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Urban spatial structure, employment subcenters, and freight travel

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ABSTRACT

Metropolitan areas in the U.S. have become increasingly polycentric. Large employment subcenters have emerged outside of central cities, competing against the traditional city center for labor and businesses. The existing literature on land use and transportation focuses on passenger travel, providing little insight into the impact of polycentric metropolitan development patterns on freight activity. In this study, we use the Los Angeles region as a case study to examine the relationship between urban spatial development patterns and freight travel. Using the National Employment Time Series (NETS) data, we identify employment subcenters in metropolitan Los Angeles. We characterize freight activities associated with the subcenters using data from the Southern California Association of Governments (SCAG). We develop a regression model that estimates freight activity as a function of geographic characteristics, such as whether a location is in an employment subcenter, measures of nearby employment, access to the highway network, and proximity to intermodal freight facilities. The results indicate that employment is an important driver of freight activity; however, employment subcenters have an independent effect on freight activity. The results of this study suggest that further research on urban spatial structure and freight activity should assess the effects of employment subcenters and how their particular employment composition and characteristics are associated with freight activities at the metropolitan level. Such an approach would lead to more precise policy recommendations for urban goods movement.

1. Introduction

A half-century of dispersed spatial development has intensified polycentric urban spatial patterns. In major U.S. metropolitan areas, large population and employment subcenters have emerged outside of central cities, diminishing the role of the traditional city center as a destination for businesses. While service and financial industries are more likely to locate in the central city, manufacturing and warehousing industries have decentralized to suburbs because of lower land and transport costs (Glaeser and Kahn, 2001). Moreover, employment subcenters are transforming from "business only" districts into multi-use locales that often have residential, office, retail, light industrial, and warehousing uses in close proximity, competing for space on the same road network. This changing nature and context of urban development presents challenges to many businesses trying to optimize goods and service delivery within existing transportation networks.

The previous literature on land use and transportation has focused on passenger travel (Bento et al., 2005; Boarnet and Crane, 2001; Boarnet and Sarmiento, 1998), providing little insight into the impact of polycentric metropolitan development patterns on freight activity. There is evidence that suggests that urban spatial structure at the metropolitan level has significant impacts on passenger travel behavior (Badoe and Miller, 2000; Bento et al., 2005; Naess, 2003). However, as Rodrigue (2006a) and Hesse and Rodrigue (2004) have noted, freight transport and goods movement in an urban context have been understudied despite their increasing importance on the urban economy and geography. In particular, the relationship between employment subcenters and freight travel remains largely unexplored (Hesse and Rodrigue, 2004; Woudsma, 2001). The dearth of research on urban freight transport is unfortunate given increasing policy attention to a national freight network and its significant role as a driver of regional and national economic development (Kane and Tomer, 2015).

In this study, we use the Los Angeles region as the case study to explore the relationship between urban spatial development patterns and freight travel. Los Angeles is the ideal place to study the relationship between metropolitan development patterns and freight activity because of its large number of employment subcenters compared to other metropolitan areas and the region's long history of dispersed urban spatial development (Giuliano and Small, 1999; Giuliano et al., 2007; Redfearn, 2007). We first identify subcenters in metropolitan Los Angeles using the National Employment Time Series (NETS), which has the location and industry code of all business establishments in the region. We characterize freight travel associated with major subcenters using data from the Southern California Association of

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Governments (SCAG), the metropolitan planning organization for the greater Los Angeles region. This research enables us to estimate how freight travel is associated with different employment centers, providing insights into relationships between land use, industrial structure, and the use of the road and highway system by freight.

2. Literature review

2.1. Polycentric urban model and subcenter formation

The traditional model of urban spatial structure is the monocentric urban model which assumes that all jobs are located in the city center (Alonso, 1964; Mills, 1967; Muth, 1969). Recent work from urban economics and regional studies suggests that major American cities have become increasingly polycentric, with multiple employment centers dispersed across a typical metropolitan area (Anas et al., 1998; McDonald and McMillen, 1990). A definition of employment subcenters tends to vary from one city to another, but urban researchers have long sought to develop a robust method to identify employment subcenters. McDonald (1987) used a simple employment density function to identify employment subcenters in the Chicago metropolitan area. He defined subcenters as a zone whose measure of employment concentration is higher than all other zones in the surrounding area. McMillen (2001) and Craig and Ng (2001) used a similar approach using a nonparametric employment density function to identify subcenters. They identified subcenters as areas with high employment concentration where the estimated density function is increasing rather than decreasing with distance from the city center. For the Los Angeles region, Giuliano and Small (1999) developed a criteria to identify employment subcenters as a cluster of contiguous zones having a minimum employment density of 10 jobs per acre and total subcenter employment of at least 10,000 jobs. A series of follow-up studies was conducted to ensure that this cut-off point is robust and consistent over time (Giuliano et al., 2007; Redfearn, 2007).

