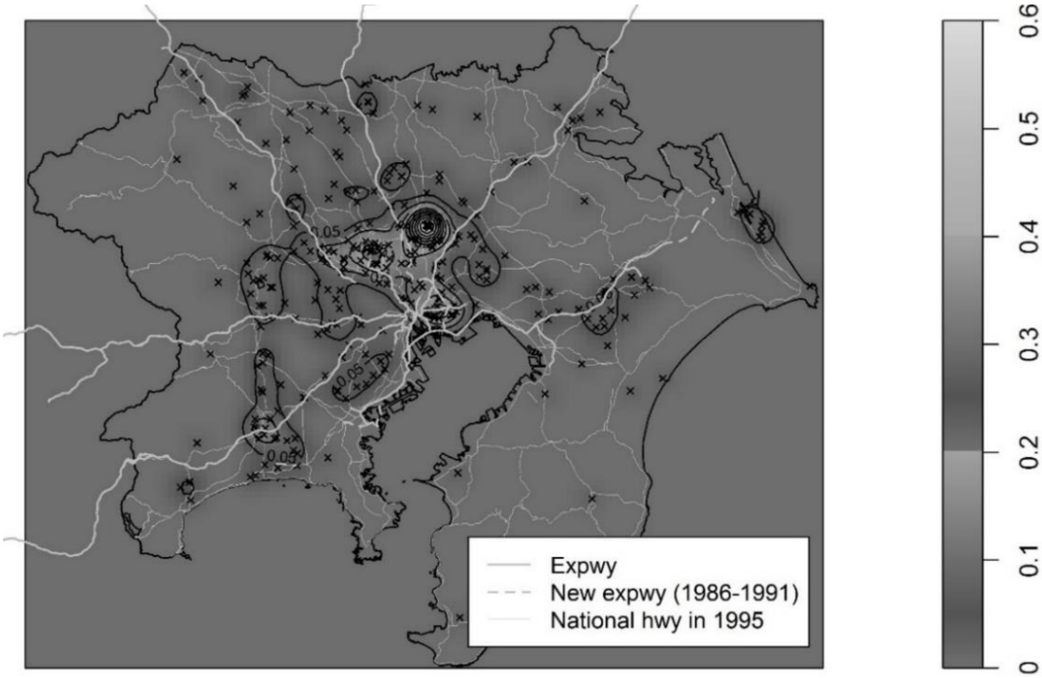
Table 3 summarizes the distance from the urban center, 2003 land price and floor area of the facilities established in each of the target time periods. The average distance from the urban center increased during the first three periods of the analysis, 1980-1985, 1986-1991 and 1992-1997, and then dropped for the last period, 1998-2003. While the average distance of the logistics facilities established prior to 1980 from the urban center is 26.5 km, the average for all the existing logistics facilities in 2003 is 30.7 km[1], which is higher by 4.2 km. On the other hand, the average distance of the population from the urban center increased only by 0.4 km during the period 1980-2005 (MIAC, 2014). Similar to the studies of other cities, such as Dablanc and Rakotonarivo (2010) and Dablanc and Ross (2012), the result supports the occurrence of logistics sprawl in the TMA although the possible bias caused by the closure or conversion of facilities has to be taken into account.



Source: TMFS data, visualization by authors.

