



Spatial reorganization of urban logistics system and its impacts: Case of Tokyo



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ABSTRACT

We use the comprehensive freight survey data from 2003 and 2013 to analyze how the restructuring of logistics industry that occurred amid the broad trend of decentralization in the Tokyo Metropolitan Area has affected the efficiency of truck shipments. The analysis reveals that the negative effects of the outward migration of logistics facilities were offset by the increase in average shipment load and efficient spatial distribution of logistics facilities that occurred in parallel with the decentralization. As a result, the truck shipment efficiency improved by 4%.

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1. Introduction

The spatial distribution of logistics facilities (e.g. distribution centers and warehouses) observed in large cities around the world, especially in North American and European cities, is becoming a germane topic of discussion for researchers and practitioners engaged in transport and urban planning. The advances in the Information and Communication Technologies (ICT) and globalization have led to the evolutions in logistics operations and supply chain management practices and also the restructuring of urban freight systems (Hesse and Rodrigue, 2004). While facilities with larger footprints are desired for modern supply chains, appropriate sites are rarely found near the urban centers where many activities are concentrated, traffic is congested, and the land value is prohibitively high. As a result, logistics sprawl, “the movement of logistics facilities away from urban centers” (Dablanc et al., 2014) has occurred in many metropolitan regions. The outward migration of logistics facilities is a concern because it may lead to an increase in vehicle-kilometer-traveled (VKT) and exacerbate negative externalities, such as traffic congestion, carbon emissions, local air pollution, infrastructure damage and traffic accidents.

In recent years, a large number of studies of logistics sprawl have been conducted in various cities around the world. In most studies, the outward migration of logistics facilities was verified. On the other hand, studies that measure traffic impacts of such outward migration have been almost nonexistent due to the fact that such study requires

shipment data at a reasonable level of geographic resolution if not at the facility level. One such study is Sakai et al. (2015) that use the Tokyo Metropolitan Freight Survey (TMFS) from 2003 to examine the inefficiencies associated with the outward migration of logistics facilities observed for the Tokyo Metropolitan Area (TMA). Their analysis identifies the outward migration of logistics facilities in the TMA and also finds higher shipment inefficiencies for the logistics facilities that are located far from the urban center. However, the study is limited in that it relies on the data from a single year; especially, the changes in the spatial distribution of shipment demand cannot be measured accurately without the data from more than one time period.

In 2013, the latest urban freight establishment survey (2013 TMFS) was conducted in the TMA with a survey design similar to the 2003 version of the TMFS. In this study, we use both 2003 and 2013 TMFS to overcome the limitations of Sakai et al. (2015) and expand the analysis to reveal how the outward migration of logistics facilities influences truck shipments. We combine the TMFS data with other socio-economic data to analyze the changes in urban structure, including the distributions of shipment demand locations, and urban freight system in the TMA. As far as we know, this is the first detailed diagnosis of the dynamics of the migration of logistics facilities and its impacts on truck shipments based on the comprehensive freight survey data from two different years, and we believe this paper contributes beneficial insights for the research on the spatial distribution of logistics facilities.

The rest of the paper consists of the following contents; in Section 2, we introduce the literature on the structural changes that modern logistics practices have gone through in the past few decades, the measurements of the outward migration of logistics facilities, and the impacts of such migration; in Section 3, the data and the methodology of the

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analysis are discussed; in Section 4, the results of the analysis are presented and the findings are discussed; finally, Section 5 concludes the paper with a summary of the findings and their implications.

2. Literature review

In this section, we first provide a brief overview of the changes in logistics and supply chain industries that took place over the last two to three decades and associated impacts. The discussion is intentionally brief since there are many references on the topic including the ones mentioned here. We then provide a more detailed review of research on the outward migration of logistics facilities, followed by the discussion of the gaps in the existing literature.

2.1. Transformation of logistics operations and its impacts

The evolutions in the logistics operations that took place during the last two to three decades have led to the changes in the location and design of logistics facilities such as distribution centers and warehouses. Hesse and Rodrigue (2004) argue that various components of logistics activities have adapted to the process of globalization and the innovations in the ICT. The globalization, or the rise of global production networks (Coe et al., 2004), entails the fragmentation of spatial locations for production, which requires supply chain management that integrates various logistics components and realizes the complex institutes of production and transport. Such process of integration cannot be achieved without managing information flows by the ICT connecting the different components of supply chain and making them function seamlessly. The transformation of logistics operations and the supply chain managements that are based on the demand-side information, instead of supply-side information, allowed logistics operators to minimize their total operation cost through the decrease in inventory cost. This has led to the need for modern logistics facilities that are designed to handle higher through-put in an efficient manner, instead of storing products as the foremost objective. Such process of logistics evolution is backed by several empirical evidences (e.g. Allen et al., 2012; Hesse and Rodrigue, 2004; McKinnon, 2009). The changes in logistics operations enhance the values of land that have sound transport access and also are relatively inexpensive and expandable, as potential sites for new logistics facilities (Hesse, 2004). Wachs (2013) argues that the evolution in logistics operations also supports the restructuring in urban centers. He argues that the activities in the increasingly dense urban centers are sustained by efficient freight systems, though such relationships are often ignored by the proponents of the new urbanism in the US.