Previous literature suggests that job clusters emerge where a good labor force and transportation network exist (Giuliano and Small, 1999), however, what is still in need of further understanding is how travel behavior could be affected by the resulting changes in urban form. Firms locate near available labor supply and seek to achieve economies of scale, known as “agglomeration economies.” By locating close to each other, firms benefit from externalities of agglomeration economies, e.g. access to a large labor pool, specialized and skilled labor, knowledge spillovers, and input sharing (Giuliano et al., 2007; Puga, 2010). Businesses concentrate in space because of these agglomeration benefits, and the location choice of firms among these employment subcenters is influenced by the agglomeration economies/diseconomies in each subcenter, which in turn depend on the spatial distribution of production and consumption and the existing transportation network. With the exception of one TRB report (Bassok et al., 2013), most of the theoretical and empirical work on employment subcenters has been centered on the phenomenon itself with little discussion about how the changing urban spatial pattern has influenced travel behavior. This is an especially acute gap with regard to freight demand and movement at the metropolitan scale.

2.2. Determinants of freight activity

In understanding freight travel, it is important to make a distinction between freight generation and freight trip generation (Holguín-Veras et al., 2014). While goods movement and freight distribution is increasingly being understood within the context of integrated freight demand (Hesse and Rodrigue, 2004), freight demand occurs when there is an economic activity pertaining to the production and consumption of goods. Generation of freight trips is the result of meeting this integrated freight demand by transporting goods between production, distribution, and consumption locations. Therefore, freight trip generation is not only affected by the size of an establishment (Holguín-Veras et al., 2014) but also the size and the type of shipments being delivered (Sánchez-Díaz et al., 2014) as well as the freight distribution and transportation network (Hesse and Rodrigue, 2004).

Previous literature has shown that freight trip generation is generally proportional to establishment size; however, there are large variations in freight trip generation between individual firms and the types of industry. Holguín-Veras et al. (2011) developed an ordinary least squares (OLS) model to predict freight trip generation using employment size as an independent variable at the disaggregate establishment level. The authors assumed that a firm decides the optimal shipment size and frequency of delivery that minimizes the corresponding transportation and inventory costs, and these logistic decisions may differ by industry sector. Using data from New York City, Holguín-Veras et al. (2011) have shown that freight trip generation is proportional to business size for only 18% of the industry sectors. Iding et al. (2002) developed a linear regression model for various sectors of industry using a large-scale survey conducted in the Netherlands. The results indicated that while freight trip generation is generally proportional to establishment size, a large variability exists in freight trip generation between individual firms and the types of industry.

Sánchez-Díaz et al. (2014) explored the relationship between freight trip attraction and key features of the urban environment. Using 343 establishments in New York, the authors found that the establishment's location has a significant effect on freight trip generation. They found a significant autocorrelation in retail establishments, suggesting that location, e.g. proximity to large employment peers or high density retail establishments, plays an important role in attracting freight trips. Furthermore, Sánchez-Díaz et al. (2014) found that freight trip attraction is better modeled as a nonlinear function of employment and other locational variables. Taken together, these studies suggest that freight trip generation could be proportional to establishment size (as measured by employment), but the types of industry and the spatial clustering of firms in certain industries also play an important role in attracting freight travel.

In addition to the freight demand caused by the direct outcome of economic activities, Rodrigue (2006b) has argued that freight transport should be understood as an integrated demand, recognizing the importance of underlying economic activities (e.g. employment, population, and income). While production and consumption of goods and services play an important role in generating basic demand for goods movement, recent decentralization of warehousing and trucking activity has increasingly shaped how goods movement and distribution operate in a changing micro- and macro-economic framework (Cidell, 2010; Dablanc, 2014). Much of this changing dynamic is characterized by globalization and complex supply chain management where freight transport and distribution are interdependent within the urban and regional economy (Hesse and Rodrigue, 2004; Rodrigue, 2006b). This changing notion of freight transport also resonates with the recent development in urban economics where understanding of urban spatial structure has changed from a monocentric model to a polycentric urban model. However, little effort has been made to understand urban freight movement within the broader context of changing urban spatial structure.

A review of the previous literature indicates that most of the theoretical and empirical work on employment subcenters has been centered on either describing the patterns or identifying the causes of urban spatial structure. Likewise, the freight movement literature has largely focused on factors of freight trip generation from the perspective of firm-level logistic and business decisions. The changing nature of urban spatial structure, especially with regard to subcentering patterns of employment, has broader implications for production, consumption, and distribution of goods and services. However, urban spatial patterns and the transportation network have rarely been examined in relation to goods movement within metropolitan areas. This paper, to our knowledge, is the first attempt to understand urban goods movement