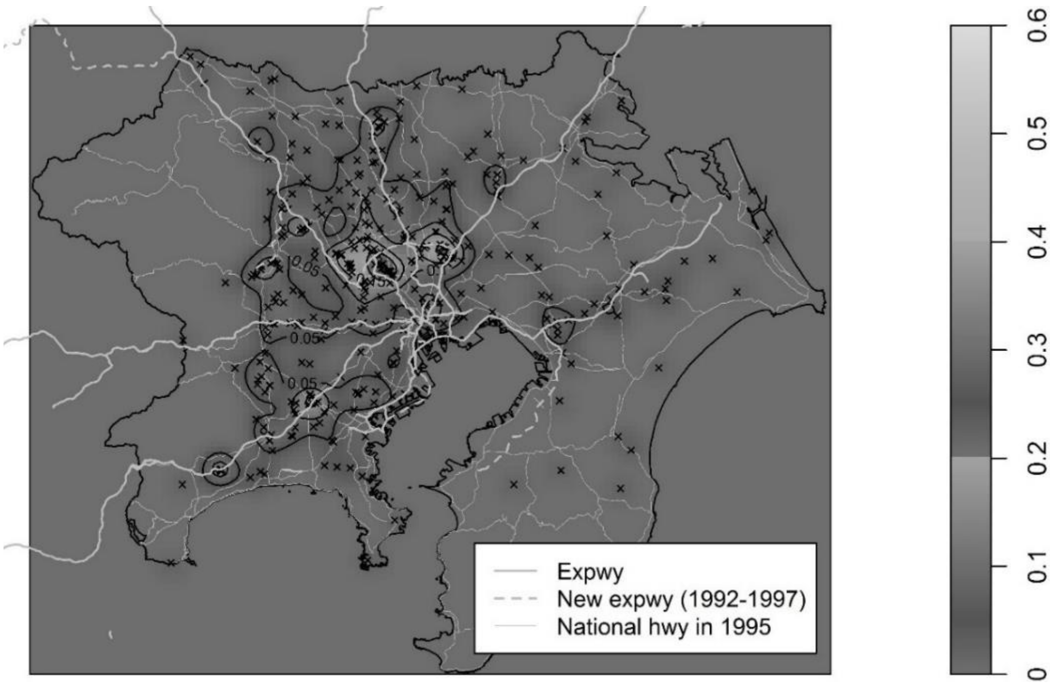
Fig. 5. The distribution of inland logistics facilities established during 1980 – 1985

[1] Exact locations of the logistics facilities are used in this research while Sakai et al. (2015) use approximate locations, which are the centroids of local municipality boundaries in which the logistics facilities are located, for the similar analysis. This makes a slight but insignificant difference between the two researches.



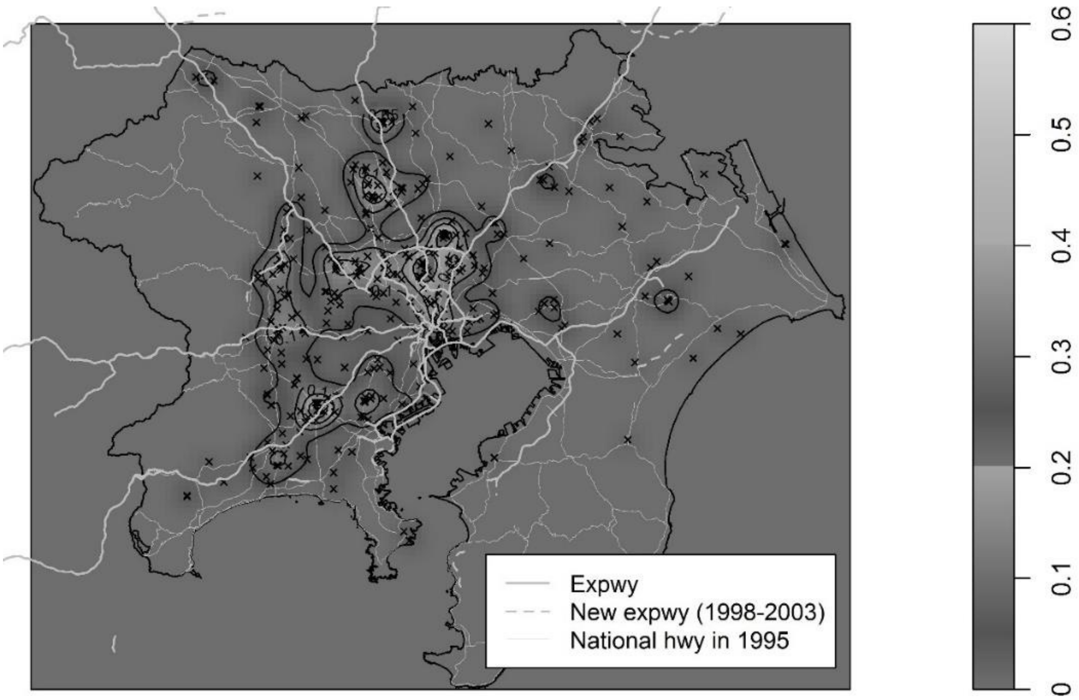
Source: TMFS data, visualization by authors.