2.2. Outward migration of logistics facilities

Given the global trend of urban growth and the increases in population density and land-price in the urban centers of many cities, it is a plausible hypothesis that the transformation of the industry mentioned earlier has led to the outward migration of logistics facilities. A good number of research in recent years measure the outward migration of logistics facilities, including Paris (Dablanc and Rakotonarivo, 2010; Heitz and Dablanc, 2015), Toronto (Woudsma et al., 2016), Atlanta (Dablanc and Ross, 2012), Los Angeles and Seattle (Dablanc et al., 2014), Tokyo (Sakai et al., 2015) and Zurich (Todesco et al., 2016). Those studies typically compare the change in the distance of logistics facilities from a reference central location (this is, in most studies, the geometric center) against that of business establishments or population. For example, Dablanc and Ross (2012) find that between 1998 and 2008, the average distance of all establishments from the geometric center increased by 1.3 miles (2.1 km) while that of warehousing establishments increased by 2.8 miles (4.5 km) in the Atlanta metropolitan area. They call such phenomenon “relative (logistics) sprawl”, which is defined as more pronounced outward migration of logistics facilities

than that of the businesses as a whole. Like Atlanta, most of other cities studied, excluding Seattle, have experienced the outward migration of logistics facilities, though the details and the process are not necessarily the same among the cities. Some of the studies also focus on the difference between the distributions of facilities by operator type. For example, Todesco et al. (2016) find the outward migration occurred for the storage and courier services establishments but not for those operated by freight transport and postal services. Heitz and Beziat (2016) compare the distributions of the parcel industry and other logistics activities in the Paris region and find that the former is more centralized. Cidell (2010) targets the fifty largest metropolitan areas in the US and analyzes the locations of warehousing establishments across the country and within the metropolitan areas. She finds that in many cities in the US, the numbers of warehousing establishments grew faster in the suburban counties than their central counterparts both in numbers and percentages and confirms the decentralization in most of the cities examined during 1986–2005.

As those studies indicate, the outward migration of logistics facilities is actually widely observed, especially in the North American and European cities. On the other hand, the impacts of such migration, including how it affects the movement of freight and truck travel in urban areas, have not been examined rigorously (Aljohani and Thompson, 2016). Although the evaluation of the systems adapting urban distribution centers, given the pre-determined shipment demands, is one of the major subjects in city logistics research (e.g. Taniguchi et al., 1999; Kia et al., 2003; Crainic et al., 2004; van Duin et al., 2012), those research focus on a subset of urban logistics system, rather than the spatial distribution of numerous logistics facilities of various types. Notable efforts include Wagner (2010)'s traffic impact assessment of logistics-related land use. She uses the data from Hamburg, Germany, to compare the impacts of a large freight village near the urban center with those of several smaller sites for logistics activities that are away. The analysis indicates that the former produces less traffic impacts due to the fact that the increase in the distance from the city center contributes to the additional lorry-kilometer-traveled. On the other hand, Davydenko et al. (2013) use a logistics chain model to evaluate the impacts of logistics sprawl in the Netherlands. They find that centralization (or decentralization) of logistics facilities in the Randstad region has only limited impacts on traffic. However, their model is at the national level and is not necessarily transferable to urban areas. Sakai et al. (2015) use the data of establishments and their shipments from the 2003 TMFS to empirically analyze the impacts of the outward migration of logistics facilities. The study compares the actual shipment distances against those under the optimized condition in which each logistics facility is assumed to be at the location that minimizes the sum of the shipment distances given actual origins and destinations of shipments. They find that the distance from the urban center positively correlates with the gap between the actual and optimum shipment distances.

2.3. Aim of this research

While the impacts associated with the outward migration of logistics facilities have been studied using models (Wagner, 2010; Davydenko et al., 2013) and the actual shipment data (Sakai et al. 2015), they are cross-sectional studies. Longitudinal analysis is essential for understanding the relationship between the outward migration of logistics facilities and spatial restructuring of urban areas that occur over years or even decades. As noted in Sakai et al. (2015), the outward migration of logistics facilities in itself may not necessarily be a problem if it is occurring as an efficient response to the broader restructuring of the shipment origins and destinations. As such, it is critical to understand how the outward migration of logistics facilities occurs and under what conditions it can lead to an increase in truck travel distances to ascertain if government intervention is needed, and if so how it may look like. This study strives to address these gaps by longitudinally analyzing the outward migration of logistics facilities and interpreting it against the

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