Fig. 6. The distribution of inland logistics facilities established during 1986 – 1991



Source: TMFS data, visualization by authors.

Fig. 7. The distribution of inland logistics facilities established during 1992 – 1997



Source: TMFS data, visualization by authors.

Fig. 8. The distribution of inland logistics facilities established during 1998 – 2003

Table 3. Distance from the urban center, land price and floor area

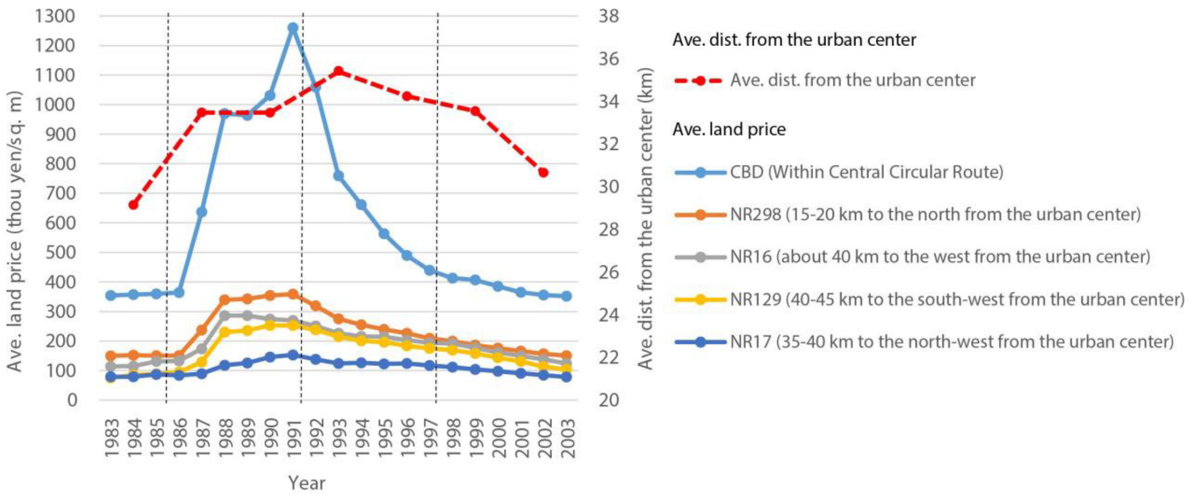
Year of establishment	No. of samples	Ave. dist. from the urban center (km)	Ave. land price in 2003 2) (thou yen/m^2)	Floor area (m^2)	
				Median	Mean
Before 1980	712	26.5 (5)1)	212.1 (1)	1,465 (5)	4,266 (3)
1980-1985	214	31.0 (4)	158.0 (2)	1,520 (4)	4,217 (4)
1986-1991	312	33.5 (2)	142.3 (4)	1,866 (1)	4,461 (1)
1992-1997	354	34.8 (1)	139.0 (5)	1,754 (2)	4,332 (2)
1998-2003	341	32.6 (3)	147.4 (3)	1,600 (3)	4,064 (5)
All in 2003	1971	30.7	171.0	1,600	4,229

Note: 1) Numbers in parentheses show rankings (1 for the highest and 5 for the lowest). 2) Land price data is based on official land prices (Publication of Land Prices and Prefectural Land Price Surveys). The price of the nearest point from a facility, which is not farther than 5 km from the facility, was applied as an approximation. Source: TMFS data and MLITT, 1983-2003a,b calculations by authors.

5.2. Possible relation between facility locations and 1986-1991 asset price bubble

Table 3 indicates a negative association between average distance from the urban center and land price. This is not surprising as the TMA is strongly monocentric, and as more facilities migrate outward to inexpensive areas, the average price would decrease. The TMA has experienced a significant asset price bubble between 1986 and 1991. Fig. 9 shows the historical land prices (for industrial land-use zones based on Zoning Districts) in five key areas for logistics facilities in the TMA. The figure also includes a graph of the average distances of the logistics facilities from the urban center (the average of every three years from 1983). The increase in land price during 1986-1991, especially at the CBD is extreme. Land price at the CBD peaked in 1991 at the level that was 3.5 times higher than the price in 1986, then dropped, drastically at first, then more gradually after 1993. Although the changes in the land prices at the other areas are not as extreme as at the CBD, they follow a similar pattern. The period 1992-1997, during which the land price dropped significantly, is also the period when the outward migration of the new facilities was most pronounced. This suggests that there was a time lag before the effect of a decrease in the land price was reflected in the logistics facility location choices. Also, it is important to note that the land prices in the CBD did not return to the pre-bubble level until around 2002. It seems plausible that logistics entities were not willing to locate their facilities in the areas where the land prices remained above the level they considered reasonable or they expected the prices to fall farther. The sprawl of logistics facilities started with the asset price bubble in 1986 and the more compact distribution around 2002 indicate that there is a threshold land price for logistics facilities to be located near the urban center.

The above discussion ignores other factors widely believed to influence logistics facility distribution such as traffic conditions, changes in the shipment demands and logistics practices, and land availability. However, the analysis is likely to support the assertion that the dynamic land price change during the asset bubble was a contributing factor for the logistics sprawl in the TMA.



Note: Average price of lands for industrial use at 2005 constant price. Source: MLITT, 1983-2003a,b, visualization by authors.

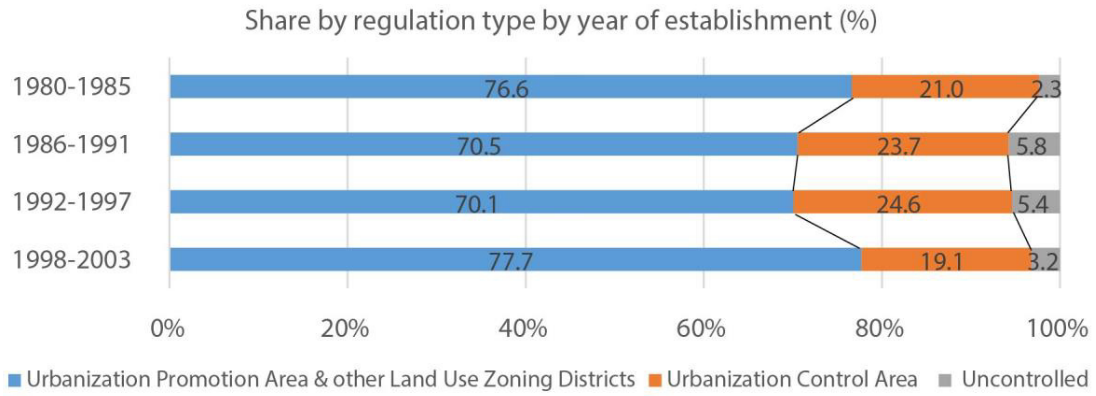
Fig. 9. Dynamics of land price in the Tokyo Metropolitan Area

5.3. Could land-use regulations have worked against logistics sprawl?

In this section, we will discuss how the land-use regulation framework might have affected the logistics sprawl during and after the asset price bubble. Fig. 10 shows the land-use regulation type based on the 2006 Area Division for the locations of logistics facilities in our data set (1,971 records). It should be noted that we were not able to obtain the data on the Area Division for the earlier periods. Therefore, there is a possibility that the conversion of the category occurred in some cases; however, we believe that such changes were rare and do not affect the overall findings presented here. The shares of the facilities in the UCA and the uncontrolled areas, which are generally exurban locations that are neither UPA nor UCA, are higher for the facilities established during the middle periods, i.e. 1986-1991 and 1992-1997, than the shares for the facilities established earlier or later periods. It implies that logistics entities faced difficulty in finding desirable spaces in UPA and/or the enforcement of the regulations in UCA was less strict during the period.

The fact that many new logistics facilities built during and after the bubble were in the uncontrolled areas that are mostly in the exurbs is worthy of attention. The increase in the facilities in the uncontrolled areas suggests that a policy or a guidance that allows some flexibility in the developments in the UCA may have been effective for easing the pressure of exurban development caused by the asset bubble. UPA and UCA and land-use zoning are considered as effective tools for controlling the sprawl in general. However, as seen in some other large urban areas, those policies, if not applied carefully, can lead to "leap frog" developments that only exacerbate sprawl.

Interestingly, the Japanese government tried to introduce flexibility in the land use regulation, albeit long after the end of the bubble. In 2005, the national government enacted the Act on Advancement of Integration and Streamlining of Distribution Business (AAISDB). The AAISDB broadens opportunities for logistics entities to develop their facilities in UCA by allowing such developments if they contribute to the streamlining of operations of applicant entities; the evaluation process includes the estimation of carbon emission reduction. By September 2013, 197 AAISDB projects including 40 in the TMA were approved (MLITT, 2015). The enactment of the AAISDB suggests that the government was cognizant of the shortage of the land available for new logistics facilities. The effects of the policy on the logistics facilities' distribution and shipment efficiency should be studied to determine its efficacy.



Source: TMFS data and MLITT, 2006, visualization by authors.

Fig. 10. 2006 Area Division applied in the locations of logistics facilities

6. Conclusion

Using the large scale urban freight survey data and available geographic information for the TMA, we analyzed the distribution of logistics facility locations by categorizing the facilities by time of establishment. We also examined the effects of land price on the distribution of logistics facilities. The asset bubble that occurred in the late 1980s and its aftermath presented a unique case study on how drastic fluctuations in land price affects logistics facilities. The analysis indicates a long-term trend of logistics decentralization in the TMA, which likely occurred independently from the distribution of population. We also found that the decentralization was most conspicuous during and just after the asset price bubble. During the years after the land price returned to the pre-bubble level and stabilized, which is around 2002, the decentralization trend was less remarkable.

Land development in Japan is controlled mainly by prefectural governments instead municipalities and there are strict regulations to contain urbanization. Those mechanisms, however, backfired during the asset bubble because many new logistics facilities were built in the uncontrolled areas in a leapfrogging fashion similar to those observed in cities with growth boundaries. To prevent leapfrogging developments, careful monitoring of logistics facility developments and the balance in the demand and supply of lands that are available for logistics facilities is necessary. This study suggests that logistics facilities are affected by land price, which in itself is not surprising. However, there seem to be some peculiarities in the relationship between the land price and the locational choice for logistics facilities. The detailed study in the demand and supply of logistics land use may further unveil the mechanism of the outward migration and subsequent return of the logistics facilities in the TMA.

Though this study did not address thoroughly, public policies related to logistics facilities, such as land use regulations, development permissions at controlled areas and public supports for the development of urban distribution centers, would possibly be important factors for the logistics facility distribution. Also, understanding of the effects of public policies such as AAISDB is indispensable for managing the urban logistics system. One avenue of research that would be of tremendous value is the analysis of policy effects on the spatial distribution of logistics facilities and resulting effects on efficiency.

Acknowledgements

We would like to thank the Transport Planning Commission of the Tokyo Metropolitan Region for sharing the 2003 TMFS data for this research. This research was partly supported by the Department of Urban Planning and Policy at the University of Illinois at Chicago, Volvo Research & Educational Foundations through the Center of Excellence on Sustainable Urban Freight Systems and the National Center for Freight and Infrastructure Research and Education (CFIRE). CFIRE is a national university transportation center supported by the US Department of Transportation.

References

Cidell, J. (2010). Concentration and decentralization: the new geography of freight distribution in US metropolitan areas. Journal of Transport Geography, 18, 363-371.

City Planning Act. Act No. 109 of November 19, 2014. (2014).

Dablanc, L., Ogilvie, S., & Goodchild, A. (2014). Logistics sprawl: differential warehousing development patterns in Los Angeles and Seattle. Proceedings of the 93rd Annual Meeting of the Transportation Research Board. Washington D.C., USA.

Dablanc, L., & Rakotonarivo, D. (2010). The impacts of logistics sprawl: How does the location of parcel transport terminals affect the energy efficiency of goods' movements in Paris and what can we do about it?. Procedia-Social and Behavioral Sciences, 2(3), 6087-6096.

Dablanc, L., & Ross, C. (2012). Atlanta: a mega logistics center in the Piedmont Atlantic Megaregion (PAM). Journal of transport geography, 24, 432-442.

Hagino, Y., & Endo, K. (2007). A potential analysis of distribution facilities locations using discrete choice modeling in Tokyo Metropolitan Region. Infrastructure Planning Review, 24, 103-110.

Ministry of Internal Affairs and Communications. (2005). 2005 National Census. http://e-stat.go.jp/SG2/eStatGIS/page/download.html. Accessed on 01 May 2014.

Ministry of Internal Affairs and Communications. (2014). Population in municipalities 1980 to 2010. http://www.e-stat.go.jp/SG1/estat/eStatTopPortal.do. Accessed on 27 May 2014.

Ministry of Land, Infrastructure, Transport and Tourism. (1960, 1970, 1980, 2005). National Land Numerical Information (Density Inhabited District). http://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-A16.html. Accessed on 20 January 2014.

Ministry of Land, Infrastructure, Transport and Tourism. (1983-2003a). National Land Numerical Information (Publication of Land Prices). http://nlftp.mlit.go.jp/ksj/gml/ datalist/KsjTmplt-L01-v2_2.html. Accessed on 19 March 2014.

Ministry of Land, Infrastructure, Transport and Tourism. (1983-2003b). National Land Numerical Information (Prefectural Land Price Surveys). http://nlftp.mlit.go.jp/ksj/gml/ datalist/KsjTmplt-L02-v2_3.html. Accessed on 21 March 2014.

Ministry of Land, Infrastructure, Transport and Tourism. (1996). National Land Numerical Information (Road). http://nlftp.mlit.go.jp/ksj/gmlold/index.html. Accessed on 26 May 2014.

Ministry of Land, Infrastructure, Transport and Tourism. (2003). National Land Numerical Information (Administrative Zones). http://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-N03.html. Accessed on 16 January 2014.

Ministry of Land, Infrastructure, Transport and Tourism. (2006). National Land Numerical Information (City Areas). http://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-A09.html. Accessed on 24 January 2015.

Ministry of Land, Infrastructure, Transport and Tourism. (2008). National Land Numerical Information (Port). http://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-C02.html. Accessed on 01 May 2014.

Ministry of Land, Infrastructure, Transport, and Tourism. (2011). Vision for the Expressway System - Interim Report (Kongo no Kousoku Douro no Arikata - Chuukan Torimatome). Committee on the Vision for the Expressway System.

Ministry of Land, Infrastructure, Transport and Tourism. (2012a). National Land Numerical Information (Airport). http://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-C28-v2_3.html. Accessed on 01 May 2014.

Ministry of Land, Infrastructure, Transport and Tourism. (2012b). National Land Numerical Information (Expressway Time-series). http://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-N06-v1_1.html. Accessed on 16 January 2014.

Ministry of Land, Infrastructure, Transport and Tourism. (2015). Act on Advancement of Integration and Streamlining of Distribution Business. http://www.mlit.go.jp/seisakutokatsu/freight/butsuryu05300.html. Accessed on 27 January 2015.

Nguyen, Y. C., & Sano, K. (2010). Location choice model for logistic firms with consideration of spatial effects. Proceedings of the 89th Annual Meeting of the Transportation Research Board. Washington D.C., USA.

Sakai, T., Kawamura, K., & Hyodo, T. (2015). Locational dynamics of logistics facilities: Evidence from Tokyo. Journal of Transport Geography, 46, 10-19.

Van den Heuvel, F. P., De Langen, P. W., van Donselaar, K. H., & Fransoo, J. C. (2013). Spatial concentration and location dynamics in logistics: the case of a Dutch province. Journal of Transport Geography, 28, 39-48.

Woudsma, C., Jensen, J. F., Kanaroglou, P., & Maoh, H. (2008). Logistics land use and the city: A spatial–temporal modeling approach. Transportation Research Part E: Logistics and Transportation Review, 44(2), 277-